TRAVELS · THROUGH THE · ALPS

JAMES D. FORBES

Travels Through the Alps

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Travels Through the Alps

BY THE LATE

JAMES D. FORBES, F.R.S., SEC. R.S. ED., F.G.S.

CORRESPONDING MEMBER OF THE INSTITUTE OF FRANCE, PROFESSOR OF NATURAL PHILOSOPHY IN THE UNIVERSITY OF EDINBURGH, PRINCIPAL OF THE UNITED COLLEGE IN THE UNIVERSITY OF ST. ANDREWS, ETC., ETC., ETC.

Sag' mir was du an diesen kalten und starren Liebhabereien gefunden hast.

GOETHE.

NEW EDITION REVISED AND ANNOTATED

BY

W. A. B. COOLIDGE

FELLOW OF MAGDALEN COLLEGE, OXFORD

AND FORMERLY EDITOR OF THE 'ALPINE JOURNAL'

With Portrait, new Maps, and many Illustrations and Diagrams

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ADAM AND CHARLES BLACK

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PREFACE TO THE PRESENT EDITION

In 1859 Professor Forbes collected his scattered essays and notes relating to his scientific observations on glaciers in a volume entitled, *Occasional Papers on the Theory of Glaciers, now first collected and chronologically arranged* (Edinburgh, A. & C. Black). Forbes, however, never seems to have thought of similarly collecting his writings which describe his travels in the Alps. The present volume is an attempt to fill this gap, and is thus a companion to that of 1859, the one being purely scientific and the other purely narrative.

The present volume comprises four of Forbes's chief writings relating to his Alpine travels :—

1. *Travels through the Alps of Savoy and other parts of the Pennine chain*

Originally published at Edinburgh in 1843 by Messrs. Black, a second and enlarged edition was issued in 1845, and this has formed the basis of the new edition herewith given to the reading public. The text has been reproduced *in extenso*, a few misprints being silently corrected, and the spelling of the place names being brought into accordance with modern usage. But the entire appendix to the second edition has been omitted, as it is exclusively scientific, and has been reprinted in the 1859 work mentioned above. Some of the chapters in *Travels* deal indeed more or less with scientific matters, but in a popular fashion, while Forbes's account of his survey of the Mer de Glace at Chamonix is too valuable and interesting to be thrust out of the position to which the author himself assigned it. The whole of the text has been carefully annotated with the special view of enabling the reader of to-day to appreciate the full meaning of Forbes's wonderfully interesting narrative. In particular, pains have been taken to give the most recent determinations of the heights of the various peaks and passes mentioned, so that the reader may see for himself how slight are the variations from those obtained by Forbes half a century ago by the aid of comparatively imperfect instruments. The present editor's notes are always enclosed within square brackets, while the quotations from works of Alpine travel have been carefully verified, and corrected if necessary.

The large lithographs have not been reproduced, as they are very old-fashioned. The topographical sketches have been reduced in size (but not corrected), and are now inserted in the text. The large map of the Mer de Glace is given without any changes being made in it, but that of the Pennine Alps has been replaced by a new large scale outline map, on which Forbes's route is marked in red. All the diagrams have been retained in the present edition.

2. *Journals of Excursions in the High Alps of Dauphiné, Berne, and Savoy*

These journals were printed at the end of Forbes's *Norway and its Glaciers visited in* 1851 (Edinburgh, A. & C. Black, 1853), and so are but little known to the Alpine reading public. Yet they are of extreme importance and interest, for they narrate some very early explorations in the snowy ranges of Dauphiné, the first British ascent of the Jungfrau, and the first visit by a traveller to the great Glaciers of Tour and Saleinaz in the chain of Mont Blanc.

As in the case of the *Savoy*, the large lithographs have been omitted, but all the other illustrations and diagrams have been retained. The spelling of the place names has been revised, and the text fully annotated. Entirely new maps (there were none in the 1853 issue) of the Dauphiné and Bernese Alps (with Forbes's routes marked in red) are supplied, as well as an accurate diagram of the intricate topography of the head of the Tour, Trient, Argentière, and Saleinaz Glaciers, since Forbes's diagram is very faulty, and is now only of historical interest.

3. *Pedestrianism in Switzerland*

This is an article originally printed in the *Quarterly Review* for April, 1857, and is a most interesting review by one of the early pioneers of the principal new works relating to the Alps. It has also considerable historical importance, as it appeared nine months *before* the foundation of the English Alpine Club.

4. *Topography of the Chain of Mont Blanc*

This is an article published in the *North British Review* for March, 1865, and is here reprinted by the kind permission of Mr. Douglas. It is specially concerned with Mr. Adams Reilly's map of the Chain of Mont Blanc, which in a way was the continuation of Forbes's own labours on the Mer de Glace. The reproduction of an early form of this map is in this edition replaced by a more recent map of the chain. We have omitted the reproduction of Peter Martel's quaint old map, and also the diagram showing the Argentière, Tour, and Saleinaz Glaciers, as the more accurate diagram (given under 2 above) completely supersedes it.

It is hoped that the present edition of the Alpine writings of one of the first British pioneers in the High Alps may be acceptable to a wide circle of readers. I acknowledge gratefully much help received from M. Louis Kurz of Neuchâtel (the chief authority on the chain of Mont Blanc), who has read through all the proofs, especially of that portion of the volume relating to the chain of Mont Blanc.

W. A. B. Coolidge.

Grindelwald, *February* 1900.

INTRODUCTION TO THE PRESENT EDITION

THE PLACE OF FORBES IN THE HISTORY OF THE EXPLORATION OF THE HIGH ALPS

THERE is a vague idea afloat that the exploration of the High Alps (*i.e.* those above the snow-level) has been mainly due to English travellers. But like many others this idea is so far from being accurate that it would be truer to assert as a general proposition that the contrary was the case. In particular districts and in the case of some very famous peaks, English climbers have no doubt been to the fore, as well as in the detailed study of certain ranges, originally first visited by travellers of other nationalities. But till about the middle of the fifties English climbers were few and far between, though since then they have done their best to make up for lost time and lost ground. Yet to all general rules there are exceptions, and Forbes merits an honourable pre-eminence as one of the earliest British explorers of the High Alps, as the author of the first detailed book in English relating to such explorations, and as a link between Saussure and the founders of the English Alpine Club.

Before, however, dwelling on these characteristics of his Alpine career it may be well to set down the main facts of that career as contained in his own writings or in his letters and diary, printed in the interesting *Life and Letters* which was compiled by Principal Shairp, Professor Tait, and Mr. Adams Reilly, and published in 1873.

Born in 1809 of an ancient Scotch family, Forbes was elected (against Sir David Brewster) to the Professorship of Natural Philosophy in the University of Edinburgh in 1833, when not quite twenty-four years of age. This post he exchanged at the end of 1859 only, and that in consequence of ill health, for the Principalship of the United College in the University of St. Andrews, a dignified position which he filled till within six weeks of his death on the last day of 1868. In the framework of this life of industrious simplicity are set his frequent visits to the Alps, one of the chief features of which was that they meant to him simply the continuation of his studies and researches, amid different surroundings, but yet on the same lines as in his quiet home. This feature explains why he always preferred to travel leisurely, and to make expeditions which might supply him with information such as his studies required rather than those which would only serve topographical or gymnastic ends. In other words, his mountain explorations were made with a fixed object in view—the study of hitherto more or less unexplained phenomena of nature, in particular all that relates to glaciers, their motion, characteristics, etc. This was the primary object Forbes set before him. In this paper, however, we have not to consider him as a student of the physical sciences, but as a wanderer among the Alps, a topographical explorer, and an Alpine climber—that is, in short, to lay stress on what to him were the secondary objects of his travels. But from this point of view his place in the history of Alpine exploration is certainly not lower than that which he worthily occupies in the history of the Glacier Theory.

In **1826**, when but seventeen, he paid his first visit to the Alps, spending a day at Chamonix, and making an excursion on the Mer de Glace, the future scene of his remarkable labours. In **1832** he again visited Chamonix and the Mer de Glace, pushing on as far as the Jardin, but had to cut his trip short in order to return home to enter on the contest for the Professorship, which he succeeded in obtaining. His visits in 1835 to the Pyrenees, and in 1837 to the Tyrol (including the Dolomites), do not concern us here, especially as he seems to have reached no great height during these wanderings. It is in **1839** that his career as a mountain explorer may be said to begin. From Marseilles (which he had reached after spending some days in Auvergne) he made his way up the Durance and Ubaye valleys to Barcelonnette, and crossed from the head of the latter valley by the Col de la Cula (c. 9700 feet) to St. Véran (the highest village in France), and so to Abriès in the Guil valley.

Following the latter valley to its very head he made the "Tour of Monte Viso" by several laborious passes—the Col de la Traversette (9679 feet), the Col dei Viso (8704 feet), either the Sagnette (9761 feet), or the San Chiaffredo Passes (9069 feet), and the Col de Vallante (9269 feet). He then recrossed from the Guil valley by the Col de la Croix (7576 feet) to the Waldensian valleys of Piedmont, where he spent a few days. Thence he made his way up the Chisone valley, and crossed successively the Col de Sestrières (6631 feet), the Mont Genèvre (6083 feet), and the Col du Lautaret (6808 feet) to the little town of Bourg d'Oisans in the Dauphiné Alps; hence he made an excursion up the Vénéon valley to La Bérarde in the heart of the Dauphiné Alps, being probably the first English traveller to visit that remote hamlet. Then by way of Grenoble and Geneva he made his way to Chamonix for the third time, once more exploring the Mer de Glace and the Jardin, and later in the season making the "Tour of Mont Blanc" to Courmayeur. Turin was reached *viâ* Cogne, the Col della Nouva (9623 feet), and Cuorgnè. A few days later Forbes returned to Savoy by the Mont Cenis (6893 feet), and then crossed from Lanslebourg by the Col d'Iseran (9085 feet) to the head of the Isère valley, down which he made his way past Tignes, Bourg St. Maurice, and Moûtiers Tarentaise, in order to gain Chambéry and Lyons. The published notices of this long journey are very scanty. This is much to be regretted, for it led him through regions which even now are not very familiar to English travellers, and in which he was often probably the first Englishman ever seen. But save on one or two excursions he did not on this occasion penetrate very far into the high snow regions.

The case is very different with his travels in 1841 and 1842, on which his fame as a mountain climber must rest. In **1841** he went from Grenoble to Allevard, and then by the Sept Laux (7169 feet) to Bourg d'Oisans. Thence he again went up the Vénéon valley to La Bérarde, but this time did not return by the same route. On July 25 he traversed the high snowy Col du Says (10,289 feet)—this being the first known passage by a traveller—to the remote Val Gaudemar. Thence, after a day spent in geologising in the Navettes glen, he crossed another high glacier pass, the Col du Sellar (10,063 feet), being no doubt the first foreign traveller to achieve this expedition—to the Vallouise. A visit to Arvieux in the Queyras (the scene of the devoted labours of Félix Neff, who had only died in 1828) was followed by a geological excursion to a remarkable phenomenon at the foot of the Pic de Combeynot on his way over the Col du Lautaret to La Grave. The long but easy Col de l'Infernet (8826 feet) led him to the Mont Cenis road at St. Jean de Maurienne. This campaign in the Dauphiné Alps is of very great historical interest, for they were then all but unknown to English (or indeed to any) travellers, and Forbes's expeditions form the starting-point of the later explorations of this district, many years after his visit. From Dauphiné Forbes hurried by the Little St Bernard (7179 feet), the Col Ferret (8311 feet), and the Grimsel Pass (7139 feet) to the Grimsel Hospice to keep an engagement with Agassiz and his party, then occupied in studying the Unteraar Glacier. On the very first day he set foot on that glacier (August 9) Forbes's attention was attracted by the striking phenomenon of the veined or ribbon structure of the ice, a noteworthy instance of his perspicacity. He remained some time at the Grimsel, or at Agassiz's hut on the Unteraar Glacier (the hut is best known as the "Hôtel des Neuchâtelois"), excursionising to the Gross Sidelhorn (9452 feet) and to the Rhone Glacier. On August 20 he crossed the Gauli Pass (10,519 feet) to the Urbachthal, climbing on the way up the Ewigschneehorn (10,929 feet), of which the first ascent had been made a few days earlier by Desor. The whole party on August 27 crossed the Oberaarjoch (10,607 feet) from the Grimsel to the chalets by the now well-known Märjelen lake, and next day made the ascent of the Jungfrau (13,669 feet). This was but the fourth recorded ascent of this beautiful peak, which had not been attained since 1828. It was the first ascent of the mountain in which any other than Swiss took part, and it was not till 1856 that another native of Great Britain (Mr. Chapman) attained this summit. Forbes's Alpine travels in 1841 were brought to a close by visits to Saas Fee and to Zermatt (where he made several excursions, including one to the summit of the St. Théodule Pass), and then by a day's geologising at Vernayaz and Salvan. On the way home he called in upon Agassiz and Desor at Neuchâtel, and on Professor Bernard Studer at Berne. In many respects this journey of Forbes in 1841 was the most important that he ever made in the High Alps, for the expeditions were the most difficult he achieved in the course of his Alpine career; he never attained in later years a greater height than the Jungfrau; and (last but not least) his observations on the Unteraar Glacier induced him to form the project of himself instituting a systematic and thorough examination of a great Alpine glacier.

Hence, in **1842**, the greater part of his summer was occupied by such observations on the Mer de Glace at Chamonix, which he selected as the scene of his labours. The very day (June 24) he reached Chamonix from St. Gervais by the Col de la Forclaz (5105 feet) he made the acquaintance of Auguste Balmat (who had been recommended to him by the Curé of Chamonix), a man who became his faithful guide and companion during his examination of the Mer de Glace, and on his later travels, though oddly enough not on the Col du Géant or on the round with Prof. Studer. He made a journey to Turin to observe a total eclipse of the sun, and on his way back stopped some days at Courmayeur, making excursions to the Cramont (8980 feet) with Chanoine Carrel of Aosta, the Col de Chécouri (6431 feet), and the Croix de la Bernarda (8314 feet), as well as to the great Brenva and Italian Miage glaciers. On July 23, as in duty bound, he followed in the steps of his revered master, H. B. de Saussure, across the Col du Géant (11,060 feet), thus regaining his head-quarters at the Montenvers. A few days later he received a visit at Chamonix from Prof. B. Studer, whom he agreed to meet at the Great St. Bernard on August 12.

The friends met at the convent on the appointed day (Forbes having with him Victor Tairraz of Chamonix), and then set out on a most interesting journey through the mountains in the direction of Zermatt. After descending to Orsières they mounted the entire Val de Bagnes, and on August 15 crossed the Col de Fenêtre (9141 feet) to the village of Valpelline above Aosta. Thence they ascended the Val Pelline to the Prarayé huts, and on August 17 traversed the little known Col de Collon (10,270 feet) to Arolla and Evolena, names now familiar to summer travellers, though Forbes was probably the first English traveller to visit either spot. The bad accommodation at Evolena so disgusted Prof. Studer that he fled to the Val d'Anniviers, thus leaving Forbes the honour of making (August 19) the first certain passage by travellers of the snowy Col d'Hérens (11,418 feet), with which he combined the ascent of the Stockhorn (11,795 feet). This pass brought him by the Z'Mutt glacier to Zermatt, whence he climbed the Riffelhorn (9617 feet), which he had tried in 1841, but which had been first scaled by some students a few days before Forbes's arrival at Zermatt in 1842. After a slight detention at Zermatt (due to an injured foot) he started off again with Prof. Studer to make the "Tour of Monte Rosa." This involved crossing the St. Théodule (10,899 feet) to the village of Val Tournanche, the Col de Portola (7924 feet) thence to Brusson in the Val d'Ayas, the Col della Ranzola (7123 feet) to St. Jean de Gressoney, the Col d'Olen (9420 feet) to Alagna and Riva in the Val Sesia, the Turlo Pass (8977 feet) to Macugnaga in the Val Anzasca, and the Monte Moro (9390 feet) to Saas and Visp. On the way Forbes made the acquaintance of Zumstein and of Gnifetti (two of the early explorers of Monte Rosa), and visited the Lys and Macugnaga glaciers. He then returned to Chamonix *viâ* Martigny, not failing to examine the Argentière and Trient Glaciers *en route*. He had accomplished a splendid summer's work, whether in carrying out his great survey of the Mer de Glace or in his Alpine wanderings in unfrequented parts of the Pennine chain. He himself writes in his journal that this summer "was the happiest he had ever spent" (*Life and Letters*, p. 155).

All the winter of 1842-43 he was engaged in writing his *Travels through the Alps of Savoy*, which forms the first portion of the present volume. It is mainly devoted to his campaign of 1842, for the notices of his earlier Alpine travels appeared only in the form of an "Appendix" (the second portion of the present volume) to his book on *Norway* that was not published till 1853. The *Savoy* book gave him much work, not merely in reducing his observations, but also in drawing the splendid map of the Mer de Glace, in the preparation of the numerous smaller topographical sketches to illustrate the exact topography of certain parts of his journeys, and in the superintendence of the reproduction of his larger and smaller diagrams. The dedication to his friend Prof. B. Studer is dated July 1, 1843, and on the 4th of the same month Forbes married, starting at once to pass his honeymoon in the Alps. But his brilliant Alpine career was now (the pity of it!) to be brought practically to a close, for on July 20 at Bonn he was struck down by gastric fever, and it was only after a most dangerous illness (and one from the effects of which he never completely recovered) that, about the middle of August, he at last reached Switzerland. After spending some time at Bex, where he discussed glacier problems with Charpentier, he succeeded on September 4 in getting across the Col de Balme to Chamonix, where he was warmly welcomed by his many humble friends. He was even strong enough to resume his observations on the Mer de Glace in a certain degree. On the way home he crossed the Gemmi Pass (7641 feet), visited Grindelwald and its Eismeer, ascended the Faulhorn (8803 feet), and travelled by way of the Great Scheidegg (6434 feet) and Meiringen to Thun and Berne. But what a sad contrast was his trip of 1843 to those of 1841-42!

In **1844** Forbes made a tour through the Italian Lakes, and then entered Switzerland by the Simplon Pass (6592 feet). He spent some days at the Simplon Hospice, and on July 22 made thence, in the company of one of the Austin Canons, his last important Alpine ascent, that of the Wasenhorn (10,680 feet), above the Kaltwasser Glacier. A few days later he minutely studied the Märjelen lake (known to him from his bivouac near by in 1841), the Great Aletsch Glacier, and the Massa gorge through which the Great Aletsch Glacier sends its waters to the Rhone. Then he spent three weeks at Chamonix and the Montenvers, again making a long series of observations on the various phenomena presented by the Mer de Glace. These served to complete and to correct his previous work, and are not unfrequently mentioned in the second edition of his *Savoy*, issued in 1845.

Forbes did not go abroad in 1845, but in **1846** he spent a long time at the Montenvers. On the way thither he visited Bishop Rendu (a great authority on glaciers) at Annecy. But, apart from renewed visits to the Brenva and Italian Miage Glaciers, Forbes that summer did little climbing. He was unsuccessful in an attempt to climb the Aiguille du Moine, and also in another to explore the Tour Glacier. On August 22 he crossed the Col de Cheville (6273 feet) from Bex to Sion, and wound up his summer wanderings by visits to the Rhone and Unteraar Glaciers.

Several years passed by before Forbes in **1850** again caught a glimpse of his beloved Alps. He naturally went to his well-known haunts at Chamonix, and on July 17 climbed the Aiguille de la Glière (c. 8800 feet) in the chain of the Aiguilles Rouges, north of Chamonix. And on July 20 he had the satisfaction of at last carrying out his long-planned exploration of the Tour Glacier, crossing thence by the Col Blanc (11,162 feet) to the upper plateau of the Trient Glacier, and then through the Fenêtre de Saleinaz (10,709 feet) to the Saleinaz Glacier, and so to Orsières. This was his last expedition in the High Alps, so that a peak in the neighbourhood was fitly named many years later the "Aiguille Forbes" (11,418 feet) in honour of the first great British explorer and mountain climber. The narrative (see Chap. V. of Part II. below) of this expedition is printed in the Appendix to his *Norway* book, which is mainly concerned with the account of a visit to Norway in 1851, and was published in 1853.

In the spring of 1853 his faithful companion, Auguste Balmat, came to England to see Forbes at Clifton, near Bristol. That summer Forbes made a short journey to Switzerland, visiting Zürich and the St. Gotthard,—his last visit, for an attempt in 1857 broke down at Folkestone. But though he never again set eyes on the Alps he loved them to the last. "My heart," he wistfully said, "remains where my body can never be. . . . My yearnings towards the Colinton banks" (the home of his youth) "and towards the Swiss mountains are much on a par—both *home-sickness*" (*Life and Letters*, p. 340).

Naturally, therefore, he took the keenest interest in the growth and spread in the early fifties of the taste for Alpine climbing among the younger generation of Englishmen. In 1857 he made the acquaintance of Mr. Alfred Wills (now the Hon. Mr. Justice Wills), who a few months later was one of the founders of the club. Forbes made Mr. Wills's book, *Wanderings among the High Alps*, one of the subjects of an article in the *Quarterly Review* for April, 1857, on "Pedestrianism in Switzerland" (reprinted as the third portion of the present volume). At the instance of Forbes Mr. Wills in 1858 carried out the complete exploration of the Col du Tour, and so rounded off Forbes's work in that region. On July 19, 1859, Forbes was elected an honorary member of the Alpine Club, deservedly the first man to receive this honour. He appreciated keenly the success (in

1861) of Mr. F. F. Tuckett in reaching Mont Blanc from St. Gervais by way of the Bosses du Dromadaire, and the same mountaineer's epoch-making explorations in 1862 of the high glacier passes of Dauphiné, which had been all but totally neglected since Forbes's own journey of 1841. He was very specially drawn towards Mr. Adams Reilly, who had undertaken to construct a detailed map of the entire chain of Mont Blanc, and made an early version of it the text of an article on the "Topography of the Chain of Mont Blanc" in the *North British Review* (reprinted as the fourth portion of the present volume) for March, 1865, the complete map itself appearing later in the same year.

Such are the main facts of Forbes's Alpine career, the keynote of which is given in the enthusiastic words of Charles Kingsley: "We have heard Professor Forbes's book on glaciers called an Epic Poem, and not without reason. But what gives that noble book its epic character is neither the glaciers, nor the laws of them, but the discovery of those laws; the methodic, truthful, valiant, patient battle between man and Nature, his final victory, his wresting from her the secret which had been locked for ages in the ice-caves of the Alps, guarded by cold and fatigue, danger and superstitious dread" (*Life and Letters*, p. 162).

Let me now briefly dwell on the three characteristics which, as I pointed out at the beginning of this paper, seem to me to distinguish Forbes's work in the Alps other than his purely scientific observations on glaciers.

1. *He was one of the Earliest British Explorers of the High Alps*

His known predecessors are indeed few and far between, while they all made isolated expeditions, not prolonged tours among the snow and ice regions. Here are the names of some of them. In 1786 Mr. Hill crossed the Col du Géant, and his footsteps were followed by one or two English parties, among them being Mrs. and Miss Campbell in 1822. Colonel Beaufoy, in 1787, was the first Englishman to reach the summit of Mont Blanc, and was succeeded by a bare dozen English parties before 1839. Mr. Cade's party crossed the St. Théodule in 1800, and was followed by a few other travellers. Sir John Herschel ascended the Breithorn in 1822, and Lord Minto in 1830;

while in 1835 Mr. Callander crossed the Mittelgrat or "Old Strahlegg" Pass. Mr. Brockedon, between 1824 and 1829, crossed several high glacier passes in the Tarentaise and the Maurienne, and in 1845 Mr. Speer made the first ascent of the Mittelhorn, the highest summit of the Wetterhorn. Mr. A. T. Malkin's climbs among the High Alps began in 1839, as did those of Forbes. But all these were, so to say, "spurts" or "tours de force," while it will be noticed as a curiosity that the Scotch element is very strong among these early Alpine climbers. On the other hand, Forbes's climbs are spread over several successive summers, and were made in widely distant regions of the Alpine chain. In particular his ascent of the Wasenhorn, in 1844, is noteworthy as being, so far as I can discover, the earliest "first ascent" of a peak over 10,000 feet ever made by a native of Great Britain, for Forbes thus beat by just a year his brother Scotchman, Mr. Speer, on the Wetterhorn. In face of this enterprise one is surprised that it never seems to have occurred to Forbes to attempt the ascent of Mont Blanc itself, though his master Saussure had vanquished it, or even to explore any portion of that great mountain, despite his many and prolonged visits to Chamonix and the Mont Blanc range in general.

2. *Forbes was the author of the first Detailed Book in English relating to such Explorations in the High Alps*

This may seem astonishing, but I believe my statement is perfectly accurate. Before 1843 the various English climbers mentioned above had published very little as to their doings. Save the pamphlets or booklets given to the world by pretty well every one of the English parties which had ascended Mont Blanc, and Mr. Brockedon's articles in *Blackwood* in 1836, and in *Fraser* in 1839 (for his *Journals of Excursions in the Alps* does not deal with the High Alps save as regards the St. Théodule and Gries Passes), the notes left by the other English parties were generally published very many years later, and in no case do they amount to more than notes or short magazine articles. Forbes's *Savoy* therefore led the way in the matter of English works relating to the High Alps, the number of such works being now very great.

But it must not be forgotten that as non-Englishmen had climbed many peaks, and had crossed many passes in the High Alps before the time of Forbes, so they had also published several works relating more or less to their doings; a list of these (all quoted or mentioned by Forbes himself) is given at the end of this paper.

3. *Forbes was a link between Saussure and the Founders of the English Alpine Club*

Forbes always regarded Saussure as his master, for as he tells us himself in the early pages of his *Savoy*, "It is now a good many years since I proposed to myself to travel, not as an amusement, but as a serious occupation, and with De Saussure before me as a model." And his *Savoy* is avowedly an "endeavour to follow De Saussure in his own country and to meet him on his own ground"—in short a continuation (though of a more special nature) of the *Voyages dans les Alpes*, both works treating of scientific subjects as well as giving a narrative of the excursions during which these scientific observations were made. There is even a very interesting personal link between Saussure and Forbes. In Forbes's journal of his first visit to the Alps in 1826, he tells us how on his very first exploration of the snow regions one of his guides was Cachat "le Géant," who had travelled so much with Saussure, particularly on his ascent of Mont Blanc and on his passage of the Col du Géant.

On the other hand, Forbes, while thus looking back towards Saussure, looks forward towards the younger Englishmen who were to successfully carry out the minute exploration of the Alps. We have seen above how he encouraged Mr. Wills, one of the founders of the Alpine Club and its third President, while it was to Mr. Wills that Forbes handed on his guide Auguste Balmat. We have seen too how interested he was in the explorations of Mr. Tuckett and the Mont Blanc map of Mr. Adams Reilly. No doubt he showed the same friendly encouragement to many others of the rising English climbers. And thus, whether by his example, or by his personal help ever generously rendered, Forbes forms the true link that binds together in one long golden chain the mountaineers of the eighteenth century who first systematically attempted to penetrate the secrets of the world of ice and snow in the Alps with their successors a hundred years later, to whom it has been given to complete the explorations thus set on foot.

For all these reasons, and doubtless others could be added, Forbes fills a very high position in the history of the exploration of the High Alps, especially in the British chapter of that history, so that should a calendar of Alpine worthies ever be drawn up his name would deserve a foremost place therein, whether as an Alpine pioneer, as an Alpine writer, or as a link between past and present Alpine climbers.

W. A. B. Coolidge.

1. *Principal Expeditions above the Snow Line made by Forbes*

1832. Jardin (9833 feet).
1839. Col della Nouva (9623 feet).
1841. Cols du Says (10,289 feet) and du Sellar (10,063 feet).
Gauli Pass (10,519 feet).
Ewigschneehorn (10,929 feet).
Oberaarjoch (10,607 feet).
Jungfrau (13,669 feet).
1842. Cols du Géant (11,060 feet), de Fenêtre (9141 feet), de Collon (10,270 feet), and d'Hérens (11,418 feet).
Stockhorn (11,795 feet).
St. Théodule (10,899 feet).
1844. Wasenhorn (10,680 feet).
1850. Col Blanc (11,162 feet), and Fenêtre de Saleinaz (10,709 feet).

2. *Principal Books relating to the Alps which are quoted by Forbes*

Agassiz (*L.*) "Etudes sur les Glaciers." Neuchâtel, 1840.
Auldjo (*J.*) "A Narrative of an Ascent to the Summit of Mont Blanc on the 8th and 9th of August, 1827." 2nd edition. London, 1830.
Bakewell (*R.*) "Travels in the Tarentaise, &c., in 1820-22." 2 vols. London, 1823.
Ball (*John*). "The Alpine Guide." Vol. i. "The Western Alps." London, 1863.
Baruffi (*G. F.*) "Pellegrinazioni autunnali." 4 vols. Turin, 1841-43.
Bourrit (*M. T.*) "Nouvelle Description des Glacières, Vallées de Glace, et Glaciers qui forment la grand chaine des Alpes de Suisse, d'Italie, et de Savoie." 3 vols. Geneva, 1785.
Brockedon (*W.*) "Journals of Excursions in the Alps." London, 1833. 2nd edition, 1845.
Browne (*J. D. H.*) "Ten Scenes in the Last Ascent of Mont Blanc." London, 1853.
Charpentier (*J. de*). "Essai sur les Glaciers et le Terrain Erratique du Bassin du Rhône." Lausanne, 1841.
Charpentier (*J. de*). "Notice sur la cause probable du transport des Blocs Erratiques de la Suisse." Article in vol. viii., 1835, of the "Annales des Mines." Paris.
Coleman (*E. T.*) "Scenes from the Snow-Fields; being Illustrations from the Upper Ice-World of Mont Blanc." London, 1859.

Desor (*E.*) "Excursions et Séjours dans les Glaciers et les Hautes Régions des Alpes de M. Agassiz et de ses compagnons de voyage." Neuchâtel and Paris, 1844.

Ebel (*J. G.*) "Manuel du Voyageur en Suisse." 2nd French edition. 4 vols. Zürich, 1810-11.

Engelhardt (*C. M.*) "Naturschilderungen, Sittenzüge, und Wissenschaftliche Bemerkungen aus den höchsten Schweizer-Alpen, besonders in Süd-Wallis und Graubünden." Paris, Strasburg, and Basel. 1840.

Fröbel (*Julius*). "Reise in die weniger bekannten Thäler auf der Nordseite der Penninischen Alpen." Berlin, 1840.

Godeffroy (*Charles*). "Notice sur les Glaciers, les Moraines, et les Blocs Erratiques des Alpes." Paris and Geneva, 1840.

Gruner (*G. S.*) "Die Eisgebirge des Schweizerlandes." 3 vols. Bern, 1760.

Hall (*Captain Basil*). "Patchwork." 3 vols. London, 1841.

Hirzel-Escher. "Wanderungen in weniger besuchte Alpengegenden der Schweiz, und ihrer nächsten Umgebungen." Zürich, 1829.

Hudson (*C.*) and *Kennedy* (*E. S.*) "Where there's a Will there's a Way: An Ascent of Mont Blanc by a New Route and without Guides." London, 1856.

Hugi (*F. J.*) "Naturhistorische Alpenreise." Soleure, 1830.

Latrobe (*C. J.*) "The Alpenstock: or Sketches of Swiss Scenery and Manners, 1825-26." London, 1829. 2nd edition, 1839.

Meyer (*J. R.* and *H.*) "Reise auf den Jungfrau-Gletscher und Ersteigung seines Gipfels." Aarau, 1811. See also *Zschokke.*

Meyer-Ahrens (*Conrad*). "Die Bergkrankheit." Leipzig, 1854.

Murray's "Handbook for Travellers in Switzerland and the Alps of Savoy and Piedmont." 1st edition, 1838; 2nd edition, 1842; 7th edition, 1856; 10th edition, 1863.

Necker (*L. A.*) "Etudes Géologiques dans les Alpes." Vol. i. (all published). Paris, 1841.

Rendu (*Louis,* later Bishop of Annecy). "Théorie des Glaciers de la Savoie." Originally published in 1840 at Chambéry in the "Mémoires de la Société Royale Académique de Savoie." Reprinted, with an English Translation, by Mr. Alfred Wills at London in 1874.

Ruskin (*John*). "On Mountain Beauty" (vol. iv. of "Modern Painters"). London, 1856.

Saussure (*H. B. de*). "Voyages dans les Alpes." 4 vols. Neuchâtel and Geneva, 1779-96.

Saussure (*H. B. de*). "Partie Pittoresque de ses ouvrages." 3rd edition. Paris, 1855.

Scheuchzer (*J. J.*) "Itinera per Helvetiæ Alpinas Regiones facta annis 1702-11." Collected Edition. Leyden, 1723.

Schlagintweit (H. and A.) "Untersuchungen über die physicalische Geographie der Alpen." Two series. Leipzig, 1850 and 1854.

Schott (*Albert*). "Die deutschen Colonien in Piemont." Stuttgart and Tübingen, 1842.

Sherwill (*Markham*). "Historical Sketch of the Valley of Chamouni." Paris, 1832.

Simler (*Josias*). "Vallesiæ Descriptio et De Alpibus Commentarius." Zürich, 1574.

Simond (*L.*) "Voyage en Suisse fait dans les Années 1817-19." Paris, 1822. English translation. 2 vols. London, 1823.

Smith (*Albert*). "The Story of Mont Blanc." 2nd edition, 1854.

Studer (*Gottlieb*). "Topographische Mittheilungen aus dem Alpengebirge." With an Atlas of Mountain Outlines. Bern and St. Gallen, 1843.

Ulrich (Melchior). "Die Seitenthäler des Wallis und der Monterosa." Zürich, 1850.

Venetz (L.) "Mémoire sur les Variations de la Température dans les Alpes de la Suisse." Zürich, 1833. Article in vol. i. part 2 of the "Denkschriften der Allgemeinen Schweizerischen Gesellschaft für die gesammten Naturwissenschaften."

Welden (L. von). "Der Monte Rosa." Vienna, 1824.

Windham (W.) and *Martel (P.)* "An Account of the Glacières or Ice Alps in Savoy, in Two Letters. One from an English gentleman to his friend at Geneva; the other from Peter Martel, engineer, to the said English gentleman. Illustrated with a map and two views of the place, etc. As laid before the Royal Society." London: printed for Peter Martel, 1744.

Wills (Alfred). "Wanderings among the High Alps." London, 1856.

Zschokke (H.) "Reise auf die Eisgebirge des Kantons Bern und Ersteigung ihrer höchsten Gipfel im Sommer 1812." Aarau, 1813. Compiled from information given by the Meyers. Compare R. Meyer's original narrative printed in the "Alpenrosen" (Aarau and Thun) for 1852.

TO M. BERNARD STUDER

DOCTOR IN PHILOSOPHY, CORRESPONDING MEMBER OF THE ACADEMIES OF BERLIN, TURIN, AND MILAN, OF THE NATIONAL INSTITUTE OF WASHINGTON, OF THE GEOLOGICAL SOCIETY OF FRANCE, ETC., ETC., AND PROFESSOR OF GEOLOGY AND PHYSICS IN THE UNIVERSITY OF BERNE

MY DEAR SIR — In former times Dedications were usually the fulfilment of a stipulation, by which Patronage was to be purchased by Eulogy. But since Patronage has ceased to secure success to mediocrity, and complimentary phrases have become too trite to be gratifying, a Dedication has become a rare appendage to a book.

Nevertheless, it has always appeared to me an opportunity to be valued by a literary man, of expressing publicly his respect for the talents, and his esteem for the character of another, in terms requiring no rhetorical embellishments, because, in that case, the language of Truth and of Eulogy is the same.

That you were my companion through several of the most interesting scenes described in this volume would alone be a good reason for requesting permission to dedicate it to you, especially as its appearance is not wholly unconnected with conversations which then passed between us.

But when I add, that your intimate acquaintance with the Alps and their structure, derived from many years of unwearied research, gives you an especial right to judge of a work relating to their Geography and Natural History—a further reason for this Dedication will be understood by those who are aware that the best-informed are usually the most candid judges of the merits of others.

Independently of this, I am happy in being able to claim your sympathy and friendship as the best reason of all,—a sympathy derived from common pursuits, and a friendship which, though not yet old, may certainly be affirmed to be not untried.—I remain, my dear Sir, yours very sincerely,

JAMES D. FORBES.

EDINBURGH, 1st *July* 1843.

PREFACE TO THE SECOND EDITION (1845)

In the present Edition the alterations have been chiefly confined to verbal corrections, and to the addition of some more important points of recent information in footnotes and in the Appendix. The text has been as slightly altered as possible, for I have often observed with regret how new Editions may become new Books without any corresponding advantage. If a work require to be so entirely recast, it ought to be considered as a new one. The narrative form adopted in the present volume, and its constant reference to observations and theories made at the time, render it difficult to incorporate new matter in the same manner as if it were, or professed to be, a Systematic Treatise. These Observations and Theories prove their own date: — this work was written to give them publicity, and I should wish it still to be considered as the depository of them in essentially the same shape in which they were originally given to the world.

Of course, this ought not to prevent ambiguities from being explained or errors corrected. It would be culpable not to take the opportunity of making such important alterations. I have, however, found few such to be requisite, though it may be feared that others have escaped me. But I have had favourable opportunities of reconsidering the entire subject of the present volume, and particularly the Facts of observation and Theories connected with Glaciers, by the aid of subsequent journeys, of comparative leisure, and of the generally candid and intelligent criticism to which my work has fortunately been subjected.

I owe this acknowledgment not only to the Reviews of this country, of America, and of the Continent, which have done me the honour of noticing it, and to the highly qualified Translator [1] who has introduced it to the German public, but to the numerous Scientific Friends who, with much kindness and courtesy, have privately acquainted me with the difficulties and objections which suggested themselves during the perusal of my work. From the number and variety of the letters which I have received, it is probable that no considerable oversight has escaped my attention. In many instances I have been able to explain difficulties to the satisfaction of the proposer; if in all cases the new Edition may not seem to have removed them entirely, it must not be ascribed to a want of respectful attention, but either to the remaining obscurity of the subject, or to a wish not to mix up what I consider to be plain and certain, with explanations merely specious, and theories which a few years might possibly overturn.

The Map of the Mer de Glace has been verified in many parts, and considerable additions and corrections have been made, especially to the part north of the chain of Aiguilles; but the topography of the upper part of the Glacier du Géant remains still imperfect, as mentioned at page 109. The height of the Croix de Flégère, being questionable, has been removed from the Table, page 116; it is, however, certainly lower than the Montanvert.[2]

The facts and laws of the motion and structure of glaciers contained in Chapters VII. and VIII., have been not only verified by myself, but confirmed by independent authorities. The additional footnotes are, for the most part, distinguished by brackets, thus, [ ].[3] The most important are those at p. 145, on the annual motion of the Mer de Glace; at p. 160, on the Dirt Bands; and at pp. 164, 165, on the Law of the Crevasses,

[1] Dr. G. von Leonhard [Stuttgart, 1845].

[2] [The Flégère is 6158 feet, and the Montenvers 6267 feet.]

[3] [In the present edition by the date "1845"; as [ ] indicate notes added by Mr. Coolidge.]

illustrated by figures. A fuller detail of recent observations will be found in the Fifth, Sixth, Seventh, Eighth, and Ninth Letters on Glaciers, now added to the Appendix, and which form in themselves a nearly complete supplement to the first edition.[1] Part of the close of Chapter VIII., which was virtually repeated in Chapter XXI., has been suppressed in order to make room for the additional notes, and some sentences have been transferred to that chapter. In this way, the original arrangement of the matter has been very little interfered with, and the references to the pages will be found to be almost the same as in the First Edition; a convenience which has been studied throughout.

In the concluding chapter, on the Theory of Glacier Motion, the only modification requiring notice is a rectification of certain conclusions drawn from the models described and figured at pages 378-381 of the First Edition [and of this edition also]. The boundaries of the coloured pastes do not, as Mr. Hopkins has justly remarked, *necessarily* coincide with the surfaces of greatest tension. I have, therefore, re-written the passage explanatory of them; and I have removed from a footnote into the text the description of the other and more important models in which the veined structure is produced by the movement of a surface strewed with coloured powder. This experiment was first made whilst the previous edition was in the press, which will account for its insertion in a note, added after the text was written. It is now put in a more prominent position, and illustrated by a figure.

The theory itself has not undergone any alteration, either in substance or expression, unless a qualification of the efficiency of the cold of winter as the sole cause of the congelation of the blue bands in the depth of the glacier may be considered as such.

[1] [These "Letters" are omitted in the present edition, as the complete set was published by Forbes in his *Occasional Papers on the Theory of Glaciers*, 1859. It is to this volume that references are given whenever in his "Travels" Forbes makes mention of any of these "Letters."]

I have the pleasure of adding, in Appendix No. V., a short summary, by M. Studer himself, of his Geological Observations in the part of the Alps which we travelled over together, and which forms a valuable addition to the statements of Chapter XVII.[1]

[1] [These "Geological Observations" have been omitted in the present edition.]

EDINBURGH, *9th June* 1845.

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PART I

TRAVELS THROUGH THE ALPS OF SAVOY

CHAPTER I

THE ALPS AND ALPINE TRAVELLERS

Ways of travelling and books of travels—The Alps an unexhausted field—De Saussure—His successors—The author's experience—Travelling in Switzerland—Action and speculation in travelling—Plan proposed—The Pennine Alps.

MEN travel from a great variety of motives, and they publish their travels perhaps from a still greater. The manner of travelling and the forms of publication are equally diverse, and mark strongly the features of the age. The folio of the sixteenth and seventeenth centuries, and the quarto of the eighteenth, and even of our own time, have melted into the modern duodecimo: and something like a corresponding change may be traced in the contents. "Pilgrimages" are out of date, and the traveller's portfolio on his return is as light in comparison as his portmanteau at starting: both are necessarily proportioned to the rapidity of his movements. The modern facilities for locomotion extend not only to England, France, Germany, and what in former days was called the *grand tour*, but gentlemen now walk across Siberia with as little discomposure as ladies ride on horseback to Florence. Even the Atlantic is but a highway for loungers on the American continent, and the overland route to India is chronicled like that from London to Bath. The Desert has its post-houses, and Athens has its omnibuses.

One consequence of this surprising change has been, upon a great scale, like that which the existence of railways has produced in any particular district. Persons who travel for the purpose of seeing, and relating what they have seen, are in such haste to escape from more familiar and accessible objects, that the world gradually accepts it as a principle, that what is worth describing must be distant by at least the breadth of an ocean, or half a continent, from the home of the traveller. The result is, that those who write books of travels with other objects than to make money, or to indulge a harmless vanity, have usually sought remote countries for the subject of their writings. Thus by an insatiate thirst for novelty, and for communicating what is most new or strange, rather than what is worth knowing, we find that the proper dignity of an intelligent book of travels has been often overlooked. The question may yet remain, whether it is not a greater service to the community to show how much remains to be seen and studied in countries, comparatively speaking, accessible to all, than to write detailed descriptions of regions presenting few natural objects of importance, or of remote tribes, unvisited perhaps only because uninteresting or dangerous.

To write a book of Travels in the Alps will no doubt appear to many persons a very unpromising as well as superfluous undertaking, it being taken for granted that what is so easily accessible must be perfectly well known; and the absence of any recent book of the kind, intended for more than a temporary object, and speedy oblivion, might tend to confirm the idea that no such work is required. It has, however, been the result of journeys continued throughout several summers, in countries commonly called the best known in Europe, that I am persuaded that even in these there is yet much to be seen, much explained, and much of which a general account may prove as interesting as that of visits to more distant, though scarcely more unknown lands. An excellent work might be written—and it would be a large one—on the less known or undescribed parts of the most frequented districts of Europe, which would show what a narrow line it is—no broader sometimes than the common border on a coloured map, separating one province or kingdom from another—which divides the known from the unknown; the highway along which roll daily the luxurious travelling equipages of Russian wealth or English fashion, and the remote valley scarcely outlined in our atlases, with a population speaking no acknowledged European language, and to whom the sight of a foreign pedestrian occurs perhaps but once or twice a year. Nor this alone. Even where all men go, none may have stopped; what all men see, none may have observed. As in many parts of experimental science unexpected discoveries are made in a workshop or manufactory, so the book of nature, whose pages are open to all, is read but by a few; and the notoriety of a fact, or a supposed fact, is often exactly the cause why no explanation of it is sought, or its questionable authenticity tested.

It is not too much to say that the natural history of a great part of the chain of Alps, the most instructive and grandest theatre of natural operations in Europe, is in this predicament. Thousands of travellers, many of them amongst the most enlightened men of their day, frequent them. But where is the fruit? Whilst Parry, and Franklin, and Foster, and Sabine, and Ross, and Darwin brave the severities of Arctic and Antarctic climates, to reap the knowledge of the various phenomena of earth and atmosphere, climate and animals, the geology, meteorology, and botany of countries comparatively uninteresting to us, are we perfectly informed of all these particulars even in our own quarter of the globe? Undoubtedly not. Where are we to look for travels like De Saussure's, and why are comprehensive works, adapted for the general reader and student of nature, to be replaced entirely by studied monographs connected with some single science in some single district?

The belief that the narrative form is at once the most agreeable and the most natural, both to author and reader, when truths progressively attained, and founded on numerous observations of detached facts, are the subjects, has finally determined me to fulfil an early and nearly abandoned project of writing a book of travels. The present volume is the result. It may be considered as an attempt to show, upon a small scale, what it is believed might advantageously be pursued upon a larger one. The aim of the work is confessedly to illustrate the physical geography of a particular district in one of the most frequented regions of the Alps; and more especially to arrive at results of a definite kind, respecting the natural history of glaciers, those great masses of ice which so generally attract the casual, though only the casual, notice of travellers.

It is a duty which every one who writes owes to the public and to himself, to be informed, generally at least, of the labours of his predecessors, that he may not, even involuntarily, assume to himself credit for that which belongs to another, nor invite attention to that which is already well known.

The duty is not an easy one. Topographical literature, more than almost any other, is diffused over bulky and unindexed compilations, or more irrevocably lost in fugitive pamphlets. I well know, from some former experience, the labour of an attempt to analyse all the writings connected with even a small district, and, generally speaking, its little value as regards substantive information; and I soon saw that such an attempt in the present case would be wholly incompatible with the proposed extent of this work, and with the time which I could withdraw from other duties for writing it. I hope that it will appear, notwithstanding, that I have not been inattentive to what my predecessors have done, and that I have endeavoured throughout, in matters of original observation, to render to them their due. I do not, indeed, pretend to have read the *whole* works of Simler, Scheuchzer, and Gruner,[1] the older Alpine historians; but I have carefully examined them in many parts, especially those which bear upon the doctrine of glaciers.

The writings[2] of De Saussure[3] have been the subject of perpetual reference—not only at home, but amongst the very scenes which he has described, and where it is easy to retrace the exactness of his assertions, and the faithful yet sober colouring of his descriptions. Himself a man of independence and station at Geneva, early imbued with a taste for exploring mountain scenery; well instructed in the then existing state of natural history and the allied branches of physics, he was exactly in the proper position for advancing a knowledge of his own country, and of those natural laws which may best be studied amongst its mountains. His journeys were not "*tours de*

1 [Josias Simler, born 1530, died 1576; *De Alpibus commentarius*, Zürich, 1574. J. J. Scheuchzer, born 1672, died 1733; *Itinera per Helvetiae alpinas regiones facta annis 1702-1711*; collected edition, Leyden, 1723. G. S. Gruner, born 1717, died 1778; *Die Eisgebirge des Schweizerlandes*, Bern, 1760.]

2 *Voyages dans les Alpes*, 4 vols. in 4to [1779-1796]; also in 8 vols. 8vo [1780-1796].

3 [Horace Bénédict de Saussure was born in 1740 and died in 1799. Portraits of him are given at pp. 24 and 72 of Mr. C. E. Mathews' *Annals of Mont Blanc*, London, 1898.]

force," miracles of rapidity and boldness, from which, if anything were gained, it must have been by a sort of intuition. On the contrary, even his more adventurous expeditions were commenced with a calm foresight, peculiar to himself, of the ends to be gained, and the best methods of attaining them. He did not court dangers; he did not affect to despise even inconveniences. His fortune permitted him to travel and observe in a manner which is as rare at the present day as formerly. He was frequently accompanied by ten or twelve men, and four or six mules carrying baggage, provisions, instruments, beds, and a tent; and perhaps to this precaution may be partly attributed the long period of life through which he was able to extend his laborious researches, trying to most constitutions, and from which, he states, that even he did not fail to suffer at last. Owing to his convenient position (for he always resided at Geneva) he acquired a familiarity with many of the scenes which he described, by repeated visits, each one clearing up the doubts of the last. For many years he made an annual journey, and a great part of the Alps was traversed by him, although unnoticed in his published Travels. De Saussure had a particular caution and anxiety about the editorial part of his writings;—it is probable that he only selected the most complete for publication.[1] It undoubtedly requires a very long apprenticeship to the art of travelling to learn how to group facts,—to observe with intelligence, and to record observations on the spot with sufficient clearness and detail.[2] De Saussure had seen some other countries which he was able to compare with the structure of the Alps, although he does not appear to have travelled much beyond Switzerland and France, excepting one journey to Sicily. It is

[1] See the Advertisement to the first volume of his Travels, dated 1779.

[2] The practice which I have long adopted with advantage is this: to carry a memorandum-book with Harwood's prepared paper and metallic pencil, in which notes, and observations, and slight sketches of every description are made on the spot, and in the exact order in which they occur. These notes are almost ineffaceable, and are preserved for reference. They are then extended, as far as possible, every evening, with pen and ink, in a suitable book, in the form of a journal—from which, finally, they may be extracted and modified for any ultimate purpose. The speedy *extension* of memoranda has several great advantages; it secures a deliberate revision of observations, whether of instruments or of nature, whilst the circumstances are fresh in the mind, whilst further explanation may be sought, and very often whilst ambiguities or contradictions admit of removal by a fresh appeal to facts. By this precaution, too, the not inconsiderable risk of losing all the fruits of some weeks of labour, by the loss of a pocket-book, is avoided.

not easy to ascertain from his published journeys, and still less from the meagre biography which exists of him by Senebier,[1] the exact time which he spent upon his travels each summer. As far as I can gather, however, it appears not to have been very long; and we are struck with the circumstance that many remarkable parts of the Alps, within easy reach of Geneva, are wholly undescribed, and that he would appear very seldom to have taken up his residence for a considerable time at one station.

That De Saussure was a bold mountaineer is plain from his well-known ascent of Mont Blanc,[2] at a time when such difficulties, little understood, seemed far more formidable than at present, when the chief obstacles to such a feat arise from its very familiarity, and the ostentatious and expensive precautions which, not unwisely perhaps, have been interposed to its accomplishment. But the most interesting and most adventurous feat which De Saussure performed, was his residence of seventeen days on the Col du Géant, a height of above 11,000 feet;[3] of which I shall give a separate account in the course of this work.

De Saussure's style is generally easy and interesting, without any pretension to elaboration, and in this respect his work contrasts most happily with that of Bourrit, published about the same time;[4] who, though by no means an uninteresting writer, conveys the simplest facts through a medium of such unmixed bombast as to disgust the reader, rather than arouse his sympathies for admiration or for awe. In both, however, it must be admitted that here and there a natural passage of calm eloquence may be found, descriptive of natural beauty, and of the sentiments, irrepressible in most minds, of Natural Religion, which familiarity with great mountain scenery peculiarly calls forth.

De Saussure has aimed at variety in his work—and beyond

[1] [J. Senebier, *Mémoire historique sur la vie et les écrits de H.-B. de Saussure*, Geneva, 1801.]

[2] [in 1787.]

[3] [11,060 feet.]

[4] [Marc Théodore Bourrit, born in 1739, died in 1819. His principal work was *Description des Alpes Pennines et Rhétiennes*, originally published in 2 vols. at Geneva in 1781, reprinted in 1783 (under the title of *Nouvelle Description des glacières, vallées de glace, et glaciers qui forment la grande chaîne des Alpes de Suisse, d'Italie et de Savoye*), and re-published, with additions, in 3 vols. in 1785. In the 9th vol. of the *Alpine Journal* Mr. Douglas Freshfield has given a more just appreciation of Bourrit's real importance in Alpine history.]

a doubt successfully. Topography, natural history, and personal adventure are happily combined; and many persons who would have been repelled by a professed work on the geology of the Alps, have read with avidity one which offers so much else to their attention. Even at the present time De Saussure's Travels can hardly be called obsolete, because no other work has replaced them;[1] and though the geology of his day is in some degree exploded, the texture of the work is sufficient to retain for it a permanent interest. The arrangement is generally topographical; if any place has been repeatedly visited, the description refers to the general result of the observations. If only once visited, the narrative form is adopted. Occasional chapters are devoted to the explanation of subjects which have occupied much of his attention, without reference to particular localities. Such an arrangement has many advantages. The plates in De Saussure's work, though more faithful than those of Bourrit, are not happy, and the maps give but an unfavourable impression of the state of topography or of art at that time in Switzerland.

There is scarcely one of the more modern writers, with whom I am acquainted, whose writings can be classed with those of the great historian of the Alps. The reputation of De Saussure seems to have deterred others, however well qualified, from resuming and continuing a work which, whether we regard the state of knowledge when it was written, or the vast extent of Alpine country scarcely noticed or unmentioned in its pages, ought rather to have been considered as a commencement and a model, than as the completion of an undertaking so vast and so varied. Far be it from me to underrate what has been accomplished since his time for the natural history of Switzerland by most able and zealous observers in special departments of science, to which the excellent Journals, and the valuable Academical Transactions published there,—especially those of Geneva and of the Swiss Society,[2]—bear ample testimony. Far be it from me to overlook the mongraphs, by Necker and Studer, Escher and De Charpentier, Lardy and Zumstein in the country itself, and those of many eminent foreigners, connected with geology; and

[1] [It must be remembered that Forbes was writing in 1842.]

[2] [*Mémoires de la Société de physique et d'histoire naturelle de Genève. Denkschriften der allgemeinen schweizerischen Gesellschaft für die gesammten Naturwissenschaften*; or perhaps Forbes alludes to the *Verhandlungen der allgemeinen schweizerischen naturforschenden Gesellschaft.*]

of Venetz, De Charpentier, Agassiz and Rendu on the subject of glaciers, which have recalled attention to what De Saussure had only outlined, and whilst showing the incompleteness of his generalisations, revived in us at the same time admiration of his genius, his fidelity, and his varied knowledge. Two works only of late years seem at all to emulate De Saussure in style or matter—the *Naturhistorische Alpenreise* of Hugi,[1] and the *Études dans les Alpes* of Necker.

The former is a singular, we might call it a fantastical work. With a praiseworthy desire to benefit experimental philosophy, as well as the sciences of observation, by his very unusual and intrepid journeys, the Professor of Soleure describes in detail his instruments and the results he obtains with them, which are often, however, so much at variance with those of indubitable authority, as to render us somewhat diffident in the adoption of them. We cannot but remark, too, that the ostentatious style of travelling which he preferred, often with twelve or fifteen companions and guides largely paid, was necessarily confined to very short and interrupted excursions, which in most cases were brought to a premature close by bad weather, when he was compelled to break up his band, and relinquish his objects. Amidst much which appears so paradoxical in Hugi's writings, as to pass with many for fabulous, we perceive a bold and determined spirit daring to follow nature, and in the lively, sometimes really eloquent, descriptions of scenery, we discover, too, the heart that can feel nature. Amidst a mass of dry details there is sufficient narrative to render the volume of Hugi agreeable reading, and this is another testimony to the value of the style of writing of which we speak, which presents even scientific truths in a form calculated to interest persons at large.

Very different is the volume of M. Necker, Honorary Professor of Mineralogy at Geneva, and grandson of De Saussure.[2] It forms only a portion of an extended work, calculated to embrace the geology of a large district of the Alps. Its arrangement, is, however, rather systematic than local, and, therefore, it wants some of the liveliness which characterises the writings of the author of the *Voyages dans les Alpes*. Containing, as it

[1] [Soleure, 1830. Franz Johann Hugi was born 1796 and died 1855.]

[2] [L. A. Necker *Études géologiques dans les Alpes*, vol. i.—no more published —Paris, 1841.]

does, abundant references to the localities of the Alps, to which the author's inquiries are especially directed, it is enriched with the fruits of his observations and long residence in other countries. Still, by its nature and arrangement, it is a book of geology, and not of travels.[1]

With respect to the present work, it is considerably more special than I could have wished it to be, had my sole object been to give a specimen of a continuation of travels in the Alps in the manner of De Saussure. Whilst general geology may be considered as the basis of his work, or the investigation which guided the course of his travels, the theory of glaciers, and of the departments of geology and topography more immediately connected with them, forms the groundwork of mine. This circumstance has led me in the journeys, which are to be described in this volume, through more wild and remote scenery than any other inducement, except, perhaps, a passion for the chase, is likely to carry a traveller. Some account of these scenes may have sufficient interest for the general reader, to induce him to excuse the more scientific details. I can at least plead, in excuse for an attempt which I feel to border on presumption,—the endeavour to follow the great historian of the Alps[2] in his own country, and to meet him on his own ground,—that it is upon no sudden impulse that I came forward with the hasty notes of a few months' tour to lay them before the public. It is now a good many years since I proposed to myself to travel, not as an amusement, but as a serious occupation, and with De Saussure before me as a model. I have reason to be glad that circumstances, by postponing its execution, led me to appreciate

[1] For a copious list of works published in Switzerland, see Ebel's *Manuel du Voyageur en Suisse*, tome i. Many of these contain valuable information; and even from common tour and guide-books useful facts may often be gained. Those of Ebel himself, of Latrobe and Simond, of Fröbel and Engelhardt, of Brockedon and Bakewell may be mentioned; but they do not properly come under the class of works referred to in the text. [A very *complete* list of works of travel in Switzerland is given in A. Wäber's *Landes- und Reisebeschreibungen*, Bern, 1899; while a *select* list of similar works relating to all parts of the Alpine chain is given in Appendix A of *Hints and Notes, Practical and Scientific, for Travellers in the Alps*, a new edition — London, 1899—of Mr. John Ball's "General Introduction" to his *Alpine Guide*.]

[2] [This name properly belongs to Bourrit, to whom it was given by Frederic II. of Prussia. The Emperor Joseph II., when at Geneva, paid a special visit to Bourrit, *l'historiographe des Alpes*.]

more fully the difficulties of the plan, and to come to its fulfilment after some experience, with moderated expectations of ultimate success. The habit of observation, I have already said, is of slow growth,—to use opportunities, we must prepare to seize them. I had the advantage of receiving my first impressions of Switzerland in early youth;[1] and I have carefully refreshed and strengthened them by successive visits to almost every district of the Alps between Provence and Austria. I have crossed the principal chain of Alps twenty-seven times, generally on foot, by twenty-three different Passes,[2] and have, of course, intersected the lateral chains in very many directions. In my journeys I have most frequently been alone, although occasionally I have had the advantage of eminent naturalists and esteemed friends for my companions, from whose superior knowledge I have been happy to gain information as a learner, and by whose urbanity and kindness the roughest way has been smoothed, and the longest day beguiled.

I have likewise undertaken similar journeys in other

[1] [Forbes' first visit to the Alps took place in 1826, when he was 17 years of age.]

[2] The following are the names and directions of these passes [a number of corrections of various kinds have been made in this list and the latest heights of the passes inserted. Several of these passes are *now* traversed by railways, carriage roads, or mule paths, while but four at the most are "glacier passes"—Géant, Fenêtre, Collon, and St. Théodule], commencing with the Maritime Alps:—

Col de l'Argentière (6545 ft.)	From Barcelonnette	To Coni (Cuneo).
Col de Vallante (9269 ft.)	Abriès	Castel Delfino.
Col de la Traversette (9679 ft.)	Abriès	Saluzzo.
Col de la Croix (7576 ft.)	Abriès	Tórre Pellice.
Mt. Genèvre (6083 ft.)	Briançon	Turin.
Mt. Cenis (6893 ft.)	Lanslebourg	Turin.
Petit St. Bernard (7179 ft.)	Moûtiers Tarentaise	Aosta.
Col du Bonhomme (8147 ft.)	St. Gervais	Chapieux.
Col du Géant (11,060 ft.)	Chamouni	Courmayeur.
Col Ferret (8311 ft.)	Martigny	Courmayeur.
Grand St. Bernard (8111 ft.)	Martigny	Aosta.
Col de Fenêtre (9141 ft.)	Chable	Valpelline.
Col de Collon (10,270 ft.)	Evolena	Valpelline.
St. Théodule (10,899 ft.)	Zermatt	Châtillon.
Monte Moro (9390 ft.)	Saas	Macugnaga.
Simplon (6592 ft.)	Brieg	Domo d'Ossola.
St. Gotthard (6936 ft.)	Altdorf	Bellinzona.
Splügen (6946 ft.)	Coire	Chiavenna.
Stelvio (9055 ft.)	Innsbruck	Bormio.
Brenner (4495 ft.)	Innsbruck	Bozen.
Velber Tauern (8334 ft.)	Mittersill	Windisch Matrei.
Mallnitzer Tauern (7910 ft.)	Gastein	Ober Vellach.
Prebichl (3950 ft.)	Eisenerz	Bruck an der Mur.

mountainous countries with a view to compare the results. I have spent a part of ten summers on the Continent, and six of these in the Alps and adjacent country.[1] I have thus repeated my visits to the same spot, and, without almost any exception, I have found more to enjoy, to admire, and to learn on the renewal of my acquaintance with it. Most of the places described in this volume have been visited twice, and several of them in four different years. As the mere novelty of travelling wears off, its deeper charms impress themselves more indelibly —the habits of observation and of thought are strengthened—the short term of human life itself seems to expand in proportion to the variety and greatness of the objects contemplated; and if the solitary pedestrian in foreign parts feels his heart often glow with thoughts which bear him untiring company, incommunicable, and with which the stranger cannot intermeddle, he may yet have an honest gratification in attempting to convey to others some part of his enjoyment in the conquest of obstacles, and in the pursuit of truth.

Switzerland is undoubtedly one of the most agreeable, as well as most interesting countries in the world to travel in. The Alps rise to all the elevation which is necessary in order to convey to the imagination the fullest sense of the sublime in such objects, whilst their dimensions—gigantic, no doubt, compared to the mountains of the British islands—do not present the unwieldy extent of the Andes or Himalaya. There is no *transverse* valley in the Alps—that is, one leading directly from the plains to the highest ridge—up which an active man cannot walk in two days, and the actual passage of the chain may usually be effected in one. Now, any great increase upon such a scale necessarily wearies the traveller with monotony, even though it be the monotony of grandeur, whilst it tasks his physical powers by keeping them too long upon the stretch. The circuit of Mont Blanc or Monte Rosa is quite as long and fatiguing as most persons will consider necessary to give them a vivid conception of an immense hill; and if we accurately examine the slow progress which the uneducated eye makes to a correct estimate of magnitudes and distances in the Alps, we find that, practically, their scale is sufficiently great to afford to at least

[1] [1826, 1832, 1837, 1839, 1841, 1842. The author is writing in the winter of 1842-43.]

nine-tenths of travellers the most majestic conceptions with which such objects can at all inspire them.

Add to this, that the actual height of the zone of perpetual snow is as great as that of any mountains in the world, with one or two exceptions; for the highest land on the surface of the globe is near the equator, where the corresponding high temperature raises the limit at which perpetual snow *commences* to nearly the extreme height of European mountains. The eye—which must always have some actual or conventional standard of reference—if it cannot judge by the level of the sea, takes the level of the plain as a starting-point, or, if there be no plain, the level of perpetual snow is a natural index of elevation, which, connected as it is with height, solitude, and vastness, impresses the mind with the highest sense of grandeur in natural scenery. It has often been observed, that Chimborazo is less elevated above the table-land from which it rises than Mont Blanc is above the valley of Chamouni; and taking the level of perpetual snow in the Alps at 8500 feet, Mont Blanc is snow-clad throughout its higher 7000 feet. Now, a peak in the Himalaya range, in order to show as much, would need to rise to above 23,000 feet—a height which few of them exceed.

The climate of the Alps, as well as their scale, is highly favourable to observation and to personal exertion; and it must not be reckoned a small advantage, that shelter, if not accommodation, is to be found within a moderate distance of the most retired and wildest scenery. Obstacles to travelling, whether from rude curiosity or violence on the part of the inhabitants, are undoubtedly smaller in Switzerland that in any other country in Europe. The traveller who makes a sojourn of some length in the remoter parts of even the most frequented countries, is as often subjected to the suspicions of the authorities as of the people. The mere fact of his traversing mountains where no one habitually passes, is a sufficient crime in the eyes of the vigilant police; and if to this he add a turn for sketching, or the use of a hammer or barometer, or any such instrument, he is likely to raise a host of popular prejudices, whose extent can often only be guessed from the extraordinary conjectures which he occasionally finds to be current respecting his character and pursuits. Having, at different times, had my own share of these troubles, I appreciate highly the happy independence of a pedestrian in Switzerland, where, partly from the peculiar character of the people, partly from their form of government, and partly from their familiarity with strangers of every country, race, occupation, and fancy, no one need fear being set down either for a magician or a political agent—the two offensive categories in which he is often elsewhere included; and even the philosopher, with all his whims and his chattels, his labours and hardships which seem to end in nothing, is allowed, after a short cross-examination, and a significant shrug from the questioner, to pursue quietly an avocation which is considered at least as harmless as walking in a motley suit would be, or twenty other vagaries. I own, that although the character of the Swiss or Savoyard peasant can rarely excite much enthusiasm or admiration, I always feel a satisfaction and a freedom from restraint when I approach these mountains and their exhilarating atmosphere, which dispel anxiety, and invite to sustained exertion.

What a field, indeed, for those whom professional and other cares, and even the habits of the society which they frequent, leave, during a great portion of life, but a few hours together, never a whole day, which can be called their own, to find themselves transplanted to a new position—time at command—no interruptions—no calls, invitations, or engagements—no letters to write or receive but those which give pleasure—surrounded by nature in its grandest forms, delighting the eye, yet affording far keener pleasure to the intellect, by the interest of the problems which it presents for solution! The attention, undistracted, dwells on the objects around without hindrance or satiety. The sense of perfect health—the rapid and refreshing sleep which attends most persons escaped from the hot-bed languor of towns to the freshness of the Alps, stimulate the powers of thought; and thought is without fatigue when each passing event gives a varied tone to it—when each step furnishes a new subject for its exercise—when all nature is our laboratory, and we read the axioms of *her* philosophy indelibly engraven on the eternal hills.

Mere change of scene and active exercise produce fatigue at last, unless the mind have some wholesome employment as well as the body; and most of those who have made the trial will probably regard as amongst the happiest periods of their lives those in which a favourite study has been pursued in the retirement of mountain scenery. Mornings of active exercise, from sunrise till afternoon, and evenings of quiet thought and speculation, with here and there a day interposed of easy society with intelligent travellers, or employed in reducing and digesting the knowledge previously acquired by observation, give the sense of living twice over. The body and the mind are alike invigorated and refreshed; weariness from fatigue, and weariness from inactivity, are forgotten, together with the other evils of our more artificial existence. The student in his closet exhausts his powers by one kind of toil, whilst the fox-hunter and deer-stalker exhausts them by another; both call it pleasure; but the one is all too exclusively speculative, the other too exclusively active. Let speculation and action minister to one another; then, like a well-compacted body, the members act in harmony,—the double exercise prevents fatigue. Happy the traveller who, content to leave to others the glory of counting the thousands of leagues of earth and ocean they have left behind them, [and] established in some mountain shelter with his books, starts on his first day's walk amongst the Alps in the tranquil morning of a long July day, brushing the early dew before him, and, armed with his staff, makes for the hill-top—begirt with ice or rock, as the case may be—whence he sees the field of his summer's campaign spread out before him, its wonders, its beauties, and its difficulties, to be explained, to be admired, and to be overcome.

> "Ignotis errare locis, ignota videre
> Flumina gaudebat; STUDIO MINUENTE LABOREM."

It only remains to be added here, that the country which it is proposed to describe in the present [pages], includes exactly that part of the Alpine chain called by the ancients the "Pennine Alps," a term of doubtful origin, but which it is convenient to retain, as having no modern synonyme. It extends from the Col du Bonhomme on the west side of Mont Blanc to Monte Rosa inclusive, thus comprising the highest ground in Europe, and the two most colossal mountain groups. The map [in the pocket of the present volume] shows its limits, and will be found useful in tracing the routes to be described. It has been compiled with care, though on a small scale. The basis is the last edition of Keller's map. The valley of Hérens and its neighbourhood are corrected from Fröbel; those of St. Nicolas and Saas from De Charpentier and Engelhardt; the *southern* side of Monte Rosa from von Welden and the new Sardinian Survey; and the passes and glaciers between Great St. Bernard and Mont Cervin, from my own observations, so far as they go.[1]

The Pennine chain is particularly distinguished by the number and extent of its glaciers; and as the study of these formed the chief object of my journey in 1842, upon which the material of this volume is based, it presented itself as the most natural field for my inquiries. The *Mer de Glace* of Chamouni, from its very easy access, and its great extent and variety of surface, seemed to me the most eligible post, and I am inclined to think that it is, on the whole, the best fitted in Switzerland or Savoy for investigations like those which I had in view. Within a stone's throw of the ice, at the Montanvert, is to be found sufficient shelter, fitted for a permanent residence of some weeks or months, which is of the very first importance in the prosecution of a task requiring much perseverance, detail, the use of a multiplicity of instruments, the performance of calculations, and the making of drawings. I know from experience how little of this can be accomplished in a temporary residence, such as a tent or hut, without tables, chairs, or a fire; and however amusing such privations are for a time, and however pleasant it may be to laugh over them in good company, such expeditions tend rather to amusement than edification. I preferred, therefore, in general, the least expensive and least ostentatious methods of pursuing my inquiries, and I felt the necessity of carrying them out alone. I employed neither draughtsman, surveyor, or naturalist; everything that it was possible to do I executed with my own hands, noted the result on the spot, and extended it as speedily as possible afterwards. My only assistant was a very intelligent and very worthy guide of Chamouni, Auguste Balmat by name,[2] to whom I shall have frequent occasion to refer in these pages; and I am indebted to the friendship of the Curé of Chamouni, M. Lanvers, for having recommended him to me, as well as for many other

[1] [In the present edition, a new large scale map of the Pennine chain is given in place of that compiled by Forbes at a time when no trustworthy maps of that district existed.]

[2] [Forbes and Balmat became acquainted on June 24, 1842. Balmat accompanied Forbes in 1842, 1843, 1844, 1846, and 1850, and paid the Professor a visit in England in 1853. He was born in 1808, and died in 1862.]

acts of substantial kindness, for which I shall ever remain his debtor.[1]

Although, as has been said, I was acquainted, from former visits, with many of the places to be described, yet all the detailed observations which will be given were conducted during the course of last season (1842). The information collected in that time will at least, I hope, be thought creditable to my industry, and it may be an encouragement to persons who might be withheld (as no doubt many have been) from similar undertakings, by an erroneous estimate of the scale of assistance and expenditure required, which may truly be termed the trappings and paraphernalia of science, to know what may be effected with patience and previous study, in a moderate space of time, and in a very simple way.

I spent the latter part of June 1842 at the Montanvert (Chamouni), the first half of July on the southern side of Mont Blanc and in Piedmont. I then returned to the Montanvert by the Col du Géant, and continued my experiments on the *Mer de Glace* until the 9th August. I then passed a month on a journey (partly in company with M. Studer) to Monte Rosa and the adjacent country, when I returned for the second time to Chamouni, and spent the remainder of September on or near the glacier.

[1] It happened very rarely indeed that I required any other assistance than that of Balmat.

MORAINE NEAR THE MONTANVERT, CHAMOUNI

CHAPTER II

SOME ACCOUNT OF GLACIERS GENERALLY

The snow-line—The waste of ice and its supply in glaciers—Causes of waste —Motion—Fallen blocks—Moraines, medial and lateral—Glacier tables and cones—Formation of holes in ice—Veined structure of the ice in glaciers—The Unteraar and Rhone glaciers—The névé—Cause of glacier motion—De Saussure's Gravitation theory—De Charpentier's theory of Dilatation—Objections to each.

"Where so wide,
In old or later time, its marble floor
Did ever temple boast as this, which here
Spreads its bright level many a league around!"
DYER'S *Fleece*.

IT has already been said, that no small part of the present work refers to the nature and phenomena of glaciers.[1] It may be well, therefore, before proceeding to details, to explain a little the state of our present knowledge respecting these great ice-masses, which are objects of a kind to interest even those who know them only from description, whilst those who have actually witnessed their wonderfully striking and grand characteristics can hardly need an inducement to enter into some inquiry respecting their nature and origin.[2]

[1] [The standard work on glaciers in general is now Prof. A Heim's *Handbuch der Gletscherkunde*, Stuttgart, 1885; a very full summary in English was published by Mr. Tuckett in vol. xii. of the *Alpine Journal*, pp. 219-240, 300-313.]

[2] For some further details than would be consistent with the due length of this preliminary chapter, I would refer the reader to an article in the *Edinburgh Review*, for April, 1842, on the subject of glaciers, which has been admirably trans-

I have already alluded to the fact, that high mountains in every part of the world are covered with snow. It is enough for our present purpose that *the fact is*, that the atmosphere becomes colder as we ascend in it, until that cold reaches a great and hitherto unmeasured intensity. Consequently, by merely ascending the slope of a hill, we pass through successive gradations of seasons. Whilst the plains are covered with the verdure of summer, eternal winter reigns upon the summits, and thus the stupendous ranges of the Himalaya or the Andes present, in one condensed picture, all the climates of the earth, from the tropics to the poles.

Since, then, the long summer's day, of six months' duration in the Arctic regions, is insufficient to melt the accumulated ice, it is not surprising that at a certain height above the earth's surface snow always lies,—a height greatest at the equator, amounting there to 16,000 feet above the sea, which, in the Swiss Alps, has diminished to 8700 feet, and which in very high latitudes reaches to the level of the ocean, so that there the natural covering of the earth is snow, and the very soil is frozen to an increasing depth. The mere continuance of snow on any spot does not lead to the inference that snow never melts there. Were that the case, a progressive and unceasing accumulation would be the result: the position of the *snow-line*, or what is often erroneously called *the line of perpetual congelation*, is determined solely by this circumstance, that during one complete revolution of the seasons, or in the course of a year, *the snow which falls is just melted and no more.*

Now, a snow-clad mountain is *not* a glacier. Whence the real difference, or how it comes that in some climates glaciers are produced in situations and circumstances apparently similar to those which yet do *not* produce them in others, is a question which we do not mean now to handle. But let us first see what is understood by a glacier in the more familiar sense of the word.[1] The common form of a glacier is a river of ice filling a

lated into French in the *Annales de Chimie*, for October and November, 1842. From that article (written by myself) I have extracted one or two passages in this and the next chapter. [This article was for the most part reprinted by Forbes at the head of his *Tour of Mont Blanc and Monte Rosa* (1855), a reproduction of the purely narrative portions of his *Travels through the Alps of Savoy*.]

[1] *Glacier* French, *Gletscher* German, *ghiacciaio* Italian. But the glaciers have also provincial names, as *Ferner* in the Tyrolese Alps, *Käss* in Carinthia, *vedretta* in part of Italy, *biegno* in the Vallais, *ruize* in Piedmont, *serneille* in the Pyrenees.

valley, and pouring down its mass into other valleys yet lower. It is not a frozen ocean, but a frozen torrent. Its origin or fountain is in the ramifications of the higher valleys and gorges, which descend amongst the mountains perpetually snow-clad. But what gives to a glacier its most peculiar and characteristic feature is, that it does not belong exclusively or necessarily to the snowy region already mentioned. The snow disappears from its surface in summer as regularly as from that of the rocks which sustain its mass. It is the prolongation or outlet of the winter-world above; its gelid mass is protruded into the midst of warm and pine-clad slopes and greensward, and sometimes reaches even to the borders of cultivation. The very huts of the peasantry are sometimes invaded by this moving ice, and many persons now living have seen the full ears of corn touching the glacier, or gathered ripe cherries from the tree with one foot standing on the ice.

Thus much, then, is plain, that the existence of the glacier in comparatively warm and sheltered situations, exposed to every influence which can ensure and accelerate its liquefaction, can only be accounted for by supposing that the ice is pressed onwards by some secret spring, that its daily waste is renewed by its daily descent, and that the termination of the glacier, which presents a seeming barrier or crystal wall, immovable, and having usually the same appearance and position, is, in fact, perpetually changing—a stationary form, of which the substance wastes—a thing permanent in the act of dissolution.

The result of the heat of the valley in thawing the ice is a stream of ice-cold turbid water, which issues from beneath its extremity, and which, by gradually undermining, works out a lofty cavern, from beneath which it rolls. This water is derived from various sources: in the first place, from the natural springs which, it may be conceived, rise from the earth beneath the ice, just as they would do in any other valley. This source remains, in a great measure, even in winter, when the glacier stream, though diminished, does not vanish. Secondly, from the heat of the earth in contact with the ice, which probably melts annually a very small thickness of its mass. This, too, will not

[" Kees " is a better known form of " Käss," but "biegno" is very rare. "Vedretta" appears under the form "vadret" in the Engadine; "ruise" also under the forms "roesa, roise, reuse," and so "Monte Rosa."]

depend upon the season. Thirdly, the fall of rain upon the whole area which the glacier valley drains—which acts, in the first place, by melting the superficial ice and snow;—and the rain-water being thus reduced to the freezing-point, washes through the cracks and fissures of the ice by innumerable streamlets, which unite beneath its mass, and swell the general stream. Fourthly, the waste of the glacier itself due to the action both of sun and rain—a most important item, and which constitutes the main volume of most glacier streams, except in the depth of winter. It is on this account that the Rhine and other great rivers, derived from Alpine sources, have their greatest floods in July, and not in spring or autumn, as would be the case if they were alimented by rain-water only. On the same account, the mountain torrents may be seen to swell visibly, and roar more loudly, as the hotter part of the day advances, to diminish towards evening, and in the morning to be smallest.

The lower end of a glacier is usually very steep and inaccessible. This arises, in some cases, from the figure of the ground, over which the glacier tumbles in an icy cascade often a thousand feet high. Its middle course is more level, and its highest portion, again, steeper: thus the final ice-fall of the Glacier des Bois at Chamouni is inclined 20°, the mean portion between 4° and 5°, and the higher part at least 8° or 10°.

The mean or middle portion of the glacier is a gently sloping icy torrent, from half a mile to two miles wide, more or less undulating on its surface, and this undulating surface more or less broken up by *crevasses*,[1] which, generally nearly vertical in their direction, have a width of from a few inches to many feet; and a length which sometimes extends almost from side to side of the glacier. In all this there is little or no resemblance to water tranquilly frozen. The surface is not only uneven, but rough; and the texture of the ice wants the homogeneity of that formed on the surface of lakes. The hollows, which appear but trifling when viewed from a height and compared with the expanse of ice, are individually so great as to render the passage amongst them toilsome in the extreme,

[1] The translation of the French word *crevasse* into the English *crevice* is so evidently inapplicable to these vast fissured chasms, that we shall constantly adopt the French spelling.

even independent of the crevasses; and the traveller who has to walk for several hours along a glacier, will often prefer scrambling over stones and rocks on the side, to the harassing inequalities which appeared at first so trivial. In a day of hot sunshine or of mild rain, the origin of the hummocky ridges is apparent: the intervening hollows have every one of them their rill, which, by a complicated system of surface-draining, discharge the water, copiously melted by the solar influence, the contact of warm air, and the washing of the rain. These rills combine and unite into larger streams, which assume sometimes the velocity and volume of a common mill-race. They run in icy channels, excavated by themselves, and, unlike the water escaping from *beneath* the glacier, being of exquisite purity, they are both beautiful and refreshing. They seldom, however, pursue their uninterrupted course very far, but reaching some crevasse or cavity in the glacier, mechanically formed during its motion, they are precipitated in bold cascades into its icy bowels—there, in all probability, to augment the flood which issues from its lower termination. Nothing is more striking than the contrast which day and night produce in the superficial drainage of the glacier. No sooner is the sun set than the rapid chill of evening, reducing the temperature of the air to the freezing-point or lower, the nocturnal radiation at the same time violently cooling the surface—the glacier life seems to lie torpid—the sparkling rills shrink and come to nothing—their gushing murmurs and the roar of their waterfalls gradually subside—and by the time that the ruddy tints have quitted the higher hill-tops, a death-like silence reigns amidst these untenanted wilds.

Winter is a long night amongst the glaciers. The sun's rays have scarcely power to melt a little of the snowy coating which defends the proper surface of the ice; the superficial waste is next to nothing; and the glacier torrent is reduced to its narrowest dimensions.

The glacier in this part of its course is more or less covered with blocks of stone which move along with it, or rather are borne down upon its surface. The motion of the glacier we have already inferred from the subsistence of the ice in valleys where the daily waste is immense, and where yet the glacier maintains its position; but its progress is also well marked by the displacement of great blocks of stone upon its surface, which, from their size or figure, cannot be mistaken, and which may be watched from year to year descending the icy stream whose deliberate speed they mark, as a floating leaf does that of a current of water. These detached rocks fall from the cliffs which usually bound both sides of a glacier in its middle portion, and from which the alternate effects of frost and thaw rapidly and surely separate them. They may be seen to fall almost every summer's day, in consequence of the loosening of the icy bands which hold together fragments previously wrenched asunder by the irresistible expansion of freezing water. A single promontory may yield a great stream of those blocks in the course of years; were the ice stationary, they would accumulate on its surface at the base of the promontory, but as the ice advances, its charge is carried along with it, and the glacier becomes burdened on both sides with a band of blocks, which by their geological character bear the impress of their origin, and thus not unfrequently bring down to the reach of the mineralogist specimens which otherwise would be quite unattainable, and whose native place may be surely inferred by observing the direction of the ice-stream which is charged with them. Such, for instance, are fragments of the *gabbro* of Saas, which has not yet been found *in situ*, but which is discharged by the glacier of Allalin, in the Vallais, near Monte Rosa.

What a curious internal historical evidence, then, does a glacier bear to the progress of events which have modified its surface! It is an endless scroll, a stream of time, upon whose stainless ground is engraven the succession of events, whose dates far transcend the memory of living man. Assuming, roughly, the length of a glacier to be twenty miles, and its annual progression 500 feet, the block which is *now* discharged from its surface on the terminal moraine may have started from its rocky origin in the reign of Charles I.! The glacier history of 200 years is revealed in the interval, and a block larger than the greatest of the Egyptian obelisks, which has just commenced its march, will see out the course of six generations of men ere its pilgrimage, too, be accomplished, and it is laid low and motionless in the common grave of its predecessors.

The stony borders now described are called *moraines* in French, *Guffer* or *Gufferlinien* in German. The glacier retains a portion of them on its own surface, and throws up a part upon the bank or shore which confines it. If the shore be precipitous, it will be conceived that the blocks cannot be stranded, and therefore either remain on the surface of the ice, or fall into the occasional vacuities left between the ice and its wall, and there are ground and chafed, acting, of course, in a notable manner upon the rock, and producing rounded surfaces, the angles being worn off, and grooves and scratches parallel to the direction of motion of the ice. All this is an immediate and necessary consequence of the fact of the glacier moving and bearing blocks along near its edges. When the rocky slope or shore of the glacier is less steep, since the ice almost invariably sinks towards the sides, owing to the heat reflected and communicated from the ground, a portion of the load of blocks falls over, and is accumulated in a ridge as from an over-filled waggon. But the more striking cause of this accumulation is the oscillation of dimension of the glacier at different seasons, and in different years. If the glacier, from any cause whatever, becomes enlarged, and, like a swollen torrent, occupies its bed to an unusual depth, the *moraines* are uplifted with it, and when the return of summer or warmer seasons reduces the ice to its former bulk, the blocks are deposited at the higher level. Such moraines are to be seen in the neighbourhood of most modern glaciers, and they are important to be observed, because the existence of similar mounds in places remote from existing glaciers, has been inferred to demonstrate their former presence. The sketch at the head of this chapter represents a moraine about a hundred feet above the present level of the Mer de Glace of Chamouni.

It often happens that two glaciers, having separate sources, unite in a common valley, exactly as two rivers would do. Each, of course, has its edging moraine or *list*, and therefore, where the glaciers unite, the two inner moraines must unite also. This does not, however, alter their character; as in the case of the Rhone and Saône uniting their streams at Lyons, each preserves the characteristic colour of its water for a long way down, unmixed with its neighbour river—so, much more, does the compact and firm glacier. The débris proper to each unite upon the surface, and mark by a band of stones, often for miles, the actual separation of the two ice-streams, which otherwise would (at that distance) have become undistinguishable. These united bands, which are equal in number to the junctions of tributary glaciers which combine to form a great one, are called *medial moraines*, whilst those formerly described are called *lateral moraines*. The former have only been distinctly explained of late years, by Agassiz[1] and De Charpentier,[2] whilst the latter have been long perfectly understood. There is nothing more surprising to be found in the writings of De Saussure than the most unsatisfactory explanation which he gives of medial moraines.[3]

As these facts are important to be distinctly apprehended, some slight figures may tend to illustrate them. Thus, Fig. 1 represents a plan of an ideal glacier composed of five streams, A, B, C, D, E, each of which has its lateral moraines, and the union of these represented by the dotted lines, 1, 2, 3, 4, forms the superficial trains of rocks, which are carried along on the surface of the ice. A mere prominent rock or islet in the ice, as that between D and E, may yield also its small contribution of blocks. The section in Fig. 2 represents a glacier having a steep wall, *a*, where, consequently, the débris are ingulfed between the wall and the ice, producing friction; and an inclined shore, *b*, on which the lateral moraine has been deposited. There is also shown, at *c*, the position of an ancient moraine, deposited at a time when the glacier was elevated enough to have submerged the promontory *a*. One of the *medial moraines* is shown at *d*: the ice rises to a greater height under it than at any other part, owing to a circumstance to be mentioned immediately. An exact idea of the general phenomena of moraines will be obtained from the large map of the Mer de Glace of Chamouni accompanying this work.

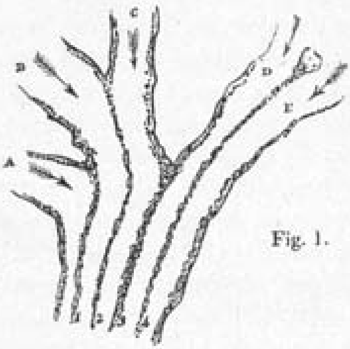
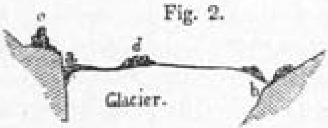


Fig. 1.

Fig. 2.


The presence of these blocks upon the surface of the glacier, and of the fine sand and débris which is produced by their trituration, gives rise to a peculiar and striking class of phenomena, easily explained, yet at first sight most astonishing. The

[1] *Études sur les Glaciers*, 1840. [2] *Essai sur les Glaciers*, 1841. [3] *Voyages*, § 537.

surface of a glacier is usually divided by numerous rents or crevasses, and into these rents blocks are continually falling. Still, the fact is, that the moraines remain upon the surface, and unless after a very long or very uneven course, they are not dissipated or ingulfed. On the contrary, the largest stones are set on a conspicuous pre-eminence,—the heaviest moraine, far from indenting the surface of the ice, or sinking amongst its substance, rides upon an icy ridge as an excrescence, which gives to it the character of a colossal back-bone of the glacier, or sometimes appears like a noble causeway, fit indeed for giants, stretching away for leagues over monotonous ice, with a breadth of some hundreds of feet, and raised from fifty to eighty feet above the general level. Almost every stone, however, rests on ice; the mound is not a mound of débris, as it might at first sight appear to be. Nor is this all. Some block of greater size than its neighbours, covering a considerable surface of the ice, becomes detached from them, and seems shot up upon an icy pedestal, in the way represented in the frontispiece,[1] from a real and very striking example which occurred in 1842 on the Mer de Glace of Chamouni. This apparent tendency of the ice to rise wherever it is covered by a stone of any size, results from the fact that its surface is depressed everywhere else by the melting action of the sun and rain; the block, like an umbrella, protects it from both; its elevation measures the level of the glacier at a former period, and as the depression of surface is very rapid—amounting even to a foot per week, during the warm months of summer—the ice, like the fields, puts forth its mushrooms, which expand under the influence of the warm showers, until the cap, becoming too heavy for the stalk, or the centre of gravity of the block ceasing to be supported, the slab begins to slide, and, falling on the surface of the glacier, it defends a new space of ice, and forthwith begins to mount afresh. These appearances are called Glacier Tables. Their origin was perfectly explained by De Saussure [§ 537].

Where sand derived from the moraines has been washed by superficial water-runs into the deep cavities which are occasionally formed in the glacier, the accumulation is at length sufficient to check the progress of the waste of ice, and what was a hole filled with sand becomes a pyramid projecting above its surface,

[1] [This frontispiece is omitted in the present edition.]

and coated with the protecting layer.[1] These produce glacier cones, which are amongst the most singular and apparently unaccountable of this class of phenomena. They are sometimes astonishingly regular, 20 or 30 feet in height, and 80 or 100 in circumference;—but this is one of the rarer appearances.

From what has been said, it will appear that a glacier has a remarkable tendency to reverse its *contour*, or to present at one time the mould or cast of what it was at another; any part of the surface prominently exposed is sure to be speedily reduced, and the hollows, whether holes or cracks or water-runs, by being silted up are protected from further decay. The valleys are literally exalted, and the hills levelled. It is owing to this beautiful compensation that the glacier maintains a tolerable evenness of surface.

A converse action, however, may be noticed. It is always on a small scale, and there are two causes. The first occurs from the collection of small objects of a dark colour and in no great quantity on the surface of the ice, which absorbing the solar heat, transmit it quickly to the ice beneath, and such particles of black sand, or even leaves which are wafted by the wind from vast distances upon the glaciers, are found sinking into cavities, whilst blocks, larger than a cottage, and weighing millions of pounds, rise above the surface. The other fact is the deepening of cavities in the ice, once formed and filled with water, but containing no considerable quantity of *detritus*. These basins, or *baignoires*, as they are usually called, appear to be formed in the following manner, first explained by Count Rumford. Water, just freezing, is *lighter* than water at a temperature somewhat higher; the water at 32°, therefore, floats on the surface of the other. Imagine a small cavity in ice, filled with water just thawed. The sun's rays first heat the surface of the water, which becoming *denser* descends, and is replaced by water at 32°. But the water which subsided with a temperature, suppose of 36°, soon communicates its heat to the sides of the icy receptacle, and being cooled to 32° it rises in its turn. The heat of the denser water is thus spent in melting the ice of the bottom of the cavity, which is deepened by the continual current.

The ice of which the glacier, in the stage which we have

[1] See Agassiz, *Études*, chap. x.

described, is composed, is unlike that produced by freezing still water in a lake or pond. Although remarkably pure and free from all intermixture of earthy matter, and even the smallest fragments of rock (except very near where it touches the soil), it is far from homogeneous or uniformly transparent. It has been described as composed of layers of perfect ice and of frozen snow intermixed, but this does not express the fact as observed in the middle and lower glacier. The ice is indeed porous and full of air-bubbles, and it is very probable that these bubbles result from the freezing of snow imbibed with water; but as it exists in the glacier it is not granular. Laminæ, or thin plates of compact transparent blue ice, alternate in most parts of every glacier, with laminæ of ice not less hard and perfect, but filled with countless air-bubbles, which give it a frothy semi-opaque look. This peculiar structure, which gives to glacier ice its extreme brittleness (which makes the formation of steps with a common hatchet a very easy task compared to what it would be in common ice), may be compared to what geologists call the *slaty cleavage* of many rocks, rather than to stratification, properly so called. The distinction is important, and amounts to this: that strata are deposited in succession, and owe their form and separation to that circumstance only; whereas, slaty cleavage, or structural planes, occur in rocks, and in many bodies, wholly irrespective of stratification or deposition, and may be communicated to a mass after complete or partial consolidation.

The alternation of bands, then, in a glacier, is marked by blue and greenish-blue or white curves, which are seen to traverse the ice throughout its thickness whenever a section is made. It is, therefore, no external accident, it is the intimate structure of a glacier, and the only one which it possesses, and may be expected to throw light upon the circumstances of the formation and motion of these masses. I became acquainted with this fact by observing these bands on the Unteraar glacier when I visited it for the first time in company with M. Agassiz and Mr. Heath in August, 1841.[1] It appeared so plain, that I was surprised to find that M. Agassiz, who had passed a part of two

[1] [The first observation of this phenomenon by Forbes was made on August 9, 1841. See *Occasional Papers*, p. 3; and *Life and Letters*, pp. 258, 259, and 546.]

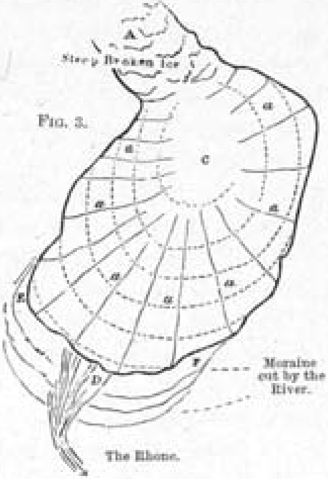
preceding summers on the same glacier, should have overlooked it. At first he maintained that it was a superficial striping of the ice, owing to the washing of sand along its surface; but when I showed that it descended to a depth of twenty feet or more in the crevasses, he stated that it must certainly have appeared since the previous year. I speedily, however, verified its occurrence in other glaciers, where it had not been remarked any more than on the Unteraar glacier, and from that time the attention of glacial theorists has been generally directed to this curious, important and quite general phenomenon. M. Guyot, an ingenious professor of Neuchâtel, stated, after I had left Switzerland, that he had observed a similar appearance in one glacier (that of the Gries) some years before, which he described along with a number of other facts connected with glaciers, in a Memoir read[1] before a provincial meeting of naturalists at Porrentruy in France. This Memoir remained unprinted, and the insulated fact observed on the Gries glacier was forgotten until I drew attention to its importance and generality in 1841. It is singular, that not only in the writings of De Saussure and the older naturalists (so far as yet appears) can there be traced no notice of this veined structure which pervades glaciers, but in the modern literature of the subject, Hugi's *Travels*, published in 1830, and the writings of Agassiz, Godeffroy, De Charpentier and Rendu devoted exclusively to glaciers, and published in 1840 and 1841, there is an equal silence as to the real nature of glacier structure, which we can scarcely account for, if so obviously important a fact, however difficult to explain, had been known to any of these authors. It will be seen, from the descriptions we shall have to give in another place (Chap. VIII.), that this appearance is in many glaciers a striking one. It has, I know, been distinctly remarked by several ingenious persons, both in this country and abroad, who yet, from not having been engaged in the special study of glaciers, or from having attached to it no particular importance, or perhaps from a very natural supposition that it must be already described, have published no account of it. Amongst others, Colonel Sabine and M. Elie de Beaumont have mentioned it to me as a circumstance which they recollected to have attracted their attention whilst on the

[1] [In 1838, at a meeting of the Geological Society of France.]

ice; and Sir David Brewster has shown me a memorandum to the same effect in 1814.[1]

As observed on the Unteraar glacier it exhibited an appearance of almost vertical layers nearly parallel to the length of the glacier, inclining outwards a little, like the rays of a fan, as it approached either shore. It was difficult to make out its form at the lower termination. A visit which I subsequently paid to the glacier of the Rhone satisfied me that these apparent layers bent round the lower extremity of the glacier, dipping forwards as the surface was depressed, and at last becoming nearly or quite horizontal. This circumstance was mentioned by me at the time to M. Agassiz (who was not present when I visited the Rhone glacier), and explained in a paper read in December, 1841, to the Royal Society of Edinburgh.[2] It was illustrated by the sketch of a ground plan of the glacier of the Rhone, Fig. 3, which shows, by the dotted lines, how these structural veins followed the circumference of the ice; but the circumstance of the varying dip and cup-like form which they assume will be better understood from Fig. 4, in which an attempt is made to represent by ideal sections a glacier of this kind.

FIG. 3.



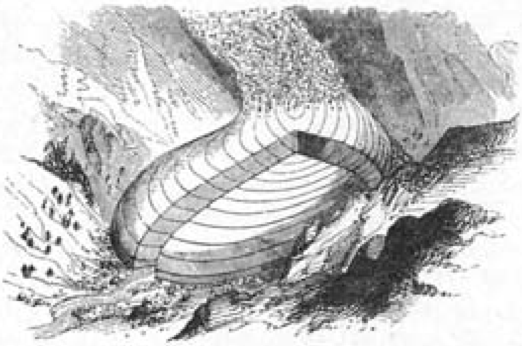


FIG 4.—IDEAL SECTIONAL VIEW OF A GLACIER.

[1] Since the above was written, it appears that Sir David printed his observation in the *Edinburgh Encyclopædia*, article "Glaciers."

[2] [*Occasional Papers*, pp. 1-9.]

My later observations will be detailed in another part of the present work.

The phenomena we have described belong to the *middle* and *lower* part of glaciers: let us now trace them to their origin amongst the perpetual snows, of which it is impossible to doubt, that the glaciers are in some sense the outlets,—that is, that they are fed or maintained by the snow, which otherwise would accumulate in the higher valleys. But let us at once and for good dispel the natural error which induces many persons who have never seen a glacier, to suppose, that in its middle or lower part it is fed or increased by the snows which fall annually upon its surface, or are wedged in at its sides. Let it be distinctly understood that the snow as regularly disappears and melts from the surface of the glacier as it does from the surface of the ground in its neighbourhood. Here and there a patch of the last winter's snow in a shady nook, or a deep crevasse, enables us in a moment to draw the distinction between ice and mere hardened snow;—the one is blue or bluish-green, and transparent, though filled here and there with air-bubbles and cavities; the other remains throughout the whole year of a dull white, without an approximation to the character of ice, or the least tendency to enter into a complete union with it at the point of contact: the two things remain as distinct as the geological contact of sandstone with slate. In whatever way the middle and lower glacier may be maintained, it is most assuredly not by the assimilation into its substance of the fallen snow of winter, either superficially or laterally.

The case, however, differs in the higher ice-world. We find the snow disappearing more and more tardily from the surface of the ice as we ascend, and at length we reach a point where it never disappears at all. This is, of course, the *snow-line* upon the glacier. It is somewhat lower than the snow-line upon the ground, but it is fundamentally the same thing. Here a well-marked change occurs. There is often a passage nearly insensible from perfect snow to perfect ice: at other times the level of the superficial snow is well marked, and the ice occurs beneath it.[1] No doubt the transition is effected in this way: The summer's thaw percolates the snow to a great depth with

[1] See the description of the glacier of Macugnaga in the latter part of [Part i. of this] this volume, and the references to *veined structure* in the Index.

water; the frost of the succeeding winter penetrates far enough to freeze it at least to the thickness of one year's fall, or by being repeated in two or more years, consolidates it more effectually. Thus M. Elie de Beaumont most ingeniously accounts for the alleged non-existence of glaciers between the tropics,[1] by the fact that the seasons there have no considerable variations of temperature, and the thaw and frost do not separately penetrate far enough to convert the snow into ice.

The part of a glacier covered with perpetual snow is what I understand to be meant by the term *névé* in the writings of the modern glacialists, although that term is vaguely defined. It will appear, however, to offer a very distinct and important line of demarcation in this view. It is where the surface of the glacier begins to be annually renewed by the unmelted accumulation of each winter. It is called *Firn* in German[-speaking] Switzerland. These accumulations of snow produce a true stratification, which has been recognised by De Saussure, Zumstein, Hugi and all later writers. I agree with De Charpentier[2] in thinking that this stratification is entirely obliterated as the névé passes into complete ice. Other writers, and particularly M. Agassiz,[3] have attempted to trace these layers throughout the lower glacier, and maintain that the whole glacier is stratified horizontally—an oversight which appears to have arisen from the appearance of the veined structure or the terminal front of the glacier being nearly in parallel horizontal lines (see Fig. 3, p. 29), which were imagined to be a continuation of the stratification of the névé, the intermediate structure having been overlooked.

The granulated structure of the névé is accompanied with the dull white of snow passing into a greenish tinge, but rarely, if ever, does it exhibit the transparency and hue of the proper glacier. The deeper parts are more perfectly congealed, and the bands of ice which often alternate with the hardened snow, are probably due to the effect of a thaw succeeding the winter coating, or any extraordinary fall. On exposed summits, where the action of the sun and the elements is greater, the snow does

[1] *Annales des Sciences Géologiques*, par Rivière, 1842. I find a notice of glaciers in Little Thibet, lat. 36° N., in Vigne's *Travels in Kashmir*, vol. ii. p. 285.

[2] *Essai*, p. 3.

[3] "Un autre caractère propre à la glace des glaciers et qui tient à son mode de formation, c'est qu'elle est stratifiée," etc.—*Études sur les Glaciers*, p. 40.

not lie so long in a powdery state, and the exposed surface becomes completely frozen. Hence the highest part of Mont Blanc, the Jungfrau, and other summits, is covered with hard ice, though always of a whitish colour. The floating masses called icebergs in the polar seas are, for the most part, of the nature of névé, mere consolidated snow. The occurrence of true ice is comparatively rare, and is justly dreaded by ships.

The crevasses in the névé differ from those in the glacier by their greater width and irregularity, and by the green colour of the light transmitted by their walls, and the appearance of horizontal stratification. The substance is far more easily fractured than ice, and also more readily thawed and water-worn; hence the caverns in the névé are extensive and fantastical, often extending to a great distance under a deceptive covering of even snow, which may lure the unwary traveller to destruction. Sometimes, through a narrow slit or hole opening at the surface of the névé, he may see spacious caverns of wide dimensions, over which he has been ignorantly treading, filled with piles of detached ice-blocks, tossed in chaotic heaps, whilst watery stalactites—icicles of ten or twenty feet in length—hang from the roof, and give to these singular vaults all the grotesque varieties of outline which are so much admired in calcareous caverns, but which here show to far greater advantage, in consequence of their exquisite transparency and lustre, and from being illuminated, instead of by a few candles, by the magical light of a tender green colour, which issues from the very walls of the crystal chambers.

Considering, then, the glaciers as the outlets of the vast reservoirs of snow of the higher Alps,—as icy streams moving downwards, and continually supplying their own waste in the lower valleys, into which they intrude themselves like unwelcome guests, in the midst of vegetation, and to the very threshold of habitations,—it is a question of the highest interest to explain the cause of this movement of the ice. The inquiry may not result in any immediately useful application, but its interest is the same as that which belongs to the theories of physical astronomy, or to the cause of any other natural effect which commends itself to our attention by its grandeur, its regularity, and its resistless power. The glacier moves on, like the river, with a steady flow, although no eye sees its motion; but from day to day, and from year to year, the secret, silent cause produces the certain slow effect;—the avalanche feeds it, and swells its flowing tide, the mightiest masses which lightning or the elements roll from the mountain side upon its surface, are borne along without pause; when the glacier, advancing beyond its usual limit, presses forward into the lower valleys, it turns up the soil, and wrinkles, far in advance, the greensward of the meadows, with its tremendous ploughshare; it brings amongst the fields the blasts of winter, and overthrows trees and houses like stubble in its ruthless progress; no combination of power and skill can stay its march, and who can define the limit of its aggression? Its proud waves are, however, stayed; and by causes as mysterious as those of its enlargement, it retreats year by year within its former limits; but where the garden and the meadow were, it has left a desolate spread of ruin, like the fall of a mountain, which never again may be tilled, and over which for at least half a century not even a goat shall pick the scanty herbage.

The theory[1] which appears at first sight most readily to account for the leading facts, is that maintained by De Saussure, that the valleys in which glaciers lie being always inclined, their weight is sufficient to urge them down the slope, pressed on by the accumulations of the winter snows above, and having their sliding progress assisted by the fusion of the ice in contact with the ground, resulting from the natural heat of the earth.[2]

[1] [For an historical sketch of the various theories as to glacier motion see Heim, chap. vi., summarised in the *Alpine Journal*, vol. xii. pp. 232-240. These theories are classified under two heads :—

1. *Those which invoke impelling causes other than gravity, i.e.*, non-Gravitation Theories. *E.g.*, Scheuchzer, Charpentier, Hugi, Forel.
2. *Those which regard the weight of the glacier itself as the moving force, i.e.*, Gravitation Theories. *E.g.*, Bordier, Saussure, Rendu, Forbes, Croll, Tyndall.

An interesting sketch of the history of observations on glaciers and their motion, from Scheuchzer to Heim, and of the Geological Survey of Switzerland is given by Professor Theophil Studer in vol. ii. pp. 215-240 of *Die Schweiz im 19ten Jahrhundert* (Bern and Lausanne, 1899). On p. 226 there is a very generous and appreciative notice of Forbes's own work. Many portraits are given, *e.g.*, of Venetz, Charpentier, Agassiz, Bernard Studer, Escher von der Linth, and Heim, as well as several curious views.]

[2] I wish to quote De Saussure's own statement of his views, which is very distinct : "Ces masses glacées entraînées par la pente du fond sur lequel elles reposent, dégagées par les eaux de la liaison qu'elles pourraient contracter avec ce même fond,

This theory of motion has been rejected as insufficient by M. de Charpentier,[1] who has supported another which (though like the last, suggested originally by an older author, Scheuchzer, as De Saussure's was by Gruner), having received a scientific form and detail in his hands, we will call "Charpentier's Theory of Dilatation," as the other may be called "Saussure's Gravitation Theory," or the sliding theory.

De Charpentier's theory is this. The snow is penetrated by water and gradually consolidated. It remains, however, even in the state of ice, always permeable to water by means of innumerable fissures which traverse the mass; these are filled with fluid water during the heat of the day, which the cold of the night freezes[2] in these fissures, producing by the expansion which freezing water undergoes in that process an immense force, by which the glacier tends to move itself in the direction of least resistance—in other words, down the valley. This action is repeated every night during summer, in winter the glacier being assumed to be perfectly stationary.[3]

soulevées même quelquefois par ces eaux,[1] doivent peu-à-peu glisser et descendre en suivant la pente des vallées ou des croupes qu'elles couvrent. C'est ce glissement lent, mais continu, des glaces sur leurs bases inclinées, qui les entraine jusques dans les basses vallées, et qui entretient continuellement des amas de glaces dans les vallons assez chauds pour produire de grands arbres, et même de riches moissons."—*Voyages*, § 535. For De Saussure's very clear views respecting the action of the heat of the earth, see §§ 532, 533, 534, 535, 739, etc.

[1] [Jean de Charpentier, from 1813 to 1855 Director of the salt mines at Bex, born 1786, died 1855; his *Essai sur les Glaciers* was published at Lausanne in 1841. A portrait of him will be found in *Die Schweiz im 19ten Jahrhundert*, 1899, vol. ii. p. 220.]

[2] The following quotations make it quite plain, that it is to the difference of the temperature of the day and night alone, that the freezing of the water in the capillary fissures is attributed:—

"Il résulte . . . que pendant les jours d'été les glaciers s'imbibent d'eau, et que celle-ci s'y congèle pendant les nuits."—Charpentier, *Essai*, p. 11.

"Dans la plupart des nuits durant l'été les glaciers augmentent de volume par la congélation de l'eau qu'ils ont absorbée pendant le jour."—*Ib.* p. 14.

"Cette alternative de gelée et dégel, comme je viens de le dire, a lieu pendant la belle saison, surtout à l'époque des jours les plus chauds suivis de nuits fraiches."—P. 15. See also p. 23. Compare Agassiz, *Études*, pp. 165, 211.

[3] "Une troisième objection contre le mouvement des glaciers par leur propre poids se tire de leur immobilité pendant l'hiver. Car c'est un fait reconnu et attesté par tous ceux qui demeurent dans leur voisinage, tels que les habitants de Chamounix, de Zermatt, de Saas, de Grindelwald, etc., que les glaciers restent *parfaitement stationnaires* dans cette saison, et ne commencent à se mouvoir qu'à la fonte des neiges."—Charp. p. 36.

"Le mouvement des glaciers suppose des alternances fréquentes de chaud et de

[1] This singular expression seems to point to a cause of motion like that developed in a curious paper on glaciers, published by Mr. Robert Mallet at Dublin in 1838.

In the *Edinburgh Review* for April, 1842, I have stated some leading objections to both of these theories, to which I refer the reader. I shall content myself with specifying one against each, which seems conclusive.

1. If the glacier *slide* down its bed, why is not its motion continually accelerated—*i.e.*, why does it not result in an avalanche? And is it conceivable that a vast and irregular mass like a glacier, having a mean slope of only 8° and often less than 5°, can *slide*, according to the common laws of gravity and friction, over a bed of uneven rock, and through a channel so sinuous and irregular, that a glacier is often embayed in a valley whence it can only escape by an aperture of half its actual width? On all mechanical principles, we answer, that it is impossible. We may add, that many small glaciers are seen to rest upon slopes of from 20° to 30°, without taking an accelerated motion; and this is conformable to the known laws of friction. It is known, for instance, to architects, that hewn stones, finely dressed with plane surfaces, will not slide over one another until the slope exceeds 30°.

2. The dilatation theory is founded on a mistake as to a physical fact. I am sorry to put it in this way, but it is unavoidable; and the respectable author of the only intelligible or precise account of the theory will, I hope, excuse me for pointing it out.

"The maximum temperature which a glacier can have," observes M. de Charpentier,[1] "is 0° Centigrade, or 32° Fahr., and the water in its fissures is kept liquid only by *the small quantity of heat* which reaches it by the surface water and by the surrounding air. Take away this sole cause of heat—*i.e.*, let the surface be frozen, and the water in the ice must congeal." Now, this is a pure fallacy; for the fact of the latent heat of water is entirely overlooked. The latent heat of water expresses the fact that when that fluid is reduced to 32°, it does not immediately solidify, but that the abstraction, not of "a small quantity of heat," but a very large quantity indeed, is necessary to con-

froid. . . . Il en résulte que l'hiver est pour les glaciers l'époque de repos."—Agassiz, p. 175.

"Pendant l'hiver toute sa masse (c.-à-d., du glacier) est dans un état de rigidité permanente qui la maintient dans *une immobilité complète* jusqu'à l'époque du retour des variations de la température."—Agassiz, p. 212.

[1] *Essai*, pp. 9 and 104.

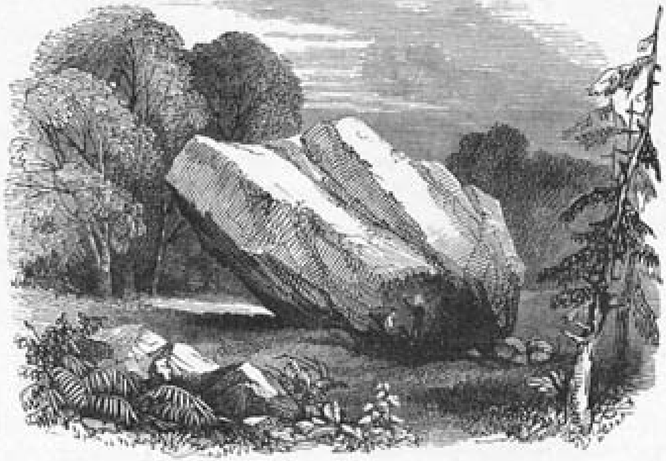
vert the water at 32° into ice at 32°. Not a great deal less heat must be abstracted than the difference of the heat of boiling water and that at common temperatures. The fallacy, then, consists in this: Admitting all the premisses, the ice at 32° (it is allowed that in summer, during the period of infiltration, it cannot be lower) is traversed by fissures extending to a great depth (for otherwise the dilatation would be only superficial), filled with surface water at 32°. Night approaches, and the surface freezes, and water ceases to be conveyed to the interior. Then, says the theorist, the water already in the crevices and fissures of the ice, and in contact with ice, instantly freezes. Not at all; for where is it to deposit the heat of fluidity, without which it cannot, under any circumstances, assume the solid form? The ice surrounding it cannot take it; for, being already at 32°, it would melt it. It can only, therefore, be slowly conveyed away through the ice to the surface, on the supposition that the cold is sufficiently intense and prolonged to reduce the upper part of the ice considerably below 32°. The progress of cold and congelation in a glacier will therefore be, in general, similar to that in earth, which, it is well known, can be frozen to the depth of but a few inches in one night, however intense the cold. Such a degree and quantity of freezing as can be attributed to the cold of a summer's night must therefore be absolutely inefficient on the mass of the glacier.

I will not stop to consider the attempt made by M. de Charpentier to show, that the friction of any length of a glacier upon its bed may be overcome as easily as the shortest, from a consideration of the forces producing dilatation; but it is as indefensible on mechanical grounds as the preceding theory is on physical ones (*Essai*, p. 106). I quote from M. de Charpentier, not because his defence of the theory of dilatation is more assailable than that of others, but because his work is the only one in which an attempt is made to explain its physical principles with precision.

I cannot admit then, that either the sliding or dilatation theory can be true in the form which has hitherto been given to them. When I first began to study the subject minutely, under the auspices of M. Agassiz, in 1841, its difficulty and complication took me by surprise, and I soon saw, that to arrive at any theory which, consistent with the rigour of physical science at the present time, would be worthy of the name, a very different method of investigation must be employed from that which was then in use by any person engaged in studying the glaciers.

To a person accustomed to the rigour of reasonings about mechanical problems, the very first *data* for a solution were evidently wanting—namely, the amount of motion of a glacier in its different parts at different times. A few measures had indeed been made from time to time by MM. Hugi and Agassiz, of the advance of a great block on the Unteraar glacier from one year to another, but with such contradictory results as corresponded to the rudeness of the methods employed; for in some years the motion appeared to be *three times* as great as in others. I then pointed out to M. Agassiz, how, by the use of fixed telescopes, the minutest motions of the glacier might be determined,—a suggestion which he has, I believe, since put in practice. It seems very singular that ingenious men, with every facility for establishing facts for themselves, should have relied on conclusions vaguely gathered from uncertain data, or the hazarded assertions of the peasantry about matters in which they take not the slightest interest. The supposed immobility of the glaciers in winter,—the supposed greater velocity of the sides than the centre of the ice, were amongst the assumptions traditionally handed down, upon no sufficient authority, and, I believe that I may safely affirm, that not one observation of the rate of motion of a glacier, either on the average or at any particular season of the year, existed when I commenced my experiments in 1842. Far from being ready to admit, as my sanguine companions wished me to do in 1841, that the theory of glaciers was complete, and the cause of their motion certain, after patiently hearing all that they had to say, and reserving my opinion, I drew the conclusion that no theory which I had then heard of could account for the few facts admitted on all hands, and that the very structure and motions of glaciers remained still to be deduced from observation.

The preceding sketch of the phenomena of glaciers is, I am aware, very imperfect. It would, however, make this chapter too long, and encroach upon the special topics of this work, to enlarge further; but several explanations and references to other authors will be made immediately, in the chapters where they may be naturally introduced.



PIERRE À BOT, NEAR NEUCHÂTEL.

CHAPTER III

ON THE GEOLOGICAL AGENCY OF GLACIERS

Reasons for supposing glaciers to have caused the transportation of primitive blocks in Switzerland—Playfair—Venetz—De Charpentier—Agassiz—Action of glaciers upon rocks—The Pierre à Bot—The blocks of Monthey—Abraded surfaces near the Pissevache—Objections to the theory of ancient glaciers considered.

"Zuletzt wollten zwey oder drei stille Gäste sogar einen Zeitraum grimmiger Kälte zu Hülfe rufen, und aus den höchsten Gebirgszügen, auf weit in's Land hingesenkten Gletschern, gleichsam Rutschwege für schwere Ursteinmassen bereiten, und diese auf glatter Bahn fern und ferner hinausgeschoben im Geiste sehen. Sie sollten sich, bei eintretender Epoche des Aufthauens, niedersenken und für ewig in fremden Boden liegen bleiben."

Wilhelm Meisters Wanderjahre, edit. 1829.[1]

TRANSLATION.

Finally, two or three hitherto silent guests called to their aid a period of intense cold, with glaciers descending from the highest mountain ranges, far into the low country, upon which, as on an inclined plane, heavy primitive blocks were slid farther and farther onwards, so that, at the period of thawing of the ice, they sank down and remained permanently on the foreign soil.

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[1] [According to M. de Charpentier (*Essai*, p. 247), this passage does *not* occur in the first edition (1821) of the *Wanderjahre*, but is found in that of 1829, revised by Goethe himself. Forbes's translation is somewhat free.]

It has been stated in the last chapter that glaciers are useful geological emissaries, which bring down from the inaccessible mountain chains where they originate specimens of rock which otherwise would be unattainable. The glaciers have a *carrying* power which exceeds that of any other agent, vital or mechanical. Hence, geologists having observed the benefit which existing glaciers conferred on their cabinets, naturally enough considered whether the enigmatical dispersion of blocks of foreign materials upon wide surfaces of country, in the most singular positions, might not be due to the former existence of extensive glaciers in those regions.

The occurrence of vast masses of primitive rocks, apparently without any great wear and tear of travelling, upon secondary or alluvial surfaces, at great distances from their origin, has been one of the numerous *opprobria* of geology. It is peculiarly so, because a thousand circumstances demonstrate that the deposition of these masses has taken place at the very last period of the earth's history. No considerable changes of surface have occurred since. These blocks are superficial, naked, deposited upon bare rock, which has received no coating of soil since, and are often placed in positions of such ticklish equilibrium that any considerable convulsion of nature, whether by earthquake or *débâcle*, must inevitably have displaced them. A geologist might, therefore, fairly be asked,—"If you cannot account for these very latest and plainest phenomena of change and transport on the earth's surface, whose various revolutions you pretend to explain, how shall we follow you when you tell us of the metamorphoses of slates and the throes of granite?" And certainly geologists were put to their wits' end by such questioning, for no hypothesis seems too absurd to have found a place amidst their conjectures on the subject. Explosions, without apparent origin or cause, which projected the primitive blocks in a shower carrying them to a distance of a hundred miles or more,—currents of water which, derived from some unknown source, took their way on either side of the axis of a great chain of mountains, and with so stupendous a velocity as to carry with them blocks containing hundreds of thousands of cubic feet, and not only that, but transported them across lakes and up hills, and finally deposited them unshivered, and even with sharp angles and edges,—such were amongst the speculations proposed to account for these phenomena. A more plausible theory was that of ice rafts, by which (as on the icebergs of the polar seas, which are masses detached from the great glaciers of the north) blocks of stone were to be transported across lakes and wafted to the sides of distant mountains; but the immense changes which must in many cases have been admitted in the *contour* of the country, to permit the existence of such lakes, besides many peculiarities in the distribution of the blocks, at least in Switzerland, renders this ingenious theory not universally applicable.

The first person, so far as I know, who perceived the possible importance of glaciers as geological agents, was my respected predecessor, Professor Playfair. This indication, which forms part of the very able note on the Transportation of Stones, in the *Illustrations of the Huttonian Theory*, is neither vague nor indirect. It is put forward as the most probable explanation of all cases of transport where immense power was obviously required:—

"For the moving of large masses of rock," says Professor Playfair, "the most powerful agents without doubt which nature employs are the glaciers, those lakes or rivers of ice which are formed in the highest valleys of the Alps and other mountains of the first order. These great masses are in perpetual motion, undermined by the influx of heat from the earth, and impelled down the declivities on which they rest, by their own enormous weight, together with that of the innumerable fragments of rock with which they are loaded. These fragments they gradually transport to their utmost boundaries, where a formidable wall ascertains the magnitude, and attests the force, of the great engine by which it was erected. The immense quantity and size of the rocks thus transported, have been remarked with astonishment by every observer, and explain sufficiently how fragments of rock may be put in motion even where there is but little declivity, and where the actual surface of the ground is considerably uneven. In this manner, before the valleys were cut out in the form they now are, and where the mountains were still more elevated, huge fragments of rock may have been carried to a great distance; and it is not wonderful if these same masses, greatly diminished in size, and reduced to gravel or sand, have reached the shores, or even the bottom of the sea. *Next in force* *to the glaciers,* the torrents are the most powerful instruments employed in the transportation of stones."[1]

Now, as the passage immediately preceding that which we have quoted contains a statement of the problematical facts presently to be mentioned respecting the distribution of the travelled blocks over the plains of Switzerland and on the Jura, we cannot but give to Professor Playfair the credit of having clearly pointed out the probability of the former greater extension of glaciers as the most powerful known agents of transport. This was in the year 1802, before the author had had the opportunity of personally estimating the applicability of the theory to phenomena. The following passage from the notes of his journey in 1816 shows that his views in this respect had undergone no change in the interval, and were only confirmed by an inspection of the erratic blocks on the Jura, which he unhesitatingly ascribes to the former existence of glaciers which once *crossed* the lake of Geneva and the plain of Switzerland. "A current of water," he says, "however powerful, could never have carried it (the Pierre à Bot, near Neuchâtel) up an acclivity, but would have deposited it in the first valley it came to, and would, in a much less distance have rounded its angles, and given to it the shape so characteristic of stones subjected to the action of water. A glacier which fills up valleys in its course, and which conveys rocks on its surface free from attrition, is the only agent we now see capable of transporting them to such a distance, without destroying that sharpness of the angles so distinctive of these masses."[2]

Like many other anticipations of new theories, these pointed and just observations of Professor Playfair lay dormant until the opinion which he had advanced had been separately originated and discussed. M. Venetz,[3] an intelligent engineer of the canton of Vallais, speculating upon the irregular periods of increase and decrease of glaciers, collected partly from history and partly from tradition a variety of curious and distinct facts bearing upon these oscillations of the great glaciers of the Alps. He united them with judgment and impartiality in a memoir which was read in 1821 to the Swiss Natural History Society, and pub-

[1] *Huttonian Theory,* Art. 349. [2] Playfair's *Works,* vol. i. p. xxix.

[3] [Ignaz Venetz, born 1788, died 1859. See his portrait in *Die Schweiz im 19ten Jahrhundert* (1899), vol. ii. p. 217.]

lished in the second part of the first volume of their *Transactions*.[1] In this paper, M. Venetz classifies separately the facts which prove an increase, and those showing a decrease of glaciers in modern times. The former are certainly the most remarkable—showing that passes the most inaccessible, traversed now, perhaps, but once in twenty years, were frequently passed on foot, sometimes on horseback, between the eleventh and fifteenth centuries. Thus, the Protestants of the Haut Vallais took their children across what is now the Great Glacier of Aletsch to Grindelwald for baptism;[2] and at the same period horses passed the Monte Moro from Saas into Italy; and the peasantry of Zermatt, at the foot of the Monte Rosa, went annually in procession through the Eringer Thal to Sion, by a pass which few inhabitants of either valley would now venture to attempt.[3] We regard these facts, not as forming any proof of the former great extension which carried the glaciers even over to the Jura, but as evidencing one only of many oscillations which the glacier boundaries have undergone; and as important in showing that a *very notable* enlargement of these boundaries was consistent with the limits of atmospheric temperature, which we know that the European climate has not materially overpassed within historic times. It may not, therefore, require so violent a depression of temperature as we might at first sight suppose, to account for any extension of the glaciers which the facts may require us to admit. The causes of these oscillations are, as yet, very obscure. I purposely refrain (for the sake of conciseness)

[1] [This paper is still a storehouse of valuable information, though it needs corrections and additions. It fills pp. 1-38 of Part II. of vol. i., Zürich, 1833, of the *Denkschriften der allgemeinen schweizerischen Gesellschaft für die gesammten Naturwissenschaften*, and is entitled *Mémoire sur les variations de la température dans les Alpes de la Suisse*. The Mönchjoch reference is at p. 8, and that relating to the Col d'Hérens at pp. 7, 8, while the Monte Moro is mentioned on p. 9.]

[2] [These supposed passages of the Mönchjoch have been disproved by the careful examination of the baptismal registers of Grindelwald; the error was due to the fact that certain natives of the Vallais, resident in Grindelwald, had their children christened in the Grindelwald church. See Herr A. Wäber's excellent article in vol. xxvii. of the *Jahrbuch* of the Swiss Alpine Club, pp. 262-264, 270-272.]

[3] [The passage of the Col d'Hérens in early times by such a procession seems *quite* certain, for, in consequence of a petition of the Zermatters to the Bishop, this procession was altered in 1666 to one to the neighbouring hamlet of Täsch only, part of the dues in money being payable to the curé of Täsch, and the rest reserved to the three churches in Sion to which this pilgrimage was originally made; the dues payable at Sion were commuted for a capital sum in 1816 only. There are other bits of evidence proving early direct communication between Zermatt and the Eringerthal. See Mr. Coolidge's *Swiss Travel and Swiss Guide-Books*, pp. 252, 253.]

from analysing the theories which have been given, because I find them all unsatisfactory.

M. Venetz has, in his memoir,[1] further pointed out certain ancient moraines, belonging to modern glaciers, which indicate their previously greater extension; an evidence which had formerly been accepted by De Saussure, especially in the case of the Glacier des Bois at Chamouni,[2] and that of the Rhone.[3] The remark is important, because it requires us to investigate the character of a moraine, so as to recognise it wherever it may be found.

It does not appear that M. Venetz has published any other memoir on the subject of glaciers;[4] but it is quite certain that he was the first person publicly to maintain in Switzerland the doctrine of the former extension of the glaciers to the Jura, as the transporting agents of the erratics. I was introduced personally to M. Venetz in 1832, as the man who had originated a speculation, which, though it had not then perhaps another advocate, was acknowledged to be novel, ingenious and bold; and the reputation which the author of it had acquired, as the intrepid and skilful engineer of the works on the glacier of Giétroz (the cause of inundations which threatened the town of Martigny with destruction), gave it a consequence which might not otherwise have been conceded to it.

In the second edition of Goethe's *Wilhelm Meister*, he has introduced a discussion as to the cause of the transport of erratic blocks, which I have placed at the head of this chapter, and in which the glacier theory is not forgotten, and was most likely borrowed from Playfair.

The further history of the geological theory need not be detailed. It received in Switzerland the powerful support of De Charpentier,[5] and was yet further pushed by Agassiz, who

[1] [P. 16 *sqq.*] [2] *Voyages*, § 623. [3] *Ib.* § 1722.

[4] [In 1829 Venetz *read* a paper at the meeting of the Swiss Natural History Society on the Great St. Bernard; this paper dealt with the extent of the ancient glaciers and of their retreat, but it does not appear that it was published in the *Transactions* of the Society till 1861—it is entitled *Mémoire sur l'extension des anciens glaciers et quelques explications sur leurs effets remarquables*, a posthumous work.]

[5] [Forbes does not mention Charpentier's most interesting conversation in 1815 with J. P. Perraudin, a chamois hunter of Lourtier in the Val de Bagnes, who, says Charpentier, pp. 242, 243, was the *first* to point out to him the former extension of glaciers in the Val de Bagnes, and the traces they had left behind them in the shape of huge boulders, too heavy to be moved by water. Venetz (p. 24), too,

attempted to extend it, with some variations, to every part of the temperate zone, and to explain the distribution of the Scandinavian blocks, and those of Great Britain, by a similar action. We shall confine ourselves, however, for the present, to a brief consideration of the erratic phenomena as they present themselves in Switzerland, and, without attempting to demonstrate the absurdity of other suppositions, give some reasons for considering the former existence of glaciers 100 miles long or more, as a less extravagant hypothesis than almost any one will at first sight be disposed to regard it.

There are two principal grounds upon which it is maintained that the former presence of a glacier can be proved. In the first place, from the TRANSPORTATION OF BLOCKS; and, secondly, from the FORM AND POLISH which glaciers give to the rocks which they chafe during their descent. The most weighty objections urged against the theory, are (1) the difficulty of admitting a former condition of climate cold enough to permit so vast an extension of glaciers as would be required; and (2) that under any circumstances of climate, it is difficult or impossible to conceive that glaciers could have existed in the particular situations conjectured, on account of the little declivity which the surface could have had, and which it is assumed is inconsistent with their progression.

We shall consider these points briefly in order.

The transportation of blocks by existing glaciers has been already spoken of as one of their most marked prerogatives. The quantity is often so great as almost entirely to conceal the mass of the ice under the prodigious load which, during a long descent, is accumulated upon it. Thus, the lower parts of the Glacier de Miage,[1] near Mont Blanc, and the Glacier of Z'Mutt, near Monte Rosa, are completely darkened by the quantity of rocks which they transport. And although in some cases the disappearance of these moraines, which, it would seem, ought to have formed, in the course of ages, a vast accumulation at the foot of the glacier, may require some further explanation; in others, there

mentions Perraudin as having told him of many ancient moraines in the Val de Bagnes, now far distant from their respective glaciers, and says of him that he was an *amateur de ces sortes d'observations.* Charpentier also reports how the same idea was put before him in 1834 by a Meiringen peasant, and had also been set forth by various other peasants in the Val Ferret, near Yverdon, and at Chamounix.]

[1] [The *Italian* Miage Glacier is meant.]

is no want of evidence of their geological power, filling up entire valleys, and forming lakes, as in the case of the Glacier de Miage, just mentioned, and that of Allalin in the valley of Saas.[1]

The *dimensions* of the transported masses, of which we shall presently speak, offer no difficulty on this theory; masses of nearly or quite equal size may be seen on existing glaciers, nor does there appear to be any limit to their magnitude, except the cohesion of the granite or other rock of which they are formed. I have seen a mass actually on the ice of the Glacier of Viesch in the Vallais, nearly 100 feet long (judging by the eye), and 40 or 50 feet high. There is also a block of green slate in the valley of Saas, pushed forward by the glacier of Schwarzberg, which contains, according to Venetz,[2] 244,000 cubic feet. It was deposited about twenty years ago, and the glacier has now retreated at least half a mile, leaving the intervening space covered with true erratics, and which, in that condition, is called by the German writers *Gletscherboden*.

Again, a very remarkable action of existing glaciers is to chafe and polish the rocks over which they are pushed or dragged, whether by their weight, or by any other cause. The fact is certain, that, at least at their sides, there is a continued contact between the supporting rock or wall of the glacier and the glacier itself. Its stupendous unwieldy mass is dragged over the rocky surface, it first denudes it of every blade of grass, and every fragment of soil, and then proceeds to wear down the solid granite, or slate, or limestone, and to leave most undeniable proofs of its action upon these rocks. It is very strange that this most evident and seemingly natural action should have been so long overlooked, and finally contested; it is to De Charpentier that we owe its clear assertion, and the proof, in the following passage, published in 1835: "We know that the glaciers rub, wear, and polish the rocks with which they are in contact. Struggling to dilate, they follow all the sinuosities, and press and mould themselves into all the hollows and excavations they can reach, polishing even overhanging surfaces, which a current of water, hurrying stones along with it, could not

[1] For an account of all these phenomena in this work, see the Index under the proper names.

[2] [Charpentier, pp. 41 and 252: the block was moved by the glacier in 1818.]

effect."[1] An attentive survey of the glaciers cannot leave the slightest doubt of this action on the mind of any unprejudiced person.

There can be no doubt from observation, that a glacier carries along with its inferior surface a mass of pulverised gravel and slime, which, pressed by an enormous superincumbent weight of ice, *must* grind and smooth the surface of its rocky bed. The peculiar character of glacier water is itself a testimony to this fact. Its turbid appearance, constantly the same from year to year, and from age to age, is due to the impalpably fine *flour* of rocks ground in this ponderous mill betwixt rock and ice. It is so fine as to be scarcely depositable. No one who drives from Avignon to Vaucluse can fail to be struck with the contrast of the streams, artificially conveyed on one and on the other side of the road, in order to irrigate the parched plain of Provence. The one is the incomparably limpid water of Petrarch's fountain; the other an offset[2] from the turbid Durance, which has carried into the heart of this sun-burnt region the unequivocal mark of its birth amidst the perpetual snows of Monte Viso. This is the pulverising action of ice.

Most erroneously have those argued who object to this theory that ice cannot scratch quartz—ice is only the *setting* of the harder fragments, which first round, then furrow, afterwards polish, and finally scratch the surface over which it moves. It is not the wheel of the lapidary which slits a pebble, but the emery with which it is primed. The gravel, sand and impalpable mud are the emery of the glacier.

Although the contacts of ice and rock are very generally covered by moraines, an attentive examination of almost any glacier affords evidence to the wear of the lateral rocks. We shall show in future chapters how unequivocally this appears on the Mer de Glace of Chamouni, and on the glacier of La Brenva, to which, in the meantime, we refer as evidence of the fact.

Having stated that the transporting and the abrading power of glaciers is undoubted, we shall now describe some of the

[1] *Notice sur la cause probable du transport des Blocs Erratiques de la Suisse.* Par M. J. De Charpentier. (Extrait du tome viii. des *Annales des Mines.*) 1835.

[2] [The reference is to the Guil river, which rises *near* the foot of Monte Viso; but the rare glaciers or snow-patches on that peak feed the Po, or its tributaries, the Lenta and the Varaita, only.]

phenomena at a distance from glaciers, which are supposed to give sure evidence of these powers having formerly been exerted. This evidence is so very remarkable (we speak now of Switzerland) as to deserve a most careful study before any hypothesis admitted to be *mechanically adequate* is rejected on grounds of indirect improbability or opposition to experience; for the facts to be explained, if they rested on other evidence than that of eye-witnesses, would themselves be rejected as incredible and absurd.

A glance at any map of Switzerland will show that it consists of three distinct portions—the great chain of Alps; the plain of Switzerland containing numerous lakes; and the secondary chain of the Jura, which runs parallel to the Alps, and attains a very inferior elevation. The plain, or great valley, runs of course parallel to the two ranges which bound it, that is, in a direction from south-west to north-east, and having a breadth which may be roughly stated at 30 English miles, but the distance from the highest part of the Alps to the highest part of the Jura is not less than 80 English miles. Nearly opposite to the great gap in the main chain formed by the valley of the Rhone where it opens upon the Lake of Geneva, we have the Lake of Neuchâtel, with mountains of secondary limestone, corresponding to some parts of our Oolite formation, rising to a height of nearly 3000 feet above the valley.

Upon the slope of this range,—not at the level of the lake but considerably higher, and just facing the Rhone valley, lie extensive deposits of angular blocks of the kind of granite which especially characterises the eastern part of the range of Mont Blanc, which is also the nearest point where the rock in question occurs *in situ*. It may be difficult to point out with certainty the locality whence these fragments are derived, as the kind of granite called *Protogine* (which contains talc instead of mica) of which they consist, is common in many parts of the Alps. But it is perfectly certain that no rock approaching to it in the remotest degree is to be found either in the Jura or nearer than the part of the Alps which I have mentioned, and which may be from 60 to 70 miles distant as the crow flies. A great belt of these blocks occupies a line, extending for miles, at an average height of 800 feet above the level of the Lake of Neuchâtel, and above and below that line they diminish in number, although not entirely wanting. They have been most extensively broken up and removed, for building purposes, or merely to disencumber the land, and many of them are concealed amidst the woods which clothe the mountain slope. But wherever seen they fill the mind with astonishment, when it is recollected that, as a matter of certainty, these vast rocks, larger than no mean cottages, have been removed from the distant peaks of the Alps, visible in dim perspective amidst the eternal snows, at the very instant that we stand on their débris. The most notable of these masses, called the *Pierre à Bot* (or toad-stone), lies in a belt of wood, not far from a farmhouse, about two miles west of Neuchâtel, and near the road to Valangin and La Chaux de Fonds.[1] The first height above the lake being gained (vine-clad on its lower slopes), we come rather abruptly upon a well-cultivated flat or terrace, where the farmhouse just mentioned is situated. This hollow in the hill permits some accumulation of soil, which elsewhere is very thin and bare, and probably the configuration of the ground has had something to do with the deposition of the blocks, which have no doubt been carefully cleared away from this more level spot. Immediately behind, however, the hill again rises, covered with thick wood, in every part of which, not a few, but hundreds and thousands of travelled blocks may be found; some small and rounded, but a vast number exceeding a cubic yard in contents, and perfectly angular, or at least with only the corners and edges slightly worn, but without any appearance of considerable attrition, or of violence having been used in their transport. Indeed, such violence would be quite inconsistent with their appearance and present position.

The *Pierre à Bot* is figured at the head of this chapter, from a sketch made on the spot. Its dimensions, according to von Buch, are 50 feet long, 20 wide, and 40 high, containing 40,000 cubic feet (French). It forms a stupendous monument of power. It is impossible to look at it without emotion, after surveying the distance which separates it from its birthplace. No wonder that geologists have vied with one another in attempting to account for so extensive and surprising a phenomenon. If transported by water, why do these masses form a band so high above the plain?—why, rather, were they not buried in the

[1] [It is about half an hour's walk from Neuchâtel.]

depths of the lake beneath; and why do they show such slight marks of the friction which they must inevitably have experienced? If they slid down an inclined plane, touching the Alps and Jura, of what was that plane made, and what has since become of its material? Besides, how is it possible that rough blocks could slide down any natural slope of $1° 8' 50''$, which is all that the relative positions of the blocks and their origin permit?[1]

Lastly, if these blocks were transported, like the erratics of the arctic regions, upon floating rafts of ice, what was the extent, and what the boundaries and barriers of the natural lake on which they were transported? Such boundaries or barriers cannot be pointed out, consistently with what has been said as to the unchanged condition of the superficial deposit in Switzerland generally, since the period of the transport of erratics. Their orderly distribution with respect to the nature of the rocks, those from the same origin being generally grouped together, is inconsistent with the idea of icebergs floating hither and thither, and wrecked or sunk by chance on any part of the lake. Nor is this all: the supposition of a lake washing the base of the Jura range, and cold enough to maintain a heavy fleet of ice-islands, is a supposition as gratuitous, and very nearly, if not quite, as violent with respect to change of climate, as that of Venetz and De Charpentier, who attribute this transportation of rocky masses to a mere extension of glaciers now existing, which are at this hour depositing terminal moraines of blocks similar to those upon the Jura, but which are confined to the heads of the valleys, which they formerly entirely occupied, as well as the plains beyond. Of course, this recession was not instantaneous, but went on gradually throughout a long series of years, so that the moraines which commence on the Jura have covered by degrees the whole intervening space between the former and the actual termination of the glaciers.

If this theory have any foundation, we ought to find confirmations of it in the valleys through which the supposed glaciers must have passed, and this we do in a most remarkable manner. Not to dwell too long on a general point, which would admit of much detail, I will confine myself to a few observations which I have had an opportunity of making, chiefly in company

[1] Charpentier, p. 174.

with M. de Charpentier himself, in the part of the Rhone valley between Martigny and the Lake of Geneva.

The narrow gorge through which the Rhone passes at St. Maurice is familiar to all Swiss travellers. If the glacier which then filled all the upper and tributary valleys whose waters now form the current of the Rhone passed through this place, it must have been violently accumulated in this ravine, and pressed with excessive force upon the bottom and sides of the valley. The marks of glacier wear and polish are here extremely visible, especially on the rocks which occupy the bottom between St. Maurice and Bex; and they extend to a very great height on the eastern side of the valley, exactly opposite to the village of Bex, where M. de Charpentier pointed out to me the most exquisitely polished surfaces of rock, quite as smooth as a schoolboy's slate, and displaying an artificial section of all the interior veins. After passing the defile of St. Maurice, the glacier spread itself over the enlarged basin immediately beyond, partly formed by the tributary Val d'Illiez. The north-western face of that valley fronts the tide of ice which then flowed through the rocky defile (on the theory we are discussing), and which bore upon it with its lateral moraine. The result is not less surprising than what we have described upon the Jura. The rock here, too, is limestone, and not perhaps a fourth part of the distance of the Chaumont (above Neuchâtel) from native granite, but the magnitude of the moraine is proportionally greater. The "blocks of Monthey," as they are called, from the village immediately below them, must be seen to be appreciated. I wandered amongst them for a whole forenoon, and though I had previously heard much of their magnitude, I had formed no idea of what I then saw We have here, again, a belt or band of blocks—poised, as it were, on a mountain side, it may be five hundred feet above the alluvial flat through which the Rhone winds below. This belt has no great vertical height, but extends for miles—yes, for miles along the mountain side; it is composed of blocks of granite of thirty, forty, fifty and sixty feet in the side—not a few, but by hundreds, fantastically balanced on the angles of one another, their grey weather-beaten tops standing out in prominent relief from the verdant slopes of secondary formation on which they rest. They are thickest in the midst of a wood, and the traveller has his admiration divided between the singularity of the phenomenon and the exquisite *picturesque* of the spot. For three or four miles there is a path preserving nearly the same level, leading amidst the gnarled stems of ancient chestnut trees which struggle round and among the pile of blocks, which leave them barely room to grow: so that numberless combinations of wood and rock are formed, where a landscape painter might spend days in study and enjoyment. The trees opening here and there display the valley of the Rhone beneath, and the exquisite meadows and orchards which surround the town of Bex, surmounted by the lofty and imposing summits of the Grand Muveran and the Dent de Morcles. The blocks are piled one on another, the greater on the smaller, leaving deep recesses between, in which the flocks or their shepherds seek shelter from the snow-storm,[1] and seemed not hurled by a natural catastrophe, but as if balanced in sport by giant hands. For how came they thus to alight upon the steep, and there remain? What force transported them, and when transported, thus lodged them high and dry five hundred feet at least above the plain? We reply, a glacier *might* do this. What other inanimate agent could do it, we know not.

I have adverted to the marks of friction and polish visible upon the fixed rocks near St. Maurice: I must add a word about another appearance higher up, and which gave me a strong conviction of the impossibility of currents of water producing these effects, which I examined carefully in August, 1841. The cascade of the Pissevache between Martigny and St. Maurice, upon the left bank of the Rhone, is perfectly known to travellers, but few probably have taken the trouble to ascend to the level of the higher valley through which the stream (the Sallanche) descends before being finally precipitated. When by a toilsome climb the higher level has been gained—fully 1500 feet above the Rhone valley—bare rocks are seen to rise almost precipitously on either side of the channel through which, at a great depth below, the stream leaps from crag to crag, and even the din of its greater fall is lost in the depth. Now these vertical precipices, which

[1] One of these afforded shelter to a monomaniac, disappointed in love, whose sad story is known to many of the inhabitants of the valley who recollect him. The block which is figured in De Charpentier's work is named from the poor man, who lived, I think, for forty years under it, *Pierre à Milan*. [Charpentier, however, points out on p. 361 of his work that the block figured therein as the *Pierre à Milan* is *not* that boulder.]

form the mural angle or buttress between the valley of the Sallanche and that of the Rhone (which are at right angles to one another), are scored by *horizontal* stripes, or grooves, or fluting, evidently the result of superficial wear. But what could have worn it in this position? Could a current of water, of 1500 feet deep, have borne boulders on its surface which should leave these plain horizontal markings? What could have been moved with a steady pressure as a carpenter presses his cornice plane on the wood, or as a potter moulds with a stick his clay, pressed laterally too, with a perpendicular face of 1500 feet beneath? Nothing that I am acquainted with save a glacier, which at this day presses and moulds and scores the rocky flanks of its bed, extending to a depth often certainly of hundreds of feet beneath. A torrent, however impetuous; a river, however gigantic; a flood, however terrific, could never do this.

The result of the attrition of fixed rocks attributed to glaciers is threefold. In the *first* place, the surface of rock, instead of being jagged, rugged, or worn into deep defiles, is even and rounded, often dome-shaped or spheroidal, showing the structure of the rock in section, and occasionally so smooth as to be difficultly accessible, as at the Höllenplatte, near the Handeck. Such surfaces were called *Roches Moutonnées* by De Saussure.

Secondly. Subordinate to these general forms are the long, smooth, parallel grooves or flutings which have been already mentioned.

Thirdly. These polished grooves are often traversed by fine lines or striæ, cut as it were by a hard point, which often cross one another.

These various phenomena are observed both close to modern glaciers and in the districts of the Alps and Jura which abound with erratics.

The striæ of the Pissevache are accompanied by the presence of erratic blocks. They are all, I think, from the neighbouring mountains to the westward. From this fact, and from the direction of the marks on the rock, I concluded, in 1841, that the Val du Trient was formerly occupied by a glacier which passed by the village of Salvan and joined the great Rhone glacier, by sweeping round the angle of the Pissevache. This conjecture will be found to be confirmed by more recent observations in the valley of Vallorcine, which will be found in one of the later chapters of this work.

It remains to close this very brief sketch by referring to the two chief objections already mentioned, by which the glacier theory has been most ably opposed. And (1) that the cold supposed is contrary to received geological opinions, or to probability. To this I will briefly answer, first, that the opinion of geologists appears to have been far too exclusively grounded in this, as in some other parts of their science, on zoological evidence; and in the present case that evidence appears to be both inconclusive and contradictory; inconclusive, because new recent species (I allude to inhabitants of the ocean) are being continually found in climates to which they were not formerly supposed to belong, and contradictory, because, instead of a constantly warmer climate in former times appearing from the evidence, such as it is, of the fossil shells, it is affirmed, not without plausibility, by Mr. James Smith, Mr. Lyell, and M. Agassiz, that the shells of the particular epoch corresponding to the dispersion of erratic blocks have a decidedly arctic character. I answer, secondly, that the advocates of the theory of ice rafts require a much greater degree of cold than at present, and that all geologists, from De Saussure to M. Elie de Beaumont, admit that there are traces in certain glaciers of the Alps of their having formerly extended a certain way beyond their present limits. I observe, thirdly, that the depression of temperature need not probably be so very great, as might at first sight appear, in order to cover Switzerland with ice. It will be seen in the course of the present work that many glaciers have undergone surprising variations of extent, and covered whole acres with their débris, within the memory of persons now living, and this due to causes which, though doubtless energetic, are not sufficiently developed to enable us to clearly to define them.[1] It would not be difficult to show, did space permit, that a great increase of glacier surface must result from a small depression of atmospheric temperature.

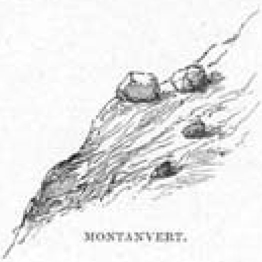
(2) A more formidable objection has been drawn from the *small inclination* under which these primitive glaciers must have moved, and carried down their débris. The *mean* inclination of

[1] See references to the glaciers des Bois, of La Brenva, of the Val de Bagnes, of Lys, and Schwarzberg in the Index.

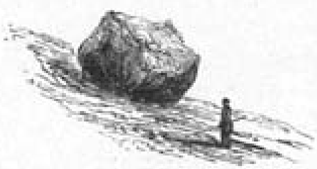
the entire glacier of the Rhone valley has been estimated by De Charpentier at 1° 8′; but the slope of a great part of its course must have been much less, and, comparing the height of the erratics near Martigny with those upon the Jura, it is estimated by M. de Beaumont at nearly 15′. The question then comes to be, can a glacier move at all under such slopes? Speaking from experience, we find the mean slope of glaciers to be much above what has been stated, but whether this is essential to their motion or not, is quite a different question; it may result merely from the actual inclination of the valleys to which the glaciers are confined by the present laws of climate. It seems impossible to give any just answer to the question, "Under what slope would a glacier 100 miles long move?" without first answering another, "What is the immediate cause and mode of glacier motion?" It is hoped that something like an answer to the latter question may be found in this volume. We may then attempt to reply to the former.

Some further illustrations of the subject of this chapter will be found in the *Edinburgh Review* already quoted, in which I have stated my opinions on several points more at large; as well as in the clear and able work of De Charpentier, where the rival theories are ingeniously handled.

In conclusion, I shall call attention to two simple woodcuts, of parallel and similar but very distant phenomena,—the one, of travelled blocks resting on an ice-worn surface, within a few fathoms of a modern glacier, by which they have been deposited,—the other represents a fragment of similar rock, upon a limestone surface, 90 miles in a right line from the preceding, and 60 miles from the nearest granite. The first figure is from blocks stranded by the Mer de Glace, near the Montanvert. The scene of the second is on the face of the Jura range above Bienne, close to the great road.



MONTANVERT.



BIENNE—JURA.

GRANITE BLOCK ON THE MER DE GLACE.

CHAPTER IV

DESCRIPTION OF THE MER DE GLACE OF CHAMOUNI

Physical geography of the ice-world—Glacier de Léchaud—Glacier du Géant—Source of the Arveyron—Hameau des Bois—Côte du Piget—Ancient moraine of Lavancher—Le Chapeau—Mauvais Pas—Cattle traversing the glacier—Blue colour of ice—Montanvert—Accommodation—The view—Les Ponts—L'Angle—Passage of the glacier—Les Charmoz—Trélaporte.

Nec vidisse sat est: durum calcavimus aequor.
OVID, *Trist.* III. x. 39.

THE glacier which occupies the vast gorge or system of valleys to the east of Mont Blanc is usually, and, I believe, correctly termed the *Mer de Glace*,—the name of *Glacier des Bois* being confined to its lower extremity, where, escaping from the rocky defile between the promontory of the Montanvert and the base of the Aiguille du Dru, it pours in a cascade of icy fragments, assuming the most fantastic forms, into the valley beneath, between the fir woods of Lavancher on the one hand, and those through which the usually frequented path to the Montanvert passes on the other. If I do not always use the *Glacier des Bois* to signify the lower, and the *Mer de Glace* the middle and upper part of this vast ice-stream, I shall not probably incur any risk of being misunderstood.

It is proposed, in this chapter, to describe such peculiarities of structure, either in the valley in which the glacier lies, or in the ice itself, as may tend to illustrate the physical geography of the district, and especially the theory of existing glaciers, and of their former extension; and if the details into which I shall enter appear somewhat minute, it may be well to recollect that the absence of such local knowledge has been the cause of much of the uncertainty under which we at present labour as to the past history of these wonderful masses. A permanent record of their present limits, condition, and phenomena will be an important document for future times; and the conviction of this led me to incur the very great labour of constructing a detailed map of nearly the whole glacier. A more particular account of the survey will, as a matter apart, and less interesting to the general reader, be found in a separate chapter. The time required for such an undertaking, and for the minute inspection of every portion, was of the highest importance in forcing upon my attention facts which it is almost impossible not to overlook on a superficial glance; and the topographical detail I am now to give may aid the reader, in a similar manner, to transport himself in imagination to the scene of the experiments on glacier motion which I shall afterwards detail.

There is nothing more practically striking, or more captivating to the imagination, than the extreme slowness with which we learn to judge of distances, and to recognise localities on the glacier surface. Long after icy scenes have become perfectly familiar, we find that the eye is still uneducated in these respects, and that phenomena the most remarkable, when pointed out, have utterly escaped attention amidst the magnificence of the surrounding scenery, the invigoration which the bracing air produces, and the astonishing effect of interminable vastness with which icy plains outspread for miles, terminated by a perspective of almost shadowless snowy slopes, impress the mind. I cannot now recall, without some degree of shame, the almost blindfold way in which, until lately, I was in the habit of visiting the glaciers. During three different previous summers I had visited the Mer de Glace, and during two of them, 1832 and 1839, I had traversed many miles of its surface; yet I failed to remark a thousand peculiarities of the most obvious kind, or to speculate upon their cause; or else the clearer apprehension which I now have of these things has wholly driven from my mind the previous faint impression. Of the existence of the moraines, generally, and their cause, as well as of the fact of the descent of the glaciers, I was aware, but I can scarcely recall another of the many singularities which they present, as affecting my imagination then in a lively manner—the wear and polish of the rocks—the vast masses of travelled stone thrown up high and dry far above the present level of the ice, like fragments of wreck, indicating, by their elevation on the beach, the fury of the past storm—the pillars of ice, with their rocky capitals, studded over the plain like fantastic monuments of the Druid age—or the beautiful veined structure of the interior of the ice, apparent in almost every crevasse,—these things, so far as I now recollect, were passed by unobserved.

Even in the summer of 1842, during which the present survey was made, I had abundant proof of how much remained unseen only for want of the faculty of concentrating the attention at once upon all the parts of so wide and glorious a field. We are not aware, in our ordinary researches in physical geography, or the natural sciences in general, how much we fall back upon our *general* knowledge and *habitual* observation in pursuing any special line of inquiry, or what would be our difficulty in entering *as men* upon the study of a world which we had not familiarly known as children. The terms of science are generally but translations into precise language of the vague observations of the uncultivated senses. Now the ice-world is like a new planet, full of conditions, appearances and associations alien to our common experience; and it is not wonderful that it should be only after a long training, after much fatigue, and dazzling of eyes, and weary steps, and many a hard bed, that the Alpine traveller acquires some of that nice perception of cause and effect—the instinct of the children of nature—which guides the Indian on his trail, and teaches him, with unerring philosophy, to read the signs of change in earth or air.

But to return to the Mer de Glace. A glance at the map will show that this great ice-river has near its origin two divided streams, derived from different sources. The westward branch, denominated the Glacier du Géant, or Glacier du Tacul, has its rise in a vast basin immediately to the eastward of Mont Blanc, confined between the proper ridge of the Alps extending to the Col du Géant, on the south, and the chain of Aiguilles of Chamouni [1] on the north, commencing nearest Mont Blanc with

[1] I retain De Saussure's spelling of this familiar name, although I am aware

the Aiguille du Midi, and terminating with that of the Charmoz, round whose eastern foot the Mer de Glace sweeps. The other branch, called the Glacier de Léchaud,[1] has its origin at the foot of the Grandes Jorasses, one of the highest mountains of the chain which separates the Val Ferret from that of Chamouni. This glacier is smaller than its neighbour, although it is swelled before their junction by the tributary ice of the Glacier de Talèfre, which falls in upon its right bank from a detached basin, encircled by inaccessible pinnacles of rock,[2] in whose centre is the spot called the Jardin, now so frequently visited. The length of the whole Mer de Glace is estimated by the guides of Chamouni at eighteen leagues, an enormous exaggeration, if leagues of the usual horizontal measure be reckoned. A league, however, is generally understood to mean an hour's walk amongst the mountains, and in that view the estimate will appear less absurd, although it conveys no correct idea of superficial extent. The distance from the foot of the Glacier des Bois to the top of the Glacier de Léchaud might probably be traversed in six or seven hours, and by the other branch to the Col du Géant, supposing that the state of the glacier permitted the traveller constantly to advance (which is not the case), in about nine. The shortest linear distance from the foot of the glacier to the highest ridge of the Alps is, by my survey, about seven miles, and the breadth of the glacier seldom, if ever, exceeds two-thirds of a mile, but is generally much less. This does not give any idea of its apparent extent. The toil of traversing it, the endless détours, and the recurring monotony of its crevasses, exaggerate inconceivably the distance, even to those most experienced.

We commence our survey at the foot or lower end of the glacier, proceeding upwards.

The view of the lower end of the Mer de Glace, from the road leading from Chamouni to Argentière, is exceedingly striking. The valley of Chamouni is here broad and flat. Three hamlets of small size are planted in sight of one another,—Les

that the most correct orthography is Chamonix. But I have, in general, preferred De Saussure's authority, on the spelling of proper names, to all others, and that of Chamouni has been usual amongst English, as well as many Swiss authors. The second syllable is pronounced rather short.

[1] [This name is now usually spelt "Leschaux," but as the old spelling causes no confusion, it is retained in deference to Forbes's opinion, expressed in the previous note.]

[2] [They have all been climbed since 1842.]

Praz, Les Tines, and the Hameau des Bois. The latter is almost in contact with the glacier; and, indeed, in 1820, it attained a distance of only sixty yards from the house of Jean Marie Tournier, the nearest in the village, when its further progress was providentially stayed. The valley down which the ice pours meets that of Chamouni at a considerable elevation: the western side of the glacier (in contact with the Montanvert) presses right upon the verge of a precipice, down which fragments of ice are precipitated at all seasons, whilst the eastern stream, following a gentle slope of ground, sweeps round the foot of the Aiguille à Bochard, and beneath the station called the Chapeau, when it is again diverted to the west, partly by the accumulation of its own moraine in front, and partly by a projecting rock of a remarkable kind, of which we shall immediately speak. From the village of Les Praz, then, this cascade of ice is seen directly in front, but the source of the Arveyron, at its lower extremity, is hid by the mass of the moraines. The source offers, however, nothing extremely remarkable, and the views which have been given of it are, in general, greatly exaggerated. It is an arched cavity, almost annihilated in winter, and gradually increasing as the season of waste and avalanches advances, until it forms an archway of considerable height and width, from which the turbid stream of the Arveyron flows. The quantity of water varies excessively at different seasons, and even, I have been assured, on different days. It is fullest, I think, in July; and, in winter, though small, I am assured by natives that it is very far indeed from altogether ceasing, retaining, I was informed, at least half as much water as when I saw it in September, when I estimated the discharge very rudely (it does not admit of exactness) at three hundred cubic feet per second. The source of this water in winter, when the glacier is frozen, may be partly from the heat of the ground in contact with the ice, as supposed by De Saussure; but it must also be recollected, that the ice valley of the Montanvert may be supposed to have a due proportion of springs taking their origin in the interior of the earth at a depth to which even the cold glacier-contact does not communicate a sensible influence, and the source of the Arveyron is the natural drainage of the springs of that valley.

The final slope of the Glacier des Bois has a vertical height of at least 1800 feet (the height of the summit called Le Chapeau, above the valley at Les Tines), down which, as has been said, the ice descends half shattered, half continuous, twisted into wild shapes, and traversed by countless fissures, whilst on the right the precipice above the source of the Arveyron raises its bare forehead without even a stunted tree or a blade of grass, for its surface is continually furrowed by avalanches, and its hollows washed clean by foaming cascades, which both originate in the diadem of jagged pinnacles of ice by which it is surmounted. To the right and left the prospect is enclosed by the warm green fir woods which touch either moraine of the glacier, and behind and aloft the view is terminated by the stupendous granitic obelisk of the Dru, which has scarcely its equal in the Alps for apparent insulation and steepness — a monolith, by whose side those of Egypt might stand literally lost through insignificance.

When we approach the foot of the glacier at the Hameau des Bois, we are at no loss to perceive that the ice has retreated. The blocks of the moraine of 1820, in which year the glacier made its greatest incursion (in modern times) into the valley, lie scattered almost at the doors of the houses, and have raised a formidable bulwark at less than a pistol-shot of distance, where cultivation and all verdure suddenly cease, and a wilderness of stones of all shapes and sizes commences, reaching as far as the present ice. The limit of the moraine of 1820 is marked in the map, whence it appears that the form of the extremity of the glacier was not very different from the present one, only that it swelled out more, and that it had very nearly divided itself into two streams, separated by the promontory marked Côte du Piget. This promontory commands an excellent view of the extremity of the glacier. Upon its southern face the glacier has spent its strength, heaping ridge upon ridge of its moraines against it. The northern slope is perfectly protected, and trees grow to the foot of it. One cannot help being reminded of the position of the Hermitage of St. Salvador, on Mount Vesuvius, round which the lava streams pass innocuous.

But this hillock has an especial interest. Its resistance to the pressure of the ice led me to suspect that it is composed of firm materials, and is not merely a heap of rubbish. And so it proved: but whilst the cliffs above the source of the Arveyron are of gneiss, whose beds dip inwards towards the axis of the chain at an angle somewhere about 30°, this hillock is of stratified limestone dipping similarly *under* the gneiss, and at about the same angle. We find it continued, in exactly the same circumstances, a little to the eastward, at the foot of the Aiguille à Bochard, on the path leading from the village of Lavancher to the Chapeau. There is there a lime-kiln, and it is burned for use. The Côte du Piget is mentioned by De Saussure,[1] and he refers to its calcareous nature, in his chapter on the secondary rocks of the valley of Chamouni. But he does not notice the section below the Chapeau.

The moraine of 1820 rises some way upon the slopes which border the east side of the terminal part of the glacier. But when we come to examine these slopes themselves, we find in them indubitable evidence of their being real moraines of a former age, left by the glacier when it had a greater extension than at present. This is a fact of which it seems scarcely possible to doubt. We find it admitted by De Saussure,[2] and most, if not all, of his followers. There are circumstances connected with this moraine which render it worthy of most particular attention, for it is a common ground on which the advocates of the former vast extension of the glaciers, and the opponents of that doctrine, are ready to meet, both admitting that this mass of débris, extending quite up the present glacier, has unequivocal marks of having been a former moraine.

Its form is not a little peculiar. It is the convex escarpment seen in the map to traverse the valley of Chamouni above the village of Les Tines, presenting its convexity towards Chamouni. Its length, reckoning from the existing glacier, was estimated by De Saussure at 1300 or 1400 feet; but by the map it would appear to be 6000 feet, or above a mile, reckoning from the rock of the Aiguille à Bochard to the opposite side of the Arve from Lavancher. It has already been said that the valley opposite to the Glacier des Bois is flat and level; the road from Les Praz to Les Tines, a distance of above half a mile, is almost perfectly so. There we reach the foot of the convex escarpment of blocks, which are covered with soil and trees on the side next Chamouni; but its composition is abundantly testified by the appearance of its summit, and especially by the section in the ravine through

[1] *Voyages*, § 709.

[2] *Ib.* § 623.

which the river Arve, descending from the Col de Balme, and swelled by the glacier streams of Le Tour and Argentière, forces its way. The cut is a deep one, and we find the mound to be almost entirely composed of detached fragments of transported granite, similar to that of the chain of Mont Blanc, rough and angular, or only rounded at the edges by partial friction, and accumulated in the utmost disorder, mingled with sand, without any appearance of stratification. The embankment has been *cut through* by the river, so that a portion remains attached to the northern side of the valley (the slopes below the Flégère and the Aiguilles Rouges), upon which vast insulated granitic fragments may be found lying at a considerable height. There can be no reasonable doubt that this mound was once continuous, and obstructed the course of the river. Of this we have a further evidence in the deposit of the alluvial flats which succeed it in ascending the valley towards Argentière, evidently formed by the waters of a lake; and just at the margin of these, close to the eastern side of the mound, the village of Lavancher now stands.

The entire mound, I have already said, is composed of materials similar to those of the moraines of glaciers generally, and of the Glacier des Bois in particular. The arrangement of these materials is also the same. The escarpment to the west does not appear to be the result of erosion subsequent to the deposit, but to be the original form into which the materials have been wrought. The summit is a long narrow ridge, sloping rather steeply both ways, and garnished with huge blocks on its very top. The largest of these is marked on the map under the name of *la Pierre de Lisboli*, and in some places these ridges are multiplied and parallel, exactly as in a modern moraine. It will be observed that the ground plan of this mound is very singular, being convex towards the glacier, instead of concave as is usually the case. This is an important fact, and requires a special explanation, on the hypothesis (generally admitted) of its being due to the former extension of the Mer de Glace. The ice must have descended in such a mass as to have blocked up completely the whole valley, and abutted against the opposite slopes of the Flégère. So great was its mass, and so nearly level the valley of Chamouni into which it descended, that when resisted in front it spread laterally in both directions, and pushed its moraine up the valley as well as down. The presence of the glacier, obstructing the course of the Arve, produced a lake, as in other well-known cases—such as the lake of Combal in the Allée Blanche, formed by the Glacier de Miage, and that of Mattmark in the valley of Saas, formed by the Glacier of Allalin. The almost entire disappearance of the moraine on the *western* or lower side of the glacier is no argument against its existence;[1] on the contrary, we have direct evidence in favour of it, derived from vast blocks of granite which are met with as far down the valley as the village of Chamouni, and which were formerly very numerous indeed, but are every day disappearing with the progress of cultivation. In external and mineralogical characters they are identical with those already noticed. A further confirmation will be found in the enormous transported blocks which lie some hundred feet above the level of the glacier on its western side near the Montanvert, and which are not, I think, alluded to by any writer. Possibly the glacier once filled the valley of Chamouni to a great extent, and thus formed its own barrier, and perhaps we are to look for the proper terminal moraine much farther down. This is indeed the more probable hypothesis, both owing to the appearance of the rocks below Les Ouches,[2] which we shall hereafter notice, and because it would be difficult to account for the removal of a vast lateral barrier on the west side sufficient to produce such an accumulation on the east. De Saussure's remark on the smallness of the terminal moraines is one of the most acute in his work. He says, "Les blocs de pierres dont est chargé le bas de ce glacier invitent à une réflexion assez importante. Lorsqu'on considère leur nombre et que l'on pense qu'ils se déposent et s'accumulent à cette extrémité du glacier à mesure que ses glaces se fondent, on est étonné qu'il n'y en ait pas des amas beaucoup plus considérables. Et cette observation, d'accord en cela avec beaucoup d'autres que je

[1] In 1843 I was fortunate enough to discover this moraine. It forms a vast terrace of débris of rocks exclusively belonging to the central chain, over which the path from Chamouni to the Montanvert passes for a considerable distance, in fact nearly all the way from the hamlet of Les Mouilles to that of Planaz (see the General Map and *Occasional Papers*, p. 42). The cultivated fields at Planaz point out plainly the terrace-like form of the moraine, and the rapid bend in the lower part of the course of the torrents of Grépon and Fouilly, as seen in the map, is owing to the opposition offered by the mass of débris to their direct descent towards the valley (1845).

[2] [Properly Les Houches, but the older form is retained for the reasons given above on p. 58 note.]

développerai successivement, donne lieu de croire, comme le fait M. de Luc, que l'état actuel de notre globe n'est point aussi ancien que quelques philosophes l'ont imaginé" (*Voyages*, § 625). The reason which we would assign for this remarkable fact is that the extremity of the glacier having a movable position, the blocks have been gradually deposited as the glacier retreated from the lower end of the valley of Chamouni to its present position.

If we continue our survey of the glacier, ascending the ancient moraine of Lavancher, we reach the rock a little higher than the Pierre de Lisboli, and the rock here is limestone, as already mentioned. It is just in contact with the gneiss, whose beds lie sloping southwards exactly at the same angle with the limestone, namely, about 30°. This limestone is, no doubt, of the same formation with that which has been noticed in other parts of the valley of Chamouni, and especially by De Saussure, as underlying the gneiss of the Aiguilles opposite Chamouni, towards the hamlet of Blaitière. Its position is very remarkable, thus interposed between two granitic masses, for the Aiguilles Rouges are also of gneiss or granite; and the almost exact symmetry, in point of arrangement and stratification, which we shall find to exist on the southern side of the chain at Courmayeur, gives to it a peculiar interest.

When we begin to command the view of the glacier in approaching the Chapeau, we are struck by the size of the blocks which seem poised on the projections of the cliff, at a great height above the ice, and which are rounded and scored in such a way as to show that the detached masses were deposited here in the usual progress of the glacier when it attained this height. The view here of the Aiguille du Dru, and of the pinnacles of ice of the Mer de Glace itself, is very striking. A portion of the moraine of 1820 is next crossed, and at length, after passing a torrent, we find ourselves at the foot of the hillock called the Chapeau, on the precipitous side of which is a cavern affording some shelter, and an excellent view not only of the glacier, but of the valley of Chamouni which it commands, and the effect is extremely beautiful, especially in the evening. This spot, although extremely easy of access, is rarely visited by tourists,[1] unless at seasons when the Montanvert is too much

[1] [Nowadays this spot—5279 feet—is the object of one of the regular excursions

enveloped in snow to be conveniently reached; but the two views have very little resemblance, since the portion of the glacier seen from the Chapeau is the lower part, or Glacier des Bois, whilst the upper part, or Mer de Glace, is commanded from the Montanvert, and the other is nearly concealed.

Beyond the Chapeau, the precipices of the Aiguille à Bochard actually meet the glacier, where it tumbles headlong from the rocks, and both seem to forbid farther passage. Nevertheless it is practicable, keeping the face of the rock, to continue the ascent along the east bank of the glacier; and indeed there is scarcely any part of this bank of the Mer de Glace as high as the foot of the Aiguille du Moine, which I have not traversed. The rocky precipice alluded to would be very difficult to pass were it not marked by rude steps [1] cut here and there in the soft steatitic rocks, which mingle with the gneiss, and which, being continually wetted by trickling rills, are very slippery. The goatherds are in the habit of continually passing, and there is nothing to daunt any tolerable mountaineer, although the spot has acquired the name of the *Mauvais Pas*, which it bears more frequently than its proper one of the Roche de Muret. This rock (which is exactly opposite to the extreme promontory of the hill of Montanvert on the west side) forms one of the barriers of the *Mer de Glace* above, past which it pours down the precipice in the manner already mentioned. Consequently, when the height of the Roche de Muret has been gained, we have a new reach of the glacier in view, and the ice begins to assume a connected and consistent appearance, although still so excessively full of crevasses as to be generally impassable but for a very short distance. But the ice is here the real icy mass of the Mer de Glace, whilst below it has been tossed and twisted so as to be entirely remoulded, and to bear none of its original impress. At the point at which we have now arrived, the glacier may be compared to the inclined, dark, unruffled swell of swift water; rushing to precipitate itself in a mass of foam over a precipice, it has all the forms of

of tourists, who from the Montanvert cross the Mer de Glace, and then go by the Mauvais Pas, Chapeau, and Lavancher to Chamouni. There is an inn on the Chapeau, reached by a mule-path from Lavancher that comes to an end a short distance only below the Chapeau.]

[1] [These form the "Mauvais Pas," which has been much improved since Forbes's time, and is further guarded by a railing.]

a compact moving mass of ice, although rent asunder across its breadth by the rapid depression of the bed along which it is urged.

The promontory of the Roche de Muret gained and passed, the slight bay behind has, as usual, been partly filled up by accumulated moraines, upon which we now walk instead of on the solid rock. Somewhat farther on a noisy, foaming torrent, called the Nant Blanc, descends from a seemingly small glacier, called the *Glacier du Nant Blanc*, lodged in a ravine interposed between the Aiguilles of Bochard and Dru; this torrent is well seen from the Montanvert—it is most copious in July, and its appearance is a good index to the state of temperature in the higher regions, instantly diminishing with the first cold nights of autumn. A second torrent descends farther on from the glacier at the foot of the Aiguille du Dru, and beyond this are some fine pasturages, which extend along the foot of the jagged and rocky chain which extends from the Dru to the point of Les Echelets marked in the map. Here, on the higher part of these grassy slopes, near the promontory of Les Echelets, are the highest stunted pines and larches which occur on either side of the Mer de Glace. From amongst them, now and then, some grand peeps may be obtained of the Aiguille du Dru, which shoots almost vertically above the eye like some tall steeple—pointing to the deep blue sky.

These pastures are worthy of notice from one circumstance, namely, that they are grazed by *cows* for a good many weeks in summer. How a cow can find footing among such rocks, or ascend and descend pathways which might be pronounced disagreeably precipitous by even a not fastidious traveller, and whose zigzags are often not half the length of the animal's body, may appear sufficiently surprising; but it is nothing compared to the seeming impossibility of ever bringing them there at all or removing them. To traverse the Mer de Glace opposite the Montanvert is at all times a feat of some difficulty for an unloaded man; it is commonly said that there exists but a single practicable pathway amongst the crevasses. That this is not correct, and that it varies much at different seasons, I know from experience—but at all times it requires an expert iceman (a correlative word to seaman or rocksman may perhaps be admitted) to effect this passage with certainty and alone. I remember to have found some stray goats, which had wandered from the shore, quite lost amidst the wilderness of crevasses, and bleating for help.[1] The only other access to this pasturage is by the Roche de Muret, and there, most certainly, no animal heavier than a goat or a man could make its way unaided. The most usual way of transporting the cows is by the glacier at the foot of the Mauvais Pas, where I have already said the ice is in the very act of tumbling headlong down. There, by the aid of hatchets and planks, a sort of rude pathway is constructed the day before the ascent or descent of the cattle is to be performed, and then about thirty peasants assemble to pass as many cows, and by the aid of ropes succeed, usually without any loss, in compelling the poor animals to traverse the rude gangways which they have prepared. The cows were taken to the valley in the end of September last (1842), and I regretted extremely that I missed the opportunity of witnessing so singular a cavalcade.

I have traversed the Mauvais Pas frequently. On one of these occasions, I proposed to Auguste Balmat to attempt to cross the glacier diagonally from just above the promontory of the Roche de Muret to the Montanvert. The thing had never been done, he said, but there was no reason why it should be impossible, and at the worst we could but come back. We got upon the ice; and after a long and circuitous progress succeeded in reaching the other side as we proposed; and I often crossed the glacier afterwards in nearly every direction (excepting just above the final *chute*) where the guides declared that no one ever had passed, or could pass without ropes or a hatchet. The former we never used and the latter rarely. Auguste, though he had lived three years at the Montanvert, had never been compelled to traverse the ice but in a few directions, and it was as new to him as to me; but his intelligence and zeal were superior to the lazy dogmas of impossibility, which are frequently heard even amongst the guides of Chamouni.

Speaking generally, the fissures of the glacier in this part (between the Montanvert and the Dru) are mostly transversal,

[1] Cattle are sometimes taken across the glacier at this place, and one of the hotel-keepers at Chamouni recounted to me a curious history of the risk which he and a companion had run in transporting a mule. They were assisting him with ropes, and the animal slipping, pulled them both into a crevasse: they escaped with difficulty, abandoning the mule to his fate.

though so interlaced, and forming so many compound fractures, that the solid part continually thins out into an edge, which at length becomes evanescent between two crevasses. It is evident that in this way a glacier maintaining its continuity beneath may become absolutely impassable, except by descending one vertical face and ascending another, which, owing to the depth and width of the crevasses here, would always be a perilous attempt. The crevasses of the western and middle part of the Mer de Glace below the Montanvert are very continuous and straight, and some of them extend for at least half the entire breadth of the glacier. They are often 15 or 20 feet wide, with walls perfectly vertical, and to move at all parallel to the length of the glacier in this place requires immense détours.

It is the east side which is so excessively crevassed, and that during the whole length of the *united* stream of the Mer de Glace. Whenever we touch the medial moraine (the mark of the junction) there the multiplied and complicated crevasses begin. The reason I believe to be this: the glacier which forms the greater or western portion, which is derived from the Glacier du Géant, moves fastest, and has by far the greater mass. The other, from the Glacier de Léchaud, uniting with it, is compelled to follow, or rather accompany it. It is, therefore, drawn out, and at the same time squeezed into very much narrower limits, as the united stream is forced through a space not greater than the larger alone had before occupied,—just as when two rivers unite, the smaller and weaker is thrown into turbulent eddies by the union with the swifter and more powerful.

Turning now to the western side of the Mer de Glace in its inferior part, but a few remarks occur. The usual path from Chamouni to the Montanvert, and the steep ascent of La Filiaz,[1] from the source of the Arveyron, require no particular mention, but the examination of the promontory north of the chalet of Montanvert is not without interest. It is possible there to get a little way upon the glacier, amongst the immense fissures which precede its abrupt descent; and from this icy platform a fine view of the valley is obtained. The ice here is remarkably pure,

[1] I do not know the origin of the name. Thinking that it might refer to some legendary story of a young woman lost at the source of the Arveyron, I once asked a native of Chamouni its meaning, to which he replied, simply enough,—"Je ne sais pas si ce n'est parcequ'on y *file* tout droit," which all who have *descended* it will readily admit to be the case.

and the fine blue caverns and crevasses may be as well studied as in almost any glacier in Switzerland. Of the cause of this colour I may observe once for all, that I consider it to be the colour of pure water, whether liquid or solid; though there are no doubt conditions of aggregation which give it more or less intensity, or change its hue. But this has a parallel in very many cases not considered as paradoxical. Most bodies when powdered have a different hue than when crystallised and compact, the topaz and the iodide of starch change their colour with temperature, and many bodies change their tint with their consistency, or lose it altogether when mixed with grosser matter. During an expedition which I made upon the ice in the month of September, during a snow-storm, I observed that the snow lying eighteen inches deep exhibited a *fine blue* at a small depth (about six inches) wherever pierced by my stick. Nor could this possibly be due to any atmospheric reflection, for the sky was of an uniform leaden hue, and snow was falling at the time.[1]

The west bank of the Mer de Glace is here extremely steep, though not absolutely precipitous. It is clothed with grass and rhododendron, and in many places with spruce firs of considerable size. Amongst these lie fragments of transported granite, wherever a ledge exists sufficient to maintain them, and they are accumulated especially at the promontory at the foot of which the glacier still sweeps, though at a great depth below. On the steep side of the hill facing the valley of Chamouni, and therefore sheltered from the glacier, these masses are comparatively rare. They extend quite up to the dwelling of the Montanvert, a height of 240 feet above the glacier, and even somewhat higher; but the limit is perfectly well marked; for although the rocky ridge which descends from the Aiguille des Charmoz to the Montanvert (and which is here called simply Les Charmoz) is covered with vast débris,—these débris are all *in situ*, and in contact with the native rock, a slaty talcose gneiss. These blocks constitute, therefore, an undoubted moraine, corresponding to that of Lavancher and Les Tines on the east side, and indicating the maximum level of the glacier in very remote times.

[1] On the colour of pure water see Newton, *Optics*, Book I. Part ii. Prop. 10; Humboldt, *Voyages*, 8vo, vol. ii. p. 133; Davy, *Salmonia*, 3rd edit. p. 317; Arago, *Comptes Rendus*, July 23, 1838; Count Maistre, *Edin. New Phil. Journal*, vol. xv.

I may add, too, for the sake of connection, that the fixed rocks in the immediate neighbourhood of the house of the Montanvert, exhibit clear traces of being rounded and furrowed, though too much weathered to exhibit anything like polish. Such rocks occur on the descending path to the glacier.

The earliest habitation on the Montanvert is thus described by De Saussure:—"Mais où couche-t-on sur le Montanvert? On y couche dans un château; car c'est ainsi que les Chamouniards, nation gaie et railleuse, nomment par dérision la chétive retraite du berger qui garde les troupeaux de cette montagne. Un grand bloc de granit, porté là anciennement par le glacier, ou par quelque révolution plus ancienne, est assis sur une de ses faces, tandis qu'une autre face se relève en faisant un angle aigu avec le terrain, et laisse ainsi un espace vuide au-dessous d'elle. Le berger industrieux a pris la face saillante de ce granit pour le toit et le plafond de son château, la terre pour son parquet; il s'est préservé des vents coulis, en entourant cet abri d'un mur de pierres sèches, et il a laissé dans la partie la plus élevée un vuide où il a placé une porte haute de quarante pouces et large de seize. Quant aux fenêtres, il n'en a pas eu besoin, non plus que de cheminée; le jour entre et la fumée sort par les vuides que laissent entr'elles les pierres de la muraille. Voilà donc l'intérieur de sa demeure: cet espace angulaire, renfermé entre le bloc de granit, la terre et la muraille, forme la cuisine, la chambre à coucher, le cellier, la laiterie, en un mot, tout le domicile du berger de Montanvert." (*Voyages*, § 627.)

This was in 1778. But it appears that things were soon improved; for, in one of Link's excellent coloured views (published at Geneva, and very superior to all the more recent ones), entitled "Vue de la Mer de Glace et de l'Hôpital de Blair, du Sommet du Montanvert, dans le mois d'Aoust 1781," a regularly built cabin, with a wooden roof, is represented, with this inscription above the door:—

"BLAIR'S HOSPITAL.
UTILE DULCI"—

from whence I conclude that this hut was built by an Englishman named Blair, between the years 1778 and 1781.[1]

[1] [Mr. Blair, an Englishman resident at Geneva, gave four guineas for the construction of a cabin, which was built in 1779 and used that year by Goethe. It subsisted till 1812.]

At a later period a small, solid stone house of a single apartment[1] was built at the expense of M. Desportes, the French Resident at Geneva,[2] having a black marble slab above the door, with the inscription, *A la Nature*. On my first visit to Chamouni this was the only building, but soon after[3] a much more substantial and effectual shelter was erected at the expense of the *Commune* of Chamouni, and is let to the present tenent, David Couttet (together with the grazing round), for the considerable sum of 1400 francs. The principal floor consists of an ample public room, a small kitchen, a guides' room, and three bedrooms for strangers, besides accommodation below for the servants of the establishment, of whom two or three remain here for four months of the year. This establishment, though simple and unobtrusive, is sufficiently comfortable and cleanly; and I should be very ungrateful not to acknowledge the kindness and attention which I uniformly experienced during many weeks' residence in this house; cold and desolate it certainly was occasionally—in September the thermometer fell to 39° F. in my bedroom, and there was little choice of provisions beyond the excellent mutton of the Montanvert; yet, on the whole, I preferred the tranquillity of the arrangements to the bustle of the hotels of Chamouni, whither I seldom resorted but under stress of weather.

We are almost tempted to forget that a view so universally seen, and so often described as that from the windows of the Montanvert loses none of its real majesty in consequence of the ease and familiarity with which it is visited by thousands of travellers. For myself, repeated visits and a long residence have only heightened my admiration of this, certainly one of the grandest of Alpine views. The Aiguille du Dru has in its way scarcely a rival, and there are very few glaciers indeed with a

[1] [This house was built in 1795, mainly through the exertions of Bourrit, to whom Desportes gave 2000 francs for that purpose. It still exists.]

[2] Ebel gives the following account of it: "M. *Bourrit* de Genève, l'aubergiste *Terraz* [Tairraz], et les guides *Jacques* [Balmat] *des Dames* et *Cachat le Géant* ont exécuté le plan de M. *Desportes*. Le bâtiment offroit une grande salle pourvue d'une cheminée, de deux fenêtres, de quatre lits de sangle, avec des chaises, des tables, des glaces, etc. Les frais de l'établissement montèrent à 95 louis."—*Manuel du Voyageur* (1810), tome ii. p. 364.

[3] [In 1840. This first inn was replaced in 1879 by the present three-storied building, which can accommodate from forty to fifty persons. Needless to add that the rent is now far higher than in Forbes's time. The height of the hotel is 6267 feet.]

course so undulating and picturesque as the Mer de Glace, and with banks so wildly grand, of which the general effect can be so well seized from any one point.[1] Besides former visits, I have this year (1842) seen it under every circumstance which could enhance its sublimity,—under the piercing glow of the almost insupportable midsummer's sun, and again in the snowy shroud of premature winter—in the repose of the stillest and serenest moonlight, and lit up at midnight by the brilliancy of almost tropical lightning.

The glacier immediately below the Montanvert is easily accessible, whilst it presents at the same time all the grander and more remarkable features of glacier ice. The moraine is abundant, and the crevasses moderately large. A few hundred feet farther down, there was this year (1842) a mass of travelling rock of enormous dimensions upon the ice. A sketch of it is given at the head of this chapter. Its position, which is accurately fixed on the map (where this block is marked D 7), will define the motion of the glacier in future years. There is a footpath here along the moraine, which is a steep stony ridge, about thirty feet high on the landward side, and much more towards the glacier at its present level. The masses of which it, and, indeed, all the older moraines of this neighbourhood are composed are not larger than those which are at present to be seen on the surface of the glacier.

Proceeding upwards in our survey of the Mer de Glace, we find a footpath which conducts us from the house of the Montanvert, first nearly down to its level, and then nearly parallel to its length. By and by we come to pretty smooth faces of rock, which go down sheer under the ice, evidently ground away by its friction, or rather that of the mass of abraded rocks mixed with sharp stones and sand, which it drags along with it. To cross this rocky face, some rude steps are cut in the slaty gneiss, and the two passes of this description are called the *premier et second Ponts*. De Saussure mentions (§ 628) having employed[2] two men to blast the rocks to facilitate this passage, and the marks may still easily be seen. Opposite to this promontory the glacier is greatly heaved and contorted, owing probably to the

[1] It may be seen to most advantage from a station some hundred feet higher on the Charmoz.

[2] [In 1778. Of course the path has since been greatly improved.]

inequalities of its bed. It is not easy to estimate the magnitude of these icy hillocks or waves, as they have been termed. This arises chiefly from the enormous magnitude and great angular elevation of the peaks and wild rocks beyond. I had a proof of this one day on the rather rare occasion of a fog settling down to near the level of the glacier, which enveloped entirely the scenery of the farther bank. Then the ice inequalities seemed to rise to mountains, and it was difficult to persuade oneself that the glacier, like the ocean, did not now and then raise its billows in a storm, to twice or thrice the height which continual observation had made so familiar. It might be easily, and indeed is generally, supposed, that the glacier is here impassable; but on the 18th September last (1842) I crossed it with Balmat, and found it less difficult than the oblique traverse we subsequently made to return to the Montanvert.

Having passed the second "Pont," the path descends to the moraine, which partly fills a sinuosity in the outline of the hill; and, having followed this for some hundred yards, we are met by a perpendicular cliff, the foot of which is abraded by the ice. This is the point marked *L'Angle* on the map, nearly opposite to the promontory of Les Echelets, formerly mentioned. Here there is no alternative but to descend upon the ice, and its contact with the rock offers some peculiarities worth observation. When the ice of the glacier, in the course of its progress downwards, has been forced against an opposing promontory of rock, and has passed it, it will easily be understood, that a cavity will be left behind the promontory, which the ice does not immediately fill up. Here it is easy (occasionally at least) to descend into such a cavity, with a wall of ice on the left hand, and of rock on the right. Between the two are wedged masses of granite, which have slipt from the moraine between the ice and rock, and which, pressed by the incumbent weight of the glacier, and carried along in its progress, evidently must, and really do, wear furrows in the retaining wall, which is all freshly streaked, near the level of the ice, with distinct parallel lines, resulting from this abrasion. The juxtaposition of the power, the tool, and the matter operated on, is such as to leave not a moment's doubt that such striæ must result, even if their presence could not be directly proved.

The *Angle* is the point noticed by De Saussure as the junction of the true granite with the rocks of gneiss. It is a full half-hour's walk from the Montanvert.

To advance higher up the glacier, two courses may be taken; either to resume the moraine as soon as the promontory has been passed, and thus advance as far as possible along the foot of the Aiguille des Charmoz, or to follow the glacier near its western border, by an intricate passage amongst the numerous crevasses by which it is traversed. The former is very fatiguing, and not without danger from the frequent fall of stones from the small glacier at the foot of the Charmoz. On one occasion I saw an immense discharge of stones and mud take place, arising from some sudden change in the glacier, with loud noise, which continued for several minutes. The passage of the Mer de Glace almost requires an experienced guide.[1] I know of no better instance of the confusing monotony of the glacier surface, and the kind of skill required to retrace one's steps on the ice, than the passage of the Angle. The crevasses are so multiplied, yet so similar, that each seems to rise endlessly "another yet the same." We continually fancy that we recognise a particular feature, which is perhaps a hundred times repeated, with the slightest possible variation of form. Once strayed from the right path, it is difficult to find it again, because a false turn may separate us from the region we are endeavouring to reach by impassable crevasses. Consequently, the guides, who very frequently pass during the season in conducting travellers to and from the *Jardin*, resort to piling stones here and there upon the ice, or upon blocks, as landmarks, such as are used occasionally on moors or hills subject to fogs. Even one who has great facility in retracing a path once pursued on solid ground, or in discovering a track for the first time, finds himself here quite at fault; and I have frequently known experienced guides of Chamouni go astray, and lead travellers into difficult and embarrassing situations, or place landmarks in altogether wrong positions, so as to mislead future passers-by. I suppose that I passed the Angle at least forty or fifty times last summer (1842), and although I at last became pretty well acquainted with its intricacies, yet it was impossible to extricate oneself mechanically, or without vigilant attention. M. Bourrit has given a just and not exaggerated description of similar difficulties. "Rien ne peut donner une idée du nombre

[1] [One must not forget that Forbes wrote this in 1842.]

prodigieux des crevasses de cette vallée, que la difficulté d'en sortir. Il n'est jamais arrivé de retrouver au sortir le même banc de glace par où l'on est entré ; souvent, au contraire, l'on erre pendant trois quarts d'heure, et les guides étonnés recourent aux enchantemens pour expliquer cet effet de la multiplicité d'objets semblables et qu'une longue fréquentation n'apprend point à distinguer."[1] It deserves, however, to be mentioned, as a point not only curious in itself, but highly important in considering the constitution of glaciers, that they present year after year a surface so very similar, that an experienced guide will make his way over the ice in the same direction, and seem to avoid the same crevasses, whilst he is, in fact, walking upon ice wholly changed—that is, which has replaced in position the ice of the previous year, which has been pushed onwards by the progressive movement of the glacier.

This is a fact which, though generally enough admitted, has not yet excited sufficient attention. The surface of the glacier has, for the most part, the same appearance as to the variations of level, the occurrence of moraines, the systems of complex crevasses, and the formation of superficial watercourses, in any one season as in another. These phenomena, then, are determined by the form of the bottom and sides of the rocky trough in which the glacier lies, and by its slope at the spot. Just as in a river, where the same molecules of water form in succession the deep still pool, the foaming cascade, and the swift eddy, all of which maintain their position with reference to the fixed objects past which the water itself is ever hurrying onwards. The passage of the Angle is more difficult in some seasons than others, but it probably varies much more in its character between spring and autumn of any one year than between one year and another. This I have, on the unanimous testimony of the guides, and my observations of three different years confirm it.

The Angle past, the most conspicuous object is the imposing Aiguille des Charmoz, which rises on the right. The rocky pinnacles of which it is composed exceed in sharpness those which I have seen in any other part of the Alps. There is one which is conspicuous from the Montanvert, and which has an unnatural and exaggerated appearance in most of the engravings,

[1] *Description des Glacières*, vol. iii. pp. 106, 107.

which is really as attenuated as it is possible to represent it. The mass is of granite, in which sapphires are found, though rarely, in the *Couloir* immediately beyond the Angle; I have found a singular porphyritic rock amongst the fragments, containing felspar and epidote, which it is difficult to refer to any class of primitive rocks.

From the foot of the high summits of the Aiguille des Charmoz, a small glacier, which has been already alluded to, takes its origin. It is one of those short limited glaciers termed by De Saussure *glaciers of the second order*.[1] They may be studied to advantage in these valleys, though the ice of which they are composed rarely descends so as to touch the principal glacier, which occupies the bottom of the valley. Their extent would hardly be conceived from the foreshortened view which we have in looking up at them. The map shows that they cover a large surface. They do not essentially differ in structure from other glaciers, but are shorter, owing in all probability to the little surface which they present for receiving snow, and thus increasing their dimensions, as well as to the great angle of inclination of the beds on which they commonly rest. This is indeed such as to render their adhesion to the ground an astonishing circumstance. M. de Charpentier has very justly quoted several examples as proving, that if these glaciers merely slid over the soil, as De Saussure supposed, these could not for a moment sustain their position at an angle of 30° or more. In the higher part of the Mer de Glace, or rather, on the great chain between the Grandes Jorasses and Mont Mallet, there are some of the icy masses which seem to hold on to the face of the rocks by mere adhesion, presenting precipices certainly of several hundred feet in height. I have watched these masses day after day, when the sun shone so as to throw the deep shadow of the ice-cliff northwards, giving it a magnificent relief, when the stability of these glaciers appeared little short of miraculous. It would be of importance to ascertain the rate of motion of such glaciers. I had intended doing so, but the bad weather of the month of September, 1842, put an end to this as to several other plans.[2]

It is evident that the little glacier at the foot of the Charmoz

[1] *Voyages*, §§ 521, 529.

[2] This I have since done elsewhere, see *Occasional Papers*, pp. 61-77 (1845).

has been more extensive and thicker, within no very long time. The former level of the ice remains perfectly well marked on the rock behind, showing its subsequent diminution; and occasionally these glaciers altogether disappear, and probably reappear again after a series of cold seasons. I noticed [see p. 247 below] on the Glacier d'Argentière, at the foot of the Aiguille of the same name, the vacant bed of a glacier which had melted away. De Saussure asserts the appearance of new glaciers (§ 540), though he does not give any instance of them within his own knowledge; but there is no reason to doubt the fact. From the glacier of Charmoz[1] the Passage de l'Etala,[2] said to be difficult, communicates with the Glacier of Nantillons, passing between the Aiguille des Charmoz and the rocky summit called Petits Charmoz.[3]

A rocky ridge, descending eastwards from the Charmoz, composes the massive promontory of *Trélaporte*, round the foot of which the Mer de Glace struggles more violently in its passage than at any other part. The result is a series of fissures, which immediately at the turn of the rock are quite impassable, and which extend radially outwards, like the joints of a fan, in the same way as M. Agassiz has figured in the great glacier of Gorner, at the north foot of Monte Rosa. To pursue the course up the glacier, these crevasses must be crossed nearly at right angles, until the centre of the glacier has been gained, or the great moraine descending from the promontory of the Tacul, which divides the glacier into two portions. We may, however, ascend the promontory of Trélaporte itself, which commands a very interesting view.

[1] [Called Thendia glacier on M. Kurz's map.]

[2] [Now known as the Col de la Bûche.]

[3] [The former summit is now called the Aiguille des Petits Charmoz, and the latter the Aiguille de l'M.]

CHAPTER V

DESCRIPTION OF THE MER DE GLACE—CONTINUED

Trélaporte—A traveller crag-fast amongst precipices—The moraines of the Mer de Glace—"Moulins"—Discovery of De Saussure's ladder—Tacul—Lake—Bivouac under a rock—Thunder-storm—The chamois hunter—Superb glacier table—Glaciers of Léchaud and Talèfre—Jardin—Pierre à Béranger.

No part of the valley of the Mer de Glace shows better than the Trélaporte the abrading action of the ice upon the rocks, or the height to which the glacier has evidently once risen. The forms are everywhere smoothed and rounded. Vast sheets of bare granite, nearly vertical, and without a fissure, occur up to a great height, and a few hundred feet above the glacier level is a sort of shelf, covered with large detached masses of granite, which have formed an ancient moraine. On the top of one of these my surveying station G was actually planted. There is something singularly desolate about the appearance of these rocks, broken here and there by a tuft of grass, which adheres in the midst of an inaccessible precipice; and as a few sheep pasture here every year, without any resident shepherd, these poor animals, straying in search of food, perish in considerable numbers from famine, or by falling down the cliffs. A singular incident occurred here in the past autumn, which shows the danger of venturing into such places without a guide, or at least an attendant.

On September 17, 1842, I walked up to this lonely promontory, which, as it leads nowhere, is unfrequented, except by the occasional visit of the shepherd, to carry salt to his sheep.[1] Having stopped to sketch the bold outlines of the *Dru*

[1] Accordingly, here and elsewhere, a traveller may be incommoded by the importunate earnestness with which the sheep surround and follow him, supposing that he has brought salt with him. They are as tame as domestic animals.

and *Moine*, which form the opposite boundary of the glacier, I sent Auguste to seek some water, which, owing to the form of the rocks I have mentioned, it is difficult to find. I was not surprised that he did not immediately return, but when, having waited half an hour, and finished my sketch, I saw nothing of him, I began to fear that he had got entangled amidst these wild rocks, and proceeded in search of him. After some time I saw him coming up with two lads of Chamouni, whom he had seen start from the Montanvert in the morning for the Jardin, and leading between them a man evidently exhausted, confused, and his clothes torn to rags. On approaching I found Auguste scarcely less excited than the man he led, and to rescue whom from a ledge of rock, on which *he had passed the whole night*, he had placed himself in imminent danger. This person proved to be an American traveller, who had wandered all alone the morning of the day before over the hill of Charmoz, above the Montanvert, and scrambled as far as the solitary precipices of Trélaporte, unvisited, as we have said, except casually by a shepherd, and still more rarely by some chamois hunter. Towards afternoon (by his own account) he had slipped over a rock, and being caught by the clothes on some bushes had his fall checked, so as to gain a little ledge surrounded by precipices on every side, where he found himself lodged in a perfectly hopeless prison. Here he passed the whole night, which, fortunately, was not cold, and in the morning he succeeded in attracting, by his cries, the young men of Chamouni, who were on their way across the glacier, at a great distance below. The two boldest, with difficulty, climbed, by a circuitous path, so as to gain a position above him; but their united efforts would have been unequal to rescue him had I not providentially gone, with my guide, the same morning, to this remote spot. Whilst he was on a search for the water which I required, he came within sight of the boys, vainly attempting to extricate the traveller. Balmat instantly joined them, and by great personal courage, as well as strength, succeeded in dragging the man up by the arm, from a spot whence a chamois could not have escaped alive. Balmat told me, that whilst he bore the entire weight of the man on a slippery ledge to which he himself clung he felt his foot give way and for a moment he thought himself lost, which was the cause of the very visible emotion of which he bore traces when he joined me. I gave wine and food to the traveller, and the others, and especially applauded the humanity and courage of the lads, one of whom conducted the traveller back to Chamouni, for his nervous system was greatly affected, and for a time I doubted whether he was not deranged.[1] I returned with Balmat to view the exact spot of the adventure, and a more dreadful prison it is impossible to conceive. It was, as I have said, a ledge about a foot broad in most places, and but a few feet long, with grass and juniper growing on it. It thinned off upon the cliff entirely in one direction, and on the other (where widest) it terminated abruptly against a portion of the solid rock, not only vertical, but overhanging, and at least ten feet high, so that no man, unassisted, could have climbed it. The direction of his fall was attested by the shreds of his *blouse*, which were hanging from some juniper bushes, which he had grazed in his descent, but for which evidences it would have appeared to me inconceivable that any falling object could so have attained the shelf on which he was almost miraculously lodged. Immediately below the spot he fell from, the shelf had thinned off so completely that it was plain he must have fallen obliquely across the precipice, so as to attain it. The ledge was about twenty feet below the top of the smooth granitic precipice, to which a cat could not have clung, and below, the same polished surface went sheer down, without a break, for a depth of at least 200 feet, where it sinks under the glacier, whose yawning crevasses would have received the mangled body, and never would have betrayed the traveller's fate. A more astonishing escape, in all its parts, it is impossible to conceive. It is probable, that had the young men not crossed the glacier at the fortunate moment, my guide and I would have passed the rock fifty yards above him (it was in the direction in which we were going) without either party having the remotest idea of the other's presence.

The same day I climbed, with some difficulty, towards the ridge of the Charmoz from this spot, intending to gain a remarkable cleft[2] in the rock, conspicuous both from the upper and lower part of the glacier, and denoted on the map by the mark G*.

[1] I regretted to learn afterwards that he had not shown himself generously sensible of the great effort used in his preservation.

[2] In 1844 I was fortunate enough twice to reach this point, and to take a great number of angles with the theodolite, for the improvement of the map. The view is one of the most comprehensive and splendid of the entire glacier (1845).

There was fresh snow on the rocks, which made the ascent very disagreeable, and the secondary glacier, which extends for a long way on the south-eastern foot of the Charmoz, facing the Tacul, sent down an intermitting fire of stones by the passage which we chose to attempt, and rendered it prudent to abandon the ascent until more favourable weather. This never came, and I was obliged to quit the Montanvert without accomplishing it. This I regretted, for the station G* would command the whole glacier, and would have enabled me to make observations of use for the perfecting of my map.[1]

To return to the Mer de Glace. The foot of the Trélaporte offers several excellent contacts of the ice and rock, which is there, as at the Angle, much worn by the abrasion of the stones or gravel. It is quite practicable to traverse the glacier from hence to the Tacul, or promontory at the bifurcation of the Glaciers du *Géant* and de *Léchaud*. The usual course of proceeding is, as we have observed above, to cross the glacier before reaching Trélaporte, until the principal medial moraine is attained. The whole of the eastern part of the glacier is here much lower than the western, which is heaped up against the promontory, and the effect is to squeeze the moraines together into the smaller or eastern portion of the glacier. The regular curvature and general parallelism of these moraines, amidst all this confusion and dislocation, is exceedingly remarkable. From the point we have now reached, upwards, four of them may be most distinctly traced. Two descending the Glacier de Léchaud, one from the promontory of the Tacul, and one the principal medial moraine of the Glacier du Géant, which, descending from the promontory called La Noire (see the map), we shall designate by that name. Of the first two, one descends all the way from the foot of the Courtes, on the Glacier de Talèfre, and the other is the medial moraine of the Glacier de Léchaud. The moraine of La Noire has a remarkable *dislocation* or lateral displacement, opposite to Trélaporte, which arises from some cause which I am unable to determine. Nor do I know whether this apparent dislocation advances with the progress of the glacier.

Near the same spot are the "Moulins," which the guides always take care to point out to travellers going to the Jardin. They are deep and nearly cylindrical holes in the ice, into which

[1] [See last note on previous page.]

the water accumulated in the rills, which form the superficial drainage of this part of the glacier, is precipitated in a more or less copious cascade according to the season. Sometimes these cascades are double in the same hole, or one stream separates into two cascades; but always, *whatever be the state or progress of the glacier, these cascades or "moulins" are found in almost exactly the same position*, that is, opposite to the same fixed objects on the side of the glacier. This is an evident proof of the continued renewal of the glacier as to its state of aggregation, the external forms remaining fixed, whilst the integrant parts are advancing.

I was greatly struck by the change which I perceived in this part of the glacier, between the month of June, when I first visited it last season (1842), and the close of September, when I quitted it. At the former time the crevasses were comparatively trifling, and they continued to open more and more the whole summer, so that at the end many places were nearly impassable, which earlier I had traversed without difficulty. This is a most important fact, for it shows that during winter the glacier consolidates, and that every summer its crevasses open afresh, whilst its continued adaptation to the external constraint which its walls or bed impose show that the glacier mass is far more passive and plastic than has usually been supposed. I might have stated that in the lower part of the glacier this is perhaps even more striking, for there, the thaw beginning earlier, and being more complete, the crevasses which have opened in spring attain their widest extension in July and the beginning of August, and afterwards by the collapsing of their sides, and the general softening of the mass, they subside into rounder forms, and the cavities being partially filled are more easily crossed.

It was nearly opposite the "Moulins,"—that is, between the stations marked G and H on the map, that in 1832, on my way to the Jardin, my guide, Joseph Marie Couttet, pointed out to me some fragments of wood, evidently much wasted and rubbed, which he assured me were part of the identical ladder which De Saussure had used on his memorable journey to the Col du Géant, forty-four years before. I kept a portion of the wood as a relic, without, however, attaching very great faith to its history; but the inquiries which I made this year (1842) dispose me to believe it probably correct. Couttet and his brother repeated to me exactly the same story as before, and mentioned the year 1832 as that in which the ladder reappeared, and pointed out the very spot where I had myself found it, without having the least idea that I had heard of the thing before. They further mentioned that there was no question that it was a ladder, for Captain Sherwill had seen and taken some of the steps still adhering to the lateral props. It was certain that the morsels in question had descended from La Noire, or at least in that direction, for this, the most westerly of the medial moraines, has its origin there;[1] and it is quite certain that De Saussure ascended the glacier on that side, and that he left a ladder there:[2] for he tells us (§ 2028) that he was unable to pass by the western side of the Glacier du Tacul, on account of the crevasses, and Couttet's father was himself on the expedition, and descended from the Col with the enormous load of 160 pounds after the termination of the expedition, and he assured his sons that the ladder had been left there. Besides, among the few ascents to the Col du Géant since the time of De Saussure, perhaps every one has been performed by the western side of the glacier, which, as I have said, is the safer and more usual course; and had a ladder been left there, it could never have reached the medial moraine of La Noire. There is indeed one other alternative,—that the ladder had been used by the crystal hunters, who used to frequent the rocks of La Noire for the black quartz crystals, which, perhaps, occasioned the name of the spot. But in this case it is more than probable that the

[1] The fact that the *origin* of the medial moraines is familiarly known to the guides of Chamouni seems equivalent to the possession of a true theory of these moraines, so strangely misapprehended by De Saussure and most of his followers. Since a medial moraine may always be traced up to a promontory, and there be seen to originate, or at least to be combined out of the two lateral moraines which there unite, it would seem impossible to ascribe to them any other than the true origin. And that the Chamoniards perfectly understand this, is plain from the fact that they seek in each moraine the minerals proper to the source whence it is derived; for instance, the red fluor-spar in the most easterly moraine of the Glacier de Léchand, which has descended the Talèfre, and has its origin at the foot of the rocks called Les Courtes, where this rare mineral is sought *in situ*.

[2] [Saussure ascended from the Tacul and descended to Courmayeur, but makes no mention of having left a ladder. On the other hand, Bourrit, on the occasion of his passage of the Col in 1787—the year before Saussure's—had a ladder 14 feet long with him (see his *Description des Cols ou Passages des Alpes*, vol. i. p. 115). From this narrative it is impossible to determine his precise route, though he passed by the "Tacul," but Saussure asserts distinctly that the 1787 party passed by the *west* side of the Tacul glacier. Yet Bourrit, in his *Itinéraire de Genève* (1808 edition, p. 71), states clearly that his party ascended "par le milieu du glacier."]

Couttets themselves, the most experienced crystal hunters of the valley, would have been aware of the circumstance. On the whole, then, in the absence of any direct information of any other ladder having been left in this particular quarter besides that of De Saussure, it seems reasonable to admit that the ladder in question descended from La Noire to the point in question, near the Moulins, between the year 1788 and the year 1832. The observation is interesting, as determining so far the mean motion of the glacier in the interval. By the map, the distance, allowing for the sinuosities of the glacier, appears to be about 13,000 feet, which, being travelled in forty-four years, gives nearly 300 feet *per annum* for the mean motion of this part of the glacier.[1] We shall afterwards consider the theoretical bearing of this fact.

A little higher up we stand in the centre of three valleys, and in the most extensive part of the Mer de Glace. The guides believe, and probably with reason, that it is here deepest. They assure me that they have sounded a "moulin" of above 350 feet deep. What is perhaps as good a proof as any of the mass and solidity of the ice, is that I have seen enormous crevasses and basins holding still water, and therefore completely closed below. The water was of an exquisite blue colour, independent of the colour of the ice.[2] The view from the centre of the glacier in fine weather is one of the finest which can be conceived.

In order to reach the promontory of the Tacul, where the glaciers divide, it is usual to cross the fourth and third moraines (I shall in future designate them by numbers, counting from the east), and in the centre the glacier is here easily traversed. The Tacul[3] is reached commonly in three hours from the Montanvert, but a practised walker will do it in two, and I have descended in much less. The union of the two glaciers is attended with some circumstances worthy of notice. That

[1] These numbers are corrected for an error in the position of the point of La Noire, contained in the first edition. See the remarks on the map in Chap. VI. (1845).

[2] I have described it in my Journal as "nearly or quite as blue as the Rhone at Geneva."

[3] [It must always be remembered that by "Tacul" Forbes means *not* the Aiguille of that name, but the base of the ridge projecting from it, where is the lake between the rocks and the moraines from the Tacul and Leschaux glaciers that here join.]

descending from the Géant is by far the most powerful one, and the other is forced to yield somewhat to its pressure. The mass of rock forming the lateral moraine of the Glacier de Léchaud is, however, the most considerable, and this is wildly tossed up into a lofty medial moraine at the meeting of the ice-streams. The Glacier de Léchaud clings, as it were, to the rocky wall of the promontory,—the Glacier du Géant has thrown up a vast mound of débris, which prevents it from approaching the rock within some hundred feet, and leaves a hollow between, part of which is faced by a huge icy barrier, of considerable elevation, and difficult to scale. In this hollow—between the edge of the Glacier du Géant and the promontory of Tacul—there exists, at certain seasons of the year, a small lake. I first visited it in 1842, on the 25th June, when it contained no water, but a few days of continued hot weather, by melting the ice, filled it, and it remained more or less full during the remainder of the season. I have seen it, however, vary exceedingly in level from one day to another, so that there can be no doubt that it has an outlet through the moraine under the glacier. Balmat affirms that the source of the Arveyron is seen suddenly to burst forth with great vigour, and that this is attributed to the emptying of the *Lac du Tacul*,—which is by no means impossible. It appears from the testimony of Bourrit (*Description des Glacières*, vol. iii. p. 90) that De Saussure was the first stranger who reached the Tacul.

The point marked B on the promontory of the Tacul was one of my principal stations, commanding an extensive view of nearly the whole glacier. It was at a height of 277 feet above the lake, so that the view embraced not merely the three branches of the glacier, but that of Talèfre, the Jardin and the mountains beyond, and a portion of the valley of Chamouni opposite the Montanvert, the range of the Aiguilles Rouges, and the snowy summit of the Buet peeping over beyond.

Near the side of the lake, at the foot of the promontory, lies an enormous block of granite belonging to the moraine of Léchaud. The cavity beneath its south-west side is a well-known refuge for chamois hunters, and for the few travellers who pass the Col du Géant, who usually save from two to three hours of fatiguing walking by sleeping here instead of at the

Montanvert.[1] It is, in fine weather, a pretty, tranquil spot. The glacier is in a great measure concealed by its lofty embankments, which shelter it from the chillest winds. The slopes round are grassy, and diversified with juniper bushes, and the little piece of water, when unfrozen, has a cheerful effect. Here I spent two nights with Balmat, with a view to advance my survey and the experiments on the ice; for whilst pursuing my inquiries on the higher glaciers, it was found to make a most laborious day to ascend so far from the Montanvert (carrying instruments and food) before the day's work could be begun, and to return again in the evening. Day after day I have been out thus from ten to thirteen hours upon the glacier. A bivouac was, in favourable weather, a preferable alternative. The juniper bushes afforded a cheerful and serviceable fire, and with the aid of a chamois skin to protect me from the damp ground, and a strong blanket hastily sewed into the form of a bag, in which I slept, the nights passed not uncomfortably. But, on both occasions, when I meant to have passed some days here, I was forced to descend from the bad weather, against which we had no sufficient protection, the cavity under the stone being quite open in front. The last time that we were driven from this poor shelter was on the 6th August, when a day of unnatural mildness was succeeded in the evening by the most terrific thunder-storm I have ever witnessed. We were overtaken by it, and thoroughly drenched, before we could reach the Montanvert; but after sunset it raged with the greatest fury. From the windows of the little inn I watched with admiration the whole scenery of the Mer de Glace, lit up by the explosive lightnings which followed for some hours with little intermission, whilst the frail building seemed to rock under the fury of the gale, and vibrate to every peal of thunder. Each tiny torrent now gave tongue increasingly, until the fitful roar became a steady din, with now and then a crash arising from the discharge of stones hurried along by the flood, or an avalanche prematurely torn from the glacier of the Nant Blanc. It was a Saturday night, and Balmat had gone down to Chamouni to attend mass next morning. He told me afterwards that the dazzling effect of the lightning was such, that it was with the

[1] [Now of course there is the little inn—till lately a club hut only—on the Col du Géant, besides the inn of Mont Fréty on the Italian side of that pass.]

utmost difficulty he could keep the familiar path from the Montanvert, and that he wandered, drenched to the skin, as if blindfold, through the wood. Next day brought tidings of disasters from the valley. The road at Les Ouches had been broken up by the torrents, so as to be impassable; many cottages were filled with stones and gravel, and deserted by the inhabitants; and I believe some small barns were carried away—but no lives were lost.

One night I had a guest in my rude shelter. It was a poor man of Chamouni, who, impelled by an irresistible passion for the chase, came to pass the night on the glacier, in hopes of finding his game in the morning;—a hopeless task,—for the Mer de Glace is now so completely bereft of chamois, that, during the whole summer, I do not recollect to have seen more than two upon it, though on other less frequented glaciers I have seen whole herds.[1] The *chasseur* was very poor, and by no means young; he gladly partook of the provisions which I could spare; and learning that he was a respectable man, though unsettled in his habits, I could not but feel an interest in the singular ardour with which he pursued his thankless toil. Truly might he say with the hunter in "Manfred"—

> her nimble feet
> Have baffled me; my gain to-day will scarce
> Repay my break-neck travail.

The poor fellow owned the infatuation of what he called his "malheureuse passion"; but he seemed willing to die for it. Late on the afternoon of next day I met him; his sport consisted in having seen a chamois' track, and killed a marmot. By his want of dexterity, however, he had very nearly made a victim of one whom I could ill have spared. Balmat, whilst employed for me on the ice, heard a ball whiz close past him, and, looking up, saw our guest of the previous evening behind a rock, whence he had taken aim at a marmot! These animals are very abundant in every part of the higher Alps. They emit a shrill cry like a whistle; they lie torpid in holes a great part of the year, and are valued for their fat. When young they are eaten.

The chamois hunter seeks the limits of the glacier region

[1] Singularly enough, during a comparatively short residence in 1844, I saw a herd of chamois more than once (1845).

in the evening; lies under a rock, as we did, and starts before dawn to watch the known avenues by which the chamois descend to feed. If alarmed, they take to the hill-tops—to crags rather than glaciers; there he must follow them, heedless of danger, impelled alone by the excitement of the sport. The day is soon spent in fruitless ambuscades—night arrives—and his previous shelter is luxury compared to what he has now the option of;—a face of rock, or leafless bed of débris must be his couch, and his supper is bread and cheese. After a few hours' rest, he repeats his meal, drinks some brandy, and starts again. If the chase be prolonged, physical endurance is pushed to the utmost. A most respectable man of the Canton of Berne, who had himself killed seventy-two chamois, assured me that he had wandered thus for three days together, tasting nothing but water; which would seem incredible if we did not recollect that hunger is often repelled for a time by fatigue. De Saussure mentions three hunters, father, son, and grandson, who successively lost their lives in the chase;[1] but such accidents are, I conceive, now more rare. The value of a chamois is only from twelve to fifteen francs, including the skin, so that it offers little pecuniary temptation to the exposure of life.[2] No doubt, as the historian of the Alps[3] adds, the excitement is the real reward, as in the soldier, sailor, and gamester; and perhaps the naturalist has little reason to express surprise at the risks and privations of the hunter's life, when his own would appear to so many persons much less intelligible.

But to return to the glacier. Following the eastern branch above the separation at the Tacul, we find ourselves on the Glacier de Léchaud. Two conspicuous moraines belong to it, which I have called Nos. 1 and 2. The first is the medial moraine of the tributary glacier of the Talèfre; the other comes from the eastern side of Léchaud, above the union with the Talèfre. It is in connection with the former of these moraines, and nearly opposite the promontory of the Couvercle, that there lies upon the ice a very remarkable flat block of

1 *Voyages*, § 736. [All three belonged to Sixt.]

2 [The pecuniary value of a chamois is now far higher, partly in consequence of the increasing rarity of this animal, partly because of the increased demand for its skin and horns.]

3 [Saussure is meant, but the name properly belongs to Bourrit. See note on p. 9 above.]

granite, which particularly attracted my attention on my first visit in 1842 to this part of the glacier. It is a magnificent slab (marked C on the map, being the position which it occupied in the month of June), of the dimensions of 23 feet by 17, and about $3\frac{1}{2}$ feet in thickness. It was then easily accessible, and by climbing upon it, and erecting my theodolite, I made observations on the movement of the ice. But as the season advanced it changed its appearance remarkably. In conformity with the known fact of the waste of the ice at its surface, the glacier sunk all round the stone, while the ice immediately beneath it was protected from the sun and rain. The stone thus appeared to rise above the level of the glacier, supported on an elegant pedestal of beautifully veined ice. Each time I visited it, it was more difficult of ascent, and at last, on the 6th August, the pillar of ice was *thirteen feet high*, and the broad stone so delicately poised on the summit of it (which measured but a few feet in any direction) that it was almost impossible to guess in what direction it would ultimately fall, although, by the progress of the thaw, its fall in the course of the summer was certain. On a still later day I made the sketch in the frontispiece,[1] when probably it was the most beautiful object of the kind to be seen anywhere in Switzerland.[2] The ice of the pedestal presented the beautiful lamellar structure parallel to the length of the glacier. During my absence in the end of August it slipped from its support, and in the month of September it was beginning to rise upon a new one, whilst the unmelted base of the first was still very visible upon the glacier.

The Glacier de Léchaud is on the whole pretty, even on its surface—I mean that part which lies to the south-west of the medial moraines. On account of its great elevation it is covered in its higher part with snow almost the whole year, and until the month of August it offers very disagreeable walking, on account of the half-melted snow on the surface, which likewise conceals the crevasses, and renders it somewhat dangerous. It is joined by some small tributary glaciers from the Aiguille du

[1] [Omitted in the present edition.]

[2] [Forbes here as elsewhere uses the term "Switzerland" as equivalent to "the Alps"; of course in 1842 Chamouni and the rest of Savoy belonged to the kingdom of Sardinia.]

Tacul. Opposite the Glacier de Talèfre occur two "moulins," one of which was remarkable last summer for its great depth and perfect verticality. I had intended to ascertain the depth precisely, but was impeded by a fall of fresh snow, and broke the cord which I had lowered with my geological hammer attached to a weight for the purpose. About an hour's walk above the Tacul is station E, on the east side of the glacier, whence I watched its motion. It is here just passing into the state of névé, which defines the limit of perpetual snow on the surface of the glacier, whilst there is true ice beneath. The view here is very grand. The level is 7926 feet above the sea, and the glacier, almost free from crevasses, is spread out like a magnificent level floor, from which rises the tremendous and inaccessible[1] wall terminating the view to the southward, of which the Grandes and Petites Jorasses form a part. The Grandes Jorasses is the highest mountain of the range, next to Mont Blanc,[2] and its northern side is quite precipitous. From the point E it is seen under an angle of 30 degrees, the horizontal distance of its summit being less than two miles. The origin or feeders of the Glacier de Léchaud are derived from the right and left. From the immediate top or head it has no proper feeder except the fallen snows, which cannot adhere to the rocky precipice before mentioned. To the south-east there is a tributary glacier, which runs up to between the Petites Jorasses and the range of the Aiguilles de Léchaud,[3] which separate the glaciers of Talèfre and Léchaud. It has its origin at a lofty and remote summit, considerably to the eastward of the Petites Jorasses, about which I made frequent inquiries of the guides, and I found that it was called (in translation from the patois) the Montagne des Eboulements, ou des Ruines, being, as they assured me, and I daresay with reason, the summit at the head of the Glacier de Triolet, which descends into the Val Ferret in Piedmont, and of which the

[1] [The great wall at the head of the Leschaux glacier has since Forbes's time been crossed at five points at least.]

[2] ["And its satellites," for the Mont Blanc de Courmayeur, the Dôme du Goûter, the Mont Maudit, and the Mont Blanc du Tacul all surpass the Grandes Jorasses in height.]

[3] [Forbes evidently includes under this general term the three perfectly distinct summits of the Aiguilles de Leschaux, de l'Eboulement, and de Talèfre. On his map the name "Aiguille de Léchaud" is given to the last-named peak, which rises between the Leschaux, Talèfre, and Triolet glaciers.]

fall (partly of the glacier and partly of rocks) was attended with disastrous consequences about a century ago.[1] The western feeder of the Glacier de Léchaud descends from behind the Aiguille du Tacul, from the serrated ridge which connects it with the great Alpine chain. This ridge is called *Les Périades*, and its culminating point, Mont Mallet, which, however, is to be distinguished from the Aiguille du Géant in its neighbourhood, which bears also the name of Mont Mallet on the Italian side of the Alps, from which it alone is visible. From the eastern foot of the pinnacle of Mont Mallet the tributary glacier descends. It is pretty extensive, and not wholly inaccessible, for the brothers Couttet assure me that they have thus gained the summit of the Aiguille du Tacul from behind, which, at the best, must be a very long and difficult journey.

The higher part of the Glacier de Léchaud is scarcely ever visited, except by crystal and chamois hunters. Tourists who venture across the Mer de Glace always make their way to the Jardin, and with good reason, as it offers some of the grandest points of view anywhere to be found on this glacier; nor is there perhaps in the Alps any expedition so practicable in fine weather, which repays so completely the traveller who appreciates the wildest and grandest natural scenery. The traveller to the Jardin does not need to touch the Tacul at all. He crosses two of the medial moraines at the moulins between Trélaporte and the Couvercle, and higher up he passes the other two, near the great stone, C. It is difficult to approach the lower part of the Couvercle much nearer. I have more than once ventured down the east side of the glacier, under the Aiguille du Moine, towards station F, but the passage is embarrassing, often impossible. When the two glaciers meet (as I have already remarked) the eastern half is dislocated excessively, and is all but impassable. The promontory of the Couvercle itself, opposite C, may be easily reached, and offers some interest from the visible friction to which it is subjected by the descent of the glacier. Farther up we stand in front of the descending ice of the Glacier de Talèfre, which presents a majestic and perfectly inaccessible

[1] [This fall took place on September 12, 1717. See the Latin account by an eyewitness in Signor Vaccarone's *Le vie delle Alpi Occidentali negli antici tempi* (Turin, 1884), p. 118, and the French translation in the *Bollettino* of the Italian Alpine Club, No. 50, p. 68.]

accumulation of icy pyramids and fragments ejected through the narrow opening which gives vent to the basin of the glacier, which pours over the precipice in a solid cascade, presenting a perfect chaos of forms. Of the structure of the ice here I shall afterwards speak; but I may observe that the preservation of the medial moraine in the midst of this mass of confusion is a very startling fact. It is indicated merely by a stripe of dirt, which discolours the centre of the icy cascade, but no sooner has it reached a comparative level than the masses of rock dislodged from the side of the higher glacier are found on the surface, arranging themselves with admirable order along a line of no great breadth, which forms the medial moraine No. 1, which may be traced distinct from the others along by far the greater part of the Mer de Glace.

The ascent to the Glacier de Talèfre is usually [1] accomplished by rocks of the Couvercle at the foot of the Aiguille du Moine. It offers no kind of difficulty. The ascent, where steepest, is called *Les Egralets.* Above these the view becomes wild, but very grand. On the left is the Aiguille du Moine,[2] one of the most elegant and uniformly conical summits of the chain; at its foot are huge blocks of fallen rock, tenanted by marmots. Looking backwards, we command a large space of the Mer de Glace, and the grand view up the Glacier du Géant opens, and Mont Blanc begins to appear for the first time, fortified on this side by the impassable barriers of the Mont Maudit. The Aiguille du Midi, from its height, begins to overtop those of Grépon and Blaitière, and between it and Mont Blanc the rounded form of the Dôme du Goûter is not to be mistaken. In front, the wide basin of the Glacier de Talèfre, in a great measure concealed from the Mer de Glace by its height and the steepness of its outlet, begins to open. It has a singular and interesting appearance. It is shaped almost like a volcanic crater with one side blown out, and it is surrounded by rocky pinnacles of the wildest forms, which appear, and for the most part are, totally inaccessible. It is certain that no one [3] has succeeded in passing this

[1] [As the great shrinkage of the glacier has made the Couvercle more difficult of access than formerly, despite the iron stanchions fixed on the steepest rocks of Les Egralets, the route by the left bank of the Talèfre icefall and the Pierre à Béranger hut is now preferred to that by Les Egralets.]

[2] Called Aiguille du Talèfre by De Saussure.—*Voyages*, § 630 A.

[3] [This and the preceding statement are no longer true.]

serrated barrier at any point.[1] The topography of the Glacier de Talèfre is very ill laid down on all the maps and models. It is bounded on the west by the chain of peaks visible from the Mer de Glace, which connect the *Moine* and *Dru*. The north-east barrier, which is the longest, and tolerably straight, passes through the Aiguille Verte (which separates this glacier from that of Argentière), and a single range of very sharp Aiguilles, called in succession Les Rouges, Les Droites, and La Tour des Courtes, and it terminates in the south-east by a remarkable glacier summit, marked [A] in the map, whence a tributary glacier descends. Though I have determined the position of this point, I am unable to give its proper name;[2] but I apprehend that it belongs to the axis of the great chain, and commands the glaciers of the Val Ferret. It is possibly the lofty white peak which I saw when I visited the extremity of the Glacier d'Argentière, of which it occupies the higher termination. It is perhaps the Mondelant. The south barrier of the Glacier de Talèfre is the range of the Aiguilles de Léchaud, which separates it from the glacier of that name.

The glacier of Talèfre is pretty even on its surface, and is covered, for a great part of the year, with snow; its level, according to De Saussure, is 1334 toises, or about 8500 English feet above the sea. In the centre of the snowy basin is a very large exposed surface of rock, of a triangular form, covered with soil on its lower part, sufficient to maintain a good turf, enamelled with the usual Alpine flowers, during the few weeks of the year that it is entirely uncovered with snow. This spot is called the Jardin (or *Courtil* in patois), and is now the object of frequent excursions from Chamouni. There is a spring of water near the lower part, and lying exposed, at a high angle towards the south, it is anything but cold in fine weather. Indeed I scarcely ever remember to have found the sun more piercing than at the Jardin. On three different occasions I have visited it, and on all under the most favourable circumstances, in

[1] The Couttets wished to pass to the glacier of Argentière behind the Aiguille Verte, but having gained the ridge, they were unable to descend.

[2] [It is really the Aiguille de Triolet (12,717 feet). The "lofty white peak"—the "Pic Blanc" of Topographical Sketch, No. iv. p. 246—is the Mont Dolent (12,543 feet), which is separated from the Triolet by the rugged ridge—traversed by the Col du Mont Dolent—separating the Argentière and Pré de Bar glaciers. Each of these two peaks dominates four distinct glaciers. See below, p. 248.]

1832, in 1839, and in 1842. The reflection of the heat from the snowy basin with which it is surrounded, and its comparative shelter from the wind, probably cause this intensity. On each visit I have found the scenery if possible more admirable than before. On the last occasion I climbed to the very summit of the triangular rock forming the Jardin, a task of more labour than it would appear to be, as it is both long and steep. The top is at a level of 9893[1] English feet above the sea (trigonometrically determined), and commands an admirable range of view. From thence I took a number of magnetic bearings for the plan of the glacier. The Glacier de Talèfre presents two medial moraines, marked on the map; one takes its origin from the Jardin itself, the other is derived from Les Droites already mentioned. These become commingled during the precipitous descent of the ice, and reappear as one on the Glacier de Léchaud.

From the Jardin it is not difficult to descend to the Glacier de Léchaud by the south margin of the Glacier de Talèfre. The passage of the last-named glacier is, however, almost always wet, and the foot perpetually bursts through the frail superficial coating of ice formed in the night, and plunges ankle-deep into the snow-cold sludge beneath. The lateral moraine gained, it presents a steep and uneasy descent towards the Glacier de Léchaud. At about two-thirds of the descent is a grassy shelf upon which some of the débris of the moraine have accumulated. One mass is of enormous size, and from its peculiar form is well seen from the Glacier de Léchaud in all directions. It is a useful landmark, and is called the Pierre à Béranger,[2] no doubt from a M. de Béranger, who is frequently mentioned in M. Bourrit's narrative, though I am not acquainted with any particulars respecting him. The Pierre à Béranger is marked on the map; it is sometimes used as a shelter for the night by hunters; thence the glacier may be more easily gained by the rock than by the moraine, a bypath not generally known to the guides.

This concludes what I have to say respecting the topography of the Mer de Glace generally, and of its tributaries of Léchaud and Talèfre. The other great branch, the *Glacier du Géant* or *du Tacul*, remains to be described, but that may properly form a part of the narrative of the passage of the Col du Géant, to which I shall devote a separate chapter (XII.).

[1] [Really 9833 feet.] [2] [Near by there is now a recently rebuilt shelter hut.]

CHAPTER VI

ACCOUNT OF A SURVEY OF THE MER DE GLACE AND ITS ENVIRONS [1]

Object of the survey—The instruments—The base line—The triangulation—Heights of the stations referred to Montanvert—Slope of the glacier—Heights of the neighbouring mountains above the sea—Construction of the map—Geographical positions.

It was the especial object of my journey in 1842 to observe accurately the rate of motion of some extensive glacier at different points of its length and breadth.

In order to draw precise or valuable conclusions from these experiments it was necessary to be able to assign accurately the relative positions and distances of the points observed. It was also highly desirable to ascertain the *slope* of the glacier in its various parts, which can only be exactly done by a combination of horizontal measures with vertical heights. These, and some other proposed experiments required of necessity a geodetical apparatus, with which I provided myself, and I soon found that the only satisfactory mode of proceeding would be to add to my direct observations on the movement of the ice a general survey of the glacier in its various portions. This being resolved on, it followed as a matter of course to lay down the neighbouring mountains, and to determine their height, and hence the construction of the map [2] which accompanies this work, and which is based exclusively [3] upon my own observations.

[1] It may be right to observe that this chapter, which is little likely to interest the general reader, may be omitted by those who would avoid such details. The two following chapters on the Motion and Structure of the Ice may also be slightly passed over by those who are willing to take for granted the results which will be found in the concluding chapter of [Part i. of] this volume.

[2] [This was the first detailed and careful map of the Mer de Glace ever made, and therefore the narrative of the survey is preserved intact, although M. Kurz's later (1896) map is more accurate than that of Forbes, which, however, possesses great historical value.]

[3] It is scarcely necessary to mention as an exception a single point (the position

The instrument on which I chiefly depended, as well for the determination of the movement of the glacier as for its triangulation, was a Kater's astronomical circle, made for me by the late Mr. Robinson. It is of the larger size of such instruments, having both the horizontal and vertical circles of four and a half inches diameter, the former with three microscopes and verniers, the latter with two. The construction of the horizontal part is, as usual, most carefully executed, and the readings incomparably better than the vertical ones. The telescope is provided with five fine vertical wires, like a transit instrument, and one horizontal, and a diagonal eye-piece; there is a spare telescope, for *keeping watch*, the working of which was not, however, satisfactory, and it was seldom used, the steadiness of the instrument being scrupulously verified by a return to the starting or zero point. It is further provided with a good level, which was frequently verified, and which fortunately escaped any accident. The whole, mounted on Robinson's excellent portable tripod, was as steady as could reasonably be desired, where the ground for planting it was favourable. The use of it upon the ice was always attended with some embarrassment, owing to the unequal sinking of the supports. The working of the tangent screws was perhaps the least satisfactory part of the apparatus; but, on the whole, it would be difficult to imagine an instrument more perfectly adapted for the various uses to which it was put, or to find one which could have better answered to the character of its maker throughout a season of most trying work. The instrument, as mounted for use, is seen in the frontispiece.[1]

In selecting a station for pursuing my inquiries, I had no reason to regret my choice of the Mer de Glace of Chamouni. Its vast surface presents every variety of glacier structure and arrangement; its great length, and its remarkably uniform breadth, for some distance, adapted it peculiarly to my investigations, which had reference to the velocity of movement as affected by the former circumstance and without reference to the latter. Its easy accessibility, and the ready communication with places whence any requisite implements might be procured,

of the Col du Géant) which has been determined from De Saussure's data, and the sparing and cautious use of some published engravings in laying down some natural features.

[1] [The frontispiece is omitted in the present edition.]

aided in determining my choice;—but beyond all other circumstances, the certainty of finding a permanent shelter during all weathers, and in the immediate vicinity of the ice, such as the cottage of the Montanvert affords.

The form of a glacier like the Mer de Glace presents almost every difficulty which can be experienced in conducting a survey. The only spots nearly level (I mean on the surface of the ice itself) are unfit for measuring a base, or performing any important part in the triangulation. The walls of the glacier are excessively rugged, often inaccessible. The stations are difficult to choose so as to be visible from one another, owing to the intricate windings of the ice-stream, and the enormous height of the rocks. The fundamental triangulation must be carried up a *valley*, whose extremities, independent of *mountains*, differ in level by 4400 feet. Finally, the observer — solitary and without the assistance of any one understanding the use of instruments—is exposed, even in the finest weather, to alternations of the most intense, almost stupefying, solar heat, reflected from the snow and threatening him with blindness, with the chill winds and sudden storms of these great heights: he must often have the alternative of walking for seven or eight hours of the day over ice, merely to go to and return from a single station to gain perhaps a single observation, or else of camping out under some rock, exposed to the chances of weather. These considerations, it is hoped, will be taken into account in estimating the kind of accuracy to be expected in a survey like this, and the amount of criticism of which it may be thought deserving in respect of minuteness of detail. It will appear, however (I hope), from what is to follow, that the basis or skeleton of the map is sufficiently accurate as to the relative positions of all the great points, which are in general determined with more exactness than the scale permits in laying them down.

Besides the instrument just mentioned, I had taken with me from England a small sextant and horizon (of which I made no use), one of Troughton and Simms' standard steel tape measures, an ordinary varnished tape measure, waterproofed string and silk lines; a telescope by Tulley, $2\frac{1}{4}$ inches aperture, and a Kater's compass, which I found of admirable service.[1]

[1] In addition to these I had, for general purposes, six thermometers, a maximum

I had originally intended measuring a base line upon the ice, near the confluence of the Glaciers de Léchaud and du Tacul, which I proposed to be at once the foundation of my triangulation, and to decide the question of the supposed dilatation of the ice during its progress. I subsequently devised a better scheme for ascertaining the latter point, and soon became convinced of the inconveniences which would attend such an operation. I ultimately acquiesced in the advice which Mr. Airy had already given me, to measure my base in the valley of Chamouni, and to continue the triangulation up the glacier. The main obstacle to this was the extreme rapidity of the Montanvert, and the difficulty of finding any point from which the glacier and the valley could be at once commanded to any extent. This was, however, at length overcome, and stations, though not affording by any means the most eligible forms of triangles, were at last decided upon. The measurement of the base was one of the later operations, and the connection of it with the triangles on the higher level of the glacier the very last. I shall commence, however, with an account of—

and two minimum thermometers, one Bunten's barometer, two improved sympiezometers, two photometers, two actinometers, a Russian furnace, with alcohol for boiling water and a thermometer for ascertaining its temperature, a measuring chain of 10 mètres, borrowed at Chamouni, as well as a *jumper*, 30 inches long, for making holes in the ice; two hammers, three screw-drivers, a hatchet, numerous staves for station pointers with red and white flags, chisels, red and white paint, and brushes for marking the stations and other points permanently on the rocks, two clinometers and compasses, a portable telescope (*Feldstecke*) by Plössl, gimlets, pliers, a hand vice, a protractor, scale, drawing materials and colours, colours for injecting the ice, viz. logwood, carmine, litmus and lithographic ink. So ample had been my provision of apparatus that I had no occasion for anything in addition which was not readily procurable at Chamouni.

It may not be useless to add that in point of clothing, though my wardrobe was very far from bulky, I seldom suffered from cold. Without any voluminous cloaks or furs, I found flannel next the skin (doubled if necessary), surmounted by a complete suit of soft chamois leather to be warmer than it was generally agreeable to wear even in sleeping in the open air near the glacier in summer. To avoid the continual risk of exposure to cold during protracted observations after a laborious walk, I generally found a woollen waistcoat with sleeves, over the one I usually wear, a sufficient protection; and together with a light Scotch woollen plaid, or a common single-breasted greatcoat, sufficient for the worst weather during exercise. Long worsted stockings over short ones, and fur-lined gloves without separation for the fingers, which, however, I very seldom wore. A straw hat, on all occasions during exercise, with a velvet cap under, or exchanged for a soft fur cap during observations. For shoes nothing is equal to London ones with double soles, continually supplied with fresh nails as the old ones are knocked out. Square-headed nails or anchor-headed nails, such as are used in Switzerland, to defend the edges of the leather, are the best. Of late years I have never habitually used spikes or *crampons* of any kind for crossing the ice.

The Base Line

It being decided that the trigonometrical base should be in the valley, there was no difficulty in selecting the most proper place for it. A perfectly straight road, leading from the village of Les Praz to that of Les Tines — a distance of about an English mile—parallel to the length of the valley of Chamouni, and nearly opposite to the foot of the Glacier des Bois, at once suggested itself. A nearer inspection confirmed my opinion as to its fitness. From a little wooden bridge 500 yards east of the village of Les Praz to the woods near the hamlet of Les Tines, which begin to conceal the glacier and parts adjacent, is a clear space of 1000 yards, which seemed a sufficient length for my purpose. A mathematically straight line could be drawn throughout this space upon the road, which was sensibly level to the eye (its mean inclination being 44′ slanting upwards towards Les Tines), and which was formed of dry well-compacted gravel. In short, a more eligible spot could hardly be desired.

The *termini* of the base, marked N and O on the map, were fixed by long pins of hard wood driven into the ground, and the tops marked by a nail driven into each as a starting-point. These pins may probably remain for some years. The first is exactly at the eastern end of the beam which forms the south side of the little wooden bridge near Les Praz already mentioned. The station O is marked by a very conspicuous solitary larch tree, with its lower branches lopped off, on the south side of the road, standing quite apart from the wood near Les Tines. The terminus at O may be referred to the *centre* of this larch tree by co-ordinates perpendicular and parallel to the line O N. It is *on the road* 5 feet 7 inches nearer to N, and 4 feet 1 inch north of the said larch.

The interval was twice measured — on September 14 and 23, 1842 — by the aid of a 10-mètre chain kindly lent to me by M. Blanc of Chamouni; and the chain was compared with Troughton's steel tape divided into English feet and inches, in the interval of time between the two measurements. The chain was a good iron one, united by very solid brass rings. The first measurement was intended only as an approximation, but the second one confirmed it so well that I thought it unnecessary for the purpose in view to undergo the labour of a third. The distance was $91\frac{1}{2}$ chains, or, more correctly, 914 mètres. With the assistance of my intelligent and useful guide, Auguste Balmat, and another person, I fixed the distances of 30 and 60 chains, also by hard wood pins, and on the second measurement the difference was under one inch at both places, and a temporary mark at 80 chains appeared to give as small an error. Therefore, though on the whole measurement there appeared a difference of 5 inches, I considered myself as justified in attributing it to some mistake in the mode of counting the links, which, in my first or approximate measurement, was the only method I had used of estimating the fractional part of a chain. Having measured the space between the 80th chain and the end of the base twice over without sensible difference, and having measured the fractional residue with Troughton's tape, I think myself entitled to conclude that the probable error of the whole does not exceed materially the observed difference at 30, 60, and 80 chains—that is, one inch, or little more, or about 1-36000 of the length of the base,—a quantity much under the other inevitable errors of observation in the subsequent triangulation. The length of the base was

91 chains + 26 English feet + 2·50 inches.

The comparison of the 10-mètre chain and the steel tape was very carefully performed under the wooden gallery of the Hôtel de l'Union at Chamouni. Both the chain and the tape were stretched with a weight of about 14 lbs., which is that indicated as the stretching weight of the tape, and the chain was found not to yield sensibly to any moderate force, after being once fairly stretched. Its length was found to be

32 feet 10·675 inches,

the temperature of both being 41° F. The probable error of the measurement might amount to one-fiftieth inch. Hence the length of the base will be found to be

2992·952 English feet.

This ought to be reduced in the proportion of the cosine of 44′ to radius, that being the mean inclination of the base to the horizon. This amounts to a shortening of only *one twelve* *thousandth* part; and the calculations having been commenced without adverting to it, I have thought it superfluous to alter the numbers as to the distance and elevation of the various points of the survey by this small quantity, which, however, may easily be applied, if desired, to the results which are to be given.

The Triangulation

The plan proposed for the survey was simple enough. A series of points were taken on the rocks on either side of the glacier, and at some height above it, so as to command a view of two or more of the others. The circumstances which, as already observed, compelled the selection, and the labour of access and of observation at many points, prevented a great multiplication of the triangles, or the avoidance of some very oblique ones. Still, as the object was only to lay down correctly a very limited range of country, the accuracy of the instrumental methods was sufficient to allow me to dispense with the selection of stations, which would have been requisite in an extensive survey. But every pains was taken to ascertain that the triangles were accurately determined, of which the three angles were in most cases measured; and considering the circumstances under which they were observed, it will probably be considered as a fair proof of their exactness that the sum of the angles seldom differs 1′ from 180°, notwithstanding the great deviations from a horizontal plane. The sides of the system of triangles thus determined along the valley served as bases from which to measure the altitude of the mountains, and the bearings of the various points which were to be laid down on the glacier; whilst various subordinate stations were marked, from whence, as secondary stations, fresh angles might be taken with the compass for the better comprehension of details.

The stations were taken with particular reference to the observations which were to be made upon the ice, and they were all marked in such a way as may enable them to be recognised at a distance of some years. They were in every case (excepting at the extremities of the base, which have been already described) on rock, or, at least, the instrument was placed on some fixed stone, little likely to be removed. A cross was cut with a hammer or chisel, immediately below the centre of the instrument, determined by a station pointer, and that cross was painted red, with a large capital letter also in red, painted beside it. I shall briefly describe the position of the stations which served for the main triangulation, and which are marked on the large map.

Commencing in the valley, the extremities of the base line marked N and O on the map have been already described. From these two stations the rock above the Chapeau could be distinctly seen, and that formed the third station marked I. It is at a height of no less than 1800 feet above the other two. It is on the summit of a green saddle-shaped slope above the rock and cave already mentioned, and quite above the few trees which fringe the precipice. The cross is on a flat stone, sunk in the grass, very near the first fixed rock, at the head of the grassy ridge. The station commands the glacier to a considerable extent, even as far as the Tacul; and I was able to observe the signal which I had planted there (station B). It was, therefore, a most eligible connecting point between the valley and the upper level of the Mer de Glace.

The observed angles of this triangle were—

N I O	18° 55′ 50″
I O N	127 54 0
O N I	33 8 40
	179° 58′ 30″

The next station L is on the rocky ridge, extending above the Montanvert, towards the Aiguille des Charmoz, which ridge is itself familiarly called Les Charmoz. It is 867 feet above the Montanvert, and therefore a full half-hour's ascent along the southernmost part of the rugged ridge in question. It was found impossible to obtain a station here which should command at once the two extremities of the measured base and the middle portion of the Mer de Glace. I was obliged to select a projecting mass of rock, which commanded the eastern extremity of the base, and the station I. It is at a height 3600 feet above the former and 1800 above the latter. It is marked with a cross and pyramid of stones and the letter L. The angles are—

O L I	36° 18′ 20″
L I O	84 56 21
L O I	58 45 40
	180° 00′ 21″

The Montanvert itself was not found to be a commanding enough position to be selected as a principal station, although it has been accurately connected with four or five others.

Station F is on the eastern side of the glacier, on the promontory of Les Echelets, and is at about 150 feet above the level of the glacier, near the ridge of the hill, but rather facing the north. It commands a view at once of the Chapeau and Tacul. It is marked like the others, and connects with stations I and L, as follows:—

L F I	48° 30′ 15″
I L F	102 40 10
F I L	28 48 50
	179° 59′ 15″

Station G is on the ridge of Trélaporte, or Entre-la-Porte, on the west side of the glacier, at the foot of the Charmoz, and its elevation may be 300 feet above the level of the ice. It is on the little level space formerly alluded to, occupied by a series of blocks which appear to mark the former boundary of the glacier. It is on one of these large blocks (but to the south of the *largest*) that station G is marked by a red cross and pyramid of stones. It is one of the most conspicuous stations, and commands the glacier both ways. Only two angles of the triangle connecting G with L and F were observed, as follows:—

L F G	122° 37′ 45″
F L G	28 37 50
	151° 15′ 35″
L G F	28 44 25
	180° 00′ 00″

Station B, on the promontory of the Tacul, commands a more general view of the glacier than any other station. I could see up the ice-streams of Léchaud and the Géant, and down to the station of Le Chapeau, whence the station B was distinctly observed, and served as a verification.[1] The promontory

[1] The fluttering of a *white* flag seemed superior to any other mark of the stations. Where too distant to allow the staff bearing the flag to be seen distinctly, its motion served to distinguish the flag from any mark on the rock, or patches of snow which, in the latter part of the season, often rendered the observations difficult and uncertain. It was, for instance, with the greatest trouble that I succeeded in

is composed of rather loose rock. A pretty solid pedestal was built up of the larger masses on the ridge, at a height of 277 feet (barometrically measured) above the little lake below. The cross was cut in the centre stone under the pyramid which supports the flag, and the pyramid was removed as in the other cases, when the instrument was planted. From this station, by observations right and left, the movement of either glacier was determined.

The position of B is determined by a very oblique triangle, the precipitous nature of the rocks opposite affording no convenient station whence F and B could at once be seen. Its angles are—

G B F	11° 42′ 0″
F G B	151 52 25
G F B	16 25 5
	179° 59′ 30″

Station H was at the foot of the Couvercle, opposite station B and beneath the Aiguille du Moine. It is on a grassy shelf above rocky precipices, which rise, perhaps, 200 feet from the level of the glacier. It is accessible only by a small ravine or watercourse to the south, and even there not easily. The vegetation here is more luxuriant than on most parts of the glacier banks at so high a level. I observed particularly a luxuriant specimen of the alpine rose without thorns. It is 1177 feet above the Montanvert, or 7487 above the sea. The station is marked on a great stone imbedded in the turf. From it neither the Montanvert nor Les Echelets could be seen. The position of H is determined from G and B as follows:—

G B H	66° 40′ 10″
B H G	87 48 5
H G B	25 32 30
	180° 00′ 45″

Finally, another station was selected as high up the Glacier de Léchaud as a fixed rock conveniently accessible could be found for establishing it. It is on the eastern side of the

observing station L from I, partly owing to the badness of the light, partly to the mark not being seen against the sky, or a distant hill, and partly to the numberless patches of snow. I was obliged to return repeatedly, and on this and many other occasions was struck with the far more perfect eyesight of Balmat for distant objects than my own.

glacier, exactly opposite a remarkable rock, called *Capucin du Tacul*, and about half an hour's walk above the junction with the Glacier de Talèfre. It is marked station E, and will be more readily found by the outlines on the map, which were carefully sketched, than by minute description; it is on a rocky promontory, perhaps about sixty feet above the level of the ice, which is here extremely crevassed, so as to render this spot somewhat difficult of access in the latter part of the season. From it several of the higher summits were measured, and the motion of the ice near its origin determined. The following triangle connects it with B and H:—

B E H	21° 24′ 1″
H B E	67 50 40
E H B	90 45 40
	180° 00′ 21″

The sides of these various triangles have been calculated by two computers, and compared by a third. The result gives the following numbers (subject to the reduction of one 12000th, on the ground stated above, pp. 100-1):—

Feet.	Feet.
N O = 2992·95	G L = 8208·28
N I = 7275·78	F B = 10853·1
I O = 5043·04	G B = 6508·75
L O = 8484·49	G H = 5980·79
L I = 7282·61	H B = 2808·01
I F = 9485·56	H E = 7127·97
L F = 4686·50	B E = 7695·66
G F = 4670·13	

The station E is distant from the base line about 28,600 feet.

As these stations were to be used for the determination of the actual height of various mountain tops observed from them, as well as of various points of the glacier surface, it became necessary to ascertain their elevation above some known point, such as the Montanvert. I accordingly observed carefully the elevations, and usually also the corresponding depressions of the different stations, so far as they were visible from one another. The distances being known, the relative heights of the stations, taken by pairs, become easily known from the following data, on which it must be remarked that the observations with an asterisk prefixed are double ones, or the mean of an observed elevation and depression, which eliminates at once the effects of the curvature of the earth, atmospheric refraction, and the error of collimation, while the single observations (those of elevation are marked +, those of depression −) are corrected by the following simple but abundantly accurate formula for such small distances, which includes the effects both of curvature and refraction,—

$$\text{Correction in English feet (always +)} = {\cdot}5714\ D^2.$$

D being the distance between the stations in English *miles.*

The error of collimation in a vertical direction was ascertained by observation, and found to be

$$\pm 1'\ 15''$$

the readings being too low when the microscope A was uppermost, and too high when the microscope B was uppermost.

Stations.	Distance. Feet.	Angular Altitude.	Observed Height in Feet.	Calculated Height in Feet.
* O above N	...	0° 44′ 0″	38·3	40·0
* I ,, N	...	14 15 45	1849·5	1847·8
* I ,, O	...	19 42 15	1806·0	1807·8
* L ,, I	...	13 49 45	1792·6	1789·8
* F ,, I	...	8 40 0	1445·6	1445·5
* L ,, O	...	22 58 45	3597·7	3597·6
* L ,, F	...	4 11 0	342·8	343·3
* G ,, F	...	4 48 15	392·5	396·2
G ,, L	...	+ 0 22 15	54·5	52·9
G ,, I	...	− 7 27 30	1843·1	1842·7
* B ,, F	...	3 56 45	748·6	750·6
* B ,, G	...	3 5 30	351·5	354·4
* B ,, H	...	1 53 0	92·3	96·6
* H ,, G	...	2 26 22	254·7	257·6
E ,, G	...	+ 3 3 15	707·9	703·0
* E ,, B	...	2 26 30	350·5	348·6
* E ,, H	...	3 32 30	441·2	445·4
M[1] ,, I	5590	+ 9 20 45	920·6	922·9
F ,, M	4754	− 6 17 45	523·5	523·6
G ,, M	9006	− 5 51 45	922·0	919·8
B ,, M	15450	− 4 43 45	1273·2	1274·2

[1] M stands for the *Montanvert*, of which the position and elevation was determined by reference to these four stations; but as no observations were taken from the Montanvert itself, these are all single altitudes.

The numbers marked "calculated," were obtained as will be immediately stated.

These results plainly form so many equations of condition for the determination of the height of the stations amongst one another. There are nine stations, independent of M (the Montanvert), which we take as a starting-point or absolute level, and there are twenty-one equations of relative height. These have been combined by the method of least squares, so as to give the most probable height of each point referred to M. Double weight has been given to the observations of elevation and depression combined. The mode of proceeding is to combine, in a single equation, all those which contain any one unknown quantity. From the nine equations thus formed, the unknown quantities are successively removed by a somewhat tedious elimination. Great precautions were taken to avoid numerical errors, and the results are as follows:—

	Feet.		Feet.
N below M . .	2770·7	F above M . .	523·6
O „ M . .	2730·7	G „ M . .	919·8
I „ M . .	922·9	B „ M . .	1274·2
L above M . .	866·9	H „ M . .	1177·4
E above M	1622·8		

With these numbers those in the last column of the preceding table have been computed, and the comparison appears satisfactory.

Besides the main points of the triangulation, several other stations were assumed, either for determining the motion of the ice or for extending the subordinate triangulation, which was performed partly with the theodolite, and partly by means of Kater's compass. The determinations with the latter are manifestly inferior to the former. Some errors, perhaps, were owing to a local magnetic disturbance of no great amount, and others to a want of perfect mobility in the compass, which, bearing a heavy card, is not, after some use, so delicate as might be desired. It is hardly necessary to observe, that Kater's compass is provided with a vertical wire, and slit for taking azimuths, which are read off at the instant of observation by the aid of a reflecting prism, which conveys the image of the divisions of the scale to the eye, at the same time, and in the same direction, as that in which the distant object is viewed.

Of the subsidiary stations the chief were—

1. Station A, on the glacier opposite L'Angle, marked on the map near the foot of the Charmoz; it was the earliest station employed for measuring the motion of the glacier. It is determined in position by reference to stations L, F, and M.

2. Station C, on a block of granite on the ice, between the promontory of the Couvercle and the Tacul. It has already been described in Chapter V. Its position was ascertained by angles from B and G.

3. Station D, near the Montanvert, on a very large granite block, forming part of the ancient moraine, nearly on a level with the inn, and distant 60 yards N. 40° E., magnetic, from the south-east corner of the building. From this point the motion of the glacier was frequently determined; and, by means of a small base line, its breadth in this part, and the distances of several marks upon it.

4. A station near the source of the Arveyron, upon the moraine of 1820, near the hillock of Côte du Piget. From it a number of magnetic bearings were taken, for laying down the details of the lower part of the glacier.

5. La Croix de Flégère; a small building, exactly opposite to the Montanvert, and at almost the same level, on the north side of the valley of Chamouni. Its position is fixed by reference to stations I and M. A number of magnetic bearings were taken from hence, especially for the position of the Aiguilles and of Mont Blanc, which is laid down on the map from its bearing from hence, and from the summit of the Jardin.

6. The summit of the Jardin, fixed by reference to station B and the Aiguille du Moine.

7. A station on the border of the Glacier de Talèfre, above the Pierre à Béranger, marked [γ]. It was fixed by reference to the Aiguille du Moine and the top of the Jardin. This, and the last station, afforded angles for determining in some measure the form of the basin of the Glacier de Talèfre.

8. Station K, marked on the south-east side of the Glacier du Géant, was fixed and accurately marked for the purpose of ascertaining the motion of this part of the glacier. The cross is cut in a triangular imbedded stone at a considerable height above the glacier, and which is attained by ascending a steep couloir. Unfortunately, no second observation was ever made to determine the motion of the ice, the premature winter in September rendering it impossible.

9. For the same reason an intended station, marked[1] G*,

[1] As mentioned on page 80, I reached this commanding point in August, 1844, with the theodolite, and took a great number of angles. They confirmed excellently

between Trélaporte and the Charmoz, was never attained. By angles taken from thence the topography of the upper part of the Glacier du Géant would have been considerably improved.

For the improvement of the map in this edition, and particularly on the side of the aiguilles next the valley of Chamouni, two other subsidiary stations have been employed, L*, on the ridge near the Petit Charmoz, and another on the "Plan de l'Aiguille."

Most of the Swiss models represent the Glacier of Argentière as extending altogether behind the basin of the Talèfre, and touching the mountains at the head of the Glacier de Léchaud! In fact, the upper part of the Glacier d'Argentière is scarcely ever visited. I apprehend that the extreme boundary of these three glaciers, as laid down in the map accompanying this work, forms very nearly the real axis of the chain, and that the Glacier of Triolet, in the Val Ferret, takes its origin from the mountain to the east of the Petites Jorasses, which is marked Montagne des Eboulements.[1] The mountains at the head of the Glacier de Léchaud,—the range called *les Périades*, which connects the Tacul with the main chain,—the group of the Géant and Mont Mallet, and the rather complicated and slender ramifications in the neighbourhood of the Col du Géant, are all pretty satisfactorily understood and determined. The summit of Mont Blanc is entirely cut off from the upper ice basins of the Mer de Glace by the inaccessible[2] ridge extending from the two Flambeaux to Mont Blanc du Tacul. Of the range of the Mont Maudit, and the origin of the glacier of La Brenva, I have only vague topographical information; it is therefore not detailed. Between the elevated and wild rocky summits of the

well the positions already determined in the map, with the exception of those anticipated in the text; namely, the upper parts of the Glacier du Géant, which it is impossible to reach except in fine weather, and to which access was denied me during the latter part of the season of 1842. My observations in 1844 show that the point of La Noire should be brought down considerably towards the Tacul, and the course of the Glacier du Géant ought to sweep more rapidly towards the south. These alterations have not been introduced into the map, because I am not yet satisfied with the topography of this glacier, and I hope by another visit to Chamouni to improve it materially. In the meantime, the general features even of this more imperfect part are tolerably well represented, though the relative spaces are not quite accurate (1845).

[1] [This is so, the summit at present named Aiguille de l'Eboulement rising midway between the Aiguilles de Leschaux and de Talèfre—the latter is Forbes's Aiguille de Léchaud; this ridge separates the Talèfre and Leschaux glaciers.]

[2] [This epithet is no longer true.]

Aiguille du Midi and Mont Blanc du Tacul there is a sort of depression (probably quite inaccessible on its western side),[1] which separates the Glacier of Bossons from the tributaries of the Mer de Glace. The range of Aiguilles of Chamouni then follow. I have considered them as four in number: (1) the Aiguille du Midi, with its great subordinate glacier on the north slope. (2) The Aiguilles de Blaitière or du Plan—a great group, which some authors subdivide into two,[2] and which has a third appendage[3] on its southern side, to which I shall elsewhere (p. 237) advert. (3) The Aiguille de Grépon, which is more definite: between it and the last there is a small glacier, as well as to the eastward between it and (4) the Aiguilles des Charmoz, a many-headed group of sharp points difficult to define. I have marked on the map the position of two of the chief heads.[4] The Aiguille des Charmoz branches into two, one arm descending steeply to Trélaporte, the other embracing the Mer de Glace all the way to the Montanvert.

Elevations above the Sea

It has already been observed that the heights of the various stations have been referred to the level of the Montanvert, which thus becomes our starting-point. This level has not hitherto been very accurately ascertained. De Saussure (*Voyages*, § 607) calls it 428 toises above the valley of Chamouni, or 954 above the sea, without stating upon what this measure is founded,—probably on a single barometrical observation. It gives

6101 English feet.

Berger, quoted by Alphonse de Candolle,[5] gives

994 toises = 6357 English feet,

while Shuckburgh[6] obtained 5001 English feet above the Lake of Geneva, or above the sea

6231 English feet.

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1 [This is the Col du Midi, which is neither easy nor safe, but is far from inaccessible on the Bossons side.]

2 [This is now usually the case.]

3 [The Dent du Requin.]

4 [Really the Blaitière, the Grépon, and the Charmoz all rise round one and the same glacier—that of Nantillons.]

5 *Hypsométrie des Environs de Genève*, p. 63. A most useful work.

6 *Ibid.* There appears to be some error in De Candolle's reduction of this observation to the level of the sea. Compare *Phil. Trans.*, vol. lxvii. p. 592.

If we add 32 feet to De Saussure's measure for the admitted error of his earlier estimation of the height of the Lake of Geneva,[1] it becomes 6133, and taking the mean of these three not very concordant observations, we obtain—

Height of Montanvert, mean of Berger, Shuckburgh, and De Saussure, 6242 English feet.

But the height usually adopted is the smallest, or De Saussure's.

During my stay at the Montanvert, in June, July, and August, I frequently observed my barometer near the hours of regular observation at the Geneva Observatory, as well as the attached and detached thermometers. The barometer having been broken on the 6th August, an end was put to these comparisons. It had been carefully compared by M. Plantamour with the Geneva barometer, and found (after fourteen comparisons) to stand only 0·08 millimètre higher, a quantity so small, considering the uncertainties of a Syphon barometer (it was of Bunten's construction), that I have left it out of account.

Now the mean of twenty-seven comparisons gives

	Mm.	Att. Ther.	Det. Ther.
Montanvert .	610·35	12°·82 Cent.	9°89 Cent.
Geneva Observ.	728·50 (reduced to)	0 „	19°04 „

whence we obtain the height—

By the tables of the "Annuaire" . . . 4960·39 English feet.

By Baily's Table . . . . 4960·64 „

The height of the barometer in the observatory at Geneva is 407 mètres above the sea,[2] or . . . . 1343 English feet.

Montanvert above the sea, 6303

a result nearly 200 feet greater than De Saussure's, and 60 feet greater than the mean of the three old observers. Nevertheless, as the previous observations were, so far as I know, single and isolated, I feel bound to adopt the new value, considering the number and advantageous circumstances of the observations. It is also confirmed in a striking, though no doubt partly accidental manner, by the measurement of the Col du Géant, which, adopting the height just given for the Montanvert, by comparison with the barometer at the Montanvert, is 11,144 feet above the sea, whilst by direct comparison with Geneva, I find 11,146.[3] The

[1] *Hypsométrie des Environs de Genève*, p. 8.

[2] Meteorological Tables in *Bibliothèque Universelle*.

[3] [The height of the Montanvert is 6267 feet, and that of the Col du Géant 11,060 feet. The level road between Les Praz and Les Tines is 3540 feet.]

barometer of the Montanvert was hung at the usual height above the floor of the inn or "pavillon," which may, therefore, be reckoned at exactly 6300 feet. But the point taken as station M is the eave of the roof, and about ten feet higher, wherefore,

Level of station M above the sea . . 6310 English feet.

The mean level of the base line appears to be 3552 feet above the sea, which is, therefore, the height of the valley of Chamouni in that place.

Slope of the Glacier.—The source of the Arveyron, according to De Candolle, is 805·6 mètres, or 2643 English feet below the Montanvert. The ledge of rock over which the western side of the glacier discharges itself is near the level of the station of the Chapeau, which is 923 feet below the Montanvert. The height of that precipice is, therefore, about 1700 feet. The length of the final sweep of the glacier, from the top of the precipice to the source of the Arveyron, is about 4500 feet, following the curve; hence the mean slope of this part of the glacier (which is much dislocated and confused) is 20° 41′ 41″.

The level of the ice near the western bank, a little below the position of the Montanvert, at the point marked D 2 on the map, is 285 feet (determined trigonometrically) below station D, which is on the level of the Montanvert nearly. Hence, between the west edge of the precipice and the Montanvert, the surface of the glacier rises by about 638 feet, on a distance of 3000 feet, being an inclination of 12° 0′ 22″.

Again, from Montanvert, or rather the point D 2, reckoned along the glacier to station A, opposite the Angle, is a distance of 5200 feet. The level of station A is (barometrically) 131 feet above Montanvert, therefore 416 feet above D 2, giving a mean inclination of 4° 34′ 26″.

From station A to the foot of the Tacul, reckoning parallel to the axis of the glacier, is a distance of about 10,520 feet. Now, by three barometrical observations, the Cabane at the Tacul, near the level of the lake, is 1003, 990 and 997 feet,[1] mean 997, which may be increased by 30 feet, to bring it to the level of the glacier in this place, making 1027 feet, or a rise of 896 feet from station A, which gives a mean inclination of 4° 52′ 5″.

If we reckon along the glacier, from station A to station C,

[1] One day's observations have been neglected which had not corresponding ones, and of which the result was 70 feet above the mean of the others.

the "Pierre Plate," we have a distance of 10,600 feet. The level of C, by two barometrical observations, on different days, is 1076 or 1097 feet above Montanvert; mean 1086, which gives 955 above station A. The mean inclination from A to C is, therefore, 5° 5′ 53″.

From station C to station E is a distance of 6800 feet along the ice. A single barometrical observation gives 1668 feet above Montanvert for the level of the centre of the glacier there. I prefer, however, to deduce it from the trigonometrical height of station E, or 1623; and we may suppose the highest part of the glacier there to have a height of 1600 feet, or 514 above station C, giving an inclination of 4° 19′ 22″.

On the whole, from the precipice of ice opposite the Chapeau, where the ice becomes broken and discontinuous, to this point E, not far from the proper origin of the Glacier de Léchaud, is a distance of 25,600 feet, and a rise of 2520 feet, giving a mean inclination of 5° 37′ 19″.

I should have multiplied these observations much more, had not my barometer been unfortunately broken. In particular, I regret not to have taken the height [1] of the Glacier du Géant, at the foot of La Noire. But if we reckon the entire course of that glacier up to the Col du Géant, we find the distance of the latter from the Tacul to be 24,700 feet, and its rise 3814 feet, giving an inclination of 8° 46′ 40″.

Taking the entire length of the Glacier des Bois, Mer de Glace, and Glacier du Géant from the source of the Arveyron to the Col du Géant, we have a distance of about 47,920 feet, with a rise of 7484 feet, being a mean inclination of 8° 52′ 36″, but the higher and lower parts are precipitous.

Heights of Mountain Tops.—From the various stations several of the principal mountain tops which admitted of accurate triangulation were observed, and their elevations taken, which were then reduced to the Montanvert, and thence to the level of the sea. The differences in the following table [2] for the same

[1] [This is 8258 feet.]

[2] [To economise space the column giving the heights of the various peaks above the Montenvers is here replaced by one giving the absolute heights according to M. Kurz's excellent map. Forbes's "Dru 2" is, from the remark at the end of the table, the Grand Dru, which is visible from Chamonix though not from the Montenvers. Forbes's "Aiguille de Léchaud" is, according to his map, the true Aiguille de Talèfre, but the discrepancy in the heights assigned to the same peak contrast strongly with the more or less close approximations between the two sets of figures.]

summit arise almost entirely from the impossibility of determining the geometrical summit of the hill accurately, not one of these peaks being accessible.[1] A very small error in the distance entails a very sensible one on the height, on account of the great angles of elevation.

Mountain.	Station whence observed.	Distance.	Corrected Elevation.			Height above Station.	Mean height above the Sea.	Heights on Kurz's Map.
			Deg.	Min.	Sec.	Feet.		
Aiguille du Dru, No. 1 .	L O		25	27	45	5002	12,178	12,245
Aiguille du Dru, No. 2 .	G B	9,541 12,916	27 19	42 50	15 15	5012 4663	12,245	12,320
Aiguille des Charmoz . .	B H	7,750	25	16	15	3660	10,944	11,293
Aiguille du Moine . .	B G E	7,553 7,059 9,250	24 28 19	45 45 11	15 15 45	3684 3875 3222	11,109	11,198
Aiguille Verte . . .	G [γ]	12,350	26	39	15	6202	13,432	13,541
Jardin, highest point . .	B [γ]	11,750	11	6	15	2309	9,893	9,833
Tour des Courtes . .	B [γ]	18,000	14	7	15	4535	12,119	12,510
Aiguille de Léchaud . .	H B	8,400 9,760	22 18	18 42	45 45	3449 3308	10,914	12,268
Petites Jorasses . . .	G H B	20,174 14,100 14,628	13 18 17	58 31 43	45 45 15	5030 4730 4678	12,246	12,002
Grandes Jorasses . .	G H E	19,786 14,556 9,356	17 22 30	32 44 18	15 45 45	6261 6106 5472	13,496	13,797
Aig. du Tacul, east summit	G H	11,400 6,560	18 28	10 21	15 45	3744 3542	11,002	11,280
Mont Mallet	E G	11,730	23	37	45	5135	13,068	13,085
Aiguille du Géant . .	G H B	18,306 15,111 12,695	17 20 23	31 7 35	15 45 15	5920 5546 5530	13,099	13,170
Croix de Flégère . . .	M I	13,200	0	32	45	122	6,188	6,158

The Aiguille Verte is called the Aiguille d'Argentière in some maps, I think erroneously, as by Sir George Shuckburgh.—*Phil. Trans.* vol. lxvii.

It may be doubted whether the Mont Mallet is not as high as the Aiguille du Géant.

The Aiguille du Moine is the Aiguille du Talèfre of De Saussure.

The Promontory of Trélaporte is called Entre la Porte by the older writers.

The Aiguille du Dru, No. 1, is that visible from the Montanvert. No 2 is a higher summit in the direction of the Aiguille Verte, which is invisible from the Montanvert.

[1] [This was not true, even in 1842, of the Flégère.]

These heights vary in several particulars from those previously given, especially by De Saussure. Those of the Grandes Jorasses and Aiguille du Géant in the preceding table have been verified with especial care. The former is 300 feet greater, the latter no less than 800 feet less than the previous determinations. According to Pictet and De Saussure, the order of elevations of mountains, after Mont Blanc, would be—

Géant, *Verte,* *Jorasses.*

By the preceding table, the heights of the Grandes Jorasses and the Aiguille Verte are almost the same, and come next to that of Mont Blanc,[1] whilst the Aiguille du Géant and Mont Mallet are 400 feet lower. The following table contains the heights above the sea of points mentioned in this chapter from my own observations, and the best of those formerly made; the latter I have taken chiefly from De Candolle's *Hypsométrie des Environs de Genève,* and reduced them to English feet.

	J. D. F., 1842.	Other Authorities.		Kurz's Map, 1896.
	Eng. Feet.	Eng. Feet.		Eng. Feet.
Mont Blanc . . .	...	15,744	French Engineers	15,782
Grandes Jorasses . .	13,496	13,192·5	Pictet	13,797
Aiguille Verte . .	13,432	13,402	Shuckburgh	13,541
Aiguille du Géant . .	13,099	13,875	Saussure	13,170
Mont Mallet . . .	13,068	...	...	13,085
Aiguille du Midi . .	...	12,822	Saussure	12,608
Petites Jorasses . .	12,246	...	...	12,002
Aiguille du Dru, No. 2 .	12,245	...	...	12,320
Aiguille du Dru, No. 1 .	12,178	12,520	Pictet	12,245
Tour des Courtes . .	12,119	...	...	12,510
Col du Géant . . .	11,146	11,172	Saussure	11,060
Aiguille du Moine . .	11,109	...	...	11,198
Aiguille du Tacul . .	11,002	...	...	11,280
Aiguille des Charmoz .	10,944	9,131	Pictet	11,293
Aiguille de Léchaud[2] .	10,914	...	...	12,268
Grands Mulets . .	...	9,996	Barry	10,030
Jardin (highest point) .	9,893	...	...	9,833
Jardin	...	9,042	Pictet	...
Glacier de Talèfre . .	...	8,530	Pictet	...
Station G*	8,466	...	...	8,366 (Aiguille)
Station E ; Léchaud .	7,933	...	...	...
Station B ; Tacul . .	7,584	...	...	...
Tacul, Lake	7,300	...	...	...
Station H ; Couvercle .	7,487	...	...	...
Station C ; Pierre Plate	7,389	...	...	...
Station G ; Trélaporte .	7,230	...	...	...

1 [See note on p. 90 above.] 2 [That is the true Aiguille de Talèfre.]

	J. D. F., 1842.	Other Authorities.		Kurz's Map, 1896.
	Eng. Feet.	Eng. Feet.		Eng. Feet.
Station L ; Charmoz	7,177	...	...	...
Station F ; Echelets	6,833	...	...	...
Station A ; L'Angle	6,434	...	...	...
Montanvert, level of floor	6,300	6,242	Mean of 3	6,267 (Inn)
Station I ; Chapeau	5,387	...	..	5,279
Source of the Arveyron	...	3,667	De Candolle	...
Station O ; Tines	3,578	...	...	3,540
Station N ; Praz	3,539		...	...
Chamouni	...	3,425	Mean of several	3,416

A very few words remain to be said respecting the construction of the map [of the Mer de Glace] accompanying this work.

The sides of the fundamental triangles were, as we have seen, computed from the observations. They were then laid down on a scale of $\frac{1}{10000}$ of nature. It is much to be regretted that the practice of adopting a *natural*, instead of an arbitrary scale has not yet found its way into maps laid down in this country. It has the very obvious advantage of at once conveying to the mind an idea of the real scale on which the map is drawn, which cannot be the case otherwise, unless the person is acquainted with the local measures used as a standard. The scale of six inches to a mile offers no idea to a person accustomed to a scale of mètres or of French leagues, but a fractional scale of nature is the same in Germany, France, or England, and maps drawn to any scale may very readily be reduced to another, provided a convenient series of sub-multiples of the natural magnitude be used. A scale of $\frac{1}{10000}$ of nature is 6·336 inches to a mile, or somewhat greater than the recent Ordnance Survey of Ireland. The details of the ice, and outlines of the glacier, as far up as the Tacul, were also filled-in on the same scale. The more general map was drawn out roughly by myself on a scale of $\frac{1}{20000}$. It was then reduced by the pentagraph to $\frac{1}{25000}$, and drawn out, under my own eye, in a very artist-like manner, by Mr. Knox, the principal draughtsman of Messrs. Johnston, engravers in Edinburgh. It has been also engraved by them. The aim has been to preserve distinct the three characters of glaciers, moraines, and solid rock; these were distinguished by colouring in detailed eye-sketches taken on the spot; and an endeavour has been made, I hope not ineffectually, to preserve their character in the engraving.

The geographical position of the district of country contained in the map may be most correctly inferred from the position of Mont Blanc, as determined by the French Engineers. According to them, it has for

Latitude	45° 49′ 58″·84 N.
Longitude, East of Paris . .	4° 31′ 42″·52 „
——— Greenwich,	6° 52′ 6″·5 „

In 1832 I made observations for the latitude and longitude of Chamouni, by altitudes of Polaris for the former, and by a chronometer for the latter. The details are given in a paper in the *Philosophical Magazine* for 1833,[1] and the results are—

Chamouni, Lat. 45° 55′ 54″ N.
Long. 6° 51′ 15″ E. of Greenwich.

In the former edition (1843) of this work the magnetic variation was assumed to be 19° W., the same as at Geneva, in the absence of direct observations for placing the true meridian on the map. This has been since supplied by direct observations of altitude and azimuth of the sun from station D, near Montanvert, on September 13, 1843, from which it appeared that the *true* bearing of the line DD 1, is 83° 31′·5 E. of N. From this datum the cardinal points have been laid down; but the map is drawn by the *magnetic* meridian, the south above, and the north below.

[1] New series, vol. ii. p. 61. To these we may add De Saussure's determination of the latitude of the Col du Géant, viz. 45° 49′ 54″.—*Voyages*, § 2036.

CHAPTER VII[1]

ACCOUNT OF EXPERIMENTS ON THE MOTION OF THE ICE OF THE MER DE GLACE OF CHAMOUNI

Glacier motion a mechanical problem—Contradictory opinions respecting it—Experiments commenced—Daily motion detected—Motion by day and by night—Hourly motion—Centre moves fastest—Table of results—Laws of glacier motion from observation—As respects the length and breadth of the glacier—The season of the year, and state of the thermometer—Changes of level of the ice at different seasons.

> The glacier's cold and restless mass
> Moves onward day by day.
> BYRON.

FROM the time of my being introduced to the Theories of the Formation and Maintenance of Glaciers, maintained by M.M. De Charpentier and Agassiz, it had struck me as very singular that no *numerical tests* had been applied to ascertain their insufficiency, or to prove their correctness. A careful perusal of the writings of these and other ingenious authors had left on my mind no clear demonstration of any fact connected with the *cause of progression* of glaciers. Yet this surely lies at the very basis of any speculation respecting the causes of their existence and perpetuation, as well as their formerly greater extent and geological agency. Most of the arguments in favour of the progression being due to water absorbed by capillary fissures, and then frozen so as to produce dilatation in the whole mass, were deduced from considerations either *a priori*, or at least indirect. In 1841 I suggested to M. Agassiz the use of coloured liquors

[1] [This chapter is here retained intact, on account of its historical value as containing the first precise observations as to the motion of a glacier. Many such measurements have been made later on glaciers in all parts of the Alps, but in this respect Forbes led the way.]

to act as the injections of an anatomical preparation, in showing the fissures and capillary canals of the ice; but no such satisfactory mode occurred to me of proving directly the fact of congelation in the mass; to which, besides, there appeared to me objections arising from first principles so insurmountable as to render anything short of the most unequivocal demonstration unsatisfactory. On studying the subject at home and leisurely, I satisfied myself that experiments could be made upon the motion of the ice, which should, in a good degree, throw light upon the question. The question is reduced to one of pure mechanics, and should be treated as such by a rigorous analysis. The *motion* is the thing to be accounted for. Have the laws of the motion been determined? Have we the data of the problem of which we seek for the solution? Had not observatories existed for centuries, and empirical astronomy arrived at a very great degree of precision, the theory of Newton would have been baseless speculation. In fact, it never could have existed at all, its very essence consisting in its comformity to certain facts respecting the motions of the planets far from obvious, and the result of elaborate observation and still more elaborate efforts of combination and reduction. No doubt, many problems are so simple as not to require so elaborate a mechanism as that by which the theory of planetary motion was successfully reduced to law; and under the supposition that the glacier problem was a very simple one, and only required a general knowledge of elementary mechanics to explain it in an obvious way, De Saussure and other writers first treated it—and others followed with unhesitating assent—until De Charpentier had the courage to expose the difficulties which the sliding theory involved. But, from this moment, the glacier theory required a more elaborate analysis than had yet been given to it. The mere fact of motion seemed explicable in various ways, but to each, substantive, if not unanswerable, objections might be urged. From this moment, it became necessary to submit the phenomena to analysis, and to ascertain the Law of Variation of the Quantity of Motion, in terms of some of those varying agents which were supposed to influence that motion. Such a comparsion, such a reduction of *circumstances to measures*, has operated, in every science, in the most wonderful manner in reducing guesses to certainties. In geology, it is unfortunately not possible to ascertain the measure of effects in terms of their supposed causes, because (in the opinion of most geologists) the effects and their causes have ceased or been greatly modified, and, not reproducible by human agency nor recurring at known periods, a looser kind of induction must be tolerated in that science. The glaciers have had their phenomena more closely linked to the sciences of observation than to those of experiment—to natural history rather than natural philosophy; and hence a problem which is, in the first instance, one of pure mechanics—the motion of a mass, the nature, intensity and direction of whose cause of motion is to be ascertained,—has been left to be discussed on mere grounds of probability, or the adequacy of supposed causes to produce a certain kind of effect, of which the degree and circumstances had remained almost unstudied.

It was, accordingly, matter of the greatest surprise to me, to find that those ingenious persons who had been engaged for years in the study of glaciers, and in maintaining their theories of their motion by many curious analogies, and observations of structure, and the like, should not have thought of determining the motion accurately, with reference to season, weather, inclination of surface, alternation of day and night, and at different points of the length and breadth of the glacier. I suggested one experiment of this kind, which seemed to me to be critical:—

"If De Saussure's theory be true, the glacier moves onward without sensibly incorporating new matter into its substance—continually fed by the supplies from behind, which form a new and endless glacier. The mechanism may not inaptly be compared to that of the modern paper machine, which, from the gradually consolidated material of pulp (representing the névé) at length discharges, in a perpetual flow, the snowy web. The theory of De Charpentier, on the other hand, represents the fabrication of the glacier going on within the glacier itself, so that each part swells, and the dilatation of each is added to that which acted upon itself, in order to shove on the section of the ice immediately in advance. *In the former case, then, the distance between two determinate points of the glacier remains the same; in the latter, it will continually increase.* Again, *on the former hypothesis, the annual progress of any point of the glacier is independent of its position; on the latter, it increases with the distance from the origin* (*the transverse section of the ice being the same*). The solution of this important problem would be obtained by the correct measurement, at successive periods, of the spaces between points marked on insulated boulders on the glacier; or between the heads of pegs of considerable length, stuck into the matter of the ice, and by the determination of their annual progress."[1]

We have seen that the *motion* of glaciers has been for much more than half a century universally admitted as a physical fact. It is, therefore, most unaccountable that the *quantity* of this motion has in hardly any case been even approximately determined. I rather think that the whole of De Saussure's writings contain no one estimate of the annual progress of a glacier, and if we refer to other authors we obtain numbers which, from their variety and inaccuracy, throw little light on the question. Thus, Ebel gravely affirms[2] that the glaciers of Chamouni advance at the rate of 14 feet a-year, and those of Grindelwald 25 feet a-year; whereas, as we shall see, such spaces are actually traversed by most glaciers in the course of a few days. This statement is quoted by Captain Hall,[3] and other recent writers, and even by M. Rendu (now Bishop of Annecy), the author of a most ingenious paper on glaciers, too little known.[4] Hugi[5] perceived the errors arising from a confusion between the rate of *apparent* advance of an increasing glacier into a warm valley, whilst it is continually being shortened by melting, and the rate of motion of the ice itself.[6] He points out the correct method of observation: and although his work contains no accurate measures, he was perhaps the first who, by observing the position of a remarkable block upon the Unteraar Glacier, indicated how such observations might be usefully made, instead of trusting (as appears to have been the former practice) to the vague reports of the peasantry. Hugi's observations on the Unteraar Glacier give a motion of 2200 feet in nine years, or about 240 feet per annum.[7] Now, in contradiction to this, it would appear from M. Agassiz's observations, that from 1836 to 1839, it moved as far as in the

[1] *Edinburgh Review*, April, 1842, p. 77.

[2] *Manuel du Voyageur*, Art. "Glacier."

[3] *Patchwork*, vol. i. p. 109.

[4] *Mém. de la Société royale académique de Savoie*, vol. x. p. 95. [Reprinted at London, 1874, with a translation by Mr. Alfred Wills.]

[5] [His observations were made in 1827, 1829-30, 1832, and 1836-37; those of Agassiz commenced in 1839. Forbes did not apparently know of Hugi's *later* work, *Ueber das Wesen der Gletscher* (1842).]

[6] *Naturhistorische Alpenreise*, p. 371.

[7] Agassiz, *Études*, p. 150.

preceding nine years—that is, three times as fast.[1] There is reason, however, to think that M. Hugi's estimate is the more correct.

Bakewell[2] assigns 180 yards per annum as the motion of the Mer de Glace, and De la Beche[3] 200 yards, on Captain Sherwill's authority.[4] But both of these were hearsay estimates by the guides. M. Rendu seems to have been more aware of the importance of the determination of the rate of motion of glaciers than any other author; but the best information which he could collect in 1841 did not much tend to clear up his doubts. He gives the following rates of motion of the Mer de Glace, or Glacier des Bois, without being able to decide upon which is the most trustworthy: 242 feet per annum; 442 feet per annum; a foot a-day; 400 feet per annum; and 40 feet per annum, or *one-tenth* of the last!—a difference which he attributes to the different rates of motion of the centre and sides.[5] De Charpentier, so far as I recollect, offers no opinion in his work on glaciers as to what is to be considered as their rate of motion. I was not, therefore, wrong in supposing that the actual progress of a glacier was yet a new problem, when I commenced my observations on the Mer de Glace in 1842.

I had myself been witness to the position on the Unteraar Glacier in 1841 of the stone whose place had been noted by Hugi fourteen years before, and it was manifest that it had moved several thousand feet. In conformity with the prevalent view of the motion of the ice being perceptible chiefly in summer, I made the hypothesis that the annual motion may be imagined to take place wholly during four months of the year, with its *maximum* intensity, and to stand still for the remainder. With this rude guide, and supposing the annual motion of some glaciers to approach 400 feet *per annum* (as a moderate estimate from the previous data), we might expect a motion of at least 3 feet *per diem* for a short time in the height of summer. There appeared no reason why a quantity ten times less should not be accurately

[1] Agassiz, *Études*, p. 150. As conjectured in the text, Hugi's estimate has been almost exactly confirmed. Experience too has shown that the motion of glaciers is almost uniform from year to year. The enormous error of his successors on the Unteraar Glacier is therefore attributable to a want of the most ordinary attention to accuracy, and shows how little such considerations were deemed important by them (1845).

[2] *Travels in the Tarentaise*, vol. i. p. 365. [3] *Geological Manual*, p. 60.

[4] 100 yards, in *Philosophical Magazine*, January, 1831.

[5] *Mémoires, etc.*, vol. x. pp. 85 and 94, 95 [pp. 73 and 84 of the 1874 reprint].

measured, and I, therefore, felt confident that the laws of motion of the ice of any glacier in its various parts, and at different seasons, might be determined from a moderate number of *daily* observations.

I went to Switzerland, therefore, fully prepared, and not a little anxious to make an experiment which seemed so fruitful in results, and though so obvious, still unattempted.

The unusually warm spring of 1842 gave me hopes of commencing my operations earlier than the glaciers are usually frequented; and it was evident, that, to detect the effect of the *seasons* on the motion of the ice, they could not be too soon begun. I left Paris on the 9th of June, by the *malle poste* for Besançon. After spending a day at Neuchâtel, I proceeded to Berne to visit M. Studer, and from thence I went to Bex, to make the acquaintance of M. De Charpentier, with whose geological and other writings I had so long been familiar. I only allowed myself a hasty visit to my friends at Geneva, and left that town with lowering weather, on the 23rd June, for Chamouni, determined to await its clearing, and then proceed at once to the Mer de Glace. No patience was, however, required. The weather cleared that very day, and reaching Chamouni early on the following one, I made the requisite arrangements at the village, and, leaving my baggage to follow, I proceeded straight to the Montanvert.

I resolved to commence my experiments with the very simple and obvious one of selecting some point on the surface of the ice, and *determining its position with respect to three fixed co-ordinates*, having reference to the fixed objects around; and, by the variation of these, to judge of the feasibility of the plans which I had laid out for the summer campaign. One day (the 25th) was devoted to a general *reconnaissance* of the glacier, throughout a good part of its length, with a view to fixing permanent stations; and the next I proceeded, at an early hour, to the glacier opposite to the rocky promontory on the west side of the glacier, called *L'Angle*, thirty minutes' walk from the Montanvert, which presented a solid wall of rock in contact with the ice, so that upon the former, as upon a fixed wall or dial, might be marked the progress of the glacier as it slid by.

The instrument destined for all these observations was the small astronomical circle, or $4\frac{1}{2}$-inch theodolite already described, supported on the portable tripod. A point of the ice whose motion was to be observed, was fixed by a hole pierced by means of a common blasting iron or *jumper*, to the depth of about two feet. At first, I was much afraid of the loss of the hole by the melting of the ice, and the percolation of water from day to day; but I soon found that very little precaution was necessary on this account, and that such a hole is really a far more permanent mark than a block of stone several tons in weight resting on the ice, which is very liable to change of position, by being raised on a pedestal, and finally slid into some crevasse.

An accurate vertical hole being made, the theodolite was nicely centred upon it by means of a plumb-line, and levelled. A level run directly to the vertical face of rock gave at once the co-ordinate for the *vertical* direction, or the height of the surface of the glacier. The next element was the position or co-ordinate parallel to the length or direction of motion of the glacier. This was obtained by directing the telescope upon a distant fixed object, nearly in the direction of the declivity of the glacier, and which object was nothing else than the south-east angle of the house at the Montanvert, distant 5000 feet. The telescope was then moved in azimuth exactly 100° to the left, and thus pointed against the rocky wall of the glacier, which was here very smooth and nearly perpendicular, owing to the friction of the ice and stones. My assistant (Balmat) was stationed there with a piece of white paper, with its edge vertical, which I directed him by signs to move along the surface of the rock until it coincided with the vertical wire of the telescope. Its position was then marked on the stone with a common pencil, and the positions of successive pencil marks were carefully measured by a tape or ruler from day to day. Marks were then indented in the rock with a chisel or pick-edged hammer, and the mark painted red with oil paint, and the date affixed. These marks, it is believed, will remain for several years. The station on the ice (marked A on the map), was distant 250 feet from the rock, and, by repeating the observation frequently, I found that it could be depended on to about one-fourth or one-third of an inch.

The third co-ordinate, or that which should measure the distance of A from the rock, was not so accurately ascertained. No ready means offered itself for ascertaining with quickness and accuracy any variation of distance in respect to the breadth of the glacier. Whilst I admit that this would have been an advantage, I may observe that in most cases there is no reason to doubt that the motion of the ice is sensibly parallel to its length, and that any small error in the direction would scarcely affect the result. The direction of motion of the ice is unequivocally proved by the direction of the moraines, which are an external indication of that motion. In general, therefore, I have measured the movement of the ice parallel to the moraines where they were well marked. I am of opinion, however, that a check of some kind, such as the measurement of a third co-ordinate, would be advantageous where applicable.

It was with no small curiosity that I returned to the station of the "Angle" on the 27th, the day following the first observation. The instrument being pointed, and adjusted as already described, and stationed above the hole pierced in the ice the day before, when the telescope was turned upon the rock the red mark was left far above, the new position of the glacier being 16·5 inches lower (that is, more in advance) than it had been twenty-six hours previously. Though the result could not be called unexpected, it filled me with the most lively pleasure. The diurnal motion of a glacier was determined (as I believe) for the first time from observation, and the methods employed left no doubt of its being most accurately determined. But a question of still greater interest remained behind. Was this motion a mean and continuous one, or the result of some sudden jerk of the whole glacier, or even the partial dislocation of the mass of ice on which I stood? This could only be tested by successive days' trial, and I awaited the result with doubt and curiosity. Of this I was persuaded, that if the motion should appear to be continuous, and *nearly* uniform, it could not be due to the mere sliding of the entire glacier on its bed, as De Saussure supposed; for, admitting the possibility of gravity to overcome such intense friction as the bed of a glacier presents, it seemed to me quite inconsistent with all mechanical experience that such a motion, unless so rapid as to be an accelerated one, and that the glacier should slide before our eyes out of its hollow bed (which would be an avalanche), could take place, except discontinuously, and by fits and starts. To this most elementary question no answer founded on direct experience is to be found, so far as I know, in any work; and although the whole theory might turn upon so simple a point, as whether the glacier *flows* down evenly or moves by jerks, opinions seem hitherto to have been divided.[1] On the 28th June I therefore hastened with not less interest to my post, and found that in $25\frac{1}{2}$ hours the advance had been 17·4 inches, nearly the same, though somewhat more rapid, than on the previous day. I no longer doubted that the motion was continuous, but I hastened to put it to a still more severe test, and likewise to make an experiment critical for the theory of congelation and dilatation. I proposed to compare the *diurnal* and *nocturnal* march. I fixed its position at 6 P.M. on the 28th, and next morning by six o'clock I was again stationed on the glacier. It had moved eight inches, or exactly half the mean daily motion already observed. The night had been cold; the ice was still frozen, though the temperature of the air had already risen to 40°; a thermometer laid on the ice stood at 36°. If congelation had resulted during the night, so as to freeze the water in the capillary fissures, nearly the whole motion of the twenty-four hours ought to have taken place whilst the glacier froze: but not at all: from 6 A.M. to 6 P.M. of the 28th the glacier advanced 9·5 inches, giving a total motion of 17·5 inches in twenty-four hours, somewhat greater than either of the preceding days, the motion appearing to increase as the warm weather continued and increased in intensity: at least so I interpreted it. The same afternoon I had no difficulty in detecting the advance of the glacier, during an interval of *an hour and a half*. The continuity of motion was thus placed beyond a doubt. The marks on the rock indicated a regular descent, in which time was marked out as by a shadow on a dial; and the unequivocal evidence which I had now for the first time obtained, that even whilst walking on a glacier we are day by day and hour by hour imperceptibly carried on by the resistless flow of this icy stream, with a solemn slowness which eludes our unaided senses, filled me with an admiration amounting almost to awe, whilst I foresaw with lively interest the definite and satisfactory knowledge of *laws* which would result from these methods of observation.

[1] I have found the true opinion, that of constant, insensible motion, to be held by almost all the intelligent mountaineers with whom I have spoken; a majority, I think, of whom also declare that the glacier advances during winter as well as in summer.

The following morning (30th June) at six o'clock the glacier was 8·5 inches in advance, and during the succeeding twelve hours of day 8·9 inches, making together 17·4 inches for the twenty-four hours, a result not differing sensibly from that of the day before.

I observed distinctly the progress of the glacier on the 30th from five to six o'clock P.M., and on this occasion, as on the day before, it appeared to me that the motion at that time of day was *more rapid* than the mean motion. The motion in twenty-four hours for those four days had been:—

15·2 :—16·3 :—17·5 :—17·4 inches;

a variation which I believed (and am persuaded) to be by no means accidental, but due to the increasing heat of the weather.

These results were the more interesting (and with respect to their regularity the more unexpected) because the spot where they were made was a part of the ice deeply crevassed. It had been selected on account of the proximity of the naked rock; but though the most solid accessible part of the ice was chosen for station A, it was surrounded by chasms in every direction, and the glacier in nearly all its breadth between the Angle and the Echelets is (in ordinary language) impassable on account of its dislocated and shattered condition. Yet amidst all this turmoil and confusion there were no fits of advance, no halts, but an orderly continuous progression.

But during the last week in June, in which, stimulated by the extraordinary fineness of the weather, and the fresh interest of every day's experiments, I spent from twelve to fourteen hours daily on the glacier, I was able to make other observations of interest to the theory, and not less consistent with one another. I fixed two points in the ice by bored holes a little way below the Montanvert, one near the side, the other near the centre of the glacier. Most authors, I believe, have asserted that the *sides* of the glacier move faster than the *centre*.[1] But this seemed worthy of proof. Stationing my theodolite, not upon the ice but upon the lofty western bank at the station D, on a great boulder 60 yards in a direction north 40° east (magnetic) from the south-east corner of the house of the Montanvert, I levelled it carefully, and then turning the telescope so as to

[1] See, for example, Agassiz, *Études*, p. 167.

point *across* the glacier to the rocks on the opposite side, by unclamping the telescope I caused it to describe a vertical great circle. I caused a tall cross to be painted in red bordered with white on a face of rock opposite, making an angle of 118° with the corner of the Montanvert already mentioned, and distant from D 2898 feet. The cross is marked D 1, and is a little to the north of a small cascade laid down in the map.

By pointing the telescope upon the cross, and then causing it to describe a vertical circle (like a transit instrument adjusted upon a meridian mark) the velocity of the different parts of the glacier could be determined as they flowed past. Two stations, as has been said, were first fixed upon and marked by vertical holes in the ice renewed from time to time; the first D 2 (see the map) was about 300 feet from the west bank of the glacier, therefore nearly corresponding in position to station A, which was 5200 feet higher up; the other, marked D 3, was 795 feet farther east, or rather beyond the centre of the glacier, being within 150 feet of the first moraine. It is, however, very near the centre.

	Side (D 2).	Centre (D 3).
From 29th June to 1st July the motion in 24 hours was . .	17·5 inches.	27·1 inches.

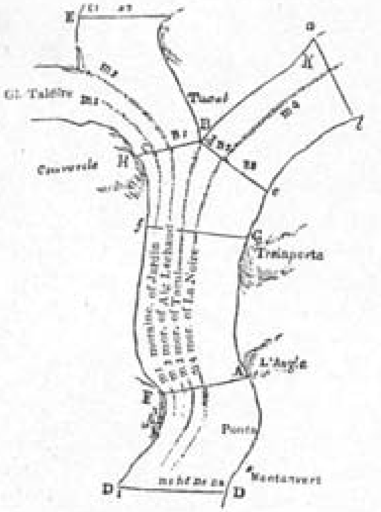
Here, then, was a difference not to be mistaken, and the near coincidence of the side station with the result at station A, I considered at the time confirmatory of its accuracy. Henceforth I entertained no doubt that the generally received opinion is incorrect, and that the glacier stream, like a river, moves fastest towards its centre.

In the same line across the glacier with D 2 and D 3, several other stations were afterwards fixed, with a view to test the modification of velocity depending on the distance from the bank or edge of the glacier. These measures proved that the velocity of the central parts is nearly alike, and that the greatest differences in velocity are close to the side, where friction may be expected to act exactly as in a current of water.

My next object was to ascertain the rate of motion of points of the Mer de Glace higher up and nearer its origin. For this purpose I fixed upon the remarkable large flat stone, or glacier table, formerly described, and marked C on the map. It lay on the Glacier de Léchaud, between the promontory of the Couvercle and the Tacul. Trusting to its apparent solidity, I did not apprehend that its position was likely to be speedily disturbed, and I fixed my instrument upon it over a red cross marked with the letter C. In this, however, I was deceived, for, three weeks later, I could no longer mount upon the stone by any effort, or even see its upper surface, and in the month of August it slipped off its pedestal of ice. This did not, however, alter the character of exactness of the observations made by means of it. It was but for a few days that I used the stone as I had done station A at the Angle, planting the theodolite upon it, fixing the azimuth by a distant object in the direction of the length of the glacier, and then turning the telescope through a certain number of degrees, and marking the progress of the ice upon the clean bare face of rock at the Couvercle. I soon, however, abandoned this plan, and stationing myself on a commanding spot of the promontory of the Tacul (station B), I directed the telescope upon a cross marked C 1, painted upon the opposite rock of the Couvercle, and causing the telescope to describe a vertical circle, I noted, exactly as at station D, the progress of the great stone C, as it flowed on with the glacier. Thus, between the 27th and 30th June, this mark had advanced $30\frac{3}{4}$ inches, or about 10·2 inches per diem, instead of 17 inches as at the *Angle*, and near the side of the glacier below the Montanvert, or 27 inches as at its centre. Hence it was quite certain that in this particular case the higher part of the glacier moved more slowly than the lower. Well aware, however, that this might be due to the variable section of the glacier, I made preparations for confirming it at different points, and still nearer the origin of the glacier, but at the season I have mentioned the higher parts were almost inaccessible from the quantities of half-melted snow which concealed the crevasses.

A week of singularly fine weather enabled me to obtain all the results which I have mentioned, and several others, previous to the 1st July, on which day I left the Montanvert, in order to proceed to Courmayeur and Turin, for the purpose of witnessing the total eclipse of the sun. In these few days I had satisfied myself of the applicability and certainty of the methods I had employed; and the marks which I left in the ice, with directions to Auguste Balmat to renew the holes, if necessary, promised me fresh results of interest on my return. In the meantime I communicated to my friend, Professor Jameson, the leading results which I had then obtained in a letter, dated the 4th July, from Courmayeur, which was afterwards printed in his Journal.[1]

After my return, the measurements were renewed on the 28th July, the holes having been all deepened in my absence by the care of Balmat. The rate of loss at the surface will be mentioned by and by. There was thus determined the motion, during one month, of the ice at station A, *L'Angle*, already mentioned; of two points in the breadth of the glacier at the Montanvert; of station C, and another point in the breadth of the Glacier de Léchaud, marked B 1, and of a point marked B 2 on the Glacier du Géant, opposite the Tacul, and at about the same distance as C and B 1 from the lower end of the glacier; B 1 and B 2 were observed in the way already described from station B.



At later periods, there were added the following points of observation, all of which are accurately laid down on the large map, but which will be more readily understood at a glance from the annexed woodcut, which shows their relative position.

D 4, D 5, and D 6, opposite station D, near the Montanvert; intermediate between D 2 and D 3, as shown on the map. D 4 and D 5 were on the same part of the glacier, but the mark, D 4, was suffered to disappear during one of my absences. Thus the order of stations, and their distances were—

E. edge glacier. { . . about 350 yds. D 3. . 60 yds. . D 6. . 75 yds. . D 5. 130 yds. . D 2. . 100 yds. } W. edge glacier.

On account of the steepness and discontinuity of the glacier farther down, it was not thought advisable to attempt to observe its velocity at a lower point.

1 [See *Occasional Papers*, pp. 9-12.]

Station A at the *Angle* was observed during the whole season, and the corresponding marks in red paint were continued on the rock. Between the end of June and the end of September the motion of the ice amounted to 103 feet.

After the great stone at station C had slipped from its icy pedestal, the velocity of the glacier was observed by means of a hole driven into the ice as at the other stations. In addition to mark B 2 on the small moraine of La Noire on the Glacier du Géant another point in the breadth of the same glacier was taken near its centre, and in the same right line from station B with the mark B 2. This line was determined by pointing the theodolite from station B upon the mark C 1, painted on the rock of the Couvercle, and then causing it to revolve through 115° to the left. The mark in the centre of the Glacier du Géant was distinguished as B 3. The position of the marks B 2 and B 3 were determined by angles from H. The only observation of velocity made during the season 1842 which I have rejected, is one of B 3. The daily velocity from August 2 to August 4 was 32 inches, whilst that of the neighbouring mark B 2 was only 14 inches. Although the proximity of the latter to the side of the glacier was a good reason that it should move slower, this disproportion seemed unlikely, and the experiment was immediately repeated. The next two days gave a velocity of 18 to the first, and 14·25 to the second, a proportion which was nearly preserved during the remainder of the season, and the former observation was rejected. The mark B 3 was fixed on the 2d August.

The next station, E, formerly described as being at the higher part of the Glacier de Léchaud, was used to determine the velocity of the ice at the side and centre of the glacier in that part. A mark, E 1, was placed 210 feet from the east edge of the glacier, and another, E 2, about 645 feet farther. These marks were established on the 29th July. The observation was made by fixing the instrument at station E, and directing the azimuthal wire of the telescope upon the sharply-defined apex of the singular rock opposite, called Le Capucin du Tacul; the telescope being then moved in a vertical circle, passed over the marks E 1 and E 2. A check reference was made to the prominent edge of the Pierre à Béranger, which, on one occasion, proved most serviceable. Owing to their great distance from the Montanvert, these points were not often visited.

I also established two corresponding stations on the higher part of the Glacier du Géant, on the 6th August, which were marked K 1 and K 2. Most unfortunately, after my return from a journey to Monte Rosa, in the beginning of September, I was prevented, by incessant bad weather and snow, from reaching this remote station, and repeating the observations, which therefore led to no result.

During the absence just alluded to, the holes at *all* the stations were visited by Auguste Balmat, and deepened, so as to preserve them for my return. I must record my gratitude for his zeal in accomplishing this fatiguing and not very agreeable task during his recovery from a rather severe illness, from which he suffered during my absence, brought on partly, I fear, by the fatigues and exposure which he underwent in my service.

My habit was to enter my observations in a journal, and reduce them immediately to the mean daily velocity of each point since the last observation, allowing for variations in the hours at which they were noted, if such occurred. The first of the following Tables contains the actual progress made by each part of the glacier, from the commencement of observations upon it, in inches and feet; the second contains the corresponding velocities, or motions in twenty-four hours, expressed in English inches.

TABLE I

GLACIER MOTION

RECKONED IN EACH CASE FROM THE COMMENCEMENT OF THE OBSERVATION

Near Montanvert (1). D 2.			Near Montanvert (2). D 4.			Near Montanvert (3). D 6.			Near Montanvert (4). D 3.			L'Angle. A.		
1842.	English. Inches.	English. Feet.	1842.	English. In.	English. Ft.	1842.	English. In.	English. Ft.	1842.	English. In.	English. Ft.	1842.	English. In.	English. Ft.
June 29	0	0	July 28	0	0	Sept. 17	0	0	June 29	0	0	June 26	0	0
July 1	35·0	2·9	Aug. 1	84·0	7·0	,, 20	59·1	4·9	July 1	54·2	4·5	,, 27	15·2	1·2
,, 28	518·5	43·2	,, 9	278	23·2	,, 26	179·7	14·9	,, 28	774·2	64·5	,, 28	31·5	2·6
Aug. 1	585·5	48·8				,, 28	227·1	18·9	Aug. 1	861·2	71·7	,, 29	49	4·1
,, 9	715·5	59·6							Sept. 16	1962·7	163·6	,, 30	66·4	5·5
Sept. 16	1390·5	116·5	D 5.						,, 17	1986·4	165·5	July 28	460·9	38·4
,, 17	1416·4	118·0							,, 20	2047	170·5	Aug. 1	515·4	42·9
,, 18	1430·2	119·2	Sept. 17	0	0				,, 26	2169	180·7	,, 9	633	52·7
,, 19	1443·3	120·3	,, 19	37·2	3·1				,, 28	2215	184·6	Sept. 16	1127	94
,, 20	1450·6	121·6	,, 20	57·5	4·8							,, 26	1238	103·2
,, 26	1544·8	128·6	,, 26	172·7	14·4									
,, 28	1583·8	132·0	,, 28	223·1	18·6									

Glac. de Léchaud. Pierre Plate. C.			Glacier de Léchaud. B 1.			Glacier du Géant. B 2.		
1842.	English. In.	English. Ft.	1842.	English. In.	English. Ft.	1842.	English. In.	English. Ft.
June 27	0	0	June 30	0	0	June 30	0	0
,, 30	30·6	2·5	Aug. 2	355	29·6	Aug. 2	454	37·8
Aug. 2	359	29·9	,, 6	395	32·9	,, 4	482	40·2
Sept. 17	758	63·2	Sept. 17	803	66·9	,, 6	510·5	42·5
						Sept. 17	949	79·1

Glacier du Géant. B 3.			Glacier de Léchaud. E 1.			Glacier de Léchaud. E 2.		
1842.	English. In.	English. Ft.	1842.	English. In.	English. Ft.	1842.	English. In.	English. Ft.
Aug. 4	0	0	July 29	0	0	July 29	8	0
,, 6	36	3	Aug. 2	45	3·7	Aug. 2	54	4
Sept. 17	564	47	,, 8	131	10·9	,, 8	152	12
			Sept. 25	672	56			

TABLE II

MEAN DAILY MOTION

D 2.	Inches.
June 29 to 1 July	17·5
July 1 — 28 ,,	17·3
,, 28 — 1 Aug.	16·2
Aug. 1 — 9 ,,	16·6
,, 9 — 16 Sept.	18·0
Sept. 16 — 17 ,,	16·9
,, 17 — 18 ,,	13·8
,, 18 — 19 ,,	13·1
,, 19 — 20 ,,	16·3
,, 20 — 26 ,,	14·2
,, 26 — 28 ,,	19·5

D 4.	
July 28 — 1 Aug.	21·0
Aug. 1 — 9 ,,	24·7

D 5.	
Sept. 17 — 19 Sept.	18·6
,, 19 — 20 ,,	20·3
,, 20 — 26 ,,	19·2
,, 26 — 28 ,,	25·2

D 6.	
Sept. 17 — 20 Sept.	19·7
,, 20 — 26 ,,	20·1
,, 26 — 28 ,,	23·7

D 3.	Inches.
June 29 to 1 July	27·1
July 1 — 28 ,,	25·7
,, 28 — 1 Aug.	21·0
Aug. 1 — 16 Sept.	24·0
Sept. 16 — 17 ,,	23·7
,, 17 — 20 ,,	20·3
,, 20 — 26 ,,	20·4
,, 26 — 28 ,,	22·5

A.	
June 26 — 27 June	15·2
,, 27 — 28 ,,	16·3
,, 28 — 29 ,,	17·5
,, 29 — 30 ,,	17·4
,, 30 — 28 July	14·
July 28 — 1 Aug.	13·6
Aug. 1 — 9 ,,	15·4
,, 9 — 16 Sept.	13·0
Sept. 16 — 20 ,,	11·15

C.	
June 27 — 30 June	10·2
,, 30 — 2 Aug.	9·9
Aug. 2 — 17 Sept.	8·7

B 1.	Inches
June 30 to 2 Aug.	10·8
Aug. 2 — 6 ,,	10·0
,, 6 — 17 Sept.	9·7

B 2.	
June 30 — 2 Aug.	13·8
Aug. 2 — 4 ,,	14·0
,, 4 — 6 ,,	14·25
,, 6 — 17 Sept.	10·4

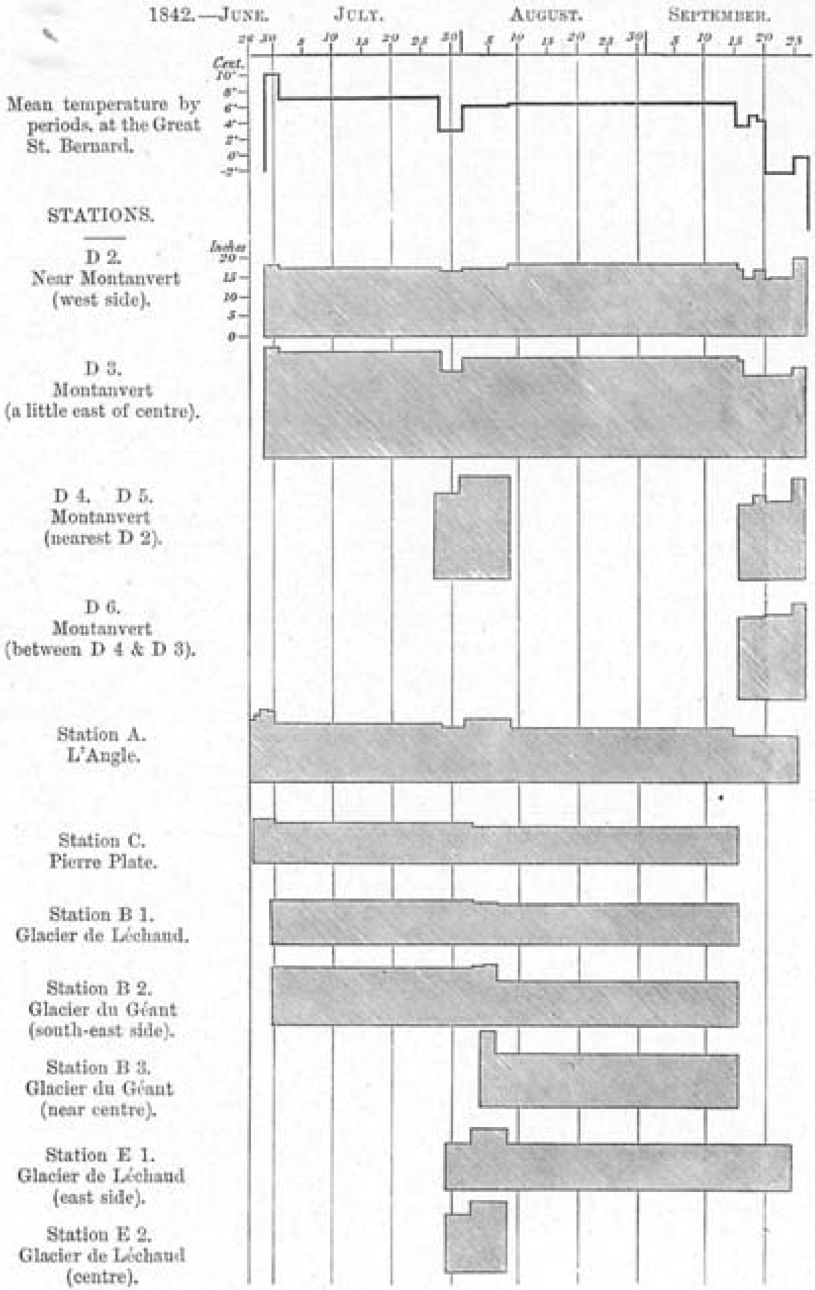
B 3.	
Aug. 4 — 6 Aug.	18·0
,, 6 — 17 Sept.	12·6

E 1.	
July 29 — 2 Aug.	11·3
Aug. 2 — 8 ,,	14·3
,, 8 — 25 Sept.	11·3

E 2.	
July 29 — 2 Aug.	13·5
Aug. 2 — 8 ,,	16·3

From the preceding tables, especially the second, we may gain a great deal of practical information. The consistency which

Diagrams of the Mean Rate of Daily Motion of Different Parts of the Mer de Glace of Chamouni, and the Corresponding Mean Temperature.



may be shown to subsist between their parts, inspires great confidence as to the results for this particular glacier, and shows that *a very few* experiments, as carefully made, would suffice to determine all that it is important to know respecting any other. A convenient way of representing the results to the eye, is to project the velocity of any point of the glacier by a vertical line, whilst the lapse of time is expressed by a horizontal line, whence the space moved over in the interval of any two times will be denoted by the area of the shaded spaces represented in the opposite figure. Had the velocities been measured daily, we should have had a curve whose height would have been constantly varying. As it is, we, of course, give to the velocity its mean value, and suppose it constant during the intervals of observation. An increase in the rapidity of motion of any part of the glacier, will be indicated by a rise in the serrated line; a decrease by a fall. A careful examination of the second Table, and of the Diagrams, will confirm the following deductions, more full and explicit than those which my first week's observations afforded, and which lay down, I believe for the first time, the General Laws of the Motion of a Glacier deduced from observation.

I. *The motion of the higher parts of the Mer de Glace is, on the whole,* SLOWER *than that of its lower portion; but the motion of the middle region is slower than either.*

I had not failed to point out, when I proposed the determination of the velocity of different points of a glacier, as a test of the cause of its motion, that this must depend materially upon the form of its section at different parts. The velocity of a river is greatest where it narrows, and is small in the large pools. Just so in the Mer de Glace. It is truly a vast magazine of ice, with a comparatively narrow outlet, as the map distinctly shows; the two glaciers of Géant and Léchaud, uniting just above the strait formed by the promontories of Trélaporte and the Couvercle. Hence results, as we have seen, the great ice-basin, where we have reason to conclude (as before observed), that the glacier attains a greater thickness than at any other part, and thus, though the breadth of the two confluent glaciers taken separately is greater than after their union, yet being shallower, their area of section is smaller, and therefore the velocity of the ice will be greater.

There will, indeed, be always a *condensation* of the ice within the triangle BHG (shown on the map), owing to the resistance opposed to its egress; and here, accordingly, the surface of the ice is most level. It is not indeed strictly true, that the quantity of ice passing through any section of the glacier in a given time, is exactly equal; because there is effusion and evaporation, amounting to an actual loss of substance, between any two sections, and this becomes especially obvious near the lower extremity of the glacier. It is like the well-known problem of the distribution of heat in a bar of iron come to a steady temperature, where the transfer of heat across any section of the bar is equal to the transfer across any other section nearer the source of heat, diminished by the amount radiated by the surface in the interval. There is, therefore, no ground for surprise at the fact, that the middle part of the glacier moves forward slower than the higher parts. Had the glacier *continued* to expand in breadth, as very many glaciers do, no check would have occurred, and the anomaly would have disappeared.

Since we have no accurate means of gauging the section of the glacier in any part, can we form any judgment of what would be the motion of the ice in a uniform canal, or draw any conclusion as to the *cause* of glacier motion? I think we can; but first let us place the observed law of velocity in a more concise shape.

The first station in order,—that at the mark D 2, a little below the Montanvert, and at 100 yards from the western edge of the glacier,—has been that, on the whole, most constantly observed throughout the whole season. Taking its motion as a standard of comparison, we may compare it with the motion of any other part of the glacier during the particular season when the latter was observed, and thus we shall obtain an *approximation* to the relative velocities of the different points of the glacier to D 2, taken as a standard. That this ratio depends in some degree on the season, will be shown farther on; still it affords the most ready way of obtaining a practical comparison. Thus, for example, it will be found, from Table I., that the point C of the glacier moved, between the 27th June and the 17th September, over 757·6 inches, whilst D 2 moved over 1579·8 inches, or more than twice the former. The exact ratio is 479 to 1000, which may be conveniently expressed by the decimal fraction ·479 for station C; and so of the others. Thus, the velocity-ratios of the different points are, as in the annexed Table:—

TABLE III.

Names of the Stations.	Relative Velocities of the Ice.
D 2	1·000
D 4, D 5	1·375
D 6	1·356
D 3	1·398
A	0·770
C	0·479
B 1	0·574
B 2	0·678
B 3	0·722
E 1	0·674
E 2	0·925

We may select from amongst these, the points most fitted for our purpose of comparison, those, for example, along the Mer de Glace and Glacier de Léchaud, not very distant from the edge, and therefore all retarded by the friction of the sides—

D 2	1·000
A	0·770
C	0·479
E 1	0·674

Let us observe then,—the mere mechanical constraint to which the glacier is subjected, by the form of its valley, would necessarily, and irrespective of all theory, infer a quicker motion at D 2 and A, than at C, where the glacier is near its greatest width, or at E, near its origin. These facts are, then, so far in conformity with the mechanical necessity alluded to. But again, if the cause of glacier motion were the expansion of the superior portion of the ice forcing down the lower end, that velocity (supposing the section constant) would be proportional to the distance from the upper end or origin. Now, to take a most extreme supposition, let us imagine the Glacier de Léchaud (see the map) to take its origin at the very foot of the Grandes Jorasses, which is 8000 feet beyond station E; then, on the Dilatation theory, the motion at E would be due to the expansion of 8000 feet of ice, by the congelation of infiltrated water. This, we will suppose, produced the mean daily motion of 14·2 inches in the height of summer. Then, considering only the influence of length, irrespective of section, the station D 2 is 23,000 feet farther down, or nearly four times as far from the Grandes Jorasses,—the velocity ought, therefore, to have been four times greater, or fifty-six inches per day. It was only 16·6 inches, or *one-seventh* part greater. And yet we have seen that the influence of *section* must have been to accelerate the motion in the lower part. I do not mean to say that the reasoning just issued is rigorous, but the results to which it leads are so wholly opposed to the truth, as to be, it seems to me, quite conclusive against the theory of Dilatation. We have two powerful glaciers uniting, forming a great *ice-pool*, which issues by a channel not wider than the smaller of its feeders; making all allowance for evaporation, we conclude, without difficulty, that, in order that the ice-stream still discharge itself, it must accumulate above the contraction, diminish in velocity there, and then rapidly increase in swiftness, as it issues through the opening, where it will certainly move faster than in either of the original tributaries, whose united breadth is far greater than the single channel of efflux. All this happens, as the simple mechanical theory of discharge without indefinite accumulation would indicate; but if we come to combine with this a theory of glacier motion which would require a velocity in the lower part of the glacier three times greater than we find it to be, we are entitled to reject the theory as inconsistent with facts, even although the mere statement, that the lower end of a glacier, on the whole, moves fastest, may appear to confirm it.

At present we have to do with the conclusions of our own observations, and not with other or hypothetical cases.[1] I may observe, however, that if a glacier widens uniformly, the *mere law of discharge without accumulation*, or change of volume, would give a diminishing velocity at the lower extremity. Such an occurrence would, evidently, be still more opposed to the theory of Dilatation.

II. The Glacier du Géant moves faster than the Glacier de Léchaud, in the proportion of about seven to six (compare B 1

[1] This First Proposition or empirical law has been carefully restricted to the "Mer de Glace" in particular, as in the above passage, and at pages 133, 135. But the conclusions regarding the Dilatation Theory have been more than confirmed by observations on other glaciers (1845). [See *Occasional Papers*, pp. 68-77.]

with B 2 and B 3 in Table III.). The vast mass of the former glacier tends to overpower the other, in some measure, and it takes the lion's share of the exit through the strait between Trélaporte and the Couvercle, squeezing the ice of Léchaud and Talèfre united into little more than one-third of the breadth of the whole. It is to this circumstance that I impute the excessively crevassed state of the eastern side of all the Mer de Glace, which renders it almost impossible to be traversed; the ice is tumultuously borne along, and, at the same time, squeezed laterally by the greater velocity and mass of the western branch. This is probably, also, the cause of the dislocation of the moraine of La Noire, opposite Trélaporte, mentioned page 81.

III. *The centre of the glacier moves faster* (as we have seen) *than the sides.* When two glaciers unite, they act as a single one in this respect, just as two united rivers would do. Now this variation is most rapid near the sides, and a great part of the central portion of the glacier moves with no great variation of velocity. Thus we find that four stations taken in order,[1] from the side to the centre of the glacier (or a little beyond it), have (by Table III.) the following rates of motion:—

1·000 1·375 1·356 1·398.

Or if we compare observations made all at the same season of the year (September), we shall find the increase of velocity in every case—

1·000 1·332 1·356 1·367.

The first point was 100 yards from the edge of the glacier; the next 130 yards farther. In this short space the velocity had increased above a third part.

The explanation which we offer of this, as due to the friction of the walls of the glacier, would lead us to expect such a law of motion. The retardation of a river is chiefly confined to its sides; the motion in the centre is comparatively uniform.

Similar reasoning would lead us to expect that (supposing the glacier to slide along its base) the portions of ice in contact with the bed of the valley will be retarded, and the superficial parts ought to advance more rapidly. The change in velocity in this case also will be greatest near the bottom.

[1] See page 137.

IV. *The difference of motion of the centre and sides of the glacier varies* (1) *with the season of the year, and* (2) *at different parts of the length of the glacier.*

1. The following numbers show the velocity-ratios of the centre and side of the glacier, near the Montanvert, at the marks D 3 and D 2, during different parts of the season 1842 :—

	Relative Velocity, D 3 : D 2.
June 29—July 1	1·548
July 1—July 28	1·489
July 28—September 16	1·349
September 16—September 28	1·367

In general, therefore, *the variation of velocity diminished as the season advanced ;* we shall presently show that it was very nearly proportional to the *absolute* velocity of the glacier at the same time.

2. *The variation of velocity with the breadth of the glacier* is least considerable in the higher parts of the glacier or near its origin. Thus, if we compare the velocities of station C, and the mark B 1 on the Glacier de Léchaud near the Tacul, the former being near the side, the latter near the centre of the glacier, we find—

	Relative Velocity, B 1 to C.
June 30—August 2	1·09
August 2—September 17	1·12

Again, higher up the same glacier, opposite E, we have the velocity-ratios at the centre and side of the glacier—

	E 2 : E 1.
July 29—August 2	1·19
August 2—August 8	1·14

This ratio is indeed a little greater than the preceding, which corresponds with the fact which we have already found, that the absolute velocity of the glacier is greater at E than at C. Hence it is highly probable in every case that *the variation of velocity in the breadth of a glacier is proportional to the absolute velocity, at the time, of the ice under experiment.* This is further confirmed by the velocities of the Glacier du Géant at the marks B 2 and B 3, of which the former is near the side, and the latter near the centre—

	Velocity-ratio, B 3 : B 2.
August 4—August 6	1·30
August 6—September 17	1·21

Now the absolute velocity of this glacier is greater than that of Léchaud, but less than that at the Montanvert.

V. *The motion of the glacier generally varies with the season of the year and the state of the thermometer.* Perhaps the most critical consideration of any for the various theories of glacier motion is the influence of external temperature upon the velocity. In this respect my observations, though confined only to the summer and autumn, are capable of giving pretty definite information. Indeed, one circumstance which on other accounts I had reason to regret, I mean the rigorous weather of the month of September, which hindered many of my undertakings, gave me an opportunity of observing the effect of the first frosts, and thus establishing some important facts as to the influence of cold and wet upon the glacier. This I apprehend to be clearly made out from my experiments, *that thawing weather and a wet state of the ice conduces to its advancement, and that cold, whether sudden or prolonged, checks its progress.* I may appeal generally to the curves of page 134 as showing the variations of velocity with the season. It is to be attended to in looking at these figures, that they only represent the *mean* motion during certain intervals which are not exactly the same at the different points, and that, therefore, the rises and falls do not appear always to coincide when they might actually do so, being lost in the average of a distinct period. A careful examination of them will, however, show that the variations of velocity have been remarkably general and simultaneous, and that we are entitled to look for a common cause.

This cause seems clearly to be found in the *temperature* of the air, combined with the degree of moisture which on a glacier usually accompanies a rise of temperature. The rapid movement in the end of June which is perceptible at D 2, D 3, A and C, is due to the very hot weather which then occurred, and the very marked reduction at the end of July, to a cold week which occurred at that period. The striking variations in September, especially at the lower stations, which were frequently observed, proved the connection of temperature with velocity to demonstration. During the continuance of cold weather, accompanied by snow, from the 18th to the 27th September, it will be observed that the glacier motion was visibly retarded at all the lower stations which were then observed. During this period the thermometer fell at the Montanvert to 20° Fahr.; but when mild weather set in again, the glacier became clear of snow (which took place in the lower part on the 27th), and being thoroughly saturated with moisture, it resumed a march as rapid as that in the height of summer.

This fact is surely most important as showing that we cannot possibly ascribe the motion of the glacier to the effect of congelation; for, saturated as the ice was by the effects of the damp and changeable weather of the month of September,—when a week of frost set in, everything must have been exactly in the condition to acquire a rapid increase of velocity, exactly in proportion as the cold penetrated the mass of the glacier, supposing that it did penetrate to a considerable depth, which I shall afterwards endeavour to prove clearly was not the case then, and *à fortiori* never can be the case in the height of summer, when the glacier motion is most rapid.

But I would further request attention to a still more direct proof of the dependence of the velocity of the glacier upon the external temperature. I have taken from the register, kept at the Great St. Bernard, the mean daily temperatures during the summer months of 1842. I have divided them into periods corresponding to those intervals at which the progress of the glacier at the point D 2 was ascertained; and I have taken the mean temperature of those periods. I find that in almost every instance a change of increase or diminution of mean temperature is accompanied with an increase or diminution of the glacier's motion. And when we consider the difference of position of the stations, the coincidence seems quite as perfect as we can reasonably expect. The convent of St. Bernard is 21 English miles distant from the Montanvert, in a right line, and 1900 feet higher;[1] but as many parts of the ice of the Mer de Glace have a still greater elevation, it may be supposed to represent pretty truly the conditions of climate to which the entire glacier was subjected.

A comparison of the first curve, or serrated line, in page 134, which represents the mean temperature of certain periods, with the curve immediately below, which shows the glacier motion for the same intervals, will fully justify the assertions just made.

I do not say that the velocity is always the same at the

[1] [Precisely 1844 feet.]

same temperature. In autumn the velocity was as great with a temperature of 0° Centigrade, as in summer with a temperature of 10° C. This was the case, however, only at the *side* of the glacier. Near its centre, as at D 3, it will be seen by the diagram that the motion is still more nearly conformable to the change of temperature. All that I infer from the comparison is, that a rise of temperature was generally accompanied with an increased rate of motion of the glacier, and the converse. If the state of *imbibition*, or wetness of the glacier, be the main cause of the increased velocity, as I believe it is, we can readily understand how mild rain, or thawing snow, produces the same effect as intense sunshine.

Whilst it appears probable, or, indeed, certain, from these facts, that the motion of the ice depends upon the temperature of the air in contact with it, and that it is greater in warm and least in cold weather, it does not at all follow, as has in general been too hastily assumed, that the glacier *stands still* in winter. On the contrary, I have long believed that it continually advances, although in a less degree. The circumstance just mentioned, that, though hot and cold weather produce *relatively* the effect of accelerating and retarding the movement of the ice, the velocity is in no direct proportion to the temperature, confirms this. The opinion of many of the most intelligent peasants, whom I have consulted on the point, are also in favour of this view. They generally believe, that the glacier pushes itself forward under the snow in winter; and when I have applied to them for the evidence, they assure me that they have seen the ice, at the lower extremity of a glacier, pressing the snow onwards. I do not, indeed, lay great stress upon this testimony, considering the facility with which such persons often adopt wrong opinions; but its generality amongst the peasantry, and its coming in direct corroboration of the same conclusion to which I have been led from other sources, entitle it to some weight. These grounds will be stated more particularly when we come to consider the question in another place in a more general form; but I may add, that as the best conjectures which I can at present form, in the absence of direct experiments, as to the *annual* motion of the Mer de Glace, would give a result so very much exceeding that which can reasonably be attributed to the progress, during the *summer* months alone, it is highly probable that the motion is continuous, though unequal, throughout the year, and is far from being nothing at any season.

I will give one example of my meaning. The motion of the Glacier du Géant, at the mark B 2, has been shown above to be ·678, or about *two-thirds* of the motion of the ice at mark D 2, near the side of the glacier below the Montanvert. Now, let us admit, for a moment, the story of De Saussure's ladder, which would assign, if true, a velocity of 300 feet per annum to this part of the glacier; consequently, the comparative advance of the lower ice would be a half more, or 450 feet. Now, of these 450 feet, only 132 (see Table I.) were performed during the three hottest months of the year, which barely amounts to the proportional rate of motion of a quarter of a year. Now, this estimate may be thought a very rude one, from the nature of the authority whence it is derived. But without supposing these facts to be more than presumptive evidence, they, at least, give strong reason for believing that the velocity of motion is not excessively small even in winter.[1]

From information which I have received since my return home, I find that my guide, Auguste Balmat, has, at my request, watched the progress of the great block of stone below the Montanvert (marked D 7 on the map), and has found that it moved:—

From October 20 to December 12, 1842, 53 days . .	70 feet.
Its daily velocity was therefore	15·8 inches,
or very nearly its average summer velocity.	
From December 12, 1842, to February 17, 1843, it moved	76 feet;
Or daily	13·6 inches.
From February 17 to April 4, 1843, it moved . .	66 feet;
Or daily	17·2 inches.

I have perfect confidence in the fidelity of these observations; as, however, in the first and last case, Balmat observed that the stone had rolled onwards, so as to fall upon a new side, and has attempted to estimate its rolling progress, there may be a slight error on this account. The measurements are in English feet, made with a line which I left at Chamouni, on purpose.[2]

[1] The preceding pages were written before I possessed the direct proofs of the winter motion of the glacier contained in the succeeding paragraphs.

[2] The following postscript was placed at the end of the first edition, carrying down the observations to the 8th June:—

"From April 4 to June 8, the great stone, D 7, moved .	88 feet 1 inch;
Or daily	16·3 inches.

I presume that the immobility of glaciers in winter, so long received as an undoubted fact, as a basis of theory, will now be admitted to have been as gratuitously assumed, as the greater velocity of the sides of a glacier compared to its centre.

The continuity of glacier motion, even in winter, might have been inferred from the well-known instances on record of the fall of great avalanches of ice during that season: such, for instance, was the fall of the Randa [Bies] Glacier in the valley of St. Nicolas, on the 27th December, 1819;[1] and such is the direct testimony of De Saussure in these words: "Les glaciers mettent aussi en mouvement, et chassent devant eux les terres et les pierres accumulées devant leurs glaces, à leur extrémité inférieure. Je vis ce phénomène en 1764, de la manière la plus évidente, et j'eus en même temps *la preuve que ce mouvement avait lieu, même dans une saison qui est encore hiver pour ces montagnes.*[2] Comme le glacier et tous ses alentours étaient en entier couverts de neige, lorsqu'il poussait en avant les terres accumulées devant ses glaçons, ces terres en s'éboulant se renversaient par dessus la

"Connecting the observations of pages 143, 144, with those of the motion of the neighbouring station, D 2, in the summer of 1842 (page 132), we obtain for the total motion of the *lateral* part of the Mer de Glace, at the Montanvert:—

June 29 to Sept. 28	132 feet.
Oct. 20 to Dec. 12	70 ,,
Dec. 12 to Feb. 17	76 ,,
Feb. 17 to April 4	66 ,,
April 4 to June 8	88 ,,
Motion in 322 days	432 feet.
Proportional motion for the whole year	483 feet.

"The movement of the centre is probably at least two-fifths greater, corresponding closely with the intervals of the 'dirt bands' of the glacier; see page 158."

I have now to add (1845), that when I visited the Montanvert in September, 1843, I found the block, D 7, thrown up so close upon the side, that it had scarcely moved since Balmat had observed it in June. The total annual motion could not, therefore, be deduced; but the measurement I then made, showing that the block had descended on the whole 375 feet since my observation of the previous year, entirely confirmed the accuracy of Balmat's partial measurements. I have, however, since obtained measurements, giving the annual motion of the glacier at the Angle, amounting to 482½ feet per annum, and at the *Pierre Plate*, or station C, in 1842-43, to 260 feet, and in 1843-44, to 288 feet, quantities giving a daily motion so near that observed in summer as entirely to bear out Balmat's observations in respect to the great amount of motion in winter. Still later, I have received observations upon two glaciers during the winter 1844-45, showing that the winter motion is a very large fraction of that in summer (1845).

[1] Agassiz, p. 158.

[2] This appears most probably to have been in the month of March, 1764, from a parallel passage in § 520 of De Saussure.

neige, et mettaient en évidence les plus petits mouvements du glacier, qui se continuèrent sous mes yeux pendant tout le temps que je passai à l'observer."[1]

On the Change of Level of the Mer de Glace.

It has already been observed, that one of my first cares on reaching the glacier in June, was to ascertain the level of the ice at station A. These levels were taken from time to time, and afford unequivocal proof of the depression of the surface of the glacier during summer, to an extent which has probably not been suspected.

1842.				The Level had lowered—		Daily Depression in the Interval.
				Feet.	Inches.	Inches.
June	26	to	June 30	1	9·0	4·1
„	26	„	July 28	10	11·0	3·6
„	26	„	Aug. 9	14	10·0	3·7
„	26	„	Sept. 16	24	6·5	2·5

Now this depression is not necessarily the result of superficial waste alone. I doubt whether it is even mainly due to that cause,—and not rather to a subsidence of the entire mass of the ice, which visibly collapses as the warm season advances. Such a collapse may be due to several circumstances: (1) the undermining of the glacier by the excavating action of the water streams which flow beneath it in summer; (2) the fusion of the ice in contact with the soil, due to the earth's heat; (3) the lower extremity of the glacier moving faster than its higher portions, and thus extenuating the mass, a cause which acts with energy at those seasons when the difference of motions of the two parts is the maximum. The superficial waste is not so easily measured as at first sight it might appear to be. M. Escher de la Linth measured it in 1841, upon the glacier of Aletsch, by the exposure of stakes inserted to a certain depth in the ice,—as the ice melted the stakes were exposed. M. Martins measured it by the geometrical depression of the surface. The last method we have seen measures several effects instead of one; the former may lead to the most inaccurate results; for when the stakes have been exposed to a certain depth, the apparent result is actually inverted—the hole is *deepened*. The irregularities

[1] De Saussure, *Voyages*, § 538.

resulting from this mode of observation will appear from the following facts:[1]—

	Inches.
At the mark D 2, the stick rose out of the hole in the ice from July 1 to July 6	17
From July 16 to July 28, only	5
At the mark D 3, during the first period the stick rose	$22\frac{1}{2}$
During the second period it actually *sunk*, showing that from some cause the hole had deepened faster than the surface wasted.	
At station A, from June 30 to July 16, the stick rose	29
From July 16 to July 28, it *sunk*	2
At the mark B 1, from June 30 to July 16 the stick rose	28
From July 16 to July 29, it *sunk*	5

The cause of this anomalous action it is not difficult to explain. It is, I apprehend, the same as we have pointed out on page 26, as occasioning the formation and perpetuation of holes in the ice, owing to the less density of freezing water than that some degrees warmer. The holes by which my stations were marked always contained more or less water. Whilst the stick fitted them accurately, it nearly or completely obstructed the fluid currents; but, in proportion as the holes widened, the water circulated more freely, and the cavities spontaneously deepened, which is one cause of their preservation.

It is evident, that the apparent loss of surface of the ice in this experiment will be generally too small, and never too great. Thus it appears, that at stations A and B 1, the superficial loss of ice was, *at least*, 29 and 28 inches respectively, during the first sixteen days of July, or about $1\frac{3}{4}$ inch per day. The actual *fall* of the surface at this time was, as we have seen, twice as great; but this I attribute mainly to the general subsidence. A method, which seems the only sure one of determining the superficial loss (an important datum), would be to drive *horizontal* holes in the vertical walls of conspicuous fissures, and to measure their distance from the surface of the glacier. At those stations which did not conveniently admit of running a level to the side, I employed a different and very simple method of measuring the *absolute* depression of the surface. It had the advantage of being applied at the same time that the motion of

[1] The holes were examined, and the sticks notched at the level of the ice by Balmat on the 16th July, when they were also deepened, and the variations were afterwards measured by myself.

the glacier was measured, and with little additional trouble. Thus, at station D, whence the various marks across the glacier were observed in succession, the progress was noted by causing an assistant to descend to the ice with a deal rod, a chisel, hammer, and pegs of wood. If the motion since the last observation was small, he was directed to lay the deal rod parallel to the length of the glacier, and to push it up or down as directed by signals until the extremity was in the exact azimuth of the opposite mark beyond the ice. A pencil mark and number were then made upon the deal rod, in order to fix the distance from the previous station. If the distance moved over was greater, the extremity of the rod was moved parallel to the glacier as before, and when duly placed, a hole was made in the ice with a chisel, and a peg inserted, until I had time myself to descend and measure with a line, and in a carefully determined direction, the whole motion from the last fixed point. Now, in addition to this, in order to ascertain the change of *level* of the ice, I had only to observe from my elevated position the angular depression of the marks in succession on any particular day. These were, for example, on the 20th September—

D 2. $= 22° \ 0' \ 0''$ D 6. $= 11° \ 31' \ 45''$ D 3. $= 10° \ 6' \ 0''$.

A vertical rod being placed at each of these points on any future day, the telescope, being depressed to the same degree, pointed, of course, to a height upon the rod equivalent to the former level of the ice, which was determined by my assistant sliding up or down a slip of paper in obedience to my signals. It is to be recollected, that the ice was here much crevassed; and though its onward movement was wonderfully regular, it was liable to local subsidences. Occasionally, I have found as great a depression as a foot per day during wet mild weather in the latter part of the season. During frost, when the glacier had more consistence, the subsidence was evidently diminished.

This much is certain respecting the level of the ice, that the glacier undergoes a surprising waste during the summer, and that there is not the slightest reason for believing that any process, whether of congelation or other, assists in its renewal during that season. The comparison of a glacier to a mass of leavened bread expanding upwards, and thus supplying the superficial waste, appears to involve an assertion wholly unsupported by evidence, and contradicted by my experiments. And as I readily admit, that such a swelling or vertical dilatation of the mass would be a necessary result of the theory which ascribes the motion of the glacier to the expansion of water frozen in its fissures, I must consider the fact, that no such dilatation is apparent at the season when the motion is most rapid, to be in itself conclusive against the dilatation theory of glacier progression.

CHAPTER VIII

ON THE STRUCTURE OF THE ICE OF GLACIERS AND OF THE MER DE GLACE IN PARTICULAR

General facts of structure—Discovery of wave-like bands on the surface of the glacier—Figures of the structure, and sections of the Mer de Glace—Details—Glacier de Talèfre—Crevasses of glaciers—Their monthly changes—Minute fissures of the ice—Its permeability to water—Veined structure explained.

SOME account has already been given, on page 28 of this work, of the structure of ice, which was noticed by M. Guyot of Neuchâtel, in 1838, in the Gries glacier, and which I rediscovered in 1841, on the Unteraar, Rhone, and other glaciers, and described as being one, probably general, and certainly important in the consideration of the mechanism and functions of glaciers.

It has already been said, that I am disposed to regard the problem of the cause of glacier motion as a purely mechanical one, and that it should be treated, like other problems of motion, by a consideration of the manner and degree in which that motion varies with seasons and circumstances, rather than by endeavouring to deduce, *a priori*, the motion from the circumstances, and from a hypothetical structure of ice, or any peculiar functions of its molecular constitution. I am far from denying, however, that a knowledge of that internal constitution will be of the utmost consequence in modifying or confirming our mechanical theories. From an early period, I felt convinced that the veined structure of ice, described by me in December, 1841,[1] was an important, though obscure, index of the mode of glacier progression; and when I proceeded, in 1842, to obtain definite information to bear upon my speculations, I proposed to myself, as a chief problem,

[1] [See *Occasional Papers*, pp. 1-9.]

to endeavour to combine the direct evidence which the observation of the velocity of the ice in different parts of its mass might furnish as to the cause of motion, with the statical or permanent evidence, which the forms of the veins or ribboned structure, which pervades its mass, undoubtedly bear to some change operated or operating in its interior.

I am inclined to think, that I have arrived at a result which combines these independent evidences; and I feel the more confidence in it, because I am conscious of having commenced my researches with no bias in favour of one theory of glacier motion rather than another, or one cause of veined structure rather than another: indeed, I might rather say, that I commenced them, in 1842, with an equal distrust of all theories proposed to account for the former, and in ignorance of any theory worthy of the name which should account for the latter. Further than this, I spent some weeks amongst the glaciers in June and July, 1842, without even approximating to a theory either of motion or of structure, until at length I began to fear, that days and months of incessant observation, or patient thought, would leave me no wiser about this great problem than when I commenced. But, as is often the process of discovery in complicated questions,—when the confusion seems greatest, and the mind is so imbued with the subject, that the very multitude of details confounds, and the antagonism of conflicting speculations sets order at defiance, then from some unsuspected corner springs up a light, unsought, and seemingly casual, but which struggles into more perfect evidence by being dwelt upon, and at last, throws a complete illumination over the scattered elements which appeared undecipherable and unmeaning, only because they were dimly seen.

Such information respecting the theory of the glacier structure, I acquired first on the 24th of July, and again a fortnight after, on the 7th August 1842. One half hour on each of these days seemed to teach me all that I learnt during my stay upon the ice. All before was preparatory to knowing, all after was simply confirmatory, or proving what I knew.

But before I can make the reader aware of the nature of the observations and reflections which then came home to me with so much force, I must endeavour to describe what I had previously observed with respect to the structure of the ice of the Mer de Glace in particular.

The external form of the ice, the crevasses by which it is fissured, and often divided into transverse slices or pyramidical blocks, and the finer network of fissures, which we shall also find to pervade its interior, all these may be described as, in some sense, the "structure" of the ice. But what we here mean by "structure" is something anterior to, and more fundamental than all these,—it is the intimate arrangement of the very particles of the frozen water, and which constitutes as properly its structure, as the pattern of a piece of curious damask does, or as the veins of a woody fibre do in a piece of mahogany. The proximate cause of the *ribboned structure* of the ice, it has been seen, that I ascribed to the alternation of bands, or parallel veins of ice, of different textures. These bands or veins were conspicuously distinguished (on the Unteraar Glacier and others) by two characters: (1) difference of hardness; (2) difference of colour. The former distinction causes the harder (which are also the *bluer*) veins to stand up in ridges, as the ice melts by the action of the sun or rain, and allows the comminuted sand from the moraines to lodge in the intervening linear hollows, which led, as we have seen, some persons to suppose that the heat of the sun, acting upon the sand, *caused* the hollows in which it lay. This peculiarity is admirably seen on many parts of the Mer de Glace; and nowhere better than upon the common route from the Montanvert to the Jardin, where it passes by the foot of the Aiguille des Charmoz, between the *Angle* and Trélaporte. Here the whole surface seems striated with fine lines; and where groups of the harder bands occur, there are projecting ridges, with grooves between, continuous for very many fathoms along the ice, resembling the cart-ruts of a much-travelled road, when covered with stiff mud, which was the accurate comparison of an English traveller, whose attention was directed to them last summer for the first time. This appearance is most conspicuous after rain. The other characteristic, that of *colour*, requires an attentive examination to perceive its immediate cause; but in any glacier, where the structure is well developed, there is no difficulty in deciding upon it. The phenomenon is not one of those which, like the colour of water, or of air, can only be seen in vast masses. I have often detached *hand specimens* of the ice, which, if they could be preserved in cabinets, would convey the most perfect idea of the structure; there, to be sure, the depth of colour has nearly vanished, but the bands and the cause of colour remain. If we attempt to look through such a piece of ice *across* the direction of the ribboned structure, it looks opaque; but if we look *parallel* to the veins, we perceive that semi-opaque bands alternate with others of glassy purity; the former appear greenish white on a great scale,—the latter blue. If we examine them closely, either with the eye or with a magnifying glass, we find that the blue and glassy part is pure smooth ice, whilst the intermediate portion is, not granular or snowy, as I myself at one time supposed, but simply frothy or full of air-bubbles of various forms, disseminated through the pure ice, and always arranged in parallel planes, of more or less abundance, producing greater or less opacity. These cavities do not *appear* to communicate, though we shall see reason to believe that they generally do so. It is a general fact, that, as ice loses the perfection of its crystalline structure, it passes from blue, *through green*, to white, which is always its colour when granulated. It is for this reason, that the transition from ice to snow, in the higher glacier regions, is *usually* through shades of green; but when even common snow has acquired a certain degree of imbibition by moisture, and is no longer dry and powdery, but allows a pretty free passage to the light, it becomes distinctly *blue*, by transmitted light, and of as great or greater intensity than I have ever observed in pure ice or water at the same thickness. I attribute it to the free admission of light, in consequence of moisture filling the cavities between the snowy granules. I have elsewhere (p. 69 above) observed, that I consider that no further explanation of the blue colour is required, or can be given, but that it is the colour proper to pure water, both in its solid and its liquid form.

It has been said, in Chapter II., as well as in [*Occasional Papers*, pp. 5-8], that the *direction* of the bands depends materially upon the configuration of the glacier, and the nature of its boundaries. In a long, canal-shaped glacier, like that of the Unteraar, it was nearly parallel to its length, and nearly vertical, but inclining upwards and outwards where the ice was supported by the lateral rocks. On the glacier of the Rhone, on the other hand, which has not a very elongated form, and which enlarges itself suddenly, these bands described oval lines upon the surface of the ice, as we have already seen, and dipping inwards at angles more nearly perpendicular, as the centre of the glacier was approached, might be compared to sections of inverted cones, having a common apex pointed downwards, but whose angles continually diminished towards the centre. Not, indeed, that the ovals were complete all round the glacier, but they were complete, or nearly so, for two-thirds or three-fourths of the circumference, as shown in page 29. Guided by what I saw at the glacier of the Rhone, I ascribed the *apparent frontal stratification* of the lower extremity of the Unteraar glacier to the same cause, namely, the twisting round of the planes of structure which cropped out (to use a geological phrase) on the slope of the lower end of the glacier, with a continually diminishing dip, as the level of the ground was approached.

Evidently, then, the one of these structures was but the *limiting* case of the other; the canal-shaped glacier is but the oval glacier drawn out longitudinally, its lower or unsupported part invariably assuming the depressed conoidal structure.

In the course of my numerous crossings and recrossings of the Mer de Glace, I observed a general confirmation of the disposition of the ice to a parallel structure, sometimes vertical, sometimes leaning against the walls of the glacier, and often, where one side of the glacier was heaved up in its progress against some opposing promontory, the whole structure (preserving the general trough-shaped section) appeared to lean over in one direction, as shown in the figure No. V., page 158. At the same time, I found so many anomalies, as to make me cautious of hazarding the assertion that the trough-shaped structure was rigorous and general, and I determined, by patient observation, and laying down on a sketch the bearing of the veins or bands, and their dip at a great number of points, to obtain an empirical representation of the structure in question, over as large a portion of the surface as possible. The labour would have been great, without some better clue to guide so extensive an inquiry; fortunately it had hardly commenced before I obtained one.

On the evening of the 24th of July, the day following my descent from the Col du Géant, I walked up the hill of Charmoz to a height of 600 or 700 feet above the Montanvert, or about 1000 feet above the level of the glacier. The tints of sunset were cast in a glorious manner over the distant mountains, whilst the glacier was thrown into comparative shadow. This condition of half illumination is far more proper for distinguishing feeble shades of colour on a very white surface like that of a glacier than the broad day. Accordingly, whilst revolving in my mind during this evening's stroll the singular problems of the ice-world, my eye was caught by a very peculiar appearance of the surface of the ice, which I was certain that I now saw for the first time. It consisted of a series of nearly hyperbolic brownish bands on the glacier, the curves pointing downwards, and the two branches mingling indiscriminately with the moraines, presenting an appearance of a succession of waves some hundred feet apart, and having, opposite to the Montanvert, the peculiar form which I have attempted to show upon the map, where they are represented in the exact figure and number in which they occur. They were evidently distinguished from the general mass of the glacier by discoloration of some kind, and indeed they had the appearance of being supernumerary moraines of a curvilinear form, detached from the principal moraines, and uniting in the centre of the glacier. Although this was my first idea I was satisfied from the general knowledge which I then had of the direction of the "veined structure" of the ice that these discoloured bands probably followed that direction; and accordingly next day I carefully examined the surface of the ice, with the view of determining, if possible, their connection and cause, being well satisfied that this new appearance was one of great importance, although, from the two circumstances of being best seen at a distance or considerable height, and in a feeble or slanting light, it had very naturally been hitherto overlooked, both by myself and others.

I had often observed that some parts of the ice were dirty, and some parts clean, but it was not until I examined its surface minutely on 25th July that I discovered that the "dirt bands," as I called them, had a definite position upon the glacier and a regular recurrence. I had no difficulty now, whilst examining the ice when on its surface, in deciding whether I was standing upon one of the "dirt bands" or on the clean ice, although, from the inequalities of the surface and local effects of light, it would have been almost impossible to have traced out, step by step, the forms of these discolorations. They are like what are called "blind paths" over moors, visible at a distance, but lost when we stand upon them.

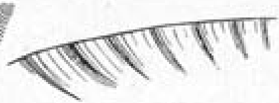
The *cause* of the discoloration was the next point, and my examination satisfied me that it was not, properly speaking, a diversion of the moraine, but that the particles of earth and sand, or disintegrated rock, which the winds and avalanches and water-runs spread over the entire breadth of the ice, *found a lodgment* in those portions of the glacier where the ice was most porous, and that, consequently, the "dirt bands" were merely *indices of a peculiarly porous veined structure traversing the mass of the glacier in these directions.*[1] A most patient examination of the structure of the ice opposite to the Montanvert satisfied me completely of the parallelism of the "veined structure" to the "dirt bands"; the former was the cause of the latter; and some more general cause, yet to be explained, caused the alternation of the porous veins at certain intervals along the glacier. This, then, tended to clear up a multitude of doubts respecting the real type of glacier structure in long or canal-shaped glaciers. That it was not merely trough-shaped was clear, but the direction and dip of the veins near the centre of the glacier was generally too confused to give a ready solution of its real structure. I now found that the veins appeared *generally* parallel to the moraines and sides of the glacier, only because the curves representing their real forms had branches which merged into parallelism, and that there really was a tendency in the direction of the veins on the two sides of the glacier to converge to a point in the centre. But the most difficult point to decide was, What is the form assumed by the veins where they meet in the centre, at the vertex of the curve? After much attention I found that the normal structure here (though often obscured or annihilated) turned round and formed a loop exactly as in the oval-shaped glacier already described, the *direction* of the structure being, for a short space, directly across the strata, and dipping inwards at a considerable angle. The ground plan, transverse section, and longitudinal section (at the centre of the glacier) of such a structure would be the following:—

[1] From the careful observations of two additional summers, I can positively affirm the correctness of this reference of the "dirt bands" to the recurrence of a highly porous structure. The dirt is *absolutely superficial*, a few blows of a hammer or axe suffice to disclose the veined structure in its highest purity beneath. What, then, are we to think of the argument of those who have explained these bands by the interstratification of impurities lying on the surface of the névé by the superposition of fresh clean snow? (1845).

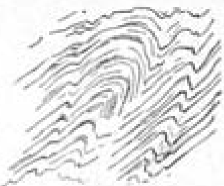
No. 1.

No. 2.

No. 3.

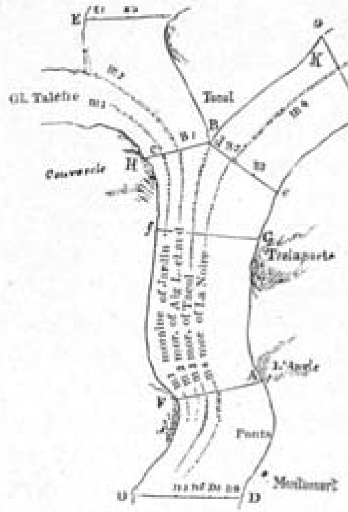


Opposite to the Montanvert the dip inwards (that is, towards the origin of the glacier) at *a a a* appeared to be 45°. This is only through a narrow space, and is often extremely confused, but whenever the structure appears clearly this is its position. The ice is often contorted in the most fantastic manner, like limestone strata in the Alps, or the veins of knotty wood.



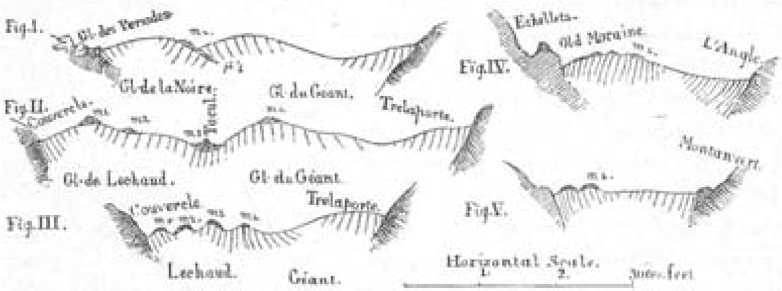
TWISTED VEINS.

Of course, after the discovery of these "dirt bands" below the Montanvert, it became an object to trace them throughout the glacier, mark their variations, and compare them with the structure of the ice, so as to ascertain that they rigorously corresponded; lastly, to fix their numbers, distances, and form. Although at most times of the day I could distinguish their position after once ascertaining their existence, yet to see them well, or to count them throughout any extent of the glacier, required an elevated position and a peculiar effect of tempered sunshine or moonlight. In broad daylight, without clouds, only the more conspicuous ones could be seen; but it is not to be supposed from this that there was anything illusory in their existence or position. On the contrary, both were so perfectly definite that I have repeatedly counted the bands visible from station L (on the Charmoz, above the Montanvert), all the way between the ice precipice at the Chapeau to the promontory of Trélaporte, which are exactly 18 in number as laid down in the map. The lower 10 bands (including 9 intervals) are contained between the right lines joining stations L and I, and L and F, and the distances of these lines are laid down on the map from actual survey. The mean intervals will be found by taking the distance along the axis of the glacier between the lines just mentioned and dividing it by 9. That distance is 6400 feet, and consequently the average interval is 711 feet. But the intervals are not all alike; indeed, they differed sensibly to the eye. The difference, however, for this part of the glacier is probably not a tenth part of the mean for any one interval. The distance between the vertices of the two dirt bands immediately opposite to station D was found trigonometrically to be 667 feet.



The ground plan of the ribboned or veined structure generally, and of those porous veins in particular constituting the "dirt bands," may be pretty correctly judged of from the map; but for a complete understanding of the structure, and its modifications, the following remarks are essential, which will be made plain by a reference to the sections on this page, taken from eye-sketches made on the spot, and to the ground plan, which is here repeated from p. 130, and which shows the lines of section. Thus,

a b	corresponds	to section	No. I.
H *d e*	,,	,,	No. II.
f G	,,	,,	No. III.
F A	,,	,,	No. IV.
D D	,,	,,	No. V.



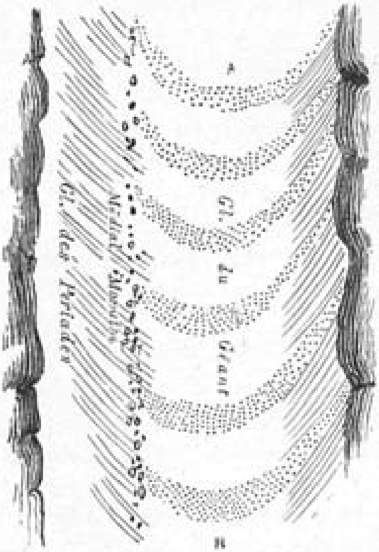
1. Opposite to the Montanvert, and up to beyond Les Echelets, the curved loops extend *across the entire glacier*. They are single, and therefore *cut* the medial moraine, at an angle of nearly 30°. The structure of the ice to the east of the medial moraine is nearly parallel to the length of the glacier. It is also

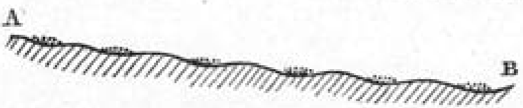
nearly vertical; but the whole trough-shaped structure, accommodating itself to the irregular form of the glacier, leans over towards the Angle, as if tilted up by the promontory of Les Echelets, which is really the case, as shown in the sections Nos. IV. and V.

2. The vertices of the curves of structure incline towards the left bank of the glacier, as we approach the promontory of Trélaporte; and about that portion of the glacier we begin to distinguish a separation in the structure of the two confluent glaciers, which do not appear to be there fully consolidated. The Glacier du Géant has its own system of curves, and the Glacier de Léchaud its system, as shown in the map. From about the position where the *dislocation* of the moraines is marked on the map, near the Moulins, up to the promontory of the Tacul, the great medial moraine of the two glaciers, marks, as it were, a common vertical wall, formed by the mutual pressure of the ice-streams, and throughout all that space the vertical structure of the ice follows precisely the direction of the moraine. On either side it begins to incline into the trough of its own glacier, as shown in the sections Nos. III. and II. After the glaciers have thoroughly amalgamated, the structure of the more powerful glacier (Géant) predominates, and absorbs the other.

3. We have seen that the Frontal Dip, that is, the dip of the veined structure *inwards* throughout the very narrow space in which its direction is *transverse* to the glacier, or near the centre of the ice-stream, is about 45°. This dip certainly increases as we ascend, exactly as I have shown [in *Occasional Papers*, pp. 1-9], and shall show (Chap. X.) that it does in those glaciers where, the ice being less confined, the frontal dip is a well-marked angular phenomenon, as in the glacier of the Rhone, of Bossons, of La Brenva, and at the lower extremities of many other glaciers. Now, just above Trélaporte, on the Glacier du Géant, though the frontal dip is undistinguishable, yet the curvature of the structural planes is perfectly clear, and likewise the occurrence of the dirt bands, which are here more rounded, and not so excessively drawn out as at the Montanvert. But, if we pursue the Glacier du Géant higher up, as opposite K, the *transverse structure in the centre of the glacier is perfectly distinct, and the frontal dip is vertical.* This is an important fact, and conformable to what I have observed on the Glacier of the Rhone.

4. The Glacier du Géant has a single or simple structure between Trélaporte and the Tacul, and for some way higher up. The system of curves, formed by the structural planes intersecting the surface of the ice, have their vertices near the centre of the glacier, and become parallel to its length near the banks, *cutting* the moraine of La Noire, and stretching quite from side to side. But as we advance higher up, and approach La Noire, which separates the great mass of the glacier from the small glacier descending from the range of Les Périades, we perceive a tendency to a double structure, as at the union of the Glaciers of Léchaud and Géant (see Section No. I.). I am unable to state the exact number of dirt bands between the foot of the ice-cascade opposite La Noire and the corner of Trélaporte.[1] Under a





[1] I am now (1845) able to supply the defective evidence as to the existence and number of the "dirt bands" on the Glacier du Géant, and to notice an additional discovery respecting them, which will be found detailed in my Fifth Letter on Glaciers [*Occasional Papers*, pp. 39-41]. In 1843, from an elevated station at the foot of the Aiguille du Moine, I counted six dirt bands beyond the promontory of Trélaporte, where my former reckoning (p. 157) ceased. Then there occurred a space equal to that of three intervals, in which the bands were undistinguishable, and beyond this the position of the bands was evidently marked by the remains of the last winter's snow lying in crescent-shaped hollows in the ice, precisely corresponding to the form and intervals of the dirt bands. These *wrinkles* in the ice (seen below in a longitudinal section) are evidently an important part of the phenomenon of the dirt bands, and appear to connect them more closely with the result of periodic change like the annual rings of trees, and the wrinkles on the horns of animals. From the final sweep of the glacier above the Chapeau to the point of Trélaporte there are 18 intervals, extending over 13,300 feet, or about 740 feet each at an average. Above Trélaporte we have 6 distinct rings, a blank equal to three which could not be observed, and 10 more marked by the snowy wrinkles, making in all 19 in a space estimated at 9000 feet, or 470 feet for one interval, fully corroborating the remark in the text as to the remarkable *condensation* of the bands and their round fronts, in the higher part of the glacier. These observations were fully confirmed by my visit in 1844 to station

favourable light they may perfectly well be counted, and I recollect doing so once, but the number was not noted, as I intended to make the observation more scrupulously another time, but was prevented by the fall of snow in September. Indeed, it is for but a very few weeks of the year that this part of the glacier is tolerably free of snow. My belief is, however, that these bands are not only more uniformly curved (as has already been said), but are *compressed*, or more numerous in the same space. This appeared to me to depend partly upon the smallness of the declivity of the glacier.

5. If we follow the Glacier de Léchaud from the *Moulins*, we have, in the first instance, as has been said, the vertical stratification accompanying the medial moraine up to the Tacul. There are two medial moraines on the Glacier de Léchaud itself; one coming from the Jardin and the other from the Aiguille de Léchaud.[1] The ice between the latter and the Couvercle is the ice of the Glacier de Talèfre; that between the same moraine and the Tacul belongs to the Glacier de Léchaud, descending from the Grandes Jorasses. Now, this moraine (*de l'Aiguille de Léchaud*) divides the separate structures belonging to these two ice-streams, whilst the structure of the ice derived from the Talèfre cuts the moraine of the Jardin at an angle, and forms only a single system of curves. Both of these systems die out about the same time, after a complete union has been effected with the Glacier du Géant. I have not particularly noticed the dirt bands on the Glacier de Léchaud, but I have carefully examined its structural planes, and traced them quite up to their disappearance, which takes place a little below station E, where the glacier is without any trace of structure. The structure commences a little below the junction of the steep glacier descending from the foot of the Capucin du Tacul, and it is manifestly augmented, and becomes general after the confluence of the Glacier de Talèfre. I have often observed (and believe it to be a general rule) that *where a glacier is contracted and jostled*

G*, above Trélaporte, which affords incomparably the finest view of the entire glacier from the Chapeau to the Col du Géant, whence I counted, exactly as in 1842, 18 bands from the precipice below Montanvert to the point of Trélaporte. The wrinkles of the higher glacier could be seen, although entirely covered with snow. (1845.)

[1] [This is the true Aiguille de Talèfre, but the moraine mentioned seems to proceed rather from the Aiguille de l'Eboulement.]

by its union with others, if not violently crevassed, *there the structure comes out best.* The structure is rather elongated here, and not so transverse as in the Glacier du Géant.

6. The structure of the ice of the Talèfre, forming the north-eastern portion of the Glacier de Léchaud, is remarkably well brought out, and instructive. At the Pierre Plate C, it is beautifully shown; and here I first distinctly remarked, that the structure is not always parallel to a medial moraine, as I had at one time supposed. It evidently cuts the moraine of the Jardin, as already mentioned. This part of the glacier is steep, and its surface convex. It has very much the character of a glacier poured out into a valley, as it really is, being derived from the stupendous ice-cascade which falls from the basin of Talèfre. The forms of the veined structure are more rounded than in most other parts of the Mer de Glace: I mean, that the superficial curves do not come to a sharp point, but have more of a circular sweep, and a well-defined transverse course, and a frontal dip inwards of 63°. But one of the most interesting points connected with this ice-stream is the sudden change of structure which it undergoes at the foot of the ice-fall descending from the Talèfre. The structure of the ice throughout the fall is more distinctly striated in a vertical direction, and parallel to the sides of the glacier, than I recollect to have observed in any glacier so violently crevassed and dislocated. The moraines are faintly perceptible by dirty stripes during the fall. But when the shattered ice is collected, and remoulded, upon reaching the foot of the precipice, by the pressure of the Glacier de Léchaud, a most remarkable and sudden change takes place. The ice, from fragmentary and fissured, becomes compact and swollen into a convex form, produced, no doubt, by the lateral pressure to which it is now subjected, and which it struggles to overcome. *Within the space of a few hundred feet, the transverse structure becomes developed,* the former longitudinal structure at right angles having disappeared in the interval, and the wave-like forms of the structure swell out more and more as the glacier is urged down the steep slope towards station C, with the Pierre Plate. The convexity of this part of the glacier will be perceived from Section II., page 158; and as the glacier is swollen and pressed onwards, the crevasses in this part radiate, as from a centre, or in directions perpendicular to the lines of

structure, exactly as I have described in the Glacier of the Rhone. These facts, which I have verified in many other glaciers, conclusively show, that *the structure is developed during the progress of the ice downwards*—is subject to the variations which its momentary conditions of constraint impress—and that it has not the slightest reference to the snow beds of the névé, or to any primitive conformation whatever.

7. When we trace the structure up to the icy basin of Talèfre, we perceive the origin of the linear vertical structure of the ice which accompanies it in its fall. The ice, near the moraines of the Jardin, is distinctly ribboned in a vertical direction parallel to those moraines; and this structure, so far as I have been able to observe it at the most favourable season, when this glacier is tolerably free of snow, spreads itself upwards, moulding itself by the forms of the rocky basin which confines it, nearly as represented in the map. The directions remind one irresistibly of the lines of floating matter upon a current of water converging towards a narrow outlet. The direction of the crevasses above the outlet, or icy cascade, is still perpendicular to the direction of the structure, and therefore their lines of fracture are *convex upwards.* Higher up the Glacier de Talèfre, as the structure of the ice becomes more snowy and less crystalline, the ribboned appearance vanishes altogether at the surface, although it is probably continued at a greater depth.

Such are the facts which I have been able to observe most carefully with respect to the arrangement and distribution of this remarkable structure over a glacier of great size and variety of surface. It will be found to represent very well the normal type of all glaciers, as we shall afterwards have occasion to illustrate by examples. In the meantime, I shall say a few words respecting the accidents of crevasses, and then endeavour to explain the views which the study of the Mer de Glace suggested with respect to the cause of the veined appearance.

Perhaps the most usual and general rule for defining the direction of crevasses, when a glacier is not violently dislocated by moving over excessively steep or irregular surfaces, is, that *they tend to a direction perpendicular to the structure;* since, however, a rent once determined is often prolonged, irrespective of the immediately producing cause, such crevasses may, throughout their length, cut the structure at different angles, which they often do. Some of the crevasses of the Mer de Glace are probably 2000 feet long. I carefully examined a crevasse near the Montanvert, extending from the medial moraine quite to the western side; and in the higher parts of glaciers, as towards the Col du Géant, crevasses extend, by communication with one another, to far greater distances.

It has been stated by some authors, that crevasses are generally in lines transverse to the glacier, and convex downwards; and others (as M. Agassiz[1]) more correctly, that they are most frequently convex towards the origin of the glacier; but he drew a wrong consequence in concluding that therefore the motion is most rapid at the sides. It is by no means so easy as it appears, to ascertain the general ground plan of a system of crevasses, for nothing is commoner, in viewing a glacier from a height, and seeing one system of crevasses, than to lose sight altogether of another set which cross the former. This is the case opposite to the Montanvert, where there are two distinct systems of crevasses, equally inclined to the axis of the glacier, and forming an angle on its surface of 65° with one another, so that each set deviates 32½° from a line transverse to the glacier. In turning round the promontory of Trélaporte, a series of fan-shaped crevasses succeed one another, as already remarked. It is extremely curious to observe the hyperbolic "dirt bands" maintaining their position amongst that confusion. Higher up, the crevasses become transverse, and less numerous.

When the glacier makes a rather abrupt turn, as between the Echelets and the Angle, it appeared to me that the crevasses of the higher glacier are stopped up by the pressure of the ice where it is *reflected* from the rock, and a new set open, corresponding to the new direction of motion. It is this interference of a current of water and its *reflection* from a promontory, which *breaks* the surface of a river into foam; and something of the same kind may be perceived, if I mistake not, between the Angle and the Montanvert. The old crevasses are sealed up, and new ones formed, cutting them across, which produce the tumultuous looking hillocks in that part of the ice.[2]

[1] *Études*, p. 167.

[2] The fact of the general perpendicularity of the crevasses to the veined structure is now so well confirmed, that after the ample details given for ascertain-

But still more important are the circumstances attending the formation and change of crevasses during different seasons. Beyond the general admission that crevasses result from a glacier being pushed over a surface presenting great irregularities, which irregularities break the semi-rigid mass over them, little or nothing has been agreed upon by authors as to their origin. That crevasses form with a sudden noise, and are at first mere cracks into which the blade of a knife would scarcely enter, is beyond a doubt. But the fact for which I was least prepared, but which my long residence on the Mer de Glace last summer convinced me of, is this, that these crevasses, if not entirely renewed every year, are so at least in a great degree; that they are formed during spring, summer, and autumn, by which time

ing the direction of the latter, the former might be, in almost every case, easily inferred; nevertheless, since some indefiniteness still prevails as to the law of crevasses, I shall state it here somewhat more particularly.

In the canal-shaped glacier of uniform breadth (Fig. 1), the crevasses nearest the banks, intersecting the elongated branches of the structural surfaces, point slightly up the glacier, and as they cut the loops nearer the centre of the glacier, the tendency to point upwards is slightly increased, but, as mentioned in the text, a crevasse is often prolonged in a direction in which it would not have originated, and hence it happens, that the two systems of lateral crevasses are prolonged till they meet, and thus form one system, rudely arched towards the origin of the glacier. In one instance I have seen, as the figure is intended to represent, two lateral systems, so rigorously perpendicular to the ground plan of the ribboned structure as to be slightly *concave* to the origin, met by a third system in the centre, which, in combination with them, gave the usual character of convexity.

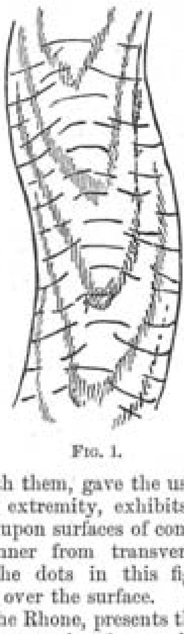


Fig. 1.

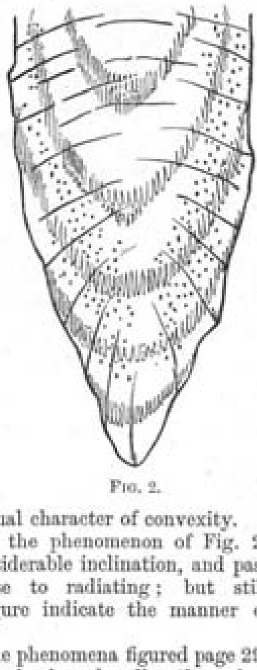


Fig. 2.

Such a glacier, at its lower extremity, exhibits the phenomenon of Fig. 2, where the crevasses are exhibited upon surfaces of considerable inclination, and pass in a beautifully graduated manner from transverse to radiating; but still perpendicular to the veins. The dots in this figure indicate the manner of dispersion of the lateral moraines over the surface.

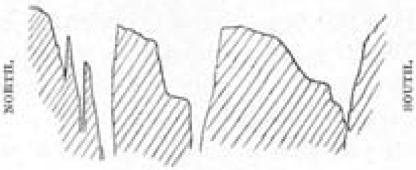
An oval glacier, like that of the Rhone, presents the phenomena figured page 29.

A glacier, like that of Talèfre, emerging from a basin-shaped valley through a narrow outlet (see the General Map), has a structure in lines diverging towards the origin, and consequently crevasses throughout in the same direction (1845).

the face of the glacier is in some respects entirely changed—much more so indeed during a few months than it ever is from one year to another—so that a traveller may revisit a glacier from year to year, and think that he recognises localities on the ice, he may map the fissures and accidents, and seem to discover them afresh, but they are only the ghosts of his departed friends, —forms, which unlike a wave which moves on whilst the substance which moulds it is still, remain planted amidst motion, as if anchored in the icy cataract. This fact has formerly been insisted on, but what I wish now to make plain is the certain fact that the crevasses are in a good measure formed afresh every season.

When I traversed the glacier in a great many directions in the end of June, I had ample means of judging of its state from the obstacles which were opposed to a passage over it; I had also an opportunity of noticing the width of the crevasses, their regularity, and the sharpness and verticality with which they generally terminated at the surface of the glacier. In July and August, during many excursions in the same directions, the change was most conspicuous, and especially in the higher parts of the glacier, between the stations G, B, and H, where the snow had recently covered the ice at my first visit. There the crevasses had increased to such a degree in number and breadth that the glacier seemed unlike what it was, and a space which I had formerly considered as almost sufficiently even for measuring a base line upon the ice, was now traversed by clefts. Even at the Montanvert the crevasses were visibly wider, and the whole texture of the ice more shaken.

But it was in the month of September that the change was most perceptible in the lower part of the glacier. I have already adverted to the loss of surface, and to the general subsidence of the whole mass of the glacier. The several stations where I made my regular observations on the ice had of course their topography and peculiarities firmly fixed on my memory, and there the change of feature within a few weeks was such as to render them scarcely recognisable. Great cavities or clefts were entirely soldered up,—others had encroached on their solid partitions so as to unite with independent ones; precipices had become gentle inclined planes; the landmarks of great stones were lost—they had tumbled into crevasses, or been so tossed over as to seem no longer the same: but the general character at this season was a subduing of all the angular rugged character of the ice in spring. The fissures, though wide, were many of them choked, their walls melted, and their edges deformed. The mid-day sun shines *along* the glacier, hence (the fissures running generally from east to west) the southern wall of ice was shaded, the northern exposed to the sun. Thus, it happened that in the month of September the northern edges of the crevasses were nearly all degraded in the manner represented opposite,[1] and the eminences falling into the hollows rendered the passage of the glacier much easier than it had been some weeks before. This occurred also in the higher parts: above Trélaporte I observed crevasses similarly deformed, and at the same time *closed*, so that a mere crack now stood in the place of the open cleft.



It may here be proper to say one word about a system of crevices, of small dimension, which appear to traverse the ice of glaciers, and about which much has been said which is unimportant, and much has been supposed which is untrue.

We have already observed that glacier ice is eminently fragile,—hence the facility of making steps with a hatchet, by which means alone many otherwise inaccessible summits are gained. This fragility depends upon the ice being traversed by an infinity of capillary fissures—generally invisible—but which become distinctly seen near the walls and moraines of glaciers, and wherever the ice is exposed to sudden alternations of temperature, by being in contact with rocks or stones. There the glacier consists of a congeries of tightly wedged polyhedrons, of the most irregular figures, often three inches or more in length, and of which a bunch may be held connectedly together, until, by melting, they become disengaged and fall asunder. But, whilst the pieces remain thus connected, the fissures impart to the mass a certain rude flexibility within small limits, and they undoubtedly permit the free infiltration of surface water to great depths in the ice. These crevices and the granules which they separate, have

[1] M. Rendu has made a similar remark. [P. 109 of the 1874 reprint.]

been particularly described, and their existence insisted on by Scheuchzer, Hugi, De Charpentier, and Agassiz; and this has been described as the peculiar structure of the ice, while the veins of cleavage, or ribboned structure, remained unnoticed; it is, however, entirely subordinate to, and superinduced upon the latter, as I may later have occasion to show. Its existence near moraines and fixed rocks is too obvious to be doubted; but I was for some time sceptical as to its pervading the glacier generally. When I had the pleasure of visiting the Unteraar Glacier with M. Agassiz in 1841, I communicated my doubts to him, and suggested making a hole in the most compact part of the ice, and putting into it a coloured liquid, which might inject the crevices by which it is traversed, and thus demonstrate their existence. M. Agassiz was obliging enough to sacrifice two bottles of red wine to this inquiry, but the result was not entirely satisfactory to me, as though the wine certainly escaped, it left no traces of its passage. I therefore resolved to perform the experiment more carefully in 1842, and took with me several portable colouring matters. To these, by the advice of M. Regnault, of Paris, I added some cakes of lithographic ink, which not being soluble, but only suspended in water, might, he ingeniously suggested, adhere to the capillary fissures, and indicate them more plainly. Holes about a foot square were made, to a small depth, in the most compact part of the ice, near the Montanvert, in the evening, when the superficial wet was least, and the black[1] and red dyes, very concentrated, were poured into them, to the extent of some pints. I shall state the result obtained the next forenoon in the words in which I noted it at the time:—

"With an axe I carefully cut the ice round the cup of ice in which the madder infusion had been put last evening, and also round another similar one, in which dissolved (diffused) lithographic ink had been placed this morning. Though much colouring matter yet remained in each, much was effectually and visibly infiltrated into the ice beneath and around; the small solid colour-particles being visibly confined in the air cavities from which no visible capillary fissures extended, and (from which) they could not be removed by ordinary washing. This

[1] The black was poured in in the morning, some hours before the final examination.

ice is seemingly compact; it does not exhibit obvious traces of capillary fissures, and mere immersion in a coloured fluid produces no true infiltration—the adhering colour may be immediately washed off; whilst, where the ice is exposed to the air, it is fissured into the grains so often mentioned, and which may be immediately infiltrated with wine, ink, or any fluid. But this experiment shows that these do exist, and unite the air-cells, or many of them, though unperceived; even the undissolved fibres of madder and grains of lamp-black had penetrated to considerable distances."

I therefore freely admit—what I formerly doubted—that a glacier in summer is penetrated to a great depth by water, which saturates all its pores. I am equally satisfied that during summer this water never freezes, and in winter only partially. Hence a glacier is not a mass of solid ice, but a compound of ice and water, more or less yielding, according to its state of wetness or infiltration.

Exactly a fortnight after observing the hyperbolic dirt bands opposite the Montanvert, I walked on the 7th August to the same spot, and I then obtained an insight into the cause of the phenomenon of the ribboned structure, and of glacier motion generally, which I have no doubt is in substance the true one. The forms of the superficial curves before me recalled almost involuntarily the idea of *fluid motion*;—they resembled perfectly the lines into which the froth or scum on the surface of a viscous fluid would form themselves if that fluid were propelled along an inclined trough or basin. The cause of such a form is evidently the greater rapidity of the centre than of the sides, a rapidity which, in the case of a viscous fluid, is occasioned by the less adhesion between its particles than between the fluid and the vessel in which it is contained; and in *any* fluid a similar effect would arise from the friction of the banks or sides. Then the reflection naturally occurred—it is not only *probable* that such would be the motion of a semi-fluid or pasty mass placed in the conditions of the glacier, but it is *certain*, from my own experiments already detailed, that the actual motion *is* such as we have supposed it might be; it *does* move faster in the centre than at the sides; it is no hypothesis to say that the glacier moves as a viscous or pasty mass would move—we know that opposite the

Montanvert the motion of the ice at the centre of the glacier is two-fifths greater than at even a very sensible distance from the bank. A glacier may, therefore, really be in its structure and formation, like what I had compared it to in 1841,—"A pailful of thickish mortar" poured out,[1] and the wrinkles on the surface of the one and of the other may have more than a vague analogy. But I carried my theory further. I considered that [in the case of] a semi-rigid mass, like a glacier, which has no pretension to be called a fluid in the common sense of the word, if it do not (as it certainly does not) move in all its parts parallel to itself, there must be a *solution of continuity* between the adjacent particles of ice to enable the middle to move faster than the sides. Imagine the surface of a glacier to be divided into a number of stripes parallel to its length, and adjoining but not cohering. If it be ascertained that each stripe nearer the centre moves faster than its neighbour nearer the side, the stripes will move past one another parallel to their length, the central stripes gaining upon the lateral ones. If we attempt to give such a varying motion to the parts of a flat stiff body, as a long sheet of paper, we cannot effect it without tearing the paper by rents parallel to its length, or the direction of movement. Now, such must be the case with a mass of ice which does not move with a uniform velocity in its transverse section, but where every line of particles has the velocity proper to its position in the ice-stream. The ice will, therefore, be rent by innumerable fissures whose general direction will be parallel to its motion, and these fissures becoming filled with water and ultimately frozen, will produce the appearance of bands traversing the general mass of the ice having a different texture.

We have hitherto spoken only of the influence of the *sides* of a canal upon fluid or viscous motion, but the *bottom* has also its influence. It cannot, I think, be doubted, after what has been stated, that the motion of the ice is more rapid at the *surface* than at the *bottom*, for the very same reason, that it is more rapid in the centre than at the side. The friction of the bottom must retard it; and the less plastic the matter, the farther from the sides or bottom will the influence of friction extend. The result must be a tendency to separation of the superficial from the

[1] *Edinburgh Philosophical Journal*, January, 1842. [See *Occasional Papers*, p. 7.]

lower parts of the ice, just as the central are dragged past the lateral ones. The consequence must be, in either case, the formation of surfaces of discontinuity; and we shall attempt to show, when we return to the theory in Chapter XXI. below, that such surfaces must have the forms already described as characterising the veined structure.

CHAPTER IX

THE TOUR OF MONT BLANC—CHAMOUNI TO COURMAYEUR

Glacier des Bossons—Its chief phenomena—Route to the Montanvert by the Glacier des Pèlerins—Glacier de Taconnaz—Roches moutonnées at Pont Pélissier—Baths of St. Gervais—Origin of the blocks of the Vallée de Montjoie—Nantborrant—Col du Bonhomme—Col de la Seigne—Allée Blanche—Courmayeur.

WHAT is called the *tour* or circuit of Mont Blanc is an easy journey round its base, beginning and ending at Chamouni. It is familiarly described in many works, and well deserves all the praise which can be bestowed upon the admirable and varied scenery through which it leads us. To those who look at matters more closely, it offers great interest, because it gives an opportunity of examining in succession every one of the valleys and ravines which take their origin in the chain of Mont Blanc, and which are usually in part or entirely filled with glaciers. I shall suppose the traveller starting from Chamouni so as to cross Mont Blanc at its western shoulder, called the Col du Bonhomme, where he comes amongst valleys which pour their streams into the Isère, and thence into the Rhone; turning next to the eastward, and crossing the Col de la Seigne, he enters the Allée Blanche, a valley of singular grandeur on the southern side of Mont Blanc, and parallel to that of Chamouni. Here the river Doire (*Dora Baltea*) takes its origin, which, joining the Po below Ivrea, goes to swell the waters of the Adriatic. Courmayeur, a Piedmontese watering-place, is situated on the Doire, immediately behind the chain of Mont Blanc. The map [in the pocket] contains the route which we are now considering.

The first object of importance after leaving Chamouni is the

Glacier des Bossons[1] (the *patois* form of Buissons, as it is spelt by De Saussure), of which the exquisite purity is known to all travellers. I shall not stop to describe the phenomena of its *aiguilles* of ice, and its greenish-blue crevasses, so familiarly known, but I shall point out shortly what seems most worthy of remark, especially in connection with the theory of glaciers.

1. The Glacier of Bossons is one, which, taking its origin at a great elevation, pours itself down in a confused mass into a valley at a low level, where it spreads itself out as far as the principle of the equality of waste and supply (page 19) will permit. This glacier has brought down beside and beneath it a great mass of débris of the rocks of Mont Blanc (including serpentines of doubtful origin, but most likely from the foot of the Aiguille du Midi), and these have formed a steep embankment, projecting into the valley, upon whose top the glacier rests. This gives to it a very remarkable appearance, especially as seen from Les Ouches, farther down the valley, where the fir woods conceal the origin of the glacier, and the lower part, thrust forward as it were from out of the side of the hill, stands forth like an island of crystal in the bottom of the valley. This part of the glacier is nearly flat, and it is there easily crossed. Quite at its termination it falls over the slope of its moraine, and forms deep chasms and lofty pinnacles.

2. The Glacier of Bossons, like most of those in the same neighbourhood, attained in 1820 its greatest extent in recent times, when the moraines advanced over cultivated fields, very near to the Hameau des Bossons. The traces of this progress are very visible. One enormous block has rolled out from amongst its neighbours on the eastern side of the glacier, and has mowed down a path for itself, through the wood, on that side, and there it lies on a slope surrounded by trees, exactly like the moraines of the Chaumont, or of Monthey (Chap. III.).

3. The Glacier of Bossons has no medial moraine. It descends (as De Saussure has remarked) in an unbroken continuity of ice from the very summit of Mont Blanc. Its great feeder is the Grand Plateau, and almost the only rocks which break its passage are the *Grands Mulets,* the first stage on the

[1] Before crossing from the right to the left bank of the Arve, some fine springs are passed at the foot of the Brévent: they are called *Eaux de Gailland.* The temperature on the 27th August, 1832, was 44·6° Fahrenheit.

ascent of Mont Blanc. The detritus of these is, however, too inconsiderable to afford any medial moraine, especially as the glacier is one of the most precipitous, for its extent, in the Alps.

4. The structure of this glacier is generally homogeneous, and almost snowy, or at least opaque white, with little green or blue tinge, except near its edges, where it is most icy. The *veins*, or bands, are distinct near the sides, and fall towards the centre in the usual manner. They are not formed in this glacier by a simple alternation of parallel layers, but the icy bands have all the appearance of *posterior* infiltration, occasioned by fissures thinning off both ways, and filled with frozen water. The icy cascade above seems to have little or no structure. The structure is gradually developed as the glacier consolidates and moves more horizontally, but it is never perfect, owing apparently to the shortness of its course, and the want of lateral barriers. The tendency, however, is evidently towards the usual type of such glaciers, the structural veins bending round in a loop, as seen on the surface, and with a frontal dip diminishing as the glacier approaches its termination, where the bands are more distinct, and indeed well defined, inclining altogether forwards and parallel to the soil on which the ice rests.[1]

5. The paucity of moraines, and the slightly developed structure near the centre of the ice, occasion the extraordinary purity of the Glacier des Bossons, in which it has a remarkable analogy with that of Rosenlaui, in the canton of Berne, which has a somewhat similar course. We have seen that it is the veined structure which intercepts and retains the sand of the moraines. Now, in the case before us, where the glacier is in contact with the lateral moraines, we perceive fragments of stone and earthy matters intermixed with the ice to a considerable thickness, and evidently following in the direction of its cleavage. These are, no doubt, the earthy beds of which De Charpentier speaks,[2] and which he distinguishes from true stratification, but of which, nevertheless, he gives a very unsatisfactory account, supposing that they arise from débris which had fallen into

[1] No glacier with which I am acquainted shows so convincingly that the ribboned structure of the ice is the result of a system of mechanical rents, infiltrated and frozen up, as the Glacier of Bossons. In this respect, as well as the ease with which the forms of the structural shells and the frontal dip may here be studied, this glacier merits especial attention. On the platform the frontal dip is 75° (1845).

[2] *Essai*, p. 75.

crevassses, and which had afterwards become parallel to the sides of the glacier, or its line of contact with the moraine, by some process which he does not explain. The real explanation, upon the theory of these veins which I have given in the last chapter, appears to be, that they are due to the fissures developed near the edge of the glacier, where its friction is greatest, and the velocity of its layers most unequal, and, owing to this inequality, the faster moving parts of the ice drag along with them some of the particles of the moraine with which they have become soiled. In these parts the icy structure is perfect, owing to the complete thaw which the near contact of the warm ground produces, for the lower level of the Glacier of Bossons is unusually deep in the valley, not probably more than 3300 feet above the sea,[1] or at least 5000 feet below perpetual snow.

6. The Glacier of Bossons, then, by showing the exact manner in which an almost homogeneous mass of opaque white ice begins to have a structure developed 10,000 feet below its origin, by the formation of fissures into which water being infiltrated assumes the appearance of bluish veins, which finally present the usual forms of glacier structure, is highly illustrative of the views formerly explained. I must add, that the peculiar phenomena of *dirt bands* on a great scale described in page 155 are not here wanting, although from the dazzling whiteness of the ice they may very easily be overlooked. They are best seen in cloudy weather, when two or three of great breadth may be easily seen traversing the lower end or *snout* of the glacier where it dies away in the valley.

The Glacier of Bossons is bounded on the east by a steep grassy hill, which rises to the foot of the Aiguille du Midi, where it is surmounted by the Glacier des Pèlerins. A very interesting and by no means dangerous excursion may be made in this direction from the Glacier des Bossons to the Montanvert, or the reverse. Above the chalet of La Para (on the slope just mentioned, and the last habitation passed on the ascent of Mont Blanc) is a grassy height,[2] which may be from 7000 to 8000 feet above the sea, and whence a most interesting view is obtained

[1] [On M. Kurz's map, 3606 feet.]

[2] [Probably the Aiguille de la Tour, 7566 feet, twenty minutes above the Pierre Pointue Inn, is meant. There is now a mule-path direct from Chamouni to the Plan de l'Aiguille.]

of the highest part of the Glacier des Bossons, the Gands Mulets rocks, the Grand Plateau, and, indeed, the whole course of the route to the summit of Mont Blanc. From thence the Glacier des Pèlerins is crossed (where De Saussure met with one of the narrowest escapes of his life [1]) to the *Plan de l'Aiguille*, or *Sommité des Croix*, another green hill-top which offers a magnificent view; and continuing nearly on the same level, avoiding or crossing with precaution the Glaciers of Blaitière and Nantillons,[2] the ridge of the Charmoz is gained, along which the descent upon the Montanvert is easy.

The western side of the Glacier des Bossons is bounded by the Montagne de la Côte, a very narrow and steep ridge of rock, covered, however, by many pines, which separates the glacier just named from that of Taconnaz, which descends immediately to the westward, and has a common origin with it amidst the snows of Mont Blanc. Naturally enough the earlier attempts to ascend Mont Blanc were made by the Montagne de la Côte, but it has been found on the whole easier to traverse the glacier. It was by the Montagne de la Côte that De Saussure ascended,[3] and he slept on the summit the first night. The Glacier of Taconnaz is remarkable from this circumstance, that it appears to have diminished notably in modern times, whilst that of Bossons has either increased or perhaps remained stationary. The modern Glacier of Taconnaz has but small moraines, whilst the ground below, and indeed the whole neighbouring valley in the direction of Les Ouches, is strewed with immense fragments of the granite of Mont Blanc, which, it seems impossible to doubt, have been transported by this glacier when it formerly attained a greater bulk, and crossing the Arve, deposited these blocks on its farther bank, where the river takes a sudden turn to enter the valley of Servoz. Limestone occurs on both sides of the Arve, in the neighbourhood of Les Ouches, and is connected with the great secondary chain to the north of the Brévent. Farther down, however, it is succeeded by a nondescript quartzose rock, forming the ridge between Servoz and St. Gervais. Between Les Ouches and the Pont Pélissier, this rock is furrowed and polished in the most characteristic manner of the glacier action of the Alps, in a direction parallel to the length of the valley, and which it is impossible for one moment to doubt being due to the abrasion of

[1] *Voyages*, § 675. [2] [It is also possible to pass *below* them.] [3] [In 1787.]

some heavy superincumbent rubbing body. These forms may be compared to those produced in ductile plaster by the wooden mould with which the workman finishes a cornice. They extend to some height on the western slope, where I first noticed them in descending from the Col de la Forclaz. The whole of this part of the valley scarcely contains one angular fixed rock—all are smoothed and polished. Near the Pont Pélissier, and on the western side of the Arve, are several hillocks presenting precisely the phenomena of *roches moutonnées*, and that their forms are due to glacier action, is rendered the more probable from the occurrence of blocks amongst them, one of which, of immense size and angular shape, seems poised on the very top of one of these bee-hive-like summits; such phenomena have been called by De Charpentier *blocs perchés*, and it is impossible to see a better example than the one I have just mentioned. It is truly surprising that in the minute mineralogical description which De Saussure gives of this route [1] he makes no allusion to these phenomena. This is one example amongst many how obvious facts may escape the most experienced and assiduous observer, for De Saussure must have passed through this valley dozens, if not hundreds of times.

Some miles below Servoz, the valley of the Arve is joined by the Vallée de Montjoie on the left, traversed by the rapid and cheerful stream of the Bon Nant, which forms a remarkably pretty and well-known cascade immediately behind the Baths of St. Gervais. These baths are situated in a deep and picturesque ravine, a little below the village of the same name, whose gay and neat appearance at a distance, with its fantastic spire, decorated, like most of the churches of the province of Faucigny, with burnished tin plate, gives a sparkling character to the landscape. The mineral springs of St. Gervais issue from alluvium, through the floor of a subterranean gallery. The three hottest vary in temperature from 104° to 106° Fahrenheit. They contain iron and sulphur. Like most thermal springs, they issue near the union of different rocks. The valley on one side being composed of slate, quartz rock, and conglomerate, and on the other of limestone, limestone shale, and thick beds of gypsum, from which copious springs rise, with a temperature of 51°, at no great distance from the others. Several excursions of interest

[1] *Voyages*, §§ 499-516.

may be made from St. Gervais, which we will not stop to particularise; the views are very striking, although the higher Alps are concealed, but the limestone range of the Aiguille de Varens, which rises above St. Martin, is singularly picturesque in its outline and detail. What interested me most, however, in my last visit to St. Gervais, was the discovery of what I cannot doubt to be numerous and extensive moraines in its neighbourhood, although the nearest modern glacier is some hours' walk distant.

It is to be observed, in the first place, that the valley is choked, as it were, in its lower part, by a mass of débris, through which the river has worked its way below the village of St. Gervais. The rock, where it appears, is usually slaty limestone; but the surface of the soil is every here and there strewed with blocks of granite, some of them insulated and of great size, at other times accumulated in ridge-like mounds along the face of the slopes, exactly like moraines. Amongst the woods on the western side of the valley, not far from the baths, I found blocks of from thirty to forty feet in length, composed of well characterised protogine or granite of the chain of Mont Blanc. An extensive and well-marked moraine stretches along the face of the hill in the direction of Sallanches, and on the slope fronting the valley of the Arve, where it is almost inconceivable that a torrent could have been embayed, so as to deposit its blocks, supposing it could have moved such immense ones. They lie high above the open plain, and in a regular ridge, exactly like that figured on page 17, from the *Mer de Glace* of Chamouni. The ridge just mentioned is partly grassy, and partly covered with small trees, but there is ample evidence of its composition being similar to that of a moraine.

The most direct route from Chamouni to St. Gervais is not by Servoz, but across the Col de la Forclaz, which rises immediately above the village of St. Gervais. For a great height on this path, angular granite blocks are strewed about.

The Col de la Forclaz[1] is a gorge, and therefore offers no view from the summit. The Col de Bellevue or Col de Voza, which crosses the chain of Mont Lachat somewhat higher up, and communicates between the village of Les Ouches, in the valley of Chamouni, and that of Bionnay in the Val Montjoie, and commands the prospect of Chamouni and Mont Blanc, is,

[1] [5105 feet.]

therefore, deservedly more frequented. It also gives an opportunity of inspecting the Glacier of Bionnassay, which descends in a north-western direction from near the summit of Mont Blanc, and approaches near the chalets of the same name. The Pavillon de Bellevue on the Col is nearly 7000 feet above the sea,[1] and yet erratic blocks are strewed all around. Not only is it inconceivable that a torrent should have passed over a hill like this, fit to carry great blocks of granite, but *the erratics of the Col mix insensibly with the modern moraine of the Glacier of Bionnassay beneath, so that it is impossible to say where the erratic phenomenon ends, and where the glacial phenomenon begins.* This is an argument, very striking on the spot, in favour of the glacial theory of erratics, and these very blocks of protogine may be traced, I believe, without any intermission, down to the Baths of St. Gervais, and perhaps to Sallanches. There are three, if not four,[2] distinct glaciers which occupy the higher parts of valleys communicating with that of Montjoie: Bionnassay (already mentioned), Miage[3] (to be distinguished from that of the same name in the Allée Blanche), and Trélatête, which descends opposite the chalets of Nantborrant. All of these transport numerous primitive blocks, and sometimes deposit them upon insulated summits near the openings of the respective valleys. From Contamines[4] (where there is an indifferent inn) to Notre Dame de la Gorge (a chapel and mission-house, without a village), the scenery is cheerful and pretty. There the defile narrows, and the steep rocks of gneiss on either hand, between which the stream struggles, are picturesquely clothed with larch and pines; and here, as is almost universal in valleys containing erratics, the surface of the rock is worn, rounded, and cut by long smooth furrows, which resemble those produced by glaciers. The torrent is passed by a bridge immediately above a fine waterfall, and we

[1] 6939 English feet. See De Candolle, *Hypsométrie*. [The Pavillon de Bellevue, 5843 feet, is some way above the Col de Voza, 5496 feet.]

[2] [Forbes omits that of Frasse, the nearest to Contamines, which is the principal hamlet in the Montjoie glen.]

[3] [This is the *French* or Savoyard Miage Glacier; that in the Allée Blanche is the *Italian* or Piedmontese glacier of that name.]

[4] [There is now a char road from the Chamouni valley at Le Fayet past the *village* of St. Gervais—the Baths lie below in a gorge and have a char road of their own from Le Fayet to Contamines—and from Contamines to Notre Dame de la Gorge. Thence there is a mule-track to Courmayeur. There are now inns at Nantborrant, La Balme, Chapieux, Mottets, and La Visaille, on the Bonhomme-Seigne route between Contamines and Courmayeur.]

find ourselves in an upland pastoral country, but still pleasingly diversified by wood. A main branch of the Bon Nant descends a narrow rough gorge from the Glacier of Trélatête. We are now at Nantborrant, where travellers, making the tour of Mont Blanc, usually pass the night.

Nantborrant is about seven hours' walk from Chamouni. The Col du Bonhomme is between two and three hours farther. The way lies chiefly over upland pastures, not unmixed with good trees, but the higher part is bare rock, with patches of snow. The upper portion of the valley is composed of secondary limestone, containing Belemnites, and presents no granite blocks. But though the little plain of La Balme is covered with vast calcareous fragments fallen from the cliffs above, these do not extend (so far as I have observed) into the valley beneath; and the numerous primitive blocks already mentioned cease entirely above Nantborrant, that is, they commence with the Glacier of Trélatête, thus showing that the transporting cause of these erratics had its origin, not in the natural prolongation of the valley (at the Col du Bonhomme), but in the highest tributary which contains a glacier.

The passage of the Bonhomme is one of the most dreary in the Alps, and in bad weather it is dreaded by the guides. The strong west wind spends itself upon this great outlier of the chain of Mont Blanc, and raises the snow into fearful eddies, called *tourmentes* in the French and *Guxen* in the German Alps, which are justly feared by those who have been exposed to them. Here two English travellers lost their lives some years since.[1] Their last entry is still to be found in the travellers' book at Nantborrant. I have crossed the Col du Bonhomme three times, and on one of these occasions, having merely a porter with me, who did not know the way, we got bewildered in fog amongst the rocks, from which we were only extricated by my referring to the map and compass, instead of following the directions of my companion. When the summit[2] is gained a wide view is seen over the valleys [N.] of the Tarentaise, and the traveller naturally thinks of descending immediately by a path right before

[1] [These were the Revs. Richard Bracken and Augustus Campbell, who perished on September 13, 1830.]

[2] [The first pass is 7678 feet in height. It is sometimes called "Col du Bonhomme," to distinguish it from the true pass, or the "Croix du Bonhomme."]

him. Let him, however, beware of this, for it will lead him into the valley of Beaufort, which, most likely, is not his intended route. If going to Courmayeur, he follows an ill-traced path on his left, over black shale (or snow during part of the season), which conducts him nearly on a level, after a quarter of an hour's walk, to a point somewhat higher than the last, which is called the Croix du Bonhomme, and which, on my last journey, I found to be 8195 feet above the sea.[1] The view from thence is striking, although Mont Blanc is concealed. The mountains of the Upper Isère, stretching away towards the Mont Cenis, are fully in view; and conspicuous amongst these is the Aiguille de la Vanoise,[2] a snow-clad pyramidal summit between Moûtiers Tarentaise and Lanslebourg, and which is undeniably one of the most elegant mountains in the Alps.

Immediately before the spectator is the very deep valley of Bonneval, which takes its rise at the foot of the Col de la Seigne, and which, turning sharply at the chalets of Chapieux (whose position may be seen at an immense depth below), forms a very wild and uninhabited gorge,[3] extending nearly to Bourg St. Maurice, in the valley of the Isère. By this route the traveller reaches the pass of the Little St. Bernard, which he may traverse to the Val d'Aoste. If, on the other hand, he wish to reach Courmayeur directly, he may either descend from the Croix du Bonhomme to Chapieux and ascend to the Hameau du Glacier at the head of the valley, or he may cross the Col des Fours, which conducts him by a shorter but rougher road; or, finally, he may scramble along the rocks by an intermediate path, without descending so low as Chapieux. The passage of the Col des Fours is still more savage than that of the Bonhomme, and it is considerably higher.[4] I shall long remember an hour spent here in magnetic and barometric observations in August, 1832, amongst perpetual snow and exposed to a biting wind. It is about 850 feet higher than the Croix du Bonhomme.[5] The middle path just

[1] [Really 8147 feet.]

[2] [It is really the Mont Pourri, 12,428 feet, second only in the Tarentaise to the Grande Casse, 12,668 feet, the name "Aiguille de la Vanoise" having been formerly applied to the latter, as it overhangs the Col de la Vanoise.]

[3] [There is now a char road through this glen from Chapieux to Bourg Saint Maurice. Two-thirds of the way down is the "Etablissement" of Bonneval les Bains. Bourg Saint Maurice is close to the foot of the Little St. Bernard.]

[4] [It is 8891 feet.]

[5] [Really 744 feet.]

alluded to is, in some respects, interesting. Instead of descending the steep pastures of Chapieux we follow an obscure track amongst the rocks towards the east, and after traversing for some distance the limestone strata rising towards the north, of which the main chain is here formed, we come to a mass of granite, rising from the valley *and overlying them* at a considerable angle. Near the same point there is a magnificent view of Mont Blanc and the adjacent mountains, seen above the Col de la Seigne, which appears just in front. It presents the whole range, from the Grandes Jorasses on the east to the summit called Aiguille des Glaciers on the west, from which the vast glacier[1] descends which occupies the head of the valley of Bonneval.

At the chalets of Mottets the traveller will probably make as short a stay as possible, and will then proceed to ascend the Col de la Seigne, which, as has been said, separates the tributary streams of the Rhone from those of the Po. The ascent is very easy, but tedious. The summit is 8422 feet above the sea,[2] by my observations, and was fortified, as I was informed, when the French army endeavoured to force this pass. From the top the extent of the Allée Blanche is well seen, with the great masses of the chain of Mont Blanc, which bound it on the left. Mont Blanc itself presents a singular appearance in this direction, and would not be easily recognised by those who know it only in a northern or eastern direction. The western and southern faces are very steep, although not so absolutely precipitous as they would appear to be when viewed in front. The former falls abruptly towards the Glacier de Miage, the latter into the Allée Blanche itself. The bottom of the valley is here not more than 4000 English feet above the sea, consequently this colossal mountain rises above it at a very short horizontal distance, and no less than 11,700 feet of vertical height, which, though not an unbroken precipice, is composed entirely of steep and savage rock, upon which the snow cannot lie for any extent. Its aspect is, therefore, far more imminent and imposing than on the side of Chamouni, where the eye is greatly deceived as to the actual *distance* of the top, and consequently as to its height. But here the details rather aid the perspective, and when seen in profile from the Col de la Seigne, the stupendous buttresses by which the mountain is supported, and especially one prodigious aiguille

[1] [Now much shrunken.]

[2] [It is 8242 feet.]

of granite, called Mont Pétéret,[1] come out in relief, although, when a front view is taken from Courmayeur or its neighbourhood, these pinnacles, thousands of feet in height, are lost against the towering mass behind, which then seems to rise like a wall. I am unable to state the exact line of junction of the limestone with the central mass of granite. I apprehend, however, that it runs from some way to the north of the Col de la Seigne (which is calcareous) to the Cime des Fours, and so down nearly to Nantborrant, leaving the Aiguille des Glaciers and the greater part of the Glacier de Trélatête within the primitive boundary. To the east the limit is, in a good measure, determined by the direction of the Allée Blanche, which separates, for some distance, the granite from the limestone. Two conspicuous summits, however, which appear near the foreground of the view, a little higher than the Col de la Seigne, are the Pyramides Calcaires de l'Allée Blanche of De Saussure. They are upon the left hand in descending. It is a walk of nearly five hours from the top of the Col to Courmayeur, during which we traverse the whole length of the Allée Blanche.[2] It is there met by another parallel valley which opens exactly opposite to it, and forms, as it were, the prolongation of the Allée Blanche for about five hours farther. This is called the Val Ferret, and terminates at the Col Ferret.

The chief glaciers of the Allée Blanche (on the north side) are the following: (1) the Glacier de l'Estellette; (2) the Glacier de l'Allée Blanche; (3) the Glacier de Miage; (4) the Glacier de la Brenva. The second and third of these have formed barriers across the valley by moraines, so as to have occasioned lakes from the interruption of the course of the river. That formed by the Glacier de l'Allée Blanche is nearly filled up by alluvial matter; but an extensive flat attests its former existence, together with the extensive barricade of débris, through which the river now tumbles in a foaming rapid. The moraine of the Glacier de Miage is, perhaps, the most extraordinary in the whole Alps, and has given rise to the Lac de Combal, which will be especially described in the next chapter. Below the moraine of Miage, which occupies the valley for a great space, are some chalets,[3] and then a level fertile plain,

[1] [Both the Aiguille Blanche de Pétéret—the loftier—and the Aiguille Noire de Pétéret are seen. The latter is probably the peak meant by Forbes.]

[2] De Saussure (§ 854) states that below the Glacier de Miage the name of Allée Blanche is exchanged for that of Val Veni.

[3] [Here is now the little Visaille inn.]

whilst the valley widens and becomes more romantic and less savage. Trees appear on both sides, especially on the right, where the forest is very fine, and clothes all the northern slope of a remarkable hill with a conical summit, called the Mont Chétif, or Pain de Sucre, which is composed of granite, although separated from the great chain by secondary rocks. The paths through these woods are amongst the most beautiful and striking with which I am acquainted. That leading to Courmayeur, after attaining some height above the torrent, proceeds nearly on a level, until, emerging from the trees, we come into full view of the majestic Glacier de la Brenva, which, formed in a hollow to the east of Mont Blanc, pours its mass into the valley, which it has, in a good measure, filled up with its moraine, forming a kind of bridge, which it has pushed before it, and on which it bestrides obliquely the Allée Blanche, abutting against its opposite side, at the foot of the Mont Chétif. Its appearance and phenomena will also be described in the next chapter. A chapel, dedicated to Notre Dame de la Guérison,[1] stands on the right-hand side of the way, exactly opposite to the ice, and another steep descent conducts us again to the bank of the river, which here turns abruptly, after its confluence with the stream of the Val Ferret, into a ravine, cutting the range of the Pain de Sucre. The united streams are passed by a wooden bridge at the Baths of la Saxe, and twenty minutes more brings the traveller to the beautifully situated village of Courmayeur, after a laborious walk of eleven hours from Nantborrant.

[1] [Or de Berrier.]

THE GLACIER DE MIAGE AND ITS MORAINE

a, PYRAMIDES CALCAIRES. b, GLACIER DE L'ALLÉE BLANCHE.
c, GLACIER DE MIAGE. d, COL DE LA SEIGNE.

CHAPTER X

THE GLACIERS OF MIAGE AND LA BRENVA

The ascent of the Allée Blanche—Moraine of Miage—Its height and extent—Chamois—Tributary glaciers—Their structure and forms of union with the principal one—Scene of desolation on a moraine—La Brenva—Its remarkable structure—A superimposed glacier—Interesting contact of the ice with the rock beneath—Increase of the glacier of La Brenva in 1818—A tradition.

"I am acquainted with only one other scene in the world which can pretend to rival, in natural magnificence, the Glacier de Miage; I mean Niagara."

BASIL HALL.

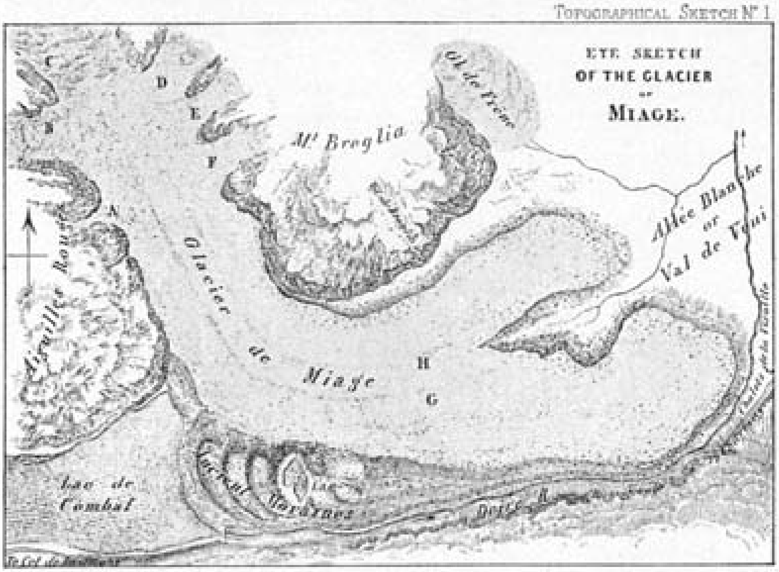
COURMAYEUR would be worth a visit, if it were only for the purpose of examining in detail the Glaciers of the Allée Blanche. But this excursion is rarely made. Travellers are usually content with what they see of them in descending from the Col de la Seigne, and there are but few guides who have ever traversed either of these glaciers. A short day is sufficient for visiting the Glacier of La Brenva, but it is a laborious day's work fully to examine the Glacier de Miage.[1] I shall begin with the latter.

I had twice before passed the Lac de Combal, and the

[1] [On this glacier Signor Martino Baretti's monograph, published at Turin in 1880 in the *Memorie della Reale Accademia delle Scienze di Torino*, series ii. vol. xxxii., should be consulted. It has a map and diagrams.]

moraine of the glacier which I have described as pushed out into the valley which it occupies for *several miles in length*, nearly a mile in breadth, and several hundred feet in depth. I had no small curiosity to see the chasm in the mountains whence this mass of débris had been derived, and to examine the glacier which had been and still continues to be so powerful an agent of degradation and transport. Accordingly, on July 15, 1842, I left Courmayeur at half-past five A.M., on foot, and reached

Topographical Sketch No. 1



the lower extremity of the moraine at the chalets of La Visaille in about two hours. The Doire there struggles through the narrow ravine left between the moraine and the foot of the calcareous hills on the south side. The path keeps the side of the moraine, and is every year more or less injured by the falls of rubbish. In this ravine on the south side is a deep hole in the gypsum rock which occurs there, in which my guide Antoine Proment assured me that chamois frequently pass the night, and their young are sometimes taken alive. This surprised me, and I was inclined to doubt it, but we saw traces of them on a patch of snow within a short distance. In three hours from Courmayeur I reached the Lac de Combal,[1] where the Doire issues

[1] [See Baretti, pp. 16-18 of the separate reprint, as to this lake.]

from it (see the Topographical Sketch, No. I.). A dam has been formed so as to secure its regulated discharge, and to prevent accidents. This lake, as has been already said, is formed entirely by the moraine of the glacier, which is here shot out from the side ravine, and occupies the entire breadth of the valley. The moraine consists of two parts, the old and the new. It is the old which bounds the lake; the new moraine rises to a greater height, and sweeps more gently round, until it becomes parallel to the length of the valley. The old moraines are still fortified by the low walls with slits of musketry, erected probably by the Piedmontese troops in 1794.[1] It is strange to see this application of the artificial-looking mounds which the glacier has raised, and which themselves bear no slight resemblance to a series of gigantic outworks of an extensive fortification. It is the outermost of these ridges which is so occupied. The arrangement of the others is abundantly singular, forming a series of four semilunar curves with their convexity up the valley, as shown in the ground-plan, which is taken from a careful sketch made upon the spot. A small lake is formed behind these moraines, which is further enclosed by other convex, though less perfect moraines beyond, of which the greater part are now grass-grown. I am by no means satisfied as to the way in which these successive ridges of débris were deposited by the glacier. They may either have been frontal moraines, or the contents of vast fissures which were deposited as the glacier melted. Something of the latter kind I have since observed to have taken place in the recent retirement of the Glacier de Lys, in the valley of Gressoney, near Monte Rosa. But as I cannot give any certain explanation, I shall not dwell upon it.

Having observed the barometer at the level of the lake, I proceeded to ascend the modern moraine, which is higher than would readily be believed from mere inspection, and when I had gained the top and commanded a view of the Glacier de Miage, I observed the barometer again, and found the vertical height of the moraine (besides what is below the level of the lake) to be 395 feet.[2] Here I found the veined structure of the ice distinct,

[1] [But they are mentioned by P. A. Arnod in his careful report as to the passes of the Val d'Aosta, written in 1691-94. See Signor Vaccarone's *Le vie delle Alpi Occidentali negli antichi tempi* (Turin, 1884), pp. 49, 103.]

[2] The height of the Lac de Combal is, by my observation, 2091 feet above Courmayeur, or 6302 feet above the sea. [Really 6365 feet.]

parallel to the length of the glacier, but dipping inwards at an angle of 70°.

The Glacier de Miage, as I have said, is here pretty level; it is shot out as it were from a narrow valley which works its way back into the very entrails of the great chain, so that the head of the valley is considerably to the north-west of the summit of Mont Blanc, which here presents inaccessible escarpments. The valley is almost straight, and the sides parallel, without subdividing itself into considerable branches. The ice is shoved along this uniform canal, and receives a few tributaries from either side,[1] which descend with great steepness. One which I remarked on the right bank of the glacier, at a spot marked A on Sketch No. I., descends at an angle, which, so far as I could ascertain it without being on its surface, was inclined 50°, and which is the steepest *unbroken* surface of ice I have ever seen. It descended a narrow couloir from the Aiguilles Rouges (called Mont Suc by De Saussure)[2] from a great height. The narrowness of the main valley makes it like an unfinished excavation intended to have cut the chain of Mont Blanc in two, and struck me with surprise, although I was somewhat prepared for it after viewing the prodigious mass of solid matter which the glacier had poured out into the Allée Blanche. It may be cited as a most striking instance of excavation by the ceaseless action of seemingly trifling causes. The continual fall of fragments detached from the neighbouring summits loads the glacier with débris, which it bears incessantly down from the head of the valley; and as we judge of the size of a quarry from viewing its rubbish heaps, so here we have the mould and the cast, the die and the relief, the matter transported and the spot of its excavation.

I traversed the glacier in several directions with a view to examine its structure, and whilst standing on the moraine I saw a female chamois and her calf cross the glacier, within a very short distance, towards the Aiguilles Rouges. They were followed by eight full-grown chamois, which I could watch all at once. They were tame, and stopped frequently to look about

[1] [The three most important descend from Mont Blanc and its north-western ridge.]

[2] [The proper name of the Aiguilles Rouges is "Aiguille de Combal," of which the lower slope bears the name of "Mont Suc."]

them without apparent alarm, and took gently up the hill. They are almost never hunted here. Near this part of the glacier, and also on the face of the Aiguilles Rouges, at a very considerable height, a mine of lead and silver was worked for some years.[1] It was a strangely wild position for the hope of gain to allure any speculators to establish themselves in. After the ore had been excavated and brought down the face of the cliffs, it had to be carried on men's backs for several miles over the ice before even a mule track was reached.

Two principal medial moraines occupy the centre of the glacier, and, as usual, their magnitude becomes apparently greater the farther the glacier descends, owing to their exposure, by the melting of the ice, as I have elsewhere explained. The materials of these moraines are rather remarkable, and have been minutely described by De Saussure (§§ 853, 854, 892-897), who is the only author I have met with who describes this glacier. He particularises a beautiful granitello, composed of crystallised felspar and schorl; amianthus, of the fine short kind like delicate fur, mixed with quartz, and which occurs in all the cabinets of the minerals of Mont Blanc; several kinds of serpentine, and (what I have not seen) carbonate of lime crystallised with quartz.[2]

The tributary glaciers of the Miage are, as already said, very steep, and sometimes pour their icy flood down unbroken, at other times they descend in *avalanches* upon the main glacier, and become gradually and completely amalgamated with it. This is in the higher part, where the descending masses are rather of compact snow than ice. In this sense it is perfectly true, as stated by De Saussure, that the glaciers are partly fed by avalanches, a position which has been too flatly contradicted.[3] Such is the feeder marked B on the Sketch. After three hours' walk upon the ice, I reached a considerable height upon the north-western tributary of the glacier, which was in this part covered with snow, and, indeed, passed into the state of névé. I took the height of the barometer, and found the elevation above the sea, the highest

[1] [This mine is much farther up the glacier than Forbes states, and is immediately under the "Col (dit) Infranchissable," which communicates with the head of the Trélatête glacier; three half ruined huts still exist on that slope.]

[2] I may mention that carbonate of lime is said to be found, though very rarely, in the granites in the very heart of the chain; as at Les Courtes, near the Jardin, on the Glacier de Talèfre. An enormous price was asked last summer (1842) at Chamouni for a large crystallised specimen of this kind.

[3] By De Charpentier and Agassiz.

which I attained upon this glacier, to be 8051 feet. I then crossed the head of the glacier, which was here wet with wide water-runs, and remarkably free from crevasses, and very carefully examined the structure of the tributary glaciers, which fall into the principal glacier from the precipices of Mont Blanc. These afforded valuable studies of the manner of development of glacier structure (a subject which at the time particularly engaged my attention), which I have since abundantly confirmed in similar cases. Each tributary is, in the *first* instance, amorphous, without any apparent structure, and confusedly thrown together in fragments, as it descends a steep and very uneven slope. As it approaches the foot of the steep, it accumulates

Fig. 1. Section.

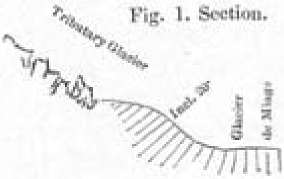


Fig. 2. Plan.

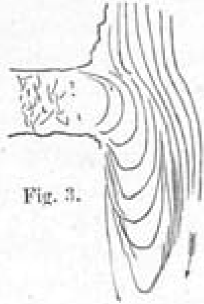


Fig. 3.

upon itself in the *second* stage of the process, and becomes a consolidated glacier, in which a wave-like structure is developed, with convex arcs on the surface, directed downwards, and the bands, which form these arcs, dipping inwards, and approaching horizontality, as the glacier approaches the level of the other. But after it has done so, and the tributary glacier no longer falls forwards, but has its advancing motion resisted by the ice of the main stream, against which it is laterally forced, the structure planes become steeper, and they gradually assimilate themselves, in the *third* stage, to those of the main glacier, becoming erect, and repressing the others. This arrangement is shown in section in Fig. 1, and in ground plan in Fig. 2. These figures were drawn on the spot from the tributaries marked D, E, and F.[1] It was from the examination of these that I first drew the conclusion, which I have since found to be quite general, that the structure

[1] [D is the Dôme Glacier; and E and F two branches of the Mont Blanc Glacier.]

of glaciers is developed from time to time, according to the conditions of the ice, that the structure of one part is not necessarily any modification of the structure of another, and that it is in vain to attempt to trace the stratification of the névé into the vertical bands of the middle glacier, or these into the conchoidal surfaces near the lower extremity. The appearance of Fig. 2 occurs when the tributary is of insignificant dimensions, compared to the primary glacier; its structure is immediately overpowered, and becomes subject to the law of the preponderating one. But where the two streams are comparable in magnitude, the inosculation is more gradual, and the structure is a more complete mixture of the two. Such a condition is shown in Fig. 3, which is the condition (for example) of the Glacier de Talèfre uniting with the Glacier de Léchaud.

In general, the structure of the glacier, whilst it is bounded by the chain of Mont Blanc, is well developed, both near the medial moraines and near the sides, in nearly vertical planes, parallel to the length of the glacier.

Near the promontory of the Monte Broglia [Mont Brouillard], round which the glacier sweeps, so as to turn sharply into the Allée Blanche, the whole structure inclines *from* that promontory, exactly as I have described in the case of the Mer de Glace, rounding the promontory of Les Echelets, and as is figured in the glacier section, No. IV., page 158. The rocks are smoothed by the action of the glacier at several points on both sides.

I was not satisfied with having traversed the upper and more level part of the glacier in its whole extent, but I resolved to follow the surface of the ice as far as possible, after it spreads itself abroad in the Allée Blanche, in order to examine its wonderful moraines, and if possible to trace its structure. From a distance, this appears not to be very difficult, for the surface is not steep, its mean inclination in its middle part being about $5\frac{1}{2}°$. Its immense extent, however, deceives the eye as to its inequalities, and I scarcely ever remember to have had a more laborious or rougher walk than the traverse of the lower part of the Glacier de Miage, which I followed down its centre to the spot where, as will be seen by the eye-sketch, it divides into two branches. This icy torrent, as spread out into the Allée Blanche, appeared to me to be $3\frac{1}{2}$ miles long and $1\frac{1}{2}$ wide; but

I am aware of the uncertainty of these measures. After struggling for a long time amongst fissures and moraines, I at length mounted a heap of blocks higher than the rest, and surveyed at leisure the wonderful scene of desolation, which might compare with that of chaos, around me. The fissures were numerous and large, not regular, like those of the Mer de Glace, traversing the glacier laterally, but so uneven, and at such angles, as often to leave nothing like a plain surface to the ice, but a series of unformed ridges, like the heaving of a sluggish mass struggling with intestine commotion, and tossing about over its surface, as if in sport, the stupendous blocks of granite which half choke its crevasses, and to which the traveller is often glad to cling when the glacier itself yields him no farther passage. It is then that he surveys with astonishment the strange law of the ice-world, that stones always falling seem never to be absorbed—that, like the fable of Sisyphus reversed, the lumbering mass, ever falling, never arrives at the bottom, but seems urged by an unseen force still to ride on the highest pinnacles of the rugged surface. But let the pedestrain beware how he trusts to these huge masses, or considers them as stable. Yonder huge rock, which seems "fixed as Snowdon," and which interrupts his path along a narrow ridge of ice, having a gulf on either hand, is so nicely poised, "obsequious to the gentlest touch," that the fall of a pebble, or the pressure of a passing foot, will shove it into one or other abyss, and the chances are, may carry him along with it. Let him beware, too, how he treads on that gravelly bank, which seems to offer a rough and sure footing, for underneath there is sure to be the most pellucid ice; and a light footstep there, which might not disturb a rocking-stone, is pregnant with danger. All is on the eve of motion. Let him sit awhile, as I did, on the moraine of Miage, and watch the silent energy of the ice and the sun. No animal ever passes, but yet the stillness of death is not there; the ice is cracking and straining onwards—the gravel slides over the bed to which it was frozen during the night, but now lubricated by the effect of sunshine. The fine sand detached loosens the gravel which it supported, the gravel the little fragments, and the little fragments the great, till, after some preliminary noise, the thunder of clashing rocks is heard, which settle into the bottom of some crevasse, and all is again still. In walking over ordinary rugged ground or rocks, the presumption is, that the masses have become shaken into the position of stable equilibrium—that is, that if a block be movable, it will tend to roll back to its former position. But, on the glacier, the conditions are exactly reversed, and the consequences are proportionably more serious.

I had the satisfaction of perceiving, as I descended the glacier, that where it spread laterally, and at the same time fell forward, the structure of the Glacier of the Rhone, and those of similar type (see pp. 29, 30), developed itself; the vertical bands bent round in front of the descending glacier, and dipped inwards at the point marked H, at an angle of 65°, and at G, at an angle of 45°. Here the fissures become longitudinal or radiating, and the ice still more difficult to traverse. Nearly the whole surface is covered with the moraine. The extreme difficulty of finding a path prevented me from ascertaining its structure right and left, where it divides into two branches; but I have no doubt that in this, as in other similar cases, the divided streams have each the usual structure of a single glacier.

The bifurcation of the glacier does not appear to be the result of any fixed obstacle in the valley itself, which interrupts its progress. It is occasioned solely by the prodigious accumulations of the medial moraines, which, having for ages discharged their contents in front of the glacier, at length accumulated a mound in the centre which parted the ice in two with less resistance than would have been required to shove the prodigious mass forward. Arrived at the point of separation, I looked from the edge of the glacier into a hollow or ravine several hundred feet deep, having very steep sides, composed entirely of the most massive blocks which the glacier has brought down, and which are piled in vast confusion. Down these I scrambled with some labour, and found at the bottom, not the natural soil of the valley, but apparently the surface of an older moraine, which had spread wider, though not to so great a height. A stream struggles from amongst the blocks, and waters a small valley [1] containing some stunted larches and alders, almost surrounded by the two arms of the glacier, whose moraines nearly

[1] [This is probably the spot now called the "Jardin du Miage," though it may be the "mound" between the two arms of the glacier, mentioned a few lines above. The Miage Glacier has greatly shrunken since Forbes' day, but is now once more advancing.]

meet below, but the two streams do not again coalesce.[1] Into this wild enclosure a few sheep are annually driven. I then crossed the torrent descending from the Glacier of Fresnay, which falls from the chain of Mont Blanc, but little below the moraine of Miage, and returned to Courmayeur by a pleasant path through the chalets of Fresnay, on the same side of the valley.

The Glacier of La Brenva may rank amongst the most accessible in the Alps. It descends more prominently into the lower valleys than almost any with which I am acquainted, and may be very completely seen from a convenient mule-road which traverses the Allée Blanche, at a distance of less than three miles from the village of Courmayeur. I have already mentioned (p. 184) the extreme beauty of the ride through the pine-woods which clothe the northern face of the Mont Chétif, from which the stupendous chain of Alps may be surveyed like a theatrical scene, and amongst the trees beneath the dazzling white of the glacier presents itself, supported on the bridge of rubbish by means of which it crosses the valley, and presents itself to our close inspection.

Two circumstances are especially worthy of note in this magnificent glacier: its veined structure, and the remarkable changes of dimension which it has lately undergone. As I am not aware of any author who has traversed this glacier, or who has described either of these interesting facts, I shall devote a short space to them.[2]

The Glacier of La Brenva consists (as De Saussure, § 855, so far very well described it) of two distinct parts: first, the rugged and fissured portion, which is quite inaccessible,[3] and which descends a ravine, having its origin very near the summit of Mont Blanc, exactly under the Mont Maudit; and the inferior, or gently sloping portion, which traverses the

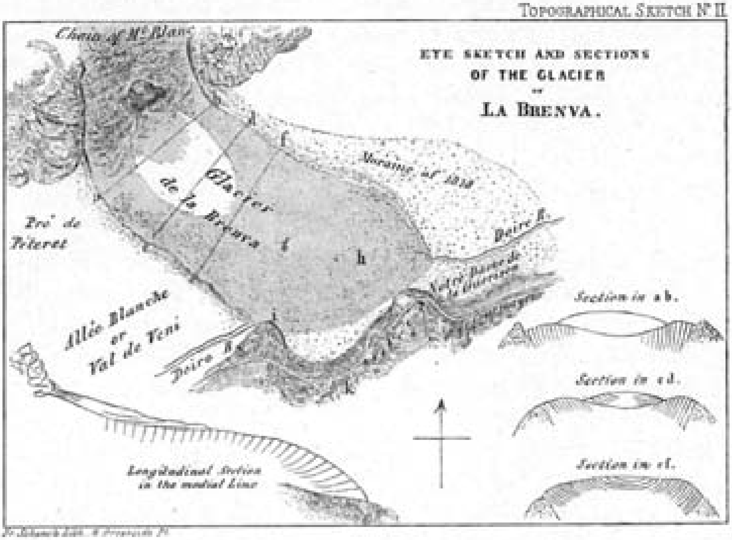
[1] The lowest part of the modern moraine is 5483 feet above the sea, or 819 feet below the Lac de Combal.

[2] [Consult the monograph, with a map, on this glacier by Signor Marengo in No. 45 (pp. 1-9), 1881, of the *Bollettino* of the Italian Alpine Club, and the historical details given by Signor Virgilio in No. 50 (1883) of the same periodical.]

[3] [This is no longer true, for a few parties have reached the head of the "Corridor" or a higher point on the final ridge of Mont Blanc, direct from the upper Brenva Glacier; while others have, from the head of that glacier, climbed the Tour Ronde, or crossed the pass of that name to the head of the Géant Glacier.]

valley, as already said, upon a mound or embankment formed by itself, and beneath which the river Doire at present makes its way.[1] The middle of the craggy descent is interrupted by a great prominence of rock,[2] over which the descending ice falls in avalanches, and is so completely pulverised, as to be reduced almost to a snowy condition, in which it lies on the surface of the consolidated glacier, and goes through the same changes as in the transformation from névé into ice in ordinary glaciers.

Topographical Sketch No. II.



It is, indeed, a little parasitic glacier, cradled in the ice of the old one. The Topographical Sketch, No. II., is only intended to explain the sections of the ice, showing its structure, and to give a general idea of the position of the glacier; but has no pretensions to exact topography, not having been sketched with a view to publication. I ascended the glacier to a little way above the line *a b*, which I found to be 1717 feet above Courmayeur, or at least 1500 above the point where the Doire issues from beneath it. The mean slope of the glacier seen from this point, looking downwards, is 12°. The first section shows the superposition of the powdery ice upon the glacier, which last is

[1] [The glacier has so much shrunk since 1842 that this phrase does not represent the actual state of things.]

[2] [This is the "Pierre à Moulin" or the "Roche du Moulin Grénon," and is 7622 feet above the sea.]

there traversed by almost vertical bands, well developed, and which I traced towards the centre, until lost beneath the other.

The cause of the sudden twist in its direction, which, as will be seen by the sketch, the glacier takes when it issues from between the rocks, is probably this. The glacier, when it descended from the mountain, gradually accumulated an enormous moraine exactly in front of it, so that a valley was formed between the rock and the moraine on either hand, down which the glacier might naturally pass. It took to the left in the direction of the valley beneath, and the old moraine formed one of its barriers. There is no doubt, that in this and similar cases, the vast moraine on which the glacier rides is hollow at its centre, and the débris on either hand form a sustaining wall.

At *c d*, the parasitic glacier assumes a tolerable structure, and it is there clearly of the cup-shaped or conchoidal form, described in page 29 as belonging to the Glacier of the Rhone. This observation is important, as showing that the arrangement of the structural bands, in glaciers of the second order, is independent of the annual layers of the névé (see page 31). The superimposed glacier is here *radially* fissured like the Glacier of the Rhone.

Between *c d* and *e f*, the parasitic glacier gradually disappears; the vertical bands of the fundamental glacier may there be seen to turn round, so as to present their edges across the glacier, and to dip inwards at a considerable angle. (See figures, page 157). In the centre of the line *e f*, the frontal dip inwards (see the longitudinal section attached to the Topographical Sketch) is 65°. Here the glacier is flattest. Its mean slope is 8°. I traversed carefully the breadth of the glacier; the sides being supported only by the moraines, the dip no longer approaches verticality. The structure planes at the sides dip inwards at 55°, as shown in the transverse section along *e f*.

The next stage of the surface (marked *g* in the plan) inclines 14°. The frontal dip inwards of the structure planes is here 30°. Opposite the chapel, at the point marked *h*, where the glacier is steep, but still is at a considerable height above its lower termination, the frontal dip inwards is 19°; and immediately above the vault of the torrent, the inward dip of the structure is only 5°. The four sections on the lithographed plan fully illustrate, it is hoped, the geometrical structure of this glacier, together with the superimposed one. It will be found to agree most accurately with what I have described as the normal type of glacier structure, and especially with the description given of the Glacier of the Rhone, which that of La Brenva very much resembles in some respects, in my earliest paper on the subject, reprinted in *Occasional Papers*, pp. 6-8.

The alternation of bluish-green and greenish-white bands, which compose this structure, gives to this glacier a most beautiful appearance, as seen from the mule-road. An attempt has been made in Plate V.[1] to give some idea of this most characteristic display, and which is better seen here than in any other glacier whatever with which I am acquainted. The sketch was taken by myself from the point marked *k* in the map, in July, 1842.

When the ice of the glacier abuts against the foot of Mont Chétif, at the promontory marked *i* on the map, it is violently forced forward, as if it would make its way up the face of the hill. Here the contact of the ice and soil is very well seen; and my friend M. le Chanoine Carrel of Aosta, with whom I walked several times in this neighbourhood, and who took an interest in such questions, discovered a point of contact between the limestone and a protuberant mass of ice which admitted of easy removal, thus showing the immediate action of the ice and rock. Having taken a man furnished with a strong axe, we proceeded together to the spot. The soil near the ice appeared to have been but recently exposed by the summer's melting of the ice. It was chiefly composed of clayey débris from the blue limestone. At the point marked by M. Carrel a piece of fixed rock opposed the ice, and was still partly covered by a protuberance of the glacier, which we speedily but gently cut away with the hatchet. The ice removed, a layer of fine mud covered the rock, not composed, however, alone of the clayey limestone mud, but of sharp sand, derived from the granitic moraines of the glacier, and brought down with it from the opposite side of the valley. Upon examining the face of the ice removed from contact with the rock, we found it *set* all over with sharp angular fragments, from the size of grains of sand to that of a cherry, or larger,

[1] [Omitted in the present edition.]

of the same species of rock, and which were so firmly fixed in the ice as to demonstrate the impossibility of such a surface being forcibly urged forward without sawing and tearing any comparatively soft body which might be below it. Accordingly, it was not difficult to discover in the limestone the very grooves and scratches which were in the act of being made at the time by the pressure of the ice and its contained fragments of stone. By washing the surface of the limestone we found it delicately smoothed, and at the same time furrowed in the direction in which the glacier was moving, that is, against the slope of the hill. We succeeded in detaching some fragments of the rock with hammers, having even the sharp sand adhering to it, which I afterwards secured with gum-water, in order to illustrate the exact condition of a rock subjected to glacier action. It would be impossible to catch nature more completely in the fact than in the observation just stated. I afterwards returned with a skilful mason, who, with much labour, succeeded in detaching several specimens of the striated and polished surface.[1] Not only was the limestone friable, but the cleavage being perpendicular to the surface, rendered it impossible to obtain a slab of any extent.

On the path leading to Courmayeur—a few minutes' walk below where the glacier now ends—are some admirable specimens of ancient polished and striated surfaces of the same limestone, which it seems impossible to doubt were produced by the ice at a former period.

So far as we can judge from the view which De Saussure has given[2] of the Glacier of La Brenva, and which he states was drawn in 1767, we must infer that the glacier was then greatly less extensive than at present. It seems almost certain that at that time the Doire did not pass *under* the glacier at all, but in front of it. He likewise mentions the chapel to which I have referred as exactly opposite the glacier, and which is indicated in the map under the name of Notre Dame de la Guérison. It is also called N. D. de Berrier. De Saussure speaks of it as in ruins in his time, having been allowed to go to decay on account of the superstitions to which it gave rise.[3] It

[1] One of these specimens is deposited in the Museum of the Royal Society of Edinburgh.

[2] *Voyages*, tome ii., Plate III., opposite p. 286.

[3] *Voyages*, § 855.

appears, however, to have been rebuilt, and was again reduced to ruins, under much more remarkable circumstances. Its position relatively to the glacier at the present time will best be judged of from Plate IV.,[1] which gives a view of it as seen from near Entrèves, looking up the course of the Doire from below. The position of the modern chapel will be observed on a rock at a great height above the glacier, on the left hand, near an aged larch tree. The height of this rock is about 300 feet. Looking at that view, it will scarcely be believed that the glacier attained, only twenty-four years ago, so enormous a size as to have risen up to the level of that rock (which is of limestone), and to have worked with such tremendous force upon the promontory on which the old chapel stood, built upon the rock itself, not fifty yards from the present one, as actually to have heaved both rock and building to such a degree as to fill both with fissures, and to cause the latter to be removed by authority, as in a dangerous state.

The notoriety and recent occurrence of these facts makes it now easy to establish them beyond a doubt; and I have thought it well to do so on account of their great interest. That a series of comparatively cold seasons should have produced so enormous an increase in the unmelted portion of a glacier, is a fact of the highest importance to any speculations as to the circumstances under which glaciers might be enormously more extended than at present. So far was there from being any *marked* change of climate at the period when this and many other glaciers were undergoing an enormous enlargement, that, for the five years preceding 1818, when the Glacier of La Brenva attained its greatest size, the mean temperature at Geneva was 7°·61 Réaumur, whilst the mean of the last forty years has been 7°·75,[2] a difference of not *one-third* of a degree of Fahrenheit. This difference is so insignificant, that it is most likely that the increase of the glaciers at that time depended rather upon an increased fall of snow than upon any change of temperature.

The height of the ice was such in 1818, that the glacier rose up against the opposing wall of rock, until it covered the path, as Captain Hall attests;[3] and I was assured by eye-

[1] [Omitted in this edition.]
[2] Dove, *Temperaturvertheilung auf der Erde*, p. 26.
[3] *Patchwork*, vol. i. p. 108.

witnesses, that the hermitage connected with the chapel was supplied with water from a conduit, which descended from the ice of the glacier, which then had a higher level.

I obtained from the Syndic of Courmayeur a certificate, in the following terms, of the fact being entered in the archives of the Commune:—"Je soussigné, Syndic de Courmayeur, déclare après la vérification sur les régistres des archives du présent lieu, que la chapelle de Berrier à coté du Glacier de la Brenva à été écroulée en 1818, dans l'endroit où elle étoit bâtie anciennement, par l'accroissement du dit glacier, qui étoit monté au niveau de la dite chapelle: que la Notre Dame a été transportée dans l'Eglise de cette Commune où elle resta pendant deux ou trois ans environ, et que la dite Chapelle fut rebâtie dans l'endroit où elle est maintenant en 1821–22."[1]

I have examined various other documents put into my hands by the Curé of Courmayeur, including the builder's report upon the state of the chapel, which leave not the slightest doubt of the extent and cause of the damage.[2] Indeed, the force by which the strata of limestone, forming the promontory, have been dislocated and rent asunder, is abundantly evident by inspection.

Tradition relates that the glacier in former times did not occupy the bottom of the valley, which was then covered with meadows and fields. My guide imparted to me the following story, which I give as I received it:—

On St. Margaret's day, the 15th July, no one knows in what year, the inhabitants of the village of St. Jean de Pertuis,[3] which was then overhung by the Glacier of La Brenva, instead of keeping the *fête* pursued their worldly occupations:—the hay is

[1] [A first chapel was built towards 1717 and pulled down in 1767 in consequence of quarrels between the builder and the Curé of Courmayeur: these were the ruins seen by Saussure. Another chapel was constructed in 1781, but the advance of the glacier so shook its foundations and walls that in July, 1819, the Curé and his parishioners removed the statue of the Madonna and the ex-votos. In 1821 the chapel was rebuilt more to the east, and reconstructed in 1867. See the interesting account communicated by the Curé of Courmayeur to Signor Virgilio, and printed in No. 50 (1883) of the *Bollettino* of the Italian Alpine Club, p. 67.

[In 1846 the glacier again advanced, but by 1878 it had retired at least 3000 yards, though since that date it has once more advanced considerably.]

[2] He says, "Je l'ai trouvée écroulée par la force du glacier, d'où il résulte de toute nécessité de la rétablir, puisqu'il n'existe que les ruines."

[3] [Signor Virgilio states that this village is mentioned in documents of the fourteenth and fifteenth centuries; the plain of Pertud is on the right bank of the lower part of the glacier.]

dry, they said; the weather is fine; let us secure it. But the sacrilege was soon punished. Next day the glacier descended in a moment, and swallowed up the village with its inhabitants. My guide added, in proof of the existence of this buried hamlet, that a person now living at Courmayeur, having gone, when a child of seven years old, with many others, for devotion, to the Chapel of Berrier, overlooking the glacier, heard the chanting of vespers from under the ice, and saw a procession come out and return; but the vision was only seen by the child, for when he called the attention of the others to it, they beheld and heard nothing.

CHAPTER XI

ENVIRONS OF COURMAYEUR—GEOLOGY

Mineral springs of Courmayeur and Pré St. Didier—Remarkable relations of limestone and granite in the Val Ferret—Mont de la Saxe—Croix de la Bernarda and Mont Chétif—Symmetry of the geology on either side of the Alps—Ascent of the Cramont—Observations on solar radiation.

COURMAYEUR, by twenty-four corresponding barometrical observations which I have made, is 876·5 mètres, or 2776 English feet above Geneva, and therefore 4211 above the sea.[1] It is the highest considerable village in the great valley of Aosta, which takes its origin in the Allée Blanche and Val Ferret, at the southern foot of Mont Blanc, and merges into the valley of the Po at Ivrea. It is frequented by the Piedmontese in considerable numbers every summer, both on account of the mineral springs in its neighbourhood, and for the sake of the exquisite freshness of its climate. A more complete contrast than between the walks of Courmayeur and the streets of Turin, in the month of July, it is hardly possible to conceive.

All who have visited this place, under favourable circumstances, agree in considering its position one of the finest in the Alps. No less than six routes diverge from it,—the road to Aosta; that of the Little St. Bernard; the Allée Blanche; the Col du Géant; the Col Ferret; and the Col Serena, leading to the Great St. Bernard.[2] I have travelled over all of these but the last, and several of them more than once. Consequently my visits to Courmayeur have been frequent; but it was only in

[1] [It is really 4016 feet.]

[2] [Strictly speaking the Little St. Bernard road branches off from that to Aosta at Pré St. Didier, two miles below Courmayeur, and the track to the Col Serena from Morgex, on the Aosta road, and four miles below Courmayeur.]

1842 that I made any stay there. I devoted a fortnight to explore its most interesting neighbourhood. At present, I shall only describe a few of the most prominent points, chiefly connected with its geology.

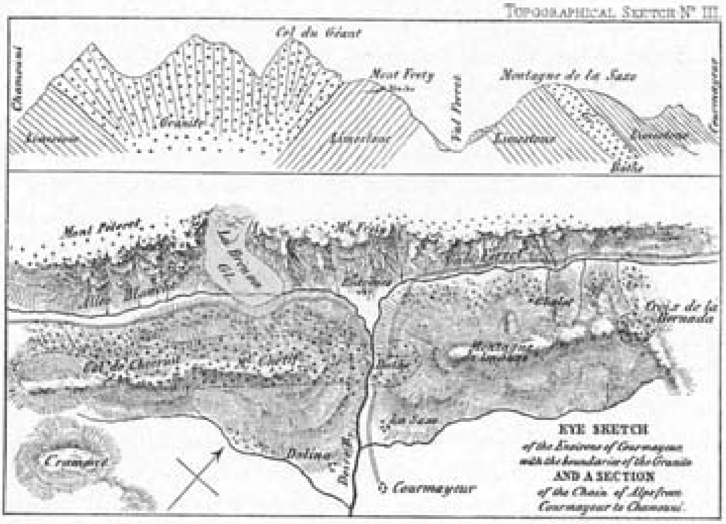
The occurrence of mineral waters first strikes us. This is a phenomenon peculiarly interesting in a geological point of view, for it very generally happens that the appearance of mineral springs, especially if warm, indicates a great disturbance of the strata, and very generally the appearance of what are called *intrusive* rocks, such as granite. I have shown, for example, that in the Pyrenees, a district unparalleled perhaps for the multitude of its thermal springs, these occur almost invariably at or near the contact of granite with stratified rocks.[1] The springs near Courmayeur have been described by De Saussure (§§ 876-882), and I have little to add respecting them. The waters of La Victoire and La Marguerite rise from alluvium, and are saline and purgative. The waters of La Saxe rise in the defile by which the Doire issues from the base of Mont Blanc, exactly at the junction of the limestone strata with a remarkable mass of granite presently to be mentioned. They are sulphurous, and are used both for baths and internally; but the bathing establishment is rather mean. All the above springs are cold. Two miles below Courmayeur, at Pré St. Didier, is another bathing house, formerly much more frequented, and which is supplied by a hot spring which issues in the deep and picturesque ravine immediately adjoining, through which a torrent descends from the Little St. Bernard. The spring is conveyed partly through a subterraneous gallery. In 1839, when I visited the source, I found the temperature to be 95°·0 Fahr., or 28° Réaumur: De Saussure found it to be 27°·5 R.

The relations of the limestone and granite in the neighbourhood of Courmayeur are very interesting and remarkable, and offer so striking an analogy to the phenomena of the same kind seen on the northern side of the Alps, that we cannot but regard them as important with respect to the formation of this chain. The Topographical Sketch and Section No. III. are intended to illustrate these peculiarities. I had observed on my former visits to Courmayeur that there were appearances of limestone dipping under the granite of Mont Blanc, or rather of the Grandes

[1] *Philosophical Transactions*, 1836.

Jorasses on the north side of the Val Ferret. This I was enabled fully to establish, on my last visit, at several points. I obtained an excellent section by passing the moraine of the Glacier of La Brenva to the west of Entrèves, and ascending the ravine marked on the sketch, between that village and the glacier. There is there a complete superposition of gneiss to lias shale forming a precise counterpart to that described in page 64, as occurring under the Aiguille à Bochard at Chamouni, and forming a portion of the fan-shaped stratification exhibited in the section,

Topographical Sketch No III



and which had been so far anticipated by De Saussure and M. Necker. In the ravine now mentioned the junction may be traced for a long way towards the centre of the chain, the line of contact between the limestone and the overlying protogine or gneiss, being inclined in the higher part of the section 38° to the horizon (dipping north-west), and in the lower part of the section 50°. The strata are therefore bent at the junction, but at a little distance they have a pretty uniform north-west dip of 38°.

There is no difficulty in reaching the junction. The limestone shale is altered and crystalline near the contact. The gneiss is altered also. These phenomena bear the most striking analogy with those which I have seen in the Alps of Dauphiné, and which have been so well described by M. Elie de Beaumont. The junction may be traced nearly as far as the Glacier of La Brenva, but not (I think) farther west. The Mont Fréty, which lies immediately to the east of the ravine in question, is also of limestone, which dips under the granite of the Col du Géant, and a close examination would, I have no doubt, give proofs of the same thing all along the north side of the Val Ferret as far as the Col of that name, where the limestone becomes nearly vertical.

This analogy in the arrangement of the rocks on either side of the great chain is not the only one, for on either side of Mont Blanc is a secondary range also composed partly of granite. The Aiguilles Rouges (which, however, are not included in the section) are granitic, although separated from the main chain by the limestones of the valley of Chamouni; and the Mont Chétif and part of the opposing Mont de la Saxe near Courmayeur are in like manner granitic. The form of the latter mass, as shown in the section, is a great tabular body of imperfect granite, greenish, slaty, and containing an excess of quartz, with limestone above and below, very nearly in the manner in which the greenstone of Salisbury Crags, near Edinburgh, is interposed between the sandstones. Both the granite and limestone *rise towards Mont Blanc*, consequently, the limestones on the two sides of the Val Ferret rise towards the axis of that valley,—a very remarkable arrangment. The tabular mass of Mont Chétif is cut through by the Doire at the baths of La Saxe, where there is an excellent section: the granite is then lost under the Mont de la Saxe to the eastward, which is chiefly composed of limestone which envelopes the granite, and is also covered with herbage. I had, however, remarked a summit parallel to the axis of Mont Blanc, on the eastern part of the ridge of this hill, which I suspected to be granite, and having made an excursion on purpose, I found my conjecture to be confirmed. This summit is called the Croix de la Bernarda [1] (see the Sketch); it may be easily reached either from the Val Ferret, or from the little valley of La Saxe. Farther east the granite is again lost under the limestone. The general dip of the limestone mountains farther from the main chain is towards the south-east.

In returning from the Croix de la Bernarda by the Val

[1] [8314 feet.]

Ferret, I observed a very remarkable accumulation of débris of granite, which occupies the bottom of the valley to a great depth, and which has been evidently cut in two by the river, the deposit being of Alpine boulders resembling a moraine, which lie heaped upon the north side of the Mont de la Saxe, as shown in the section already referred to. The existence of this moraine, if we may so call it, taken in connection with the deposit of similar blocks upon the face of the limestone outlier of the great chain called Mont Fréty, and which will be more particularly mentioned in the next chapter, certainly appears to favour the conclusion that the glaciers, such as those of Entrèves and Mont Fréty, which have now retreated towards the Alpine summits, once filled the entire space below, and transported these débris. They are deposited close to the sudden turn of the river between the Val Ferret and the baths of La Saxe.

I made another excursion towards the Mont Chétif, to determine the relations of the granite in that quarter. I ascended the little valley above the village of Dolina,[1] marked in the sketch behind the Mont Chétif, until I reached a col or passage which leads into the Allée Blanche, and which commands a magnificent view of the range of Mont Blanc. This is called the Col de Checruit.[2] I had here an opportunity of examining the granite of the ridge on which I stood, and of seeing it disappear to the westward under the limestone, which it has greatly altered just at the Col. It is impossible to trace the connection of the granite of Mont Chétif with that of Mont Blanc, owing to the mass of débris and verdure with which the north slope is covered. I apprehend, however, that there is an undoubted connection between the granite of Mont Pétéret and that of Mont Chétif, and that it crosses the valley in that place. The last exposed limestone is seen (as observed in the last chapter) on the south side of the valley just opposite to the Glacier of La Brenva.

From the Col de Checruit I saw very distinctly the dip of the limestone of Mont Fréty, under the granite of the Col du Géant, which I afterwards confirmed on the spot. The descent

[1] [Dollone.]

[2] [Col de Chécouri, 6431 feet; hence there is now a mule-path to the Lac de Combal.]

into the Allée Blanche, through some of the finest pine forests in the Alps, is a most interesting walk. Every one has noticed how rarely fine trees are to be seen in almost any part of the Alps. The forests on the north side of Mont Chétif are an exception, and whilst those in the valley of Courmayeur and La Thuille,[1] are very generally in a dying state, from some cause which seems not to be understood,—these are flourishing. Several encampments of charcoal burners are met with during the descent; and the latter part of the walk may be performed along a conduit of water through the wood, from which, at intervals, the noblest views of the unequalled range of mountains and glaciers beyond, and in both directions, may be obtained. The path of the Allée Blanche being reached, I returned to Courmayeur by La Saxe.

De Saussure mentions the granite of La Saxe, though he does not advert to the peculiarity of its position, as respects the great chain. He notices, however, what he calls "cette superposition monstrueuse des roches primitives sur les secondaires,"[2] at La Saxe. In the haste and exhaustion with which he descended from the Col du Géant,[3] he probably omitted to examine the rocks of Mont Fréty. M. Sismonda, the able geologist of Turin, mentions[4] the superposition of granite to limestone at Pra Sec, beneath the Grandes Jorasses, where I noticed it in 1841. But the remarkable symmetry of the chain on both sides, has not, so far as I am aware, been hitherto remarked.

The ascent of the Cramont is one of the best known excursions near Courmayeur. The great object is to command the complete view of the southern precipices of Mont Blanc and the adjoining chain. Its elevation is considerable, being, according to my observations, 4932 feet above Courmayeur, and, by contemporaneous observations at Aosta, I find it to be 9081 English feet (2768 mètres) above the sea.[5] The route usually followed is, to descend the valley of the Doire as far as Pré St. Didier, and to ascend the Cramont by its southern slope, although that mountain lies nearly due west of Courmayeur. It is

[1] [On the way from Pré St. Didier to the Little St. Bernard.]
[2] *Voyages*, § 881. [3] *Ib.* § 2034.
[4] *Memoria sui terreni stratificati delle Alpi*, di Angelo Sismonda, p. 12.
[5] [Really 8980 feet.]

extremely precipitous on all sides except the south. On the present occasion I walked down to Pré St. Didier in the evening, in company with M. Carrel, whom I have already mentioned; and, having gone to bed for a few hours, we started by starlight, in a beautiful morning, at half-past three A.M., so as to gain the summit early. The first stage of the journey is on the mule-path [1] of the Little St. Bernard, which rapidly ascends the ravine whence the hot spring issues, as already mentioned. On this road is one of the grandest bursts of scenery in the Alps—that, namely, which is enjoyed in descending from La Thuille, at the instant that the Aiguille du Géant, the Grandes Jorasses, and the whole of the eastern chain of Mont Blanc come first into view. The road is soon after left; and a long but easy path, through meadows, brings the traveller insensibly above the level of the adjoining hills. At length, the highest irrigation is passed, and a full hour's ascent remains, over the short turf, by which the top of the Cramont may easily be reached in four hours from Pré St. Didier. I was so fully imbued with De Saussure's enthusiastic picture [2] of the grandeur of the station, that I was a little disappointed to find it, not only equalled in height by some others in the neighbourhood, but overtopped by one, also of limestone, which stands between the Cramont and the Allée Blanche, effectually preventing the eye from diving into its depths, and thus measuring Mont Blanc at once from top to bottom, as is the case in the view from the Brevent, above the valley of Chamouni. This interfering summit, which I cannot help thinking has been mistaken by some topographers for the Cramont described by De Saussure, lies nearly west from the Cramont, and at the head of the valley whose streamlet passes Dolina. (See the Topographical Sketch, No. III.). It is, in fact, the prolongation of the Mont Chétif and Col de Checruit, and separates that valley from the Allée Blanche. The ascent is obviously easy and direct, much more so than that of the Cramont; the height is greater: it is nearer Mont Blanc, and commands completely the Allée Blanche and its glaciers. On all these accounts, I do not doubt that this hill is worth

[1] [Now a fine carriage-road.]

[2] [§§ 904-910. Saussure made the ascent twice, in 1774 and 1778, and his name has been given to the shelter-hut built near the summit by the Italian Alpine Club.]

ascending, although it appears to be unknown to tourists, and even to natives, for I could not learn its name.[1]

The Cramont is part of the limestone group, whose strata dip southwards, and the northern face being composed of the broken edges, is extremely abrupt. A ragged cliff extends for a long way, without any great variation of height.

M. Carrel, myself, and my guide, Antoine Proment, had carried to the summit a considerable collection of meteorological instruments; for my intention was to spend the entire day upon the top, in order to observe the force of solar radiation. It is a familiar fact to mountaineers, that the sun's rays have an intensity and energy at great heights, which they entirely want on the plains. At first, this might be supposed imaginary, or to result from the reflection of the heat by the snow. On a station like the Cramont, where there is no permanent snow, this error is avoided; and no one who has compared the effect of a single day's exposure amongst the Alps, in discolouring the hands and face, with that of the hottest weather at Paris or Marseilles, will be disposed to question the former assertion. The difference admits of being shown instrumentally, by means of the valuable apparatus, called an actinometer, invented by Sir John Herschel, and I was provided with two of these instruments on the present occasion. My object was, in completion of some experiments made in former years, in other parts of the Alps, to ascertain the varying solar force at different hours of the day, at a height and at a season of the year in which the sun's rays travel through the atmosphere with least resistance.[2] I had, accordingly, brought these instruments on purpose from England, and I sought this hill in the month of July, soon after the solstice, for no other purpose. But such experiments are attended with numberless chances of disappointment. The day, though fine and bright, was by no means so cloudless as to warrant any conclusions from the experiments, which I continued every hour from 8 A.M. to 5 P.M., the whole of which time I spent upon the smmmit of the mountain. I had, therefore, abundance of time to survey the magnificent panorama by which

[1] [It is no doubt the Tête-d'Arp, 9023 feet, or 43 feet higher than the Cramont. It is separated from the Cramont by the Col de l'Arp, over which a mule-path now runs from Dollone.]

[2] See a paper on this subject in the *Philosophical Transactions* for 1842, being the Bakerian Lecture for that year.

I was surrounded; and having brought up a very good telescope by Tulley, of $2\frac{1}{4}$ inches aperture, with a tripod stand, I could inspect minutely the forms and details, both of the nearer and more distant objects,—Mont Blanc, with its glaciers; the pass of the Col du Géant, exactly opposite to me, on which, with the glass, I could discover almost every step and every difficulty of the road; and to the eastward, the summits of Mont Cervin and Monte Rosa especially engaged my attention.

As it was now late, I proposed to Proment (M. Carrel had left us early) to descend to Courmayeur by the rocks. He had not before done it; but we found little difficulty in discovering a most direct and not dangerous passage of the cliff, which is here at least 1500 feet high. Observing the limit of the larch in the valley of Courmayeur to be remarkably well defined, I took the level of it, which I found to be 7200 feet above the sea. From this point, the walk to Courmayeur was easy and pleasant, and remarkably direct.

CHAPTER XII

THE PASSAGE OF THE COL DU GÉANT

Passes of the chain of Mont Blanc—History of this pass—Preliminary obstacles—Departure from Courmayeur—Ascent of Mont Fréty—Experiment on the comparative intensity of moonlight, twilight, and that of a total eclipse—Granite and granite blocks of Mont Fréty—Arrival on the Col—The view—History of De Saussure's sojourn—And of his observations—The descent—Difficulties of the glacier—Follow the track of a chamois—Reach the Mer de Glace—Montanvert.

* * * *
And followed where the flying chamois leaps
Across the dark blue rifts, the unfathom'd glacier deeps.
HEMANS.

THE chain of which Mont Blanc forms the culminating point has a very peculiar structure, and is connected in a remarkable manner with the great chain of Alps. One would hardly guess from the common maps, that Mont Blanc, and its adjacent tributaries, form a kind of oval group rather than a portion of a line of mountain continuous from the Mediterranean to the Tyrol, such as the Alps are usually represented. In length this group extends from the Col du Bonhomme, on the confines of the Tarentaise, to the Mont Catogne, in the valley of Sembrancher, above Martigny, a distance of thirty English miles in a north-east and south-west direction, whilst its breadth at right angles to the former, from Chamouni to Courmayeur, is only thirteen English miles. Now, to perform these thirteen miles, a tedious journey of two days (one of them of nearly twelve hours' walking) is necessary, because this chain or group, being, generally speaking, impassable, must be gone round.

To avoid so great a circuit, the Col du Géant offers the shortest passage from the one valley to the other. It forms the crest of the chain, where the western branch of the Mer de Glace takes its rise; and, notwithstanding its immense height, it would probably be frequented but for the dangers of the glacier on its northern side. A tradition,[1] common to this and many other passes of the Alps, states, that formerly the glacier was less formidable, and that communication was not unfrequent between Chamouni and Courmayeur.[2] This has not occurred, however, within some centuries from the present time. The passage of the Col du Géant appears to have been reckoned impracticable as late as 1785. M. Bourrit, writing in that year, and speaking of the aspect of that branch of the Mer de Glace of Chamouni called the Glacier du Tacul, says, with respect to the crevasses: "Elles sont si effroyables qu'elles font désespérer de retrouver jamais la route qui conduisait à la Val d'Aoste."[3] De Saussure, in the second volume of his *Travels*, speaking of the Glacier du Tacul, does not say one word of this historical passage of the Alps, though he seems to have thought it just possible that the summit of Mont Blanc might be gained in this direction;[4] and, in the fourth volume, written some years later, when about to give an account of his memorable residence on the Col du Géant, he speaks of "la route nouvellement découverte,"[5] from Chamouni to Courmayeur. This was in 1788.

There is said to be a passage which has been effected from the Glacier de Miage, which penetrates very deeply indeed on the south side of the chain of Mont Blanc, to the valley of Contamines, by the glacier also bearing the name of Miage, on the north side; but I have no accurate information of its accomplishment, and the appearance of the head of the glacier on the south side gives little encouragement to the attempt.[6]

[1] [It is certain that in 1689 P. A. Arnod, an official of the Duke of Savoy, tried in vain to cross this pass (as to which a local tradition prevailed), but was defeated by the huge crevasses. Yet, about 1740, a Genevese letter-carrier, named Ribel, seems certainly to have crossed the pass, though, in 1741-42, Windham and Martel were told at Chamouni that it was then impossible to cross it, as avalanches blocked the former route. The Col was certainly crossed in 1786 by an Englishman named Hill, in 1787 by M. Exchaquet, and again by Bourrit, and, in 1788 by Saussure.

Consult M. Durier's *Le Mont Blanc*, pp. 40-42, 146, 417; Signor Vaccarone's *Le vie delle Alpi Occidentali negli antichi tempi* (Turin, 1884), pp. 56-58, and the *Alpine Journal*, vol. ix. pp. 22-24, 87, 88.]

[2] Bourrit, *Description des Glacières*, vol. iii. p. 72.

[3] *Ib.* vol. iii. p. 106.

[4] § 629.

[5] § 2025.

[6] [This is the Col de Miage, 11,077 feet, the rocks on the right bank of the small

One other passage of the chain has, however, been made, and that is by the Glacier of Le Tour, near the Col de Balme, descending by the Glacier of Saleinaz into the Val Ferret. This was discovered a few years since by a guide of Chamouni, named Munier.[1] It cannot be very long, and is probably not very dangerous.

Such are the only known passes of this wild country.[2]

I was induced to undertake the passage of the Col du Géant, chiefly for two reasons: in the first place, from a desire which I had long entertained to visit a spot rendered memorable by De Saussure's extraordinary residence, and admirable observations; and, secondly, having occasion, on other grounds, to visit Courmayeur, and to return to Chamouni, I preferred any alternative to that of experiencing once more the tedium of either of the circuits, by the Cols du Bonhomme and de la Seigne, on the one hand, or the Cols Ferret and de Balme on the other. I had already traversed the former three times on foot in different years; and, though I had passed the latter only once, I wished to avoid the repetition of so long and dull a route.

Accordingly, having reached Courmayeur in the beginning of July, 1842, by the Col du Bonhomme, in order to go to Turin to see the total eclipse of the sun, my resolution was taken to return by the Col du Géant.

The guides of Courmayeur were, with one exception, unacquainted with the passage. I therefore wrote to Chamouni about the middle of July, desiring my old guide, Jean Marie Couttet, who knew the passage well, to come by the Col du Bonhomme, on the 19th, to be ready to return by the Géant on the 20th. I had previously ascertained that my guide of Courmayeur, Antoine Proment, would consent to undertake the passage with a single competent guide of Chamouni, for I had seen so much of the uselessness and inconvenience of numerous guides on such expeditions, that I resolved to take two only.

glacier that excited the fears of Forbes giving comparatively easy access to it on the Italian side. The pass was certainly crossed in 1798 by some chamois hunters, one of whom perished in a crevasse on the French side; and again in 1849 by Mollard of St. Gervais and some comrades. The first traveller was Mr. E. T. Coleman in 1858.]

[1] [This spelling is the right one: the man was a miller by profession. On p. 462 below, Forbes attributes the discovery to Michel Charlet in 1838.]

[2] [Since 1842 the number of glacier passes in this chain has greatly increased.]

Another item of expense and trouble was saved at the suggestion of Proment. Hitherto the passage had, in every instance, been effected in two days. In starting from Chamouni, the Tacul was the place of the first night's bivouac; and, in the one or two passages which have been made from the side of Courmayeur, the travellers had slept, or at least *lain* on the exposed and almost precipitous face on the southern ascent, which offers no spot at all adapted for the most indifferent night's quarters. Proment suggested passing the Col without any halt, as the first part of the way, being without danger, might be performed in the dark. I determined, accordingly, to leave Courmayeur in the night, and to reach Col soon after sunrise, or at least before the morning was far advanced.

Couttet arrived a day before his time, and the day of his arrival was also the last of fine weather, which had continued almost without interruption for a month. The south wind began to blow, the dew-point rose, fogs covered the range of the Cramont, and formed a belt along the chain of Mont Blanc, and it was but too evident that the weather was deranged for some days. The provisions were ready, the guides astir, and I was called at midnight of the 19th to consult upon the state of the weather; when it was unanimously agreed to be unfit for such an expedition. A repetition of the same occurrences took place for several successive days and nights. I was immovably fixed in my purpose to return by no other route, and as resolute not to attempt the Pass but with the finest weather. Proment, who was at home, bore the tantalising delay philosophically enough, but Couttet fretted himself into such a state of impatience, that I believed he would have left me, and returned to Chamouni. Sometimes he urged me to depart, whatever might be the weather; but, when the hour of midnight came, and the council was called, his better sense warned him not to make so rash an attempt; then he tried to induce me to give up the plan, and return by the Bonhomme,—anything to avoid the ennui of Courmayeur. But I was inflexible. The 20th, 21st, and 22nd July were spent thus. On the evening of the latter day the weather gave a promise of mending, whilst the snow which had fallen on the Col, and even a great deal lower, gave the prospect of some inconvenience from the cold, and increased difficulty in passing the glacier. Couttet put these prominently before me, as the last temptation to abandon my project; but, finding me resolute, he made up his mind for departure that night, good or bad.

I was called a little after midnight, between the 22nd and 23rd July, and to my inexpressible satisfaction, I beheld a magnificent calm night, illuminated by a moon just full. I had sent off by an opportunity some days before my heavier luggage, so that my packet was soon made. I carried, as usual, my barometer, hammer, compass, and telescope; one guide took my little knapsack, and the other a similar one containing provisions. I took some soup before departing; and we were detained, and my temper a little ruffled, by the stale imposition of a supplementary bill, containing items left out by inadvertence in the regular account paid the night before, which was presented to me at one o'clock in the morning, when remonstrance and appeal were alike unavailing. Travellers who undertake expeditions beyond the common run of excursions, cannot be too much put upon their guard against the systematic extortion of innkeepers, seconded by the love of indulgence of their guides. The better way would be to let the guides pay for themselves in every case.

Being fairly on foot at 30 minutes past 1 A.M. of the 23rd July, my ill-humour was soon dissipated by the exquisite beauty of the scene which the valley of Courmayeur presented. The full moon was riding at its highest noon in a cloudless sky—the air calm and slightly fresh, blowing very gently down the valley. The village and neighbourhood lay, of course, in all the stillness of the dead of night; and as I headed our little caravan, and walked musingly up the familiar road which led to the Allée Blanche and the foot of Mont Blanc,—that vast wall of mountain, crowned with its eternal glaciers, seemed to raise itself aloft, and to close in the narrow and half-shaded valley of Courmayeur, verdant with all the luxuriance of summer, and smelling freshly after the lately fallen rain. Of all the views in the Alps, few, if any, can, to my mind, be compared with the majesty of this, and seen at such a moment, and with the pleasing excitement of thinking that within a few hours I hoped to be standing on the very icy battlements which now rose so proudly and so inaccessibly, it may be believed that I had never before regarded it with so much complacency.

Having left the baths of La Saxe on our right, we crossed the stream descending from the Val Ferret, and skirting the village of Entrèves under the guidance of Proment, who knew the bye-paths through the fields, we gained, after about an hour of pleasant walking, the woods of larch which clothe the south-eastern foot of the Mont Fréty, as the pasture mountain is called, above which the Col du Géant stands. The Mont Fréty may be ascended either on its eastern or western side; both are steep and rugged, but not difficult. Some of the trees are of considerable size, and every now and then, from between their trunks, I caught an admirable peep of the still scenery of the low country, bathed in moonlight, whilst as we gradually but steadily ascended, our progress was measured by the successive hills or mountains which we left below our level: first, the Mont de la Saxe—then the Pain de Sucre [1]—finally, the Cramont itself sunk its head amongst more distant ranges of hills. Couttet had now taken the lead, and kept going steadily up hill at a very easy measured pace, but without the least intermission. In this way admirable progress is made; the mind yields to the monotony of the exertion, and ceases to measure time, or to long for a remission of so moderate an effort. The footing being easy, no annoyance was felt from the want of full daylight, and the eye was left generally free to dwell on the objects around.

Two hours had passed from the time of starting before we emerged from the larch wood upon the bare slope of Mont Fréty.[2] Twilight was beginning to make evident progress in the serene sky above the Col Ferret. The moon was still high in the south-west, 20° or 25° above the horizon; and I was curious to notice the relative intensity of the moonlight and the dawn with reference to some experiments which I had made during the total eclipse of the sun a fortnight before. On that occasion, the light permitted me to distinguish small print with difficulty in the open air, and I think I could not have read writing. I compared it afterwards to the darkness in a clear evening one and a quarter to one and a half hour after sunset. The moonlight now was evidently incomparably brighter than the light of the eclipsed sun, and enabled me to read writing easily. As we

[1] [Or Mont Chétif.]

[2] [Here there is now a little inn at a height of 7130 feet: it is now reached from Courmayeur by a mule-path which continues for some distance above the inn.]

ascended the slope with the increasing dawn on the right hand, and the setting moon on the left, I referred continually to a written paper in my hand, to mark the moment when it should appear equally legible by either. The difference of colour of the light caused some difficulty. It was the contrary of what we usually perceive; the moonlight seemed yellow and warm, the dawn was cold and grey. This was evidently no illusion, and arose from the quantity of blue rays reflected by the large surface of sky whence the twilight was derived. At 3 h. 30 m. A.M., I judged the two lights to be equal, and in a very few minutes the dawn had so manifestly gained upon the other, that it showed the method to be susceptible of some accuracy. Now, the summit of Mont Blanc was not touched by the sunbeams until 4 h. 20 m. or 50 minutes later. This corresponds sufficiently well with my former estimate of the darkness of the total eclipse. It was very far less bright than the light of the full moon; as much less, in fact, as the dawn 80 or 90 minutes before sunrise (in the month of July) is than the dawn 50 minutes before sunrise, which is probably not much more than a fourth part.

This little experiment required no delay, and we kept always advancing. The Mont Fréty projects considerably towards Courmayeur from the great chain, although, viewed from below, it seems an almost precipitous slope. There is a ravine on either hand, the highest portion of which contains a glacier—the Glacier du Mont Fréty[1] on the west, and the Glacier d'Entrèves on the right.[2] What may be called the summit of Mont Fréty is a green pasturage, interspersed with enormous blocks. By frequent examination from below with a telescope, I had satisfied myself that the upper part was of granite, overlying strata of limestone, which dipped inwards at a considerable angle, and also that the blocks on the summit were granitic masses removed from some distance; both of these conjectures were confirmed by examination. The dimness of twilight permitted me only to ascertain generally the fact of the superposition of the granite to the limestone. As I approached the level of the scattered blocks of granite, I was struck by the peculiarity of their position. These enormous masses lie on an isolated ridge of very little extent, and

[1] [Now better known as the Glacier de Toule.]
[2] These are the names given by De Saussure (§ 2035).

on a steep declivity. There are ravines on either hand; precipices above, and the valley nearly 3000 feet below. The level at which they occur is very remarkably preserved; and without by any means vouching for the explanation, they seem to me not to have alighted on this promontory in the course of rolling down from the cliffs above, which is scarcely probable, but rather to have been deposited by the glaciers descending on either hand. If those glaciers formerly reached the valley beneath—which is not unlikely—they probably occasioned the remarkable deposit of boulders exactly opposite to Mont Fréty, on the farthest or south side of the torrent of Val Ferret, described in the last chapter. The section in the Topographical Section, No. III., will give an idea of the combination of these remarkable phenomena, which contribute to render the environs of Courmayeur very interesting to the geologist. I have only to add, that the granite of the boulders on Mont Fréty does not resemble the rock on which they lie, being more crystalline, and evidently derived from the neighbourhood of the Col du Géant. The blocks in the valley have the same character.

Having passed the sort of top or prominent flat of Mont Fréty, and having now arrived at the foot of the final ascent after three hours of continuous walking without any pause, we halted by a spring to break our fast at 30 minutes past 4.

The sun was just about to rise, and this was the coldest period of the morning; at the height which we had now reached the frost was pretty intense, and the herbage white and crisp. I breakfasted heartily on hard eggs and cold tea, of which I had brought a good store in a gourd. After a halt of about 20 minutes, we proceeded, the cold continuing sharp—the thermometer was 30°.

The ascent now began in earnest, and before long we had left all grassy slopes behind, and clambered upon the bare rock. This was at first precipitous, though not dangerous. I had so completely studied the route with the telescope from the Cramont,[1] that I should have had no difficulty in selecting, had it been necessary, the easiest path. There was but one point where it was necessary to touch the snow, and that but for

[1] The vignette on the next page gives an imperfect representation of the ascent of the Col du Géant as seen from the Cramont. It is, however, somewhat deficient both in clearness and accuracy. [The latter phrase is but too true.]

a few steps. Keeping always along the ridge, we climbed patiently amongst the loose masses of rock, which it required some care not to overthrow upon one another. We were yet nearly 1000 feet below the top, where Couttet felt his breathing a little affected, though not distressingly so. This is a symptom very common, and depending much upon the state of health at the time. I scarcely felt it even at the top; but in 1841 I was distinctly incommoded at a lower level on the ascent of the Jungfrau. The guides say that it depends upon the state of the air; and David Couttet has assured me, that on some days, he and his brother have *simultaneously* felt inconvenience from the action of the lungs at very moderate elevations. Continuing steadily to mount, and invigorated rather than incommoded by the sun's rays, which now began to beat upon us, we reached the summit with scarcely any halt at 20 minutes past 7 A.M., or in 5 hours 50 minutes from Courmayeur. The vertical elevation is 7000 English feet,[1] and it never before occurred to me to make a long ascent so nearly in one right line. The point at which we arrived (marked *a* in the sketch) is the very lowest point of the chain, and is precisely at De Saussure's station.

The disagreeable feeling of cold had now entirely subsided. The sun's rays had taken off the frosty chill, though in consequence of our increased height, the thermometer was only 29°; we established ourselves, nevertheless, not uncomfortably, in a hollow of the rock facing the south, where we could rest after this, the most toilsome, though not the most difficult part of the

[1] [Precisely 7044 feet.]

day's work, and survey the astonishing prospect which was spread out before us.

We were at a height of 11,140 feet above the sea.[1] It is very rare to be at this elevation at so early an hour as seven in the morning, and still rarer to combine this essential for a distant prospect with such magnificent weather as the day in question afforded. The atmosphere was, perhaps, as the event proved, too clear for very permanently fine weather,—not a cloud—not even a vapour was visible. The air of this lofty region was in the most tranquil state. Range over range of the Alps, to the east, south, and west, rose before us, with a perfect definition up to the extreme limit which the actual horizon permitted us to see. Never in my life have I seen a distant mountain view in the perfection that I did this, and yet I have often been upon the alert to gain the summits before the hazy veil of day had spread itself.

Perhaps it enhanced my admiration of the scene that a great part of the labyrinth of mountains were familiar in their forms to my eye, and that from having penetrated many of their recesses in different journeys, this wide glance filled my mind with a pleasing confusion of the images of grandeur and beauty which had been laboriously gathered during many pedestrian tours, whose course and bounds I now overlooked at a glance. To the eastward the Mont Cervin, with its obelisk form, never to be mistaken, presented evidently the same outline as I had sketched last year, from a point diametrically opposed, near Zermatt; close to it, on the left, rose another peak, which I conjectured and afterwards ascertained to be the Dent d'Hérens.[2] A little to the right, most exquisitely defined in outline, yet with every detail

MONTE ROSA FROM THE COL DU GÉANT.

delicately subdued by the undefinable blue of immense distance, was the whole mass of Monte Rosa, the rival of Mont Blanc, with its many heads of nearly equal height, whose geography I looked forward to exploring in the course of the summer. The hirsute

[1] [Precisely 11,060 feet.]

[2] I cannot positively assert that the Mont Cervin is visible from the very Col. I rather think not, but I saw it as described from a little lower level. I verified my recognition of the mountains, on the spot, by the excellent reduced map of the Sardinian Government triangulation, connecting France with Italy.

and jagged rocks of the Valpelline and its neighbourhood formed the base out of which the chain of Monte Rosa seemed to rise, and a little more to the right lay the indentation of the Val d'Aoste, well marked by the complete separation which it makes between the mountains just mentioned and those which formed the middle group of the picture, the savage chain of Cogne to the south of Aosta. These mountains (which I had partly traversed in 1839)[1] contain many summits of 11,000 and 12,000 feet high, scarcely known even by name, such as the Becca di Nona, 11,738 English feet above the sea,[2] which has been repeatedly ascended by M. Carrel of Aosta, who even passed the night of the 7th July there in order to witness the solar eclipse; the Montagne de Cogne,[3] the Grand Paradis, and the Aiguille de la Sassière,[4] all streaming with glaciers. These were flanked on the left by the stern grey mountains of Champorcher, and on the right by the snowy wastes of the Rutor. Behind the last rose the vast mass of Mont Iseran,[5] which completely conceals the Alpine chain beyond, and of course the Monte Viso, which I had hoped to have recognised. Hitherward from the Rutor the pass of the Little St. Bernard carries the eye to the valley of the Isère, whose whole course I had also followed up to its parent glaciers in the year 1839.[6] Then a fresh range of snowy mountains to the right, above which rises conspicuous the Aiguille de la Vanoise[7] (between Moûtiers and Lanslebourg), a mountain which for elegance vies with any in the whole chain. To the west, and beyond, stood forth in clear perspective the yet more distant range of Mont Thabor, separating the valleys of the Arc and the Durance, and Savoy from France. There, a very well defined, though very distant, group of familiar forms reached my eye. It was the

[1] [On August 1, 1839, Forbes crossed from Cogne to Cuorgnè by the Col della Nouva, 9623 feet. See *Life and Letters*, p. 254.]

[2] [Really but 10,309 feet. It is sometimes called "Pic Carrel," as Chanoine Carrel did so much to make it known to travellers.]

[3] [Or the Grivola, 13,022 feet, and only surpassed in this district by the Grand Paradis, 13,324 feet.]

[4] [The Aiguille de la Sassière, 12,323 feet, lies west of the Cogne mountains, of which it forms no part.]

[5] [Probably Forbes means the Pointe de Charbonel, 12,336 feet, the Ciamarella, 12,061 feet, the Levanna, 11,943 feet, and their neighbours.]

[6] [In August, 1839, Forbes went from Lanslebourg to Bourg St. Maurice by the Col d'Iseran, 9085 feet, Tignes, and the upper Isère valley. See *Life and Letters*, p. 255.]

[7] [Really the Mont Pourri, 12,428 feet. It is the peak so conspicuous from the Col du Bonhomme. See p. 181 above.]

Mont Pelvoux [1] in Dauphiné, rising proudly from its rugged basis of lofty hills, the highest mountain between Mont Blanc and the Mediterranean, and of which I had laboriously made the circuit in 1841, in company with Mr. Heath, by passing Cols themselves above 10,000 feet in height.[2] The adjacent mass of the Grandes Rousses, sloping towards Grenoble, closed this admirable panorama, which was thus cut short exactly where it would have become uninteresting by the colossal mass of Mont Blanc, which, with its huge sentinel, the Mont Pétéret (that vast rocky Aiguille which guards it on the side of the Allée Blanche) stood forth in the closest proximity, and still at a height of 4600 feet above us.[3]

PROFILE OF THE POINTE DES ECRINS.

I shall not stop to describe the appearance of the valleys immediately beneath us, and of which the eye seized at once the ground plan from the great height at which we stood. It is very rare, as I have observed, to find so long and uniform a slope, affording a clear view to the very bottom, near 8000 feet deep. The Allée Blanche, with its glaciers, its lake, and its torrents, all *in plano*, the peaks of the Mont Chétif, and even the Cramont, now completely subdued, the monotonous length of the Val Ferret, the hamlets of Courmayeur and La Saxe almost at our feet, and the meadows of Pré St. Didier, green as an emerald, and set in a solid chasing of precipices, begirt with pines—all these familiar objects scarcely withdrew my attention from the magnificence of the wide Alpine view beyond.

The barometer (one of Bunten's) had been set up on our arrival, and whilst admiring the scenery, a second and more substantial breakfast of cold fowl was proceeding, with marked advantage to the prospects of the journey,—for our appetites were excellent. I scarcely tasted the wine, and not at all of the brandy which Couttet had plentifully provided and liberally partook of. We had yet many hours' walk in the heat of the day, over dry snow, where no drop of water is ever seen.

The barometer had been exposed for forty minutes in the

[1] [The Pointe des Ecrins, 13,462 feet.]

[2] [See pp. 407-425 below.]

[3] [Mont Blanc is 4722 feet higher than the Col du Géant.]

shade, and was now carefully observed. It stands ·08 millimètre lower than the corrected barometer at Geneva Observatory.

	Barom. mm.	Att. Ther. Cent.	Det. Ther. Fahr.
Col du Géant, 1842, 23rd July, 8 h. 0 m. A.M.	507·9	+0·6	29°·8

The following had been the readings at Courmayeur (hôtel de l'Ange, second floor) the previous day, during the whole of which the barometer had been steadily rising:—

Courmayeur, 22nd July,	4 A.M.	657·5	18·0	...
	10 "	659·4	18·3	61
	12 "	659·8	18·1	62
	4 P.M.	660·25	18·0	65
	8½ "	660·85	15·7	55
	12½ "	661·35	17·5	50

The corresponding height of the barometer at Geneva was—

729·85 mm. at 0° Cent. D.T. 17°·2 Cent.,

whence the height of the Col du Géant above Geneva is 9803 feet;[1] above the sea 11,146 feet; above Courmayeur, by the previous observations, 6979 feet. The Col du Géant, by observations at the Montanvert on arriving there, is 4841 feet above that station. This result we shall afterwards find to agree with the direct comparison with Geneva, and hence we are disposed to place the Col du Géant at 11,146 feet above the level of the sea.[2] De Saussure (§§ 2037-2049) determined it, trigonometrically, by reference to Chamouni; using the Aiguille du Midi as an intermediate point seen from both, and taking the barometrical height of Chamouni, he obtained for the Col du Géant 1763 toises, or 11,172 English feet. By his seventeen days' barometrical observations, compared with simultaneous ones at Chamouni, he obtained by the formula of Trembley 16 toises less, reducing the height to 11,070 English feet. I have recalculated his simultaneous observations at the Col du Géant and Geneva, and have obtained so low a result as 11,028 feet.

The rock under which we breakfasted had supported the "Cabane" of De Saussure. I pleased myself with contemplating a board which yet remained of the materials of his habitation, and a very considerable quantity of straw which lay under the

[1] Calculated both by Baily's Tables and those of the French *Annuaire*.

[2] [It is, according to the latest observations, 11,060 feet.]

stones which had formed its walls.[1] The frosts of this elevation had preserved the straw in a pretty fresh state for half a century. There was also an empty bottle entire. This, indeed, had no claim to be so old, but it might be a relic of another illustrious guest—M. Elie de Beaumont, the last traveller but one, who, seven years ago had passed this wild spot.

De Saussure's habitation, as figured very intelligibly in Plate III. of the fourth volume of his work, consisted of a wretched stone hovel six feet square, and two tents. Here this remarkable man passed sixteen days and nights, keeping, together with his son, M. Théodore de Saussure (the only surviving sharer of the expedition), almost perpetual watch upon the instruments which he had undertaken to observe.[2] No system of connected physical observations, at a great height in the atmosphere, has ever been undertaken which can compare with that of De Saussure. At any time such self-denial and perseverance would be admirable, but if we look to the small acquaintance which philosophers of sixty years ago had with the dangers of the higher Alps, and the consequently exaggerated colouring which was given to them, it must be pronounced heroic.

De Saussure and his son arrived at the Col du Géant on the 3rd July 1788, accompanied by a number of guides and porters, who carried two tents, and the utensils required for a long residence, having slept by the Lake of the Tacul. On the 19th of the same month he descended on the side of Courmayeur, having remained seventeen days at this great elevation. It may be believed, that those guides who remained to share the wretched accommodations of this truly philosophical encampment, were not a little exhausted by the tedium of such prolonged hardships. De Saussure states (§ 2034) that he believes they secreted the provisions appropriated to the day of their descent, in order to render impossible a prolongation of their exile from the world. The astonishment of the country people on the side of Piedmont, whence the position of De Saussure's cabin is

[1] [In 1853 Mr. Wills found a few fragments of straw on the site, and in 1855 Messrs. Hudson and E. S. Kennedy a few stones. Of recent years an excellent club hut has been built a few feet below the pass on the Italian side, and in 1899 a small mountain inn was opened on this spot.]

[2] [The narrative portion of Saussure fills §§ 2025-2034 of his work, but his scientific observations extend from § 2035 to § 2112. For a view of his camp see M. Zurbriggen's book (1899), p. 18.]

distinctly visible, it may be believed, was great; and it naturally showed itself in the form of superstition. It is still well remembered at Courmayeur, that that month of July, having been exceedingly dry, the report arose that the sorcerers who had established themselves on the mountain had stopped the avenues of rain, and that it was gravely proposed to send a deputation to dislodge them by force,—a task probably of some difficulty, for a few men could defend the Col du Géant against an army.

If we look to what was accomplished by these indefatigable observers, we shall find that it was fully commensurate to the efforts made to attain it. There is scarcely a point in the "Physique du Globe," which was not illustrated by their experiments. Geology, meteorology, and magnetism were amongst the most conspicuous. I shall pause a moment to state some of their leading results, which, as respects meteorology, are of permanent and, even now, almost of unique interest in the science. It were, indeed, to be desired that the original registers, which are understood to be in the possession of the family, were published entire.

After mentioning the few observations [1] which could be made on the plants and animals (§§ 2038-2040) of this wild spot, and the rocks (§§ 2041-2048) of which the Col is composed, the Meteorological Observations are next discussed.[2] These were conducted every two hours, from 4 A.M. to midnight, by the alternate care of M. de Saussure and his son. We extract the following from the simple history of their days, each so like another, as to make the time seem to pass with extreme rapidity: "Vers les 10 heures du soir le vent se calmait; c'était l'heure où je laissais mon fils se coucher dans la cabane; j'allais alors dans la tente de la boussole me blottir dans ma fourrure, avec une pierre chaude sous mes pieds, prendre des notes de ce que j'avais fait dans la journée. Je sortais par intervalles pour observer mes instruments et le ciel, qui presque toujours était alors de la plus grande pureté. Ces deux heures de retraite et de contemplation me paraissaient extrêmement douces; j'allais ensuite me coucher dans la cabane sur mon petit matelas étendu à terre à côté de celui de mon fils, et j'y trouvais un meilleur sommeil que dans mon lit de la plaine." [3]

[1] [§§ 2035-2037 deal with the geographical position and elevation of the pass.]
[2] *Voyages*, § 2049. [3] § 2032.

The mean height of the barometer during eighty-five observations was 227·355 French lines.[1] At Chamouni the corresponding mean height was 300·638 lines, and at Geneva 323·668 lines, the temperatures of the air being 3°·630, 17°·288, and 19°·934 Réaumur, respectively. The temperature of the mercury of the barometer is not given. De Saussure clearly established,—at a period, too, when the diurnal variations of the barometer were little attended to,—that these oscillations are *reversed in their direction at great heights*, the barometer standing highest at 2 o'clock in the day, and lowest in the morning and evening.

His thermometric observations (§§ 2050-2054) are not less interesting or original. His deduction of the law of decrease of temperature in the atmosphere is, probably, the best that we yet possess, 1° Réaumur for 100 toises of ascent. He shows that a decreasing arithmetical progression satisfies the observations better than the harmonic law proposed by Euler; he points out the importance of his conclusions to the theory of astronomical refractions; he insists on the diminishing range of daily and annual temperature as we ascend, and observes, that this causes a corresponding daily and annual change in the rate of decrement with height; and he shows that he had a clear idea of *space* possessing a definite temperature at a distance from any planetary body. He considers, with much neatness and simplicity, the variations in the progress and extremes of daily temperature in the month of July at the three stations of the Col du Géant, Chamouni, and Geneva. The mean daily ranges were—

4°·257 Réaumur
10°·092 „
11°·035 „

or in the proportion of 2 to 5 nearly at the first and last stations. The progress of the diurnal warmth is most rapid at the higher station, for whilst the lowest temperature of the night occurred at all the stations at 4 A.M., the mean temperature of the day was already attained at 6 A.M. at the Col, at Chamouni at 8, at Geneva only at 9 A.M. These experiments are amongst the most definite and exact which we yet possess on these subjects.[2]

[1] Ingenuity never contrived a more perverse system of notation than the subdivisions of the barometer in the time of De Saussure, who gives his results in inches, lines (or twelfths), 16ths of these lines, and 1000ths of these 16ths. I have reduced them to lines and decimals.

[2] See a paper on the Diminution of Temperature with Height in the Atmosphere, and on the Diurnal Curves.—*Edin. Trans.*, vol. xiv. p. 489.

On solar radiation the experiments of De Saussure were not so conclusive as on most other subjects. He employed undefended thermometers, exposed in the sun and shade, and generally not even blackened. Hence the difference of these was always trifling, and depended fully as much on the force of the wind (as he himself notices) as upon any other circumstance. The effect of radiation from the surface of the snow, reducing its temperature below that of the surrounding air, he seems to have particularly noticed; and though he quotes Dr. Wilson's paper [1] on the subject (§ 2054), it may be inferred that he was not familiar with that curious observation at the time of his own experiment.

This remark, however, seems to have led him to make some most interesting observations on the temperature of the interior mass of snow. He notices, that the hard crust of congealed snow on the Col du Géant extended to the depth of only some inches, and that below that, down to 12 feet, the temperature was continually 0° Réaumur, or the freezing-point. The following passage, in which De Saussure reasons respecting the progress of the winter's cold into masses of snow and ice, compared to that in common soils, is so important to the modern theories of glaciers, and is, I think, so just, that I will quote it entire: "La croûte gelée," says he, "qui recouvre les neiges, est sans doute plus épaisse en hiver qu'en été; je ne crois cependant pas qu'elle ait plus de dix pieds d'épaisseur; et je suis persuadé, qu'au delà de cette profondeur les neiges demeurent tendres, et, comme en été, au terme de la congélation. En effet, si l'on adopte le principe que j'ai posé dans l'article précédent que la différence entre la température des plaines et celle des hautes montagnes n'est en hiver que les deux tiers de ce qu'elle est en été; on verra que, puisque la température moyenne du Col du Géant n'est en été que de 15 degrés plus froide que celle de Genève, elle ne le sera que de 10 en hiver. Ainsi comme nos plus grands froids n'excèdent guère 15 degrés au-dessous de zéro, ceux du Col n'excéderaient guère 25, et ceux de la cime du Mont Blanc 30 ou 31; ce qui est un peu moins que les plus grands froids de St. Pétersbourg. Or, puisqu'à la baie de Hudson, dont le climat est beaucoup plus froid que celui

[1] [*Philosophical Transactions*, vols. lxx. lxxi.]

de St. Pétersbourg, la terre ne gèle qu'à la profondeur de 16 pieds anglais, environ 15 pieds de France; on ne s'écartera pas beaucoup de la vérité, en supposant que, sur les hautes cimes des Alpes, la neige ne gèle en hiver qu'à 10 pieds de profondeur; surtout si l'on considère que la neige se laisse pénétrer par le froid plus difficilement que la terre."[1] These views will be found to be in accordance with those which have lately been brought forward to illustrate the Theory of Glaciers.

On the electricity of the atmosphere, De Saussure made many observations (§§ 2054-2057) on the Col du Géant, of which it may be said, that the imperfections were those of every observation of the kind, and that even at the present day it would be difficult to suggest very material improvements. He found the diurnal variations similar to those at the same season in the plains, showing that variation of temperature merely is not the cause of the dissimilar phenomena presented at different seasons.

A very interesting chapter (§§ 2058-2069) refers to experiments on evaporation, and the dryness of the air, which, though tinged by the erroneous views on Hygrometry then prevalent, present several results of value. The rate of evaporation was determined by the ingenious device of exposing a moistened cloth on a stretching frame, whose loss of weight, in a given time, was determined by means of a nice balance. He thus ascertained, by direct experiment, "that other things being the same with respect to temperature and dryness, a diminution of about one-third in the density of the air doubles the amount of evaporation."[2]

Besides these, we have observations (§§ 2070-2092) of great interest upon clouds, the formation of hail, an elaborate series of experiments, with the cyanometer invented by himself, upon the blue colour of the sky, on falling stars, on the colour of shadows, on the transparency of the air, on the scintillation of stars, and on the duration of twilight. He observed a sensible twilight when the sun was 45° below the horizon, instead of 18°, as is usually reckoned in the plains. Pictet concluded,[3] that this reflected light was derived from an elevation in the atmosphere of 121 leagues, where the air must be inconceivably rare, if indeed it exist at all. It seems so much more natural to suppose, as Arago has done, that the light of twilight has undergone

[1] *Voyages*, § 2054. [2] § 2062. [3] De Saussure, *Voyages*, § 2090, note.

several successive reflections, from comparatively dense air, that one wonders that so probable an opinion was not earlier held. De Saussure likewise made use of the influence of light in facilitating certain chemical operations, as a measure of the intensity of light at the Col du Géant, compared to the level of Geneva.

Besides all these varied subjects of inquiry, we find that De Saussure devoted particular attention (§§ 2093-2104) to the phenomena of magnetism on the Col du Géant. Indeed, it was one of his chief objects, as was shown by the extreme pains which he bestowed on the arrangement and observation of his magnetic apparatus. Seven times was the pedestal of his variation instrument constructed before it presented sufficient stability to afford consistent results, and it is not easy to appreciate the zeal which, in such trying circumstances, returned so often to the fulfilment of its object. He found the diurnal variations to subsist at this height as at Geneva and Chamouni, and to have generally the same direction. Their magnitude did not appear to be considerably altered. He was also probably the first person who attempted to inquire, whether the terrestrial magnetic intensity is sensibly diminished at these great heights. The observations made at Chamouni and the Col du Géant, at nearly the same temperature, agree very closely, and do not seem to warrant the supposition towards which De Saussure seems to lean (though with his usual caution), that the diminution was very apparent.[1]

In reviewing thus hastily the results[2] of the memorable journey of De Saussure, we cannot but be struck with the completeness of a plan of observation in terrestrial physics, to which it would be difficult, even at the present day, to make any considerable addition, except as to *methods*. Himself on the borders of fifty, and with the assistance only of his son, at the age of eighteen, he filled actively the part of geologist, naturalist, and *physicien* during seventeen days and nights, at a height which, but a few years before, was believed to be inaccessible in Europe,[3]

[1] § 2103. See also a paper by the author, *Edin. Trans.*, vol. xiv. p. 22.

[2] [§§ 2105-2112 deal with physiological observations.]

[3] "Environ 180 toises plus haut que la cime du Buet, qui passait il y a quelques années pour la sommité accessible la plus élevée des Alpes."—*Voyages*, § 2032.[1]

[1] [The Col du Géant is 859 feet higher than the Buet.]

and where it might well have been doubted whether human life could continue to be supported. Whilst the ascent of Mont Blanc (1787) has ever been considered De Saussure's most popular claim to his deserved reputation, the annals of science will register the residence on the Col du Géant (1788) as the more striking, as well as more useful achievement.

I left the Col to descend its northern side towards Chamouni at 8 A.M. A few steps brought me to the edge of the glacier, which may be considered as the head of the Mer de Glace in this direction. The view, though very grand, wants the effect of distance which the southern panorama presented. The summit of Mont Blanc is perfectly distinct; but it appears close at hand, and its elevation, though still 4600 [1] feet above the spectator, loses somewhat of its grandeur from its apparent proximity. The chain of *aiguilles*, which separates this branch of the Mer de Glace (or Glacier du Géant or du Tacul) from the valley of Chamouni, completely bounds the view to the north, and yet does not rise to a great height above the eye. The row of their summits, exactly in the reversed order from that in which they are seen from Chamouni, is, however, abundantly striking, commencing with the Aiguille du Midi on the left, succeeded by the Aiguilles [2] de Blaitière, de Grépon, and des Charmoz. The great tooth-like form of the Aiguille du Géant, belonging to the chain on which we stood, rose imposingly on the right, supported by a mass which completely cut off any view in the easterly direction. The comparatively small summits of the Aiguilles Marbrées, figured by Saussure, occupied the foreground in that direction. But perhaps the most striking part of the northern prospect was the dazzling mass of glacier upon whose surface we were now to walk for some hours, which occupied the basin to the depth of several thousand feet beneath us, intermixed with craggy pinnacles, which here and there connected themselves with the rocks on either hand, or stood out as islets amidst the breadth of unbroken white.

On rising from breakfast on the Col, we had taken the precaution to tie ourselves together with two strong new cords which Couttet had provided; and as he took the lead, I being in the

[1] [Precisely 4722 feet.]

[2] [It will be recollected that Forbes, contrary to present usage, groups the Aiguilles du Plan and de Blaitière together. See p. 110 above.]

centre, and Proment behind, about 10 feet apart, we had soon occasion to test their utility. The snow had fallen to a considerable depth during the late stormy days, and added considerably to the difficulty of detecting hidden chasms in the ice; almost the first step that Couttet took upon the glacier, he sunk up to his middle in a hole. By dint of reasonable precaution in sounding with a staff, even so trifling an accident was not repeated, and we passed safely over the beautiful snow beds, sloping at first gently towards the north. The map of the Mer de Glace gives a tolerably correct idea of the serrated ridges of granite peaks which break the monotony of the scene. The first which we passed on our left is called the *Tour Ronde*. This is connected with the main ridge of Alps, a little to the westward of the Cabin of De Saussure, where it terminates in a remarkably shaped hill, called Le Flambeau. It must be observed, however, that there are two rocks of this name, and which resemble one another extremely. The one marked on the Map 2d Flambeau, is still farther west, and forms part of a transversal, and apparently inaccessible,[1] ridge, which stretches quite across from the Glacier of La Brenva on the south to that of [Géant] on the north, forming the mass of the Mont Maudit. These appear effectually to cut off access to the summit of Mont Blanc on this side, nor does De Saussure hint at the possibility of ascending it from hence.[2] The western, or Second Flambeau, is a summit conspicuous from several points, whence it could hardly be expected to be seen, as, for instance, from the Col de Balme.

The glacier here, enclosed between the Tour Ronde and the Aiguille du Géant, is very broad, but it is only one of the tributaries which aliment this branch of the Mer de Glace—another descends from between the first and second Flambeau by the foot of a promontory called Le Capucin (see the Map), owing to the fantastical forms which the granitic obelisks here assume, and one of which has the rude outline of a human figure. Another and very large ice-flow descends from the Aiguille du Midi, and is more precipitous and broken; it breaks against a

[1] [Several passes have of recent years been effected across this ridge.]

[2] [In 1888 an English party mounted in 5¾ hours from the hut on the Col du Géant direct to the ridge between the Mont Maudit and the Mont Blanc du Tacul, while the year before an Austrian party had succeeded in traversing the ridge from the Col de la Tour Ronde to the summit of the Mont Maudit. Both expeditions were "tours de force."]

small rock called Le Rognon, nearly opposite to La Noire, and surrounded entirely by the glacier. It was up this glacier that Col. Beaufoy first, and afterwards M. Romilly of Geneva, ascended the Aiguille du Midi,[1] at least up to the foot of the last rocky summit, which I believe is inaccessible.

We continued to descend with precaution, though without any inconvenience, excepting from the sun, which was now high and brilliant, and its light reflected with more intensity than I had ever felt it from the *facettes* of the highly crystallised and fresh snow by which we were surrounded. I began to think that the passage was to be effected without any difficulty worth mentioning, until we arrived at the part of the valley where the three tributary glaciers already mentioned began to unite, and are together squeezed through the comparatively narrow passage between La Noire on the right, and the rock which I have marked *Petit Rognon* on the left. It is difficult to say, whether the ascent or descent of such a glacier is more arduous; but in descending, one is at least more taken by surprise; the eye wanders over the wilds of ice sloping forwards, and in which the most terrific chasms and rents are hidden like the ditch in a *ha-ha* fence. The crevasses of the glacier gradually widened; the uniting streams from different quarters met and jostled, sometimes tossing high their icy waves, at others leaving yawning vacuities. The slope, at first gradual, and covered continually with snow, became steeper, and as we risked less from hidden rents, the multitude and length of the open ones caused us to make considerable circuits.

But the slope ended at last almost in a precipice. At the point where the glacier is narrowest it is also steepest, and the descending ice is torn piece-meal in its effort to extricate itself from the strait. Almost in a moment we found ourselves amidst

[1] [This statement is repeated by Forbes in his 1857 *Quarterly Review* article, (see p. 514 below), so far as regards M. Romilly, but nothing more unluckily seems to be known as to either expedition. Col. Beaufoy, on August 9, 1787, made the fourth ascent of Mont Blanc—the first by an Englishman—but in his published narrative of that feat (*Annals of Philosophy*, February, 1817) does not allude to any attempt on the Aiguille du Midi. Forbes states that Romilly's ascent was made "nearly forty years" before 1857, and it is odd that in August, 1818—a date that would just answer—a young Pole, Count Matzewski, with six guides, did really scale the second and lower summit of the Midi (12,412 feet), the higher summit (12,608 feet) not having been conquered till 1856. An account of Count Matzewski's expedition appeared in *Blackwood's Magazine* for November, 1818, and is reprinted in the *Alpine Journal*, vol. xvii. pp. 198, 199.]

toppling crags and vertical precipices of ice, and divided from the Mer de Glace beneath by a chaos of fissures of seemingly impassable depth and width, and without order or number. Our embarrassment was still further increased by the very small distance to which it was possible to command by the eye the details of the labyrinth through which we must pass. The most promising track might end in inextricable difficulties, and the most difficult might chance ultimately to be the only safe one.

The spectacle gave us pause. We had made for the north-western side of the glacier, near the foot of the Petit Rognon, hoping to get down near the side of the rocks, although not upon them. But when we neared this part of the glacier, even Couttet shook his head, and proposed rather to attempt the old passage by the foot of La Noire, where De Saussure left his ladder,[1]—a passage avoided by the guides on account of the steep icy slopes it presents, and the great danger which is run from the fragments of stone which, during the heat of the day, are discharged, and roll down from the rocks above. These stones are amongst the most dangerous accidents of glacier travels. A stone, even if seen beforehand, may fall in a direction from which the traveller, engaged amidst the perils of crevasses, or on the precarious footing of a narrow ledge of rock, cannot possibly withdraw in time to avoid it. And seldom do they come alone. Like an avalanche, they gain others during their descent. Urged with the velocity acquired in half rolling, half bounding down a precipitous slope of a thousand feet high, they strike fire by collision with their neighbours—are split perhaps into a thousand shivers, and detach by the blow a still greater mass; which, once discharged, thunders with an explosive roar upon the glacier beneath, accompanied by clouds of dust or smoke, produced in the collision. I have sometimes been exposed to these dry avalanches; they are amongst the most terrible of the ammunition with which the genius of these mountain solitudes repels the approach of curious man.[2] Their

[1] [See p. 83 above.]

[2] At saxum quoties ingenti ponderis ictu
Excutitur, qualis rupes, quam vertice montis
Abscidit impulsu ventorum adjuta vetustas,
Frangit cuncta ruens: nec tantum corpora pressa
Exanimat; totos cum sanguine dissipat artus.
LUCAN, *Phar.* iii. 465.

course is marked on the rocks, and they are most studiously avoided by every prudent guide.

It was, however, in the direction of La Noire that it was thought that we might pass; and we accordingly crossed the glacier to inspect the passage. But there, barriers still more insurmountable appeared. One prodigious chasm stretched *quite across the glacier;* and the width of this chasm was not less than 500 feet. It terminated opposite to the precipices of the point of La Noire in one vast *enfoncement* of ice bounded on the hither side by precipices not less terrible. A glance convinced every one that here, at least, there was not a chance of passing, unprovided as we were with long ropes or ladders. Nothing remained but to resume the track we had at first abandoned; for the whole centre of the glacier was completely cut off from the lower world by this stupendous cleft. Here the experience of Couttet stood us in good stead, and his presence of mind inspired me with perfect confidence, so that we soon set about ascertaining, by a method of trial and error, whether any passage could be forced among the labyrinth of smaller crevasses on the northern side of the glacier. A chamois, whose track we had followed earlier, seemed here to have been as much baffled as ourselves, for he had made so many crossings back and forward upon the glacier, and had been so often forced to return upon his steps, that we lost the track for a time. This animal is exceedingly timorous upon a glacier covered with snow, since the form of the foot prevents it from offering almost any resistance when hidden rents are to be crossed. We had accordingly passed earlier in many places where the chamois had not ventured; but the case was now different on the hard ice. He took leaps upon which we dared not venture; and as we were never sure of not being obliged to retrace every step we made, we took good care never to make a descending leap which might cut off our retreat. Many a time we were obliged to return, and many a weary circuit was to be made in order to recommence again; but we seldom failed ultimately to recover the chamois track, which is the safest guide in such situations. The excitement was highly pleasing. The extrication from our dilemma was like playing a complicated game, and the difficulty of the steps was forgotten in the interest of observing whether any progress had been gained; for now we were obliged to descend into the bosom of the glacier, and to select its most jagged and pulverised parts, in order to cross the crevasses where they had become choked by the decay and subsidence of their walls. Thus hampered by our icy prison, we only emerged occasionally so as to catch a glimpse of what lay beyond, and to estimate our slow and devious progress. At length, by great skill on the part of Couttet, and patience on the part of all of us (for we remained inseparably tied together all this time), by clambering down one side of a chasm, up another, and round a third, hewing our steps,[1] and holding on one by one with the rope, we gradually extricated ourselves from a chaos which at first sight appeared absolutely impenetrable, and that without any very dangerous positions.

Whilst we were in the middle of this confusion and difficulty, I could not help remarking how totally unserviceable any addition to the number of guides would have been. On saying as much to Couttet, he replied, "ils ne seraient bons que pour faire peur les uns aux autres," which was perfectly true. At length, having been for some hours engaged in these toils, we saw a comparatively clear field before us, the glacier became more level and compact, the crevasses were knit, and though no trace of life or habitation, not the most stunted tree, was within any part of the horizon, the familiar localities of the Mer de Glace were apparent, the Tacul with the branching glacier, the Couvercle, the Jardin, the Charmoz, and the Moine. Here we halted about one o'clock, for we had now reached *water*, always a joyful sight to those who have been long wandering over snow fields. We drank of it freely, and the guides added fresh libations of brandy, which caused them to complain of intolerable thirst and heat of the head all the rest of the way to the Montanvert, which, by confining myself to cold tea, and a very little wine with water, I entirely escaped.

As I have not described this branch of the Mer de Glace, above the Tacul, I shall here add the very few words which it requires.

La Noire, on the south, and the Aiguilles de Blaitière[2] and

[1] A geological hammer sharpened at one end is nearly as good an implement for this purpose as a hatchet. For this reason, amongst others, I generally wore it. A person so provided, if he falls uninjured into a crevasse, possesses the most essential means of extrication.

[2] [As usual, Forbes groups the Aiguilles du Plan and de Blaitière under one name, though they are really quite distinct. See p. 110 above.]

Grépon, on the north, here bound the Glacier of Tacul (or Géant). The former gives rise to a pretty extensive lateral glacier, which descends from the foot of the Aiguille du Géant and the Mont Mallet. I distinguish these two, as it will be seen is done on the map. But the Aiguille du Géant is itself sometimes called Mont Mallet, on the south side of the Alps. What I have termed Mont Mallet, on the authority of the guides of Chamouni, is a very remarkable peak, a little to the north-east of the Aiguille du Géant. The Géant appears to be 13,099 feet above the sea, Mont Mallet 13,068.[1] The glacier descending from them, called Glacier des Périades, is very convex and copious; and, by its union with the others, tends to consolidate the whole. It is from La Noire (probably so called from having formerly been visited in search of smoky quartz crystals), that the fourth moraine of the Mer de Glace, mentioned in a former chapter (p. 81), descends. This moraine offers a feature similar to that of the Glaciers de Talèfre and de Léchaud, namely, that it is at first imperceptible, or nearly so, and increases in distinctness and mass as we descend the glacier. It is several miles below its origin, namely, near the "Moulins," that it is best developed. This very singular fact admits of no contest, but the mode of explanation varies. Some have supposed that it arises from the rejection of the stones through the matter of the ice, which presupposes that the fragments have been mixed up with or engaged in the solid ice. I believe that it arises from a very simple cause. When two glaciers do not unite at exactly the same level (the most common case), or even where, the level being the same, the one vastly preponderates, the lower or smaller glacier flows or forces itself some way under the upper or greater, and thus the fragments of rock borne by each to the point of union, are naturally carried inwards at the sloping junction, where they lie for a time buried, as in Fig. 1, page 158, which represents the section of the glacier at this place, until the thaw or waste of the surface brings them gradually to light. This is attempted to be represented on the map, and it is one of the most striking features of these accumulations. I must add, that, at the foot of the icy precipice opposite to La Noire, I found rocks and sand appearing on the surface in a way not very easy

[1] [The Géant is 13,170 feet, and the Mont Mallet 13,085 feet; they are, of course, perfectly distinct peaks.]

to comprehend. They were probably, or almost certainly, derived from the Petit Rognon, but by what mechanism they were brought to light I am unable satisfactorily to decide. As soon as the glacier becomes compact and moderately fissured, the veined structure of the ice makes its appearance, and continues the whole way down the Mer de Glace, as has been already particularly described.

The Glacier du Tacul, below La Noire, is of great and nearly uniform width. I have, on the present and other occasions, traversed it in various directions. It is little fissured, and consequently great water-courses are formed, which pursue their way along the surface of the glacier, of which the inequalities are sometimes very considerable, so that the water at last finds an exit through some great funnel, or vertical opening in the ice; and here and there it stands in pools to a great depth. About half-way from La Noire to the Tacul, there is a rocky promontory on the right bank of the glacier, marked K in the map, which was one of my points of observation, and opposite to it is an offset from the range of the Aiguilles of Chamouni, on the left, which forms a series of very fantastical summits, one of which might deserve a peculiar name, and is figured in the map as the *Aiguille de Blaitière derrière*.[1]

Truncated glaciers of the second order festoon the wild enclosures of the valley on both sides. Those on the left are nearly continuous, and may, I believe, be traversed, so as to reach the shoulder of the Charmoz, or station G*, from the upper part of the Glacier du Géant, an experiment which I was prevented from trying by premature bad weather.

From La Noire it seems but a step to the foot of the Tacul, but the elevation is considerable, the glacier very wide, and I was surprised at the distance which separated me from the regions with which I was then familiar. I must not omit to add, that the view in descending the Glacier du Géant is admirable. The picturesque mass of the Aiguilles du Moine and du Dru, terminating in the enormous elevation of the Aiguille Verte, forms a group of singular majesty, which cannot be so well appreciated from any other point. The basin of the Glacier de Talèfre is likewise exposed, and the triangular rock of the Jardin stands forth in form and dimensions very apparent.

[1] [It is now known as the Dent du Requin, or "shark's tooth." It is 11,218 feet and was first climbed in 1893.]

We all felt an exuberant cheerfulness at being relieved from our embarrassments, and ran cheerfully down the magnificent glacier, leaping crevasses which at another moment we would rather have avoided. Soon on the platform at the confluence with the Glacier de Léchaud, all was plain and direct; and I reached the Montanvert at a quarter before four P.M., without fatigue, headache, or lassitude. Here I remained, intending to spend some weeks. My guides, having finished their brandy, descended to Chamouni, where their arrival created, I was told, some astonishment, as no one had before crossed the Col du Géant in a single day, and as it was supposed that the fresh snow must at any rate have rendered the attempt impracticable. I slept that night somewhat sounder and longer than usual, but rose next morning with a freshness and elasticity to which the inhabitant of the plains is a stranger. A threatening of inflammation of the eyes confined me partly to the house, but it fortunately subsided; I felt at first a slight shortness of breathing on ascending a hill, but that also disappeared the second day. My guides, as I afterwards learned, entirely lost the skin off their faces. The barometer on my arrival was—

			mm.	A.T.	D.T.
Montanvert, 1842.	July 23.	3 hrs. 45 min. P.M.	610·8	15·8 C.	51 F.
		5 „ 15 „ „	610·2	11·4	51

This, compared with the observation of the Col du Géant, gives 4841 feet for its height above the Montanvert, or 11,144 above the sea.[1]

[1] [The real height is 11,060 feet, or 4793 feet above the Montanvert inn.]

CHAPTER XIII

FROM COURMAYEUR TO CHAMOUNI, BY THE COL FERRET AND COL DE BALME

Piedmontese Val Ferret—Glacier of Triolet—View from the Col—Swiss Val Ferret—Martigny to Chamouni—Glacier of Trient—Col de Balme—Glacier of Argentière.

In order to complete our narrative of the tour, or circuit of Mont Blanc, I proceed to describe shortly the route by the Col Ferret across the great chain of Alps, and that from Martigny to Chamouni by the Col de Balme, and those glaciers of the valley of Chamouni which have not as yet been enumerated. The former part of the route I performed in 1841, in company with Mr. Heath; I have three times visited the Col de Balme, in different years.

The passage of the Col Ferret is tedious, and perhaps less interesting than most others in the Alps; travellers usually, and perhaps wisely, prefer the longer round, by Aosta and the Great St. Bernard, which offers greater variety. This route, however, completes the closer inspection of the great chain of Mont Blanc, which is very completely separated, both geographically and geologically, by the Col Ferret, from the mountains on the east of which Mont Vélan[1] forms the culminating point. After having ascended the Piedmontese Val Ferret (the prolongation of the Allée Blanche), and descended the Swiss Val Ferret to Orsières; and having, either by Martigny or otherwise, reached the Col de Balme, and thus passed into the valley of Chamouni, the circuit of Mont Blanc and its chain is complete. Unless by passing difficult or dangerous glaciers, as in the case of the Col du Géant,

[1] [Really Mont Vélan, 12,353 feet, is surpassed by its mighty neighbour, the Grand Combin, 14,164 feet.]

this extensive chain may be considered as impracticable, or nearly so, in its whole length.

The ascent of the Val Ferret from Courmayeur seems monotonous after the more varied grandeur of the Allée Blanche and Val Veni; for here, though there are numerous glaciers on the left hand, they do not descend completely into the valley except near the head of it, and the mural precipices of the Jorasses, which separate this valley from the tributaries of the Mer de Glace of Chamouni, although magnificent at a distance, rise here so completely overhead as to conceal their own elevation, and the magnificent summits by which they are crowned. As the secondary mountains on the right hand—forming the prolongation of the Mont de la Saxe—offer nothing of interest beyond what has been already mentioned in Chap. XI., I shall merely enumerate the glaciers which descend from the primary chain so far as I was able to ascertain their names from native guides. I am aware that the guides of Chamouni[1] differ a little in their nomenclature. Eastwards from the Glacier of La Brenva we have first the Glacier of Mont Fréty, and then that of Entrèves with the Mont Fréty between. From the Aiguille du Géant descends the Glacier de Rochefort, and between it and the Grandes Jorasses the Glacier des Grandes Jorasses.[2]

The next in order is the Glacier de Triolet, which, as already mentioned in the fifth chapter, is nearly opposite to the head of the Glacier de Léchaud, and descends from a summit called by the Chamouni guides, "Montagne des Eboulements."[3] The event to which the name refers took place, I believe, in 1728, though I failed in obtaining at Courmayeur any *authentic* documentary evidence respecting it.[4] According to a small printed work which was shown to me, the avalanche, or sudden descent of the whole glacier, took place on the night of the 15th-16th August in that year, and completely overwhelmed the chalets of Pré de Bar, which were situated exactly in front of it, destroying of course the inmates and cattle. The modern chalets of Pré de Bar are higher up on the southern side of the valley. They are very filthy.

[1] [It is not their own district.]

[2] [Formed by the Pra Sec and Planpansière Glaciers. Forbes omits the Frébouzie Glacier that descends from the Petites Jorasses.]

[3] [The Aiguille de l'Eboulement.]

[4] [Really on September 12, 1717. See p. 91, above.]

Beyond the glacier just named is the Mont Ru,[1] which separates it from the Glacier of Mondolent,[2] the highest in the valley. This one appears to have greatly retreated of late years.

There are two passages of the Col Ferret, the Petit Ferret, which is a footpath, and the horse road, which is more circuitous. It is five hours' walk from Courmayeur to the Col.[3] The path of the Petit Ferret is close to the junction of the limestone and granite. The former is nearly vertical, rising against the latter at an angle of at least 70°. The junction is well marked, and the limestone is a tabular slate. Indeed, the chief interest of this route consists in the closeness with which the geological boundary is followed. Behind the Grandes Jorasses, at a point called Pra Sec, two hours from Courmayeur, is a junction and apparent superposition of granite to limestone, which I noticed in 1841, and again from a distance in 1842. On neither occasion had I any doubt that the limestone actually dipped under the granite, as, in the interval of the two observations, I had established that it does farther west. De Saussure, however, who ascended to the junction, maintains (§ 872) that the strata rise towards the granite, although he seems to admit that farther west both the granite and limestone dip inwards; but he never asserts the superposition distinctly.

The view from the Col Ferret,[4] looking back, is certainly one of the finest which I have seen. The prodigious outworks which sustain the mass of Mont Blanc on the southern side are more conspicuous here than from any other point, especially the Mont Pétéret, which stands out like a majestic Gothic pinnacle. From hence, as from the Col de la Seigne, we see how far this side of the chain is from being an absolute precipice, as it appears when viewed in front, as from the Cramont.

The descent of the Swiss Val Ferret to Orsières offers no great interest, and it is of most tedious length. On the right hand is seen the passage of the Col de Fenêtre,[5] leading to the Great St. Bernard, by which the produce of the valley, and

[1] [Les Monts Rouges.]

[2] [Really the Pré de Bar Glacier. The name "Mont Dolent Glacier" is now given to the next glacier on the east, but this descends into the *Swiss* Val Ferret.]

[3] [There is now a char road from Courmayeur to the Feraché chalets, and from the Swiss Ferret chalets to Orsières; it will probably be soon continued across the Col.]

[4] [It is 8311 feet high.]

[5] [It is 8855 feet high, and is traversed by a mule-path.]

especially firewood, the property of the convent, is conveyed with the aid of mules.

Several glaciers are passed on the left; since, however, the side of the valley is exceedingly steep, several of these are only seen peeping over the precipices. One of them has evidently descended formerly into the valley, and has deposited in it an immense transversal moraine which now stands alone;—the glacier having retreated into the upland ravine. It is commonly supposed to be from these glaciers that the vast granite masses descended which are still found on all the neighbouring slopes at a great height above the valleys, the blocks of Monthey and those upon the Jura. The aiguilles to the east of Mont Blanc are indeed the only ones in this district capable of yielding rocks of the kind in question, and the secondary mountains adjoining Orsières are strewed with masses, having evidently a common origin with those in the valley of the Rhone. These were well known to De Saussure,[1] and accurately described by his correspondent M. Murith,[2] but they form one of the especial grounds of the theory of Venetz and De Charpentier, and have been more particularly described by the latter.

I shall not dwell upon the descent of the Dranse to Martigny, or the circumstances of the débâcle of the Val de Bagnes, to which I shall shortly again recur; but I proceed to describe a journey which I took from Martigny to Chamouni, in September 1842, in which, avoiding as much as possible the common route, I visited the Glaciers of Trient and Argentière. The Glacier of Trient may be reached from Orsières by crossing the Mont Catogne,[3] or from Martigny by the Col de la Forclaz. In the latter case, the village of Trient being passed, instead of turning to the right in ascending the valley, which would lead to the Col de Balme, I followed the eastern side of the glacier stream, and after a rough walk (having missed the path), I arrived at a group of chalets. The glacier is then well seen; it descends into a kind of

[1] *Voyages*, § 1022.

[2] [Laurent Joseph Murith, born 1742 at Sembrancher. He became a Canon of the Great St. Bernard in 1760, and Curé of Liddes in 1778. In 1779 he made the first ascent of the Monte Vélan: he was Prior of the order at the Motherhouse at Martigny from 1791 till his death in 1816. In 1810 he published a *Guide du Botaniste qui voyage dans le Valais*. He was a famous botanist, and the Botanical Society of the Vallais bears his name.]

[3] [Forbes really means past Champex—at the foot of the Catogne—and then by the glen and pass of Arpette.]

basin, apparently inaccessible in its higher parts,[1] from granitic pinnacles which divide this valley from the Val Ferret. Of these the most conspicuous is a fine point on the right hand, looking towards the head of the glacier; it was named to me Salena; and is no doubt also at the head of the glacier so called, whilst at the same time it separates the Glacier of Trient from that of Le Tour. I think it most likely that this is the Pointe d'Orny, seen from Orsières.[2]

The lower end of the Glacier du Trient is about an hour's walk above the village of the same name. It is a well-spread-out glacier, with few ramifications, and a rather attenuated front; it somewhat resembles in contour the Glacier of the Rhone, or that of La Brenva, but it communicates more directly with the higher slopes. An inspection of the structure proved it to be quite normal; so much so, indeed, that I could have accurately predicted it beforehand, by seeing merely the external form of the ice. Suffice it to say, that it corresponds generally to the structure figured on page 29. The crevasses in the lower part are also *radial*, as in every glacier of this order (see the full lines marked *a* on the figure, page 29). In its middle or mean portion, the glacier is as usual most readily traversed, and here very easily. I crossed over, making observations in different directions, and observing especially the character of the granite blocks which come down the western moraine from the summit just mentioned. These blocks are remarkably chafed and rounded, no doubt from the friction they have experienced between the ice and rocks; but neither in this or in any other case have I perceived an approach to *polish* on glacier-moved blocks, which cannot (I think) for a moment be confounded with those *smooth* pebbles and boulders plentifully found in the diluvium of all countries, and composing many of those gravel heaps which have been styled moraines. The nature of the granite, or protogine, appeared to me accurately to resemble that of the blocks of

[1] [This is by no means the case. The Plateau du Trient can be gained by keeping near the right bank of the Trient Glacier; the plateau was actually visited by Forbes in 1850. See below, p. 463.]

[2] See more on this subject in the next chapter, p. 253. [The Petite Fourche, 11,503 feet, is the only summit that dominates the three glaciers named; it is seen in the view from the Aiguille de la Glière, given on p. 456 of this volume. It is separated from the Pointe d'Orny by the extensive snowy "Plateau du Trient," but of the two peaks the Pointe d'Orny alone is visible from the Lys chalets, and that is to the *left* of the spectator.]

Monthey, and those on the Jura. Supposing them to have been derived from the Pointe d'Orny, they may either have descended the Glacier du Trient, when it filled the valley of the Tête Noire, and joined that of the Rhone below Salvan, or (as is more probable, from the distribution of the blocks) followed the exterior of the chain by Sembrancher and Martigny.

The highest chalets[1] on the eastern side, named La Lys, are somewhat higher than where I crossed the glacier, and I reached the western bank under the chalets of Chazettes,[2] which are close to a ravine which contains a stream from a glacier, which fills its higher part, and which descends from the ridge of the Aiguille du Tour. Finding nothing more particularly worth exploring, I proceeded to look for the path which, I had been informed, led directly to the Col de Balme, without descending to Trient. It was, I was told, above the precipices which bound the valley of Trient to a great height on its western side. Although I met with no one here to give me information, I succeeded in discovering the path, which is a bold and romantic one, and crosses the mountain by which the Col de Balme is separated from the Glacier du Trient, at a great height on its precipitous eastern side. In the course of this walk I obtained a more correct idea of the chain to which the Dent du Midi belongs than I before had. Instead of being an insulated pyramid, or a pair of summits, as it appears from most points, it belongs to a jagged ridge, which is very elevated, and which extends from east to west, including great fields of snow, and glaciers of the second order. I arrived early at the little inn upon the Col de Balme, and slept there.

Next morning I left the Col de Balme at six, with fine weather, intending to explore the Glacier of Argentière. I had long had a great curiosity to visit this glacier, because, though so near Chamouni, it is very little known; and still more, because on all the models it is represented like an unbroken, perfectly uniform, nearly level canal, extending to the very axis of the Alps; and I was anxious, if possible, to determine its

[1] [M. Kurz's map marks some other huts, those of Vaisevay, still higher up this side of the Trient Glacier.]

[2] [This name does not appear on the maps of the chain of Mont Blanc. Perhaps the huts meant are those of the "Plan des Cercles" (see M. Kurz's map), which are just opposite La Lys: the cross path to the Col de Balme track starts from these huts; the neighbouring glacier is that of Grands.]

boundaries as respected the barriers of the Glacier de Talèfre, to which I understood it to be contiguous. It is a glacier little known to the guides of Chamouni; but a few of whom frequent it for the sake of the crystals, with which it is said to abound; but the length of the way is so great, and the snow lies so long and so deep upon the higher parts, which are sheltered from the sun by their northern exposure, that it is an expedition only to be attempted (I mean for the search of minerals) in the finest weather, and at a late season of the year, when the boundary of the snow is highest. But as the days are then short, it is necessary to sleep out, and this is no pleasant task in so very wild and remote a spot. So far as the report of the guides may be believed as to the locality of the minerals (a matter on which the current information is little to be believed), the Glacier d'Argentière is the richest field in the chain of Mont Blanc; and specimens of red fluor-spar and smoky quartz—the most expensive in the cabinets of Chamouni—are understood to have been brought from thence, often at imminent peril to those who secured them.

I have said that few of the professed guides have been on the higher part of the Glacier d'Argentière. The makers of the two best models of this part of the Alps have admitted to me, that they took their design of its locality from the perspective view from the Buet, which looks right up it. De Saussure, I believe, only mentions it once;[1] and as he speaks of having visited it and the Glacier des Bois in early spring, it is certain that he can only have examined its lowest part. It is unnoticed, or all but unnoticed, by Ebel and by Pictet.

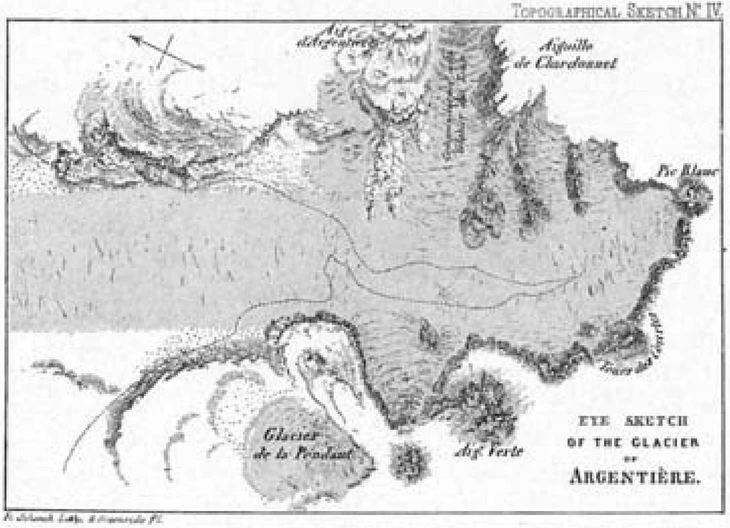
Understanding from the innkeeper on the Col de Balme—himself a good mountaineer—that the Glacier d'Argentière presented no unusual difficulties, I contented myself with taking along with me the man who usually accompanied me, although he was also unacquainted with the way. As we knew that we must again ascend, we unwillingly went down the great depth which separates the Col de Balme from the foot of the Glacier of Le Tour. I then regretted that I had not taken the guide of the Col de Balme, who offered to conduct me by a little known route[2] across the upper part of the Glacier of Le Tour, and to descend upon that of Argentière, near the Aiguille du Char-

[1] *Voyages*, §§ 739, 740.

[2] [Probably the Col du Passon.]

donnet. But I was anxious to see the glacier in all its length, and not to come upon it in the middle. The Glacier of Le Tour has considerably shrunk in its dimensions of late years, as well as that of Trient. Beyond the village of Le Tour, which I left on the right, a sharp ascent led me through extensive pastures, up to about the level whence we had started, and keeping along about that line, we there came in sight of the Glacier of Argentière, at a great depth below us. I did not descend, however, but kept along the face of the hill, represented in the upper left-hand corner of the Topographical Sketch No. IV., so

Topographical Sketch No. IV.



EYE SKETCH OF THE GLACIER OF ARGENTIÈRE.

as not to lose the height we had gained. The path became smaller,—then a mere sheep track,—and that again was subdivided. The mountain face became precipitous, and in some places went sheer down to the glacier. As my guide, or rather companion, was somewhat nervous on untried excursions,—rather, perhaps, from a caution characteristic of the Savoyard peasant of getting himself into trouble by bringing a traveller into danger than from any want of personal courage,—I took the lead both on this occasion and on the previous day, and fortunately extricated myself satisfactorily from the precipices, which, when seen in the afternoon from the opposite side of the glacier, were of a sufficiently dangerous kind, and had we attempted a passage either higher or lower, we must have failed. The precipices passed, a long and fatiguing slope of débris was to be crossed, and then a vast lateral moraine of the glacier, covering a great surface with huge blocks, which, however, afforded solid and comparatively easy footing, after what we had passed. Amongst these blocks I was astonished to observe some sheep, which must have been driven across the nearly pathless rocks which I had traversed.

Nearly opposite this moraine, which is marked on the Sketch, the glacier is tolerably flat, and might be traversed from side to side; but being precipitous both above and below, I continued along the moraine until I came to the foot of the rocks descending immediately from the Aiguille du Chardonnet to the glacier. There I made for the ice, having had, rather to my surprise, a fatiguing walk of four hours from the Col de Balme before setting foot upon the glacier.

The Aiguilles of Argentière and of Chardonnet[1] separate the Glaciers of Le Tour and Argentière, and between these Aiguilles there descends a steep tributary glacier to the level of the latter.[2] On the ridge connected with the Aiguille d'Argentière there is a remarkable instance of a glacier of the second order, which appears to be rapidly disappearing. It is marked *a* on the Topographical Sketch No. IV. Its former boundary is indicated by the whiteness of the rock where it has been beneath the ice, of which there is now scarcely a trace.

On the Glacier of Argentière there is only one medial moraine of any extent, which comes from the higher part of the glacier, on the left in ascending. There are two lateral glaciers also on the left, which appear to communicate with the Glacier of Le Tour.[3] Having gained the ice, I proceeded without difficulty, for on the higher part it is not much crevassed, and the higher we ascend the more level it becomes. The Aiguille Verte rises

[1] [Forbes always reverses the position of these two summits, and his text has been throughout corrected in this particular. The Chardonnet (12,540 feet) dominates the Argentière, the Tour, and the Saleinaz Glaciers, but the Argentière (12,819 feet) rises between the Argentière and Saleinaz Glaciers.]

[2] [This is the Chardonnet Glacier, that descends from the Col du Chardonnet (10,909 feet) between the two aiguilles, but the pass over it leads over to the Saleinaz, and not to the Tour Glacier, as Forbes imagined. This pass is alluded to by Forbes when describing his passage of the Fenêtre de Saleinaz in 1850, see p. 464 below.]

[3] [Really both communicate with the Saleinaz Glacier.]

in great majesty on the right, and from its rugged sides some short glaciers descend to meet that of Argentière. I walked on, having reached the névé, or perpetual snow, until I had left the Aiguille Verte quite behind me, and was now within a short distance of the head of the glacier, that is to say, not much exceeding an hour's walk. The surface is even, and the whole topography is easily seized. The direction of the glacier, which up to the Aiguille Verte had been S. 25° E., now became S. 50° E. This bend in the direction corresponds to the basin of the Glacier de Talèfre, which is only separated, as has been said, from the higher part of the Glacier d'Argentière by the range of the Tour des Courtes, which appears to be of small thickness, and is one continued precipice on its north-eastern side. I can only guess at the height of the upper part of the Glacier d'Argentière, as I was provided with an imperfect instrument. It is, no doubt, more than 8000 feet above the sea.[1] The extremity of the view is terminated by a snowy peak, which I believe is probably that marked [A] on the large map of the Mer de Glace, and which was also visible at the Jardin,—perhaps the Mondolent.[2]

The structure of this glacier is very confused. The vertical linear bands are, of course, visible throughout up to the névé; but it would be difficult to trace the curves. The middle and lower part is excessively crevassed; and the extremity near Argentière has very much shrunk of late years.

After a careful examination of the higher part I returned by the western side, under the Aiguille Verte, and gained the bank somewhat below the tributary glacier on that side. There is a small snowy peak[3] to the north of the Aiguille Verte, which is connected with it by a ridge dividing the ice which falls in the direction of the Mer de Glace and in that of Argentière. From the same peak descends a small glacier on the north side, called Glacier de la Pendant, or de Lognan, which, judging from the

[1] [M. Kurz's map gives the height as 9502 feet.]

[2] [Forbes's "Peak A" is really the Aiguille de Triolet (12,717 feet), which rises above the Argentière, Talèfre, Triolet, and Pré de Bar Glaciers. It is separated by the Col du Mont Dolent from the Mont Dolent—Forbes's "Pic Blanc"—(12,543 feet), which also rises above four glaciers—Argentière, Pré de Bar, Mont Dolent, and La Neuvaz, and is besides the meeting-point of the French, Swiss, and Italian frontiers. See above, p. 93.]

[3] [This is the Aiguille des Grands Montets (10,827 feet), a very fine view-point. South of it an easy glacier pass leads over to the Mer de Glace.]

polished rocks below, appears to have been formerly more extensive. From the highest chalets[1] there is a path to the village of Argentière, and another less easily found, which descends near Lavancher. Both pass through fine fir wood. From thence the village or Prieuré of Chamouni is soon reached.

[1] [Those of Lognan. Here there is now a small inn above the left bank of the Argentière glacier.]

CHAPTER XIV

JOURNEY FROM CHAMOUNI TO VALPELLINE, BY THE VAL DE BAGNES AND COL DE FENÊTRE

Traces of ancient glaciers from Les Montets to the Tête Noire—Arrival at the Great St. Bernard—Find M. Studer—Return to Orsières—The Val de Bagnes—Chable—The inhabitants—Glacier of Giétroz—The débâcle of 1818—Chalets of Torrembey—Economy of chalets, and manners of the inmates—Glacier of Chermontane—Col de Fenêtre—View into Italy—Valley of Ollomont—Goîtres—Arrival at Valpelline.

BEFORE going to Chamouni in June, 1842, I had visited my friend M. Studer,[1] Professor of Geology at Berne. We then agreed, that a plan which had been vaguely discussed between us the year before—of visiting the neighbourhood of Monte Rosa, and the almost unexplored valleys to the westward—should, if possible, be accomplished in company that summer. M. Studer visited me on the 1st August, at the Montanvert, and we then fixed the 12th of that month for a *rendezvous* at the Convent of the Great St. Bernard, he, in the meanwhile, making an excursion into the Tarentaise, whilst I remained pursuing my survey of the Mer de Glace, and determining its motion. Accordingly, on the 11th, I left Chamouni, having engaged an active young man (not a professed guide) of the neighbourhood, named Victor Tairraz, to accompany me on the expedition, and to carry my haversack and instruments. M. Studer and myself had already

[1] [This is *Bernhard* Studer, to whom Forbes dedicated his *Travels through the Alps of Savoy;* he was born in 1794 and died in 1887. His chief writings were *Geologie der Schweiz* (2 vols. 1851-53), and *Geschichte der physischen Geographie der Schweiz bis 1815* (1863). A portrait of him is given on p. 232 of vol. ii. of *Die Schweiz im 19ten Jahrhundert*, 1899. He must be carefully distinguished from his first cousin *Gottlieb* Studer, who is mentioned by Forbes in connection with his ascent of the Jungfrau—see below, pp. 442, 446; he was born in 1804, and died in 1890; a biography with portrait was published in the *Jahrbuch* of the Swiss Alpine Club, vol. xxvi. pp. 305-318.

See also *Alpine Journal*, vol. xiii. pp. 334-336, and vol. xv. pp. 343-348.]

decided on taking one man a-piece as a personal attendant, and to secure guides from time to time, to assist in carrying the provisions,—which he was well aware would be requisite, from having in 1841 visited the valley of Hérens, and seen the almost total destitution which there exists of the commoner commodities of life.

I had proposed crossing the chain of Mont Blanc, by the Glacier of Le Tour, to the valley of Orsières, a pass which has already been alluded to; but I was prevented, partly from the difficulties and endless formalities always made by the guides of Chamouni, when any unusual expedition is contemplated, with a view of enhancing their services—and partly from a trifling accident to my foot, which yet occasioned me some concern, with the prospect of a prolonged and difficult expedition before me. I therefore rode to Martigny by the Tête Noire, a route with which I was already pretty well acquainted, but which offered me new subjects of remark and speculation connected with the ancient extension of glaciers. I observed the distinct prolongation of the ancient moraine of the Glacier d'Argentière towards the pass leading by Les Montets from the valley of Chamouni into that of Vallorcine. This moraine seemed to me not less clear in its origin and details than that of the Glacier des Bois at Les Tines; and the low ridge of rock separating the two valleys is strongly marked by glacier action, which has also deposited a number of granite boulders on the summit of the pass. The whole valley of the Tête Noire shows, from time to time, proofs of having formerly been filled with moving ice, and between the cascade of La Barberine and the little inn of Tête Noire, I observed the celebrated Vallorcine pudding-stone rock, which is exceedingly hard, beautifully fluted and polished, at a great height above the bed of the torrent.

I slept at Martigny, and next day proceeded in company with other travellers as far as Liddes, in a char, whence we walked to the convent, where I had the great satisfaction of finding that M. Studer had arrived only half an hour before from the southern side of the Alps, together with his tried and faithful attendant, Glaus,[1] a peasant of the Oberland, who, for

[1] [Forbes always spells this name "Klaus," but the man was really named "H. Glaus" (see the *Schweizer Alpen-Zeitung*, vol. v. p. 124); he was of Hasli, and perhaps came from Guttannen on the Grimsel road, like his successor Peter Sulzer.]

twenty summers, has followed the indefatigable Professor of Berne in his geological rambles, and has rendered himself a deserved favourite and friend, by his experience, hardihood, simplicity, and that peculiar patience and fertility in expedients which characterises the best guides of German[-speaking] Switzerland, together with an honest warmth, and even playfulness, which is less commonly united with it.

Our greetings were hearty when we met around the hospitable fire, which, even in August, is the chiefest luxury in the domicile of the worthy Fathers of the Great St. Bernard. The evening was partly spent in discussing our plans, to which the priests lent an interested ear. One of them, the Chanoine L'Eglise, almost volunteered to accompany us on a part of our journey, but unavoidable engagements in the convent prevented it; however, he kindly gave us letters, which proved of service.

The next morning, at eight o'clock, I found water to boil at 199°·08 Fahr., the convent barometer being at 576·1 millimètres, unusually high in this position. Accordingly, the Fathers predicted favourable weather for our expedition.[1]

We walked leisurely down to Orsières by the same road as I had ascended the previous day, for we had decided upon commencing our journey by ascending the valley of Bagnes, which separates at Sembrancher,[2] a little below Orsières, from the valley of Entremont leading to the Great St. Bernard. I was struck with the extremely small interest of the Swiss side of the St. Bernard Pass. It was ten years, within a few days, since I had last visited it, but I well remembered the tedium of that interminable descent to Martigny. All the higher part is bare and wild, without either grandeur or variety,—of course I mean in comparison with other Alpine passes.

At Orsières we introduced ourselves to M. Biselx, formerly Prior of the Convent, and now Curé of Orsières, a man known in the scientific world by his zeal and acquirements, an intimate friend of M. de Charpentier, and partaking his views on glacier theories. Our introduction was easy, and the evening passed

[1] I determined the geographical position of the Great St. Bernard, as I did that of Chamouni in 1832, and found it to be

Lat. 45° 50′ 16″ N. Long. 7° 4′ 45″ E. of Greenwich.

[2] [This name is also spelt "St. Brancher," which is believed to point to its derivation from St. Pancratius or Pancras, who is certainly the patron saint of the village.]

pleasantly in his society. Indeed, we had a marked proof both of his skill and experience; for learning that M. Studer's syphon barometer was injured by having taken air, and considering the interesting results which it might afford on our present excursion, he begged to be allowed to boil the mercury in the tube, a critical and disagreeable operation, as everyone knows, but which he most effectually accomplished on the spot with his own hands over a charcoal stove in the kitchen of the inn; he then bade us a hearty farewell.

At Orsières, we made a considerable provision of food for our journey, for we were immediately to leave the beaten track. A guide was engaged to go as far as Chable, the principal village of the Val de Bagnes, where M. Studer had already been the preceding year, and had made an acquaintance who might be useful in procuring us a person as a guide to the higher parts of the valley, and the Col de Fenêtre leading into Italy.

At length, all preliminaries being settled, we left Orsières, on a beautiful morning. The view towards the chain of Mont Blanc was particularly fine, as seen by the early sunlight. The landlord of the Hôtel des Alpes particularly pointed out to us a conspicuous granite peak, which he called Pointe d'Orny, and which he assured us was known by no other name in these parts.[1] This must, therefore, undoubtedly be the same as Von Buch has referred to in his paper in the *Berlin Memoirs* on the distribution of erratic blocks, and to the neighbourhood of which he referred the origin of the Pierre à Bot and other masses of granite on the Jura range. The Mont Catogne, a conspicuous hill on the left of the road between Orsières and Sembrancher, is composed partly of granite, but its eastern face, which is very steep, presents a vast triangular *revêtement* of limestone, which here, as elsewhere, rises against the primitive rock, which, as we have seen, bounds the Val Ferret in its whole extent. On the face of this limestone slope lies one of those vast masses of transported granite described by M. de Charpentier, under the name of *blocs perchés*, which afford so strong an evidence in

[1] [Really the peak seen from the inn at Orsières is the Portalet, 10,975 feet, which is separated from the rather lower Pointe d'Orny by the Orny Glacier. Naturally, in 1842, the various summits round the Orny Glacier were not distinguished by separate names. As a matter of fact the Portalet is the highest summit dominating the Orny Glacier, so that it has some claim to be called the Pointe d'Orny, though that name is now attributed to an entirely different peak.]

favour of his theory of glacier extension. This vast mass may be distinctly seen, notwithstanding its distance and height from Orsières, on a steep part of the rock, free from the trees which nearly surround it. Its position is exceedingly remarkable, for it seems impossible to conceive a block of that size deposited by the mere force of water at such a height above the bed of the valley.

Our party now amounted to five, of whom the three guides were all considerably laden, for, besides personal effects, and some instruments, we carried a provision of rice, bread, and meat, intended for three days. M. Studer's barometer was the only instrument for measuring heights which we could at the time depend upon, but I had a portable sympiesometer, by Adie, constructed on purpose for this journey, but whose indications required a special correction difficult to determine, and one of those very convenient Russian furnaces, made by Stevenson of Edinburgh, which proved an invaluable adjunct for melting snow, for making tea, and at the same time for ascertaining the temperature of boiling water by a thermometer, which I had adapted to it, reading from 185° to 213° Fahr., and on which a fiftieth of a degree was capable of estimation. This is the only instrument which I have found capable of resisting sufficiently the influence of wind and cold to produce boiling water even from snow, in almost any situation, and it replaced the barometer usefully, on several occasions, as will be seen.[1] Our appearance was sufficiently remarkable to attract the attention of the passers-by, of whom, at this early hour, there were a number on their way to spend the day at Orsières, as it happened to be a great festival in this and the neighbouring valleys,—the eve of the Assumption of the Virgin.[2] The day, as I have said, was splendid, and promised to be very warm; but our course, as far as Chable, lay almost entirely on the shady side of the valley of Bagnes, which we entered by turning abruptly to our right, before entering the village of Sembrancher, an hour's walk below Orsières.

[1] An account of the method used for calculating heights from the temperature of boiling water will be found in the *Edinburgh Transactions*, vol. xv. part 3. I have found that the temperature of the boiling point falls 1° Fahr. for 550 feet of ascent, *uniformly* for all heights.

[2] [This great feast of the whole Roman Church falls on August 15, and it was the day before that Forbes's party started from Orsières.]

The path,[1] which was scarcely traced on the left bank of the rapid and impetuous Dranse, passed through woods and meadows, and the whole scene was refreshing and peaceful in the highest degree, and seemed to augur success to an excursion so happily commenced. Chable is a considerable village, very pleasantly situated in a tolerably open space, into which the village enlarges itself, near the foot of the Pierre à Voir, a conspicuous summit, which separates this valley from that of the Rhone, and not far from which a path leads from Chable to Riddes, on the Simplon road.[2] The neighbourhood is very fertile, covered with fruit trees and meadows, and studded with several villages; at this season it has a peculiarly cheerful and thriving aspect. As we approached the village (having joined the great road) we were struck by the appearance of the peasantry, and by the great numbers who had met together on occasion of the festival. So numerous were they, that we were not surprised to learn, that within the very small range of the Val de Bagnes, which is permanently inhabited, there is a population of 9000 souls.[3] All the avenues to the church were crowded with well dressed, respectable-looking men, the women being chiefly within the building. Our arrival and accoutrements excited some surprise, but we were allowed to pass unmolested by ill-bred curiosity, to one of the principal houses of the place, belonging to M. Gard, to whom M. Studer had been recommended on his former visit, and who, though a person of some consequence in the place, condescends, as is not unusual in similar circumstances in many countries, to make his house one of public entertainment, and the resort of the better class of peasantry, who, when the service was over, came and called for their *chopine* of wine, as they would have done in any common inn.

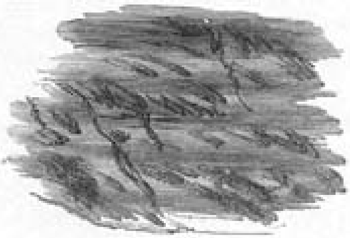
It was vain to think of proceeding any farther in a hurry. The demeanour of the people was intelligent, independent, and almost sarcastic. A guide was our first requisition; and it was evident that though there would be no difficulty in procuring

[1] [Forbes took a short-cut. But there is now a char road from Orsières past Sembrancher and Chable to Fionnay in the Val de Bagnes, and thence a mule-path to the village of Valpelline.]

[2] [This is the Col des Etablons, 7159 feet.]

[3] [These figures must be wrong, for, according to the last Swiss census—1888—the population was but 5956.]

one who was acquainted with the pass into the Pays d'Aoste, his accompanying us would be considered rather as a favour, and must be upon his own terms. These, however, were in due time adjusted with the usual success and conciliation with which M. Studer always contrived to effect these negotiations, which he kindly undertook to superintend; and after a considerable delay, which had not, however, the effect of enabling us to escape the hottest hours of a very warm day, we set forth under the guidance of Jean Pierre Feilay,[1] who had been recommended by M. Gard, and who presented a fair specimen of a manly bearing and somewhat haughty independence which I have mentioned as characteristic of the inhabitants of this valley. After half an hour's walk from Chable we reached Champsec, a small hamlet, in a great measure destroyed by the catastrophe of the inundation of 1818. Here our guide lived; and as he had some domestic arrangements to complete, we lost the greater part of another hour in waiting for him. At last all was complete, and we were fairly in marching order. A little way beyond we gained the northern side of the Dranse; and having passed the village of Lourtier, the last in the valley,[2] the path ascends rapidly. The river is discharged through a sort of chasm, which shows evident marks of the devastating force of the torrent on the occasion alluded to. The character of the scenery becomes more grand, the walnut trees and irrigation disappear, and we are once more in the region of pines and savage rocks. We remarked here a pretty illustration of the friction of glaciers as distinguished from that of water. The sides of one of the ravines through which the stream struggles is distinctly marked on its bold limestone surface by the long grooves which have been considered as peculiarly characteristic of the abrasion of glaciers. Though the descent is very steep, and the wall of



GLACIER AND WATER MARKS ON LIMESTONE.

[1] [Felley is the proper spelling.]

[2] [It is odd that Forbes never mentions Fionnay, 4912 feet, the last village, which is beautifully situated and now has good inns. It is some way beyond the steep ascent mentioned by Forbes.]

rock almost vertical, these chiselled and polished grooves are worn out in a nearly horizontal, slightly declining direction, and are *continuous* for many yards or fathoms. Superimposed upon these, on the very same surface, are the marks of wear resulting from the action of floods, probably charged with great masses of débris. The water-marks are rough and contused, quite in contrast with the smooth prolongation of the other. They also slope downwards at a angle similar to that of the river bed, whilst, as has been said, the others are nearly horizontal.

A succession of basins and rocky chasms diversifies the length of the valley during several hours. I have seldom felt heat more oppressive than during the first part of this walk, while toiling up the steeps above Lourtier. Having, for several weeks previously, been almost constantly on the ice and at a height of 6000 feet above the sea, the contrast of temperature was, I suppose, more strongly felt. The chasms presented wild cascades, containing the whole body of water in the Dranse; but the picturesque effect was certainly very much injured by the dingy and opaque appearance of the glacier stream, which rendered the sheets dull and lustreless, instead of sparkling and transparent. The valley above Chable is very confined, and almost untenanted; there are but a few chalets, inhabited during a small part of the summer, higher than Lourtier. Hence the Val de Bagnes, which is very long, acquires a wilder and more lonely appearance than many valleys more remote, and more difficult of access. Many cottages which once existed are now dismantled, and it was near one of these that we stopped to take our mid-day meal beside a brook; a little higher the defile became suddenly narrow, and presented a bold and picturesque outline. The Mont Pleureur stood before us on the left, from which descends the well-known Glacier of Giétroz. Still more on the left is the little frequented pass called the Col d'Orsera, leading to the valley of Hérémence, which had been traversed by M. Studer in 1841.[1] The Dranse emerges from a dark defile,

[1] [On Wörl's map the name of "Col d'Orsera" is given to the pass now called "Col de Louvie," 9639 feet, which really leads into the Nendaz glen, though Wörl makes it descend into the Val d'Hérémence, the middle reach of which is called Val d'Orsera. See, too, Fröbel, p. 43 and below, p. 290. But from Prof. B. Studer's *Geologie der Schweiz* (Bern, 1851), vol. i. pp. 371, 372, it is certain that he went from Evolena to the lower Barma hut in the Val d'Hérémence by the Col de Meina or d'Arzinol, 8878 feet, and thence by the Ecoulaies Glacier and the Col du Crêt, 10,329 feet—some way south of the Col de Louvie—to the Val de Bagnes. Hence

impassable on the left, and only to be traversed on the right by taking a high line above its level ; from thence the water, swelled to its fullest in the month of August by the contributions of the various glaciers which we were soon to approach, emerged, sometimes in thundering cascades, sometimes pausing in still deep pools as it passes under a fine and romantic stone-arched bridge, called Pont de Mauvoisin, by which we were to pass from the right bank of the river, which, since Champsec, we had continually followed, to its left bank, on which alone we could pass the defile. The bridge here, like almost every other in the valley, was carried away by the débâcle of 1818, and the present lofty stone one has been since built, with a solidity which is rarely met with in such sequestered spots, where but a very few persons pass during the entire year. A few huts in front—the last built with any degree of solidity—concluded the picture.

The bridge passed, we slowly gained the elevation of rock on the other side.[1] A carefully made path continues for some way farther, and traverses one of those steep inclines of shingle annually swept by avalanches, which require the track to be made afresh every year. This path continues on the left bank of the Dranse at a great height above it, affording at the same time a striking view of the Mont Pleureur, and the glacier which has been the principal cause of so much devastation.

I felt some disappointment in viewing the Glacier de Giétroz, of which I had heard so much, and of which the disastrous effects had been so great. I had expected to see one as vast and beautiful as the Glacier of La Brenva, for example, where, falling into the Allée Blanche, it forms a natural bridge above the torrent ; or that of Miage, whose stupendous moraine has formed a lake, as the ice of Giétroz did. Instead of this, I found the defile narrow and confined, and though savage, scarcely picturesque. The proper Glacier of Giétroz is situated at a great height amidst the defiles of the Mont Pleureur, so that its extent cannot be appreciated, or its beauty admired, even from the elevation of the path opposite. The real source of the

in 1842 either Forbes misunderstood Prof. Studer, or the latter made a mistake as to his route in 1841.]

[1] [Here there is now a small inn. The bridge formerly marked the limits of the lordship of Quart in the valley of Aosta.]

mischief is a secondary, and very uninteresting looking glacier, which, in its present diminished form, scarcely attracts attention in the depth of the valley, and resembles the masses of unmelted snow which so often choke elevated defiles during a great part of the summer. It is in reality composed of the fallen fragments of ice, projected in the form of avalanches over a cliff of enormous height, where the true glacier terminates, whose mass, as it advances, is broken off, and falls headlong into the abyss. The *glacier remanié* which results is soiled, and imperfectly consolidated, and still forms a partial bar to the river Dranse. It must continue to do so as long as the stream has no independent outlet, for the defile is so narrow, and the falling masses of the glacier so extensive, that the outlet must inevitably be choked in winter and spring, when the Dranse (which owes its origin almost entirely to the glaciers still higher up the valley) has too feeble a current to keep its way clear.

The story of the débâcle of the Val de Bagnes in 1818 is too well known to require to be detailed here, and I have no new facts to add. It is sufficient to call to mind, that twice in the sixteenth century [1] a similar mishap occurred, and indeed it is difficult to conceive why it should not have been much oftener repeated. The year 1818 had been, as we have seen, remarkable for the extension which most of the glaciers in Switzerland had experienced after a series of cold winters, and in this year the ice beneath the Glacier of Giétroz accumulated so much, as to have formed, by the stoppage of the Dranse, a lake no less than half a league long, 700 feet wide, and at one part 200 feet deep. The impending danger was perceived,—the bursting of the lake with the return of spring was a certainty. M. Venetz, the intrepid engineer, of the Vallais, and the founder of the modern Geological Theory of Glaciers, proposed to avert it by cutting a canal through the ice, which should gradually drain the lake. Between the 10th of May and the 13th of June this was effected, and it was trusted that the channel would be sufficiently deepened to let the water gradually escape. But water already at 32° has only a feeble action in eroding ice, and the result was, that the cascade tumbling over the icy barrier worked back upon it so fast, that the gallery or canal, which had been originally 600 feet long, was destroyed, and fell away in fragments. Nor was

[1] [One only, in 1595, seems to be known to Alpine historians.]

this all; the cascade working on the soil beneath had loosened it so as to detach the remaining ice from the mountain, and thus precipitated the catastrophe. A deluge[1] of 500 millions of cubic feet of water were let loose in the space of half an hour, to sweep through a tortuous valley full of defiles,—literally with the besom of destruction. A flood five times greater than that of the Rhine at Basle filled the bed of a mountain torrent. It was an awful but a grand lesson for the geologist. The power of water was exerted on a scale such as Hutton and Playfair would have desired to see, could it have been exerted without the destruction of life and property. Bridges yielded; that at Chable dammed back the torrent upon the village, but happily gave way just as the houses seemed doomed to ruin. In this short space of its course (from Giétroz to Chable) the fall is no less than 2800 feet. Its acquired velocity was therefore enormous,—at the commencement of its course 33 feet in a second. Its power to *overthrow* buildings, and to *carry with it* trees, hay-stacks, barns, and gravel, cannot surprise us. But its transporting force upon blocks has probably been overrated.[2] Enormous masses were certainly *moved*, especially in the neighbourhood of Martigny, as described by Captain Hall and Mr. Lyell, who were both on the spot soon after the event. But there is no kind of evidence that these granite masses were brought down from the higher valleys by the torrent. On the contrary, I believe that there is no question but that they lay (having been transported by ancient glaciers, or in some other mode) within a very short distance of their present positions, and that some of them were merely rolled over a few times by the force of the current. I apprehend that the débâcle of Giétroz gives no countenance whatever to the opinion, that blocks of 20 or 30 feet of linear dimensions can be transported to any distance even by such stupendous currents.

When we passed the Glacier of Giétroz, there were workmen (for whose use chiefly, no doubt, this road is kept in repair) employed in dividing the ice into blocks, by the ingenious process of Venetz, in order to be carried off by the stream, and prevent

[1] [This was on June 16, 1818.]

[2] On the débâcle of Bagnes, see *Bibliothèque Universelle*, 1818; *Edin. Phil. Journal*, vol. i.; Lyell's *Geology*, 1st edit., vol. i.; Captain Hall's *Patchwork*, vol. i. [See, too, a contemporary narrative printed in the *Echo des Alpes*, 1887, pp. 349-353.]

future accumulations. The process consists in turning streamlets of water (not ice-cold) by means of wooden canals upon the ice, so as to saw it through in the required direction, which is effected with rapidity and certainty. This operation is annually repeated, requiring the combined labour of several men for many weeks each summer. The expense is borne by the Canton. There is but one way of permanently avoiding the risk in future, namely, by constructing a tunnel, or cutting one through the rock, by which the torrent may have a certain egress, independent of the state of the glacier; but this has been considered as too expensive and difficult an operation under the circumstances.[1]

Our way now lay up the bed of the former so formidable lake. The bottom of the valley is flat and monotonous, the river wandering from side to side, amidst rolled pebbles. Descending to its level, we recrossed to the eastern bank. Our walk from Chable had cost us nearly four hours, and an hour and a half later we reached our humble resting-place for the night, the chalet of Torrembey, 5300 feet above the sea.[2]

The accommodation offered in the upland and unfrequented chalets is everywhere nearly the same, and may therefore be worth describing for once. There are usually two buildings, quite distinct, the day and the night apartment. The reader must not, however, suppose that these correspond in the remotest degree either in appearance or in furnishing to the correlative establishments of a drawing-room and a bed-room; the first contains neither tables nor chairs, the latter neither mattress nor pillow. The morning room is more properly a manufactory of cheese and butter than a place of ordinary accommodation. The fire is kept up for the purpose of heating the milk, which is done in copper cauldrons, whose size and weight, and bright polish, contrast strongly with the want of every ordinary convenience of life. A repetition of copper and other vessels for holding milk and raising cream occupy most of the spare room in the apartment; the floor is of earth and uneven, but, except in Piedmont, not usually dirty.[3] The fireplace is a hole in the ground, the

[1] [The glacier has much shrunk since 1842, and its snout is now 2000 feet above the level of the valley. The inundations in the valley in 1894 and 1898 were due to the bursting of a small lake formed near the foot of the Crête Sèche Glacier.]

[2] [Really 5935 feet.]

[3] [The floor is often very dirty even outside Piedmont.]

fuel is juniper, or scraps of larch wood where these can be had; and a sort of movable wooden crane, from which the copper-pot is hung, is one of the most artificial accommodations. There is no chimney, and therefore the fire is usually made near the door; nor are there windows of any description. For light, they use a little fat, burning with a wick in a small vessel, but often merely a bit of the more resinous pine-wood, which they keep on purpose. There is no such thing as a table, unless the top of a chance barrel be admitted as the representative of one; nor are there any chairs, though the *one-legged* milking stool, which affords an inconvenient repose to a weary traveller, is an indulgence which he probably owes solely to its indispensability in the great and overweening object in which all the uses and habits of a chalet centre;—the keeping and feeding of cows, and the procuring and manufacture of milk. Morning, noon, and night, the inhabitants think of but milk; it is their first, last, and only care; they eat exclusively preparations of it; their only companions are the cattle which yield it; money can procure for them *here* no luxuries: they count their wealth by cheeses.

The absolute want of culinary utensils is surprising and embarrassing. The only pot is sometimes that employed for heating milk, and of *copper;* at other times there is also an iron one; but except certain wooden skimming-spoons, nearly square, and five or six inches wide in the mouth, there is often no other kind or description of dish, vessel, platter, spoon, or ladle. Where the civilisation is a little greater (as at Torrembey), there are a few *écuelles* or wooden bowls. Of course these deficiencies only created amusement to us, and the rice we had brought was boiled with milk and salt (which is kept for the cattle) in the only iron pot, and made a most substantial and not unpalatable mess for five hungry men, with a surprisingly small consumption of our stock. The evening meal being concluded, we betook ourselves to early rest.[1] The sleeping apartment, I have said, is usually, as in this case, a separate hut, without window, fire, or chimney, built of loose stones, and with a door about three feet high, the floor being covered with grass more or less dry. On this we arranged ourselves in *parallel order*, covering ourselves with a sufficiency of the hay. It might have been hoped, that here we

[1] [Nowadays there is the excellent club hut at Chanrion, 8071 feet, at the foot of the Otemma Glacier.]

should have escaped the torments of a bad bed,—I mean the vermin; but we had the inconveniences of a hay-loft without its inestimable advantage—cleanliness; and in the course of the night I was forced to rise, and, stumbling over the bodies of four or five of my insensible companions, seek relief for a while in the open air, which was exceedingly mild.

We were astir by five. But it is impossible, generally speaking, to depart in a hurry from a chalet, any more than from a fashionable hotel. It was half-past six before we had breakfasted, and made up our packages: and having left our hosts satisfied by a moderate gratuity, our caravan was once more under way with the glaciers in our front. Before leaving the subject of chalets, I may observe that the character of the inhabitants is not undeserving of notice. I have always received, both in Switzerland and Savoy, a gentle, and kind, and disinterestedly hospitable reception in the chalets, on the very bounds of civilisation, where a night's lodging, however rude, is an inestimable boon to a traveller. These simple people differ very much (it has struck me) from the other inhabitants of the same valleys—their own relatives, who, living in villages during the busy trafficking season of summer, have more worldly ways, more excitement, wider interests, and greater selfishness. The true *Pâtre* of the Alps is one of the simplest, and, perhaps, one of the most honest and trustworthy of human beings. I have often met with touches of character amongst them which have affected me, as I may elsewhere notice; but, generally, there is an indescribable unity and monotony of idea which fills the minds of these men, who live during all the finest and stirring part of the year in the fastnesses of their sublimest mountains, seeing scarcely any strange faces, and but few familiar ones, and these always the same; living on friendly terms with their dumb herds, so accustomed to privation as to dream of no luxury, and utterly careless of the fate of empires, or the change of dynasties. Instead of the busy curiosity about a traveller's motives and objects in undertaking strange journeys, which is more experienced in villages the more remote they be, these simple shepherds never evince surprise, and scarcely seem to have curiosity to gratify. Yet far are they from brutish or uncouth; they show a natural shyness of intermeddling with the concerns of strangers, and a respect for their character testified by their unofficious care in providing and arranging what conveniences they can produce. Their hospitality is neither that of ostentation nor of necessity. They give readily what they have, and do not encumber you with apologies for what they have not. Every traveller will see in this description strong opposition to the Swiss character as usually displayed; my remarks are confined to my experience in the higher *chalets* of the Alps. Of course, I do not mean to state that exceptions are not to be met with.

The same *ménage* exists merely on a larger scale, where the *Alp* or pasture-ground is greater. In many, an extensive range of cow-houses is attached to the enclosure of the chalets. In some places the cows are brought in to be milked; in others, this operation is more picturesquely performed by ranging the cows—(*Ranz des Vaches*—whence the popular name of some Swiss airs)—on greensward terraces on a hillside, where they may be seen to the number of some hundreds, tied each to a little stake, whilst the shepherds busy themselves amongst them with their milk-pails and one-legged stools. But to return to the Val de Bagnes.

At half-past six we left Torrembey, and ascended the remaining part of the valley, which opened itself a little higher (the now small stream of the Dranse being again crossed to its western or left bank) into a scene of greater majesty than it had yet presented. A corner was turned, the valley trending more to the south-east, and several glaciers hitherto concealed came into view. The recollection of the heat of yesterday made these a welcome sight, and I looked forward with pleasure to setting foot on ice again.

The first glacier [1] visible on the right hand descended in 1821, as our guide Feilay [2] informed us, so far into the valley as to approach the torrent. It has now retreated to a great height on the mountain side. Again, on the opposite or eastern bank, a vast glacier descends from the lofty chain which separates the Val de Bagnes from that of Hérémence. It is called the Glacier de la Brēna [3] and is probably that marked "les 28" in Wörl's map. It now terminates on the bank of débris, which it has carried down on the farther side of the torrent, but we

[1] [The Zessetta Glacier.] [2] [Felley.]

[3] [The Breney Glacier. It is "les 28" of Wörl's map, this name being taken from the chalets of Vingthuit at its foot in the Val de Bagnes.]

were assured that, in 1822, it had extended so far as to cross the torrent, which made its way under it, and to rise to a great height on the western side. Indeed, this was matter of ocular evidence, for our path touched the extremity of the enormous frontal moraine which it had thrown up,—a mound of rocky fragments, from whose top we could clearly survey the vast area, of many acres in extent, which the glacier has uncovered during the last twenty years, strewed with fragments, and doomed to sterility. The material of the moraine is a true granite, the first we had met with in this valley, for below, the rock is a kind of gneiss. According to our guide, the ice then presented a front seventy feet high. A little farther in advance an extensive glacier, named Glacier du Mont Durand, descended from the Grand Combin on our right, which it was impossible to avoid; we therefore prepared to cross it, which we did without difficulty.[1] It descends quite into the valley and crosses the stream as the Breney Glacier had done, leaving a free passage beneath. The mere crossing of a valley by a glacier, if it be of any moderate breadth, is not of itself sufficient to produce a catastrophe like that of Giétroz. Here is one example: the Glacier of La Brenva in the Allée Blanche is another, and that of Allalin in the valley of Saas. It is probably the circumstance[2] that the dam was formed by the *éboulement* of the Glacier of Giétroz, and not by the glacier itself, which occasions its particular danger. A channel once formed under a glacier is kept continually open as the glacier advances gradually onwards, but the falling in of ice may produce an abrupt stoppage.

The Mont Durand Glacier presents an even and clean terminal slope of a convex form,. with few fissures, and shows the system of veins which I have elsewhere described as proper to that form.

This glacier crossed, we arrived at the upper chalets of Chermontane, at the foot of the glacier of the same name,[3] which fills the entire head of the Val de Bagnes, and nearly touches the Mont Durand Glacier (see the Map [in the pocket] and Topographical Sketch, No. V., which shows the Col

[1] [The present path now avoids traversing the glacier by crossing and recrossing the stream.]

[2] [This is certainly the case.]

[3] [Now better known as the Otemma Glacier.]

de Fenêtre). From these chalets (which are still on the western side of the valley, and at the foot of a hill called Mont Avril) there is a very fine view; the Glacier of Chermontane is a magnificent sea of ice, nearly or quite unexplored. It appears to have three great tributaries; one descending from behind the mountain called Otemma,[1] and where there is every appearance of there being a Col or pass; we thought that we clearly saw the summit level. In this direction it is probable that a passage might be effected to the Glacier of Lendarey in the Val d'Hérémence, or to that of Arolla, at the head of the Vallée d'Hérens; but the descent on the other side would be more difficult.[2] The second branch passes between the Trumma de Bouc and the Mont Gelé, derived partly from a very lofty snow-capped peak,[3] and partly from a short branch immediately behind the Mont Gelé, which can be of no great extent, since, from its direction, it must speedily reach the Valpelline; and, indeed, we were informed that the shortest way to the village of Bionaz was in that direction, but our guide had never passed there.[4] The third great arm of the glacier stretches up to the Col de Fenêtre, between the summit of Mont Gelé and Mont Avril, by which we were to pass. The Glacier of Chermontane terminates a

Topographical Sketch N° V

[1] [The Pointe d'Otemma, 11,136 feet. This is the main stream of the glacier.]

[2] [The Col de Chermontane, 10,119 feet, at the head of this glacier, properly leads to the Arolla Glacier. From the Giétroz Glacier it is possible to gain the Lendarey Glacier, but the Col de Seilon, at the head of the Giétroz Glacier, leads to the Seilon Glacier at the head of the Val d'Hérémence.—See p. 290.]

[3] [Probably the Bec d'Epicoun, 11,572 feet, is meant.]

[4] [The true Trumma des Boucs is more to the east, but the pass meant is clearly the Col de Crête Sèche, 9475 feet. It leads without difficulty, though it is not passable by mules, to Bionaz, and is described by P. A. Arnod in his report, dated 1691-94. The range between this Col and the Col de Collon separates the Otemma Glacier from the Valpelline; it is minutely described in Signori Canzio, Mondini, and Vigna's admirable monograph "In Valpellina" in No. 65 (1899) of the *Bollettino* of the Italian Alpine Club.]

little below the [upper] chalets of that name. On its farther side is a pretty pasturage, called Chanrion (*Champ Rond*), where there are two small lakes—one formed in a hollow of the hill, the other between the slope of the hill and the ice of the glacier, somewhat like the Märjelen lake on the Glacier of Aletsch.

I have already said that the upper part of the Val de Bagnes is little visited. I find no notice of it in the writings of De Saussure; but Bourrit, in his lively work on the glaciers of Savoy (vol. i. p. 55 *sqq.*), describes his having reached the chalet of Chermontane, where he slept two nights, and visited the neighbouring glacier, of which he gives a somewhat pompous account, and a most exaggerated drawing of the lake; but he did not attain any summit or Col: indeed, I have not met with a description of the Col de Fenêtre from personal observation in any work.[1] It was by this pass that Calvin fled in 1535 from persecution in Aosta, where he had been established for five years.[2] Though M. Bourrit speaks much of the discoveries which he made during his visit to Chermontane, they appear to amount merely to this: that he ascertained the existence of a great glacier, but neither its extent, its practicability, nor the connections of the ramified valleys which meet near its head. Formerly it appears that this Col, like many others in the higher Alps, was easier passed than at present, and was even a common route of commerce.[3] At that time, it is stated,[4] the Mont Durand Glacier did not extend so low as to require to be crossed, but was avoided. So small is the communication now that there is not even a station of Custom-house officers on the pass, though there is at Valpelline.

We did not stop at Chermontane, or even go to the chalets, but keeping on our way at a higher level, along the slope of Mont Avril, we gradually ascended towards the Col de Fenêtre, always on turf, and without any difficulty. The ascent was tedious, and we skirted the glacier without going upon it for

[1] [It is fully described by P. A. Arnod, 1691-94, but his narrative was not printed till 1881. It is best consulted in Signor Vaccarone's *Le Vie delle Alpi Occidentali*, pp. 113, 114, where the pass is called the "Fenêtre de Durant." The pass was fortified against the Waldensians in 1688-90.]

[2] Compare Bourrit, vol. i. p. 76, and Baruffi, *Pellegrinazioni autunnali*, Lettera 27ma, vol. ii. p. 19.

[3] [In 1476 it was crossed by an army.]

[4] Godeffroy, *Notice sur les Glaciers*, p. 63.

the greater part of the way. The Glacier de Fenêtre is but little inclined or crevassed; in its higher part we traversed a portion of it without difficulty, so as to gain the Col more quickly.[1] We reached the summit in four hours of easy walking from Torrembey. For its height—which appears to be 9213 English feet, by M. Studer's observations[2]—this must be considered as an easy pass, presenting in good weather not a shadow of danger.

The view towards Italy is wonderfully striking. The mountains beyond Aosta and the glaciers of the Rutor are spread out in the distance, and beneath we have the exceedingly deep valley of Ollomont, communicating with the Valpelline, which is itself a tributary of the Val d'Aosta. It is enclosed by ridges of the most fantastic and savage grandeur, which descend from the mountains on either side of the Col on which we stood, —on the north-west from the Grand Combin, rising to a height of 14,200 English feet; on the south-east from the Mont Gelé, which is 11,100 feet high, and almost too steep to bear snow, presenting a perfect ridge of pyramidal aiguilles stretching towards Valpelline.[3] The side of Mont Gelé towards the Col presents an adhering snowy coat so steep that, seen in front, it appears almost vertical; measured laterally with a clinometer, its angle was found to be 55°; this appeared to be loose snow. Our course to Valpelline required us to skirt the foot of the peaky ridge just described: the descent was unusually rapid, and without particular difficulty. We passed a small lake partly bordered with snow, and soon after gained the pastures. Here we made a hearty meal by a brook, which exhausted a good part of our available provisions, and we thence dismissed our guide, who had plenty of time to recross the mountain by daylight. It was a considerable way before we reached any chalet, but when we did so we caught a charming view of the bottom of the valley of Ollomont, which had hitherto been mostly

[1] [Now the path keeps to the west of the much shrunken glacier, which is, however, perfectly easy.]

[2] [Really 9141 feet.]

[3] [The Grand Combin is 14,164 feet, and the Mont Gelé 11,539 feet; the latter has a considerable glacier on its south slope, but is elsewhere rugged, if not precipitous, though the rock wall is easily scaled from the Italian side, and so the glacier and then the peak attained. The "perfect ridge of pyramidal aiguilles" is the Morion or Faudery range.]

concealed, covered with exquisite verdure, studded with houses, and traversed by lively streams, all seen as on a map, for our elevation was still 2000, if not 3000 feet above it. Beyond, the mountains near the Great St. Bernard were apparent; below, the village of Vaux, which we mistook for Ollomont. There we found copper works abandoned; they appear to have been very extensive and complete; the ore is a sulphuret, in the (metamorphic ?) gneiss of which the whole of this district is composed. There are several other villages, and Ollomont itself, composed of but a few scattered houses, distinguished by a church, is pleasingly situated. But here, as at Aosta, the enjoyment of natural beauty is rendered impossible by the loathsome deformity of the inhabitants; we were really shocked to find that none of the villages through which we passed seemed to contain one reasonable human being—goîtres and crétinism appeared universal and inseparable.[1] Repeatedly I tried to obtain an answer to a simple question from the most rational looking of the inhabitants—but in vain. This astonished and shocked us, for we were still at a height of 4000 English feet above the sea,[2] where these maladies commonly disappear; and we looked forward with despair to the prospect of obtaining a guide for the difficult and unknown country which we were next to traverse from amongst such a population. But in this, as in very many similar cases, first appearances are not to be interpreted to the letter. It was still the fête of Notre Dame de la mi-Août,[3] and the effective population had mostly gone down to Valpelline, the chief place of the district, and others perhaps were with their herds in the mountains.

The scenery continued more and more engaging. In the course of four hours' walk we had passed from ice and eternal snow to the charms of Italian scenery and climate, with more than Italian verdure. We looked anxiously about for the village of Valpelline, which we expected to have seen from a distance,—we feared that our maps had deceived us, and that we had yet a considerable walk before us, when suddenly, on turning a corner, we found ourselves in the valley of Valpelline; the church, with a spire of the Italian taste, and a few scattered houses, mantled with vines and peeping out amidst walnut trees of exquisite

[1] [Matters in this respect are now somewhat better than in 1842.]

[2] [Ollomont is 4387 feet.]

[3] [*I.e.*, the Assumption of our Lady.]

beauty, proclaimed the little capital of the district. In descending we noticed large fragments of true syenitic granite, which appeared to have their origin at no great distance, which we hoped that our next day's walk would reveal; in the meantime we entered the village.

CHAPTER XV

FROM VALPELLINE TO EVOLENA BY THE COL DE COLLON

Ascent of the Valpelline to Bionaz—Geology—Syenites—Chalets of Prarayé—Head of the valley—Ascent of the Col de Collon—Remains of travellers lost in a Tourmente — Glacier d'Arolla — Its structural bands—Magnificent view of Mont Collon—Opportune meeting with Pralong—History of the victims—Arrival at Evolena.

"C'est le domaine des glaces et des neiges, le palais de l'hiver, le royaume de la mort."
A. DUMAS.

THE village or hamlet of Valpelline offered little prospect of comfortable accommodation, but we recollected a letter with which M. Biselx had provided us at Orsières, addressed to a proprietor and householder of the place, by whom we were received in a manner which I am sure that neither M. Studer nor myself will ever forget. The unexpected appearance of travellers by so unfrequented a pass, and accompanied only by strangers (for it will be recollected that we had sent back our guide to Bagnes), produced a momentary hesitation. The wife of the gentleman to whom we were recommended had not returned from church, and an awkward pause took place at the door of the house, which was locked, whilst our arrival excited some curiosity amongst the loitering groups around. At length the lady came, and hearing our story and recommendation, instantly set about every arrangement which true hospitality could devise to ensure our comfort whilst we remained, and to speed our journey when we departed. The afternoon was not far advanced, and we spent it in repose,—in a short stroll through the beautiful meadows surrounding the village, and in conversing with our host and his sons, well educated and sensible boys, whilst our excellent hostess busied herself in preparing supper and in arranging our apartment, which was the best the house afforded. Meanwhile we made inquiry, not without anxiety, as to the possibility of finding a trusty and skilful guide who should conduct us across a glacier-pass which we understood to connect the head of the valley of Valpelline, which is in Piedmont, with the Vallée d'Hérens in the Vallais. This had always appeared the most doubtful step in our expedition. Though we had reason to believe that such a pass existed,[1] we had no information of any traveller who had actually passed it, and we had been led to think that though guides might be found on the Swiss side, it would be much more difficult to procure them in Italy. The specimen we had seen of the natives of Ollomont increased our doubts; but the very circumstance of the fête, which had drawn so many to Valpelline, gave us the greater choice of guides, and our host kindly aided us in the selection, and by his authority and consequence in the place, procured us a most satisfactory guarantee for the capacity and fidelity of any one who should accompany us. Amongst the visitors at Valpelline that day was a tall, athletic, and handsome man, below middle age, who passed for being the strongest man of the whole valley, and whose usual residence was some leagues higher up. With him our arrangement was soon made; he promised to remain all night, and to accompany us next day to the head of the valley of Bionaz (as the higher part of the Valpelline is called), whence, starting early the following morning, the glaciers might be crossed to Hérens. He assured us that he was perfectly acquainted with the pass, which he called the *Col de Collon*.

The village of Valpelline is near the opening of the valley of the same name, and only from two or three hours' walk from the city of Aosta. It possesses the Italian character of scenery and products, although 3040 English feet above the sea.[2] The morning of our departure proved the prelude to a very hot day. We were tempted to rest longer than usual in our comfortable quarters, and as we had but a short journey before us we were

[1] [It is mentioned by Sebastian Münster in 1543, and described in some detail by P. A. Arnod in 1691.]

[2] [It is 3130 feet high, and 8 miles above Aosta, with which it is now connected by a char road.]

in no hurry to depart. Madame A—— had anticipated all our wants. She had even prevented our servants from attempting to procure any of the necessaries which we wanted for our arduous journey, by insisting on providing them, much more effectually of course, from her own stores. The cordiality and genuine kindness of all her arrangements left us no room to offer any return but our truly heartfelt thanks for her generosity, and we quitted this worthy family with regret, being accompanied by one of the sons for a mile or two on our way.

The valley was always narrow, but at Oyace, a little way above Valpelline, it seems to close, and the village of that name is planted[1] upon a rocky barrier which crosses the ravine, and which we found to be composed of true syenite, the same as M. Studer first noticed in boulders the day before, when descending upon Valpelline. There appear to be from point to point among these wild hills outbreaks of syenitic rocks which have more or less metamorphosed the neighbouring sedimentary deposits, and have confounded all mineralogical characters in the result of this supervening action. Such at least was the opinion of my learned companion, whose long and close attention to the excessively intricate phenomena of Alpine geology entitles it to the greatest weight; and to which any observations which I had an opportunity of making in his company induce me entirely to subscribe. It is well known that M. Sismonda, the intelligent geologist of Turin, has endeavoured to separate the rocks of this part of the Alps into primitive and metamorphic, the one of which he has coloured red, and the other blue. So far as we could observe, this separation seems indistinct and inconclusive; and, with the single exception of the true unstratified syenites—such as those of the Breney Glacier in the Val de Bagnes, and that of Oyace—the felspathose rocks seem to admit of no subdivision, but must be classed under the common denomination of gneiss, whether primitive or metamorphic.

The boulders already mentioned, and others which occur from time to time in the valley, appear to be all derived from the neighbouring mountains; and it is exceedingly remarkable, and quite in contrast to the appearances in the Val de Bagnes, that we found few or no striated and polished rocks, nor great masses of transported materials.

[1] [At a height of 4485 feet.]

Between the villages of Oyace and Bionaz, we visited a vein of limestone, interstratified with the felspathose rocks in a direction parallel to the length of the valley, and reappearing at intervals up even to its very highest part, where, as here, it is burnt for lime. Very near this, copper is found in the same rock as at Ollomont.

The village of Bionaz is the last of any size in the valley—the last, I think, which has a church.[1] The valley takes henceforth the same name, Bionaz. We halted here, and made a hearty meal in the open air upon fresh eggs and good Aostan wine. We then resumed our march, as the day became cooler, and the scenery, at the same time, still more picturesque and interesting. An excellent foot or mule path leads all the way up the valley—a convenience which the traveller owes to the Jesuits of Aosta, who have extensive property in the higher pastures of Bionaz; and it was at the chalet belonging to them that we proposed passing the night. The village of Bionaz is 5315 feet above the sea, by M. Studer's observation.[2] Farther on, the larch trees descend into the valley, and the river passes through some picturesque defiles. The views looking back were very pleasing, and in front, at the head of the valley, rose a lofty chain of mountains (a mere appendage, however, to the great chain), separating the valley of Bionaz from the Val Tournanche; over which we afterwards learned that a passage may be effected, though not without difficulty.[3]

At length we reached the chalets of Prarayé, which belong to the Jesuits of Aosta,[4] and are marked by a lofty crucifix in front. They are pleasingly situated in a green meadow near the head of the valley, and about six hours' walk from Valpelline. There was no one visible, and it was some time before we obtained admission into the smaller and humbler building, the larger one being locked up. Whilst supper was preparing, I walked up alone to the head of the valley, which I was anxious to explore, for our guide informed us that our next

[1] [Bionaz *is* the last village, but there is a chapel near the Prarayé chalets.]

[2] [It is 5250 feet.]

[3] [The Col de Valcournera, 10,325 feet, a hunters' pass, and mentioned by P. A. Arnod, 1691-94.]

[4] [In 1649 the Jesuits became the secular canons of the Collegiate (formerly served by Austin canons regular) Church of St. Ursus at Aosta, but in 1848 this pasture was sold by them to a private individual.]

day's journey did not lie in that direction, but that we should have to return upon our steps a little way, and then turn sharply to the northward. It was an hour's walk to the commencement of the glacier,[1] which fills the top of the valley, and which descends directly from the great chain. Having gained an eminence on the south-east side of the valley which commanded the glacier, I saw that the ascent of it must be in some places very steep, though, I should think, not wholly impracticable. I recognised the limestone which we had found farther down the valley. Returning to the chalets, I found our evening meal prepared; and I observed the temperature of boiling water to be 201°·58, whilst M. Studer's barometer stood at 608·3 millimètres. The height above the sea is 6588 feet.[2] The general direction of the Valpelline is N. 60° E. (true); but for the upper two leagues N. 75° E., as far as the foot of the glacier, after which its course is N. 5° W.

We passed a comfortable night in a clean hay-loft, and slept longer than we intended, for we were not ready to start until 6 A.M. The morning was very favourable. Our guide, "l'homme fort de Bionaz," as he was called, or "*l'habit rouge*," the *sobriquet* which we had given him, from the curious practice of wearing a coat of scarlet cloth, which is common in the Pays d'Aoste—gave us at first no small concern. He was in low spirits last evening, and in no hurry to start to-day, and apparently not averse to draw unfavourable presages of the weather. We began to fear that he had undertaken more than he could perform, and that the way was perhaps known to him only by report. But our doubts gradually vanished. He took to the hill with that instinctive confidence which showed that he understood his business, and the farther we advanced the more readily did he go on, and became more communicative. We afterwards found that he had been really unwell from the results of a drunken fit, which he had not thrown off when we first engaged him, and also that some doubt whether we should be able to follow him over the glacier and rocks, and a fear that he might be brought into trouble through our means, had probably oppressed him. We

[1] [This is the great Za-de-Zan Glacier, which is divided into two portions by a great icefall. From its head the easy glacier pass of the Col de Valpelline, 11,687 feet, leads to the Z'Mutt Glacier and so to Zermatt. It would have been the shortest way for Forbes's party, but it was only discovered and crossed in 1860.]

[2] [The height is 6539 feet. There is now a little mountain inn here.]

found him gentle, docile, robust, and trustworthy. During a part of this day's journey, he carried not only all our provisions, but no light share of the contents of Glaus's *hotte*, or basket. His name was Bionaz, as well as that of his native place.

As we had been told the night before, we returned a little way upon our steps; then, following a water-course used for irrigation, we turned sharply to the right. All our maps were here at fault. That of Wörl especially, the most detailed, presents no kind of resemblance to the outlines even of the great chain, and the passage must have been put down at random. It will be seen by the Topographical Sketch, No. VI., which probably approximates to the real arrangement of the mountains, though in some degree conjectural, that the pass is through the first lateral valley of the Val de Bionaz below its head. We there find a deep gorge,[1] completely glacier-bound at its upper end; but from the nature of the rocks, it admits of an easier ascent than the glacier at the top of the Val de Bionaz. We passed some wretched shepherds' huts; and following an impetuous stream, we came to the foot of a glacier descending on our left,[2] which has blockaded the valley with its prodigious moraine, and left a swampy flat above. This passed, we kept to our right hand, having in front of us another great glacier, which descends from the Col de Collon, and more to the left a great and steep glacier, which appears to descend from the group of mountains connected with the origin of the Glacier of Chermontane.[3] The direction

TOPOGRAPHICAL SKETCH No. VI.

EYE SKETCH OF THE PASS OF THE MONT COLLON.

[1] [The Oren glen.]

[2] [The glacier descending from the Col de Sassa, that leads over to the lower portion of the Valpelline.]

[3] [The Oren Glacier, over which the Col d'Oren, 10,637 feet, leads to the great Otemma Glacier. The "probable passage to the Val Tournanche," marked on Topographical Sketch No. VI., is most likely the Col Bellaza, 10,050 feet.]

of the valley we ascended was at first N. 20° W. (true), and when we came in sight of the glacier which we were to follow, it turned sharply to N. 25° E. Pursuing a very steep and laborious ascent over rocks (without, however, any danger), we reached the glacier, where it was much more level than in its lower part, and obtained a distant view of the Col. The ice was not much fissured, and we proceeded at ease—only we came at length to where it was covered with perpetual snow, and there we required to proceed with caution. We left, upon our right hand, the mass of mountains which separate this pass from the head of Valpelline, and on our left new and hitherto unseen chains began to display themselves, and rocks rising above the Col or pass, which we were surprised to find marked by a very small iron cross,[1] showing that it is well known to the country people, although unfrequented by travellers. The only traveller whom I am aware of as having passed here[2] is M. Godeffroy, the author of an Essay on Glaciers,[3] already quoted. We now also learned the secret of our friend, "l'habit rouge," being so well acquainted with this obscure route, for he admitted that he had frequently passed it with bands of smugglers, who avail themselves of all the less frequented passes for introducing the articles of free commerce in Switzerland into Piedmont. We reached the Col in three hours from the chalet, which was sooner than we expected; and as it was only nine o'clock and a beautiful morning, we sat for a long time on the rocks on the west side of the Col, and enjoyed the noble scenery. Although the height is 10,333 feet above the sea[4] (barometer, 528·1 millimètres) it is so much surrounded by summits still more elevated as to command no very distant scenery. But before us, to the north, rose the majestic form of Mont Collon,[5] round which swept the very extensive glacier which we had yet to traverse in its entire length during several hours; and to the eastward, beyond snow-fields of seemingly great extent, rose snowy peaks, which afterwards appeared to me to be the same as I saw from the Col d'Hérens, and over which it is just possible that a passage might be effected from the Val Bionaz to that of St. Nicolas, though,

[1] [It bears the date 1754.]
[2] [In August, 1838.]
[3] *Notice sur les Glaciers*, p. 65.
[4] [Really 10,270 feet.]
[5] [11,956 feet high.]

from the distance, it might probably be impossible to accomplish it without sleeping out on the glacier.[1]

As we were far above the limits where water is found on the glacier, I used my portable furnace to melt snow for the use of the party, and afterwards to ascertain the temperature of boiling water, which I found to be 195°·15. We spent an hour of great enjoyment, for we now saw our way clearly, and all doubts were at an end of accomplishing a passage which, not to have performed, would have materially deranged our travelling plans; we then set forth in a cheerful mood to descend the long stretch of glacier which lay before us. There were few crevasses,—though whilst on the snow we walked with precaution and in a line, but without ropes;—we descended rapidly, whilst the majestic form of Mont Collon rose with increased grandeur before us. When we were fairly abreast of it our guide set up a wild and sonorous shout which the rarely wakened echoes of those stupendous precipices sent pealing back again in tones yet more fantastic. He added that this echo was well known to the smugglers, and that the reverberation of Mont Collon served to guide them in foggy weather, in a tract which must be then singularly perilous, from the great breadth and monotony of the glacier here, and the number of branches into which it divides in its higher part, any one of which might easily be mistaken for another.

Whilst we were amusing ourselves with the discordant shouts of the party, and responses of the mountain, our attention was suddenly led to a very different matter. A dark object was descried on the snow to our left, just under the precipices of Mont Collon. We were not yet low enough to have entered on the ice, but were still on snow. This proved to be the body of a man, fully clothed, fallen with his head in the direction in which we were going.[2] From the appearance of the body as it lay, it might have been presumed to be recent; but when it was

[1] [From the Col de Collon Forbes could scarcely have seen the *upper* slopes of the Za-de-Zan Glacier, whence the Col de Valpelline leads over to Zermatt. He perhaps alludes to the Col des Bouquetins, beyond the Dents des Bouquetins (his "snowy peaks"), that gives access from the Valpelline to the great snow-fields on the Evolena side of the Col d'Hérens.]

[2] [Mr. John Ball crossed the pass in September, 1853, and heard from his Val d'Hérens guide the terrible story of the adventures in 1841 of a party of Evolena men on this glacier. Three of them perished, and the body found by Forbes in 1842 was that of one of these victims. See below, p. 282.]

raised the head and face were found to be in a state of frightful decay, and covered with blood, evidently arising from an incipient thaw, after having remained perhaps for a twelvemonth perfectly congealed. The clothes were quite entire and uninjured, and being hard frozen, still protected the corpse beneath. It was evident that an unhappy peasant had been overtaken in a storm, probably of the previous year, and had lain there covered with snow during the whole winter and spring, and that we were now, in the month of August, the first travellers who had passed this way and ascertained his fate. The hands were gloved, and in the pockets, in the attitude of a person maintaining the last glow of heat, and the body being extended on the snow, which was pretty steep, it appeared that he had been hurrying towards the valley when his strength was exhausted, and he lay simply as he fell.

The effect upon us all was electric; and had not the sun shone forth in its full glory, and the very wilderness of eternal snow seemed gladdened under the serenity of such a summer's day as is rare at these heights, we should certainly have felt a deeper thrill, arising from the sense of personal danger. As it was, when we had recovered our first surprise, and interchanged our expressions of sympathy for the poor traveller, and gazed with awe on the disfigured relics of one who had so lately been in the same plight as ourselves, we turned and surveyed, with a stronger sense of sublimity than before, the desolation by which we were surrounded, and became still more sensible of our isolation from human dwellings, human help, and human sympathy,—our loneliness with nature, and, as it were, the more immediate presence of God. Our guide and attendants felt it as deeply as we. At such moments all refinements of sentiment are forgotten, religion or superstition may tinge the reflections of one or another, but, at the bottom, all think and feel alike. We are men, and we stand in the chamber of death. Our friend of Bionaz, though he was the first to raise and handle the body, from which the others rather shrunk,—and though he examined the rigid clothes for the articles which they contained, and with our consent took out a knife and snuff-box from the pocket, and a little treasury of mixed Swiss and Piedmontese small coins, concealed in a waistband all entire and untouched (by means of which we could identify the person and restore the money to his friends),—though he performed all this with seeming indifference, we had no sooner left the spot than he declared that he would rather make a circuit home by the Great St. Bernard than return alone by this spot. Indeed it might well require resolution in a solitary man, with the chances of weather, to pass alone a Col like this, where, supposing him caught in a *tourmente*, it would require no vivid sensibility to raise the image of the last sufferer before him, and hasten the moment of despair, when the spirit yields to the pressure of hunger, fatigue, and bewilderment, and subsides insensibly into the sleep which knows no waking.

A very little farther on we found traces of another victim, probably of an earlier date;—some shreds of clothes, and fragments of a knapsack; but the body had disappeared. Still lower, the remains of the bones and skin of two chamois, and near them the complete bones of a man. The latter were arranged in a very singular manner, nearly the whole skeleton being there in detached bones, laid in order along the ice,—the skull lowest, next the arms and ribs, and finally the bones of the pelvis, legs, and feet, disposed along the glacier, so that the distance between the head and feet might be five yards, a disposition certainly arising from some natural cause, not very easy to assign.

The glacier now enters a regular valley, and leaves the high slopes. It is bounded by Mont Collon on the left, sweeping for some miles round its base, and on the right by rugged cliffs, chiefly of gneiss, in which we could distinctly see well characterised granitic veins, shooting in irregular zigzags through the mass. The glacier on which we now were is the Glacier of Arolla, that which occupies the head of the western branch of the Vallée d'Hérens. It is very long. Probably we might have continued most easily all the way along the ice towards the centre; but our guide advised us to follow the right bank along the moraine, an excessively rough and fatiguing scramble, for a great distance, on angular moving blocks, without a trace of a path. This was by far the most tedious and disagreeable part of our day's journey; but M. Studer was rewarded by finding a mixture of gabbro or diallage rock, in immediate connection with real granite and metamorphic gneiss, to which he attached considerable importance.

The structure of the Glacier of Arolla is perfectly normal, presenting bands or veins nearly parallel, and vertical throughout a great part of its length, which sweep round in the conoidal forms, proper, as we have seen, to the lower termination or unsupported part of the glacier. The lower extremity is very clean, little fissured, and has from below a most commanding appearance, with the majestic summit of Mont Collon towering up behind. The frontal bands are very distinct, and even at a distance of a mile or more, those very marked ones which, in describing the Mer de Glace of Chamouni, I have called "dirt bands," and which, perhaps, are the annual rings or marks of yearly growth of the glacier, are beautifully developed, and recur at intervals marked with almost mathematical precision.

The stream which descends the valley rises from under an arch of ice at the foot of the glacier. The bottom of the valley is wide, gravelly, and waste. A number of desolate and stunted pine trees occupy the western bank, and seem chilled by the near approach of the ice; many are dead, and some fallen. They serve to give a scale to the majestic scenery behind. Their species is the *Pinus cembra,* the hardiest of their class which grow to any size in Switzerland, and they are consequently to be met with at great elevations. This pine has various names. In the patois of Savoy, and many other places, it is called "Arolla," whence the name of the valley and glacier. It is also called "Arve," and "Zirbelnusskiefer." It yields an edible fruit, and the wood is soft and well fitted for carving, for which it is preferred, especially in the Tyrol and Eastern Alps. This wood of pines lies exactly between the foot of the Glacier of Arolla and a small detached one[1] descending from the mountain called Pigno d'Arolla, a summit on the western side of the great glacier.

I ought to have mentioned, that in quitting the northern foot of Mont Collon, during our descent, we left upon our left hand a great tributary glacier,[2] steep and difficult of access, which separates the Mont Collon from the Pigno d'Arolla, and which may possibly communicate with the icy mountain of Chermontane, beyond the head of the valley of Hérémence. We

[1] [The Pièce Glacier.]

[2] [The Vuibez Glacier, with a very grand icefall. This can sometimes be forced, but in general the round by the Pièce Glacier is preferred. In either case, as Forbes rightly conjectured, the Col de Chermontane at the head of the great Otemma Glacier is attained.]

stayed some time to contemplate the wonderful majesty of the scene, of which I made a sketch, and we then proceeded down the valley.

The chalets of Arolla were a little way lower, across the torrent on our left, and the shepherd who kept them, perceiving the unusual sight of visitors, came down to meet us, and courteously invited us to rest ourselves, which, as the day was not too far advanced, and the way was now plain, we willingly did, and partook of his cheese and hard bread, with excellent butter. The chalets[1] had even a finer view of the glacier than that which we had quitted, and thus looking in front of it, I saw very plainly the succession of structural bands disposed with the remarkable regularity already alluded to. One of our first inquiries was connected with the fate of the unfortunate men whose relics we had observed; and it appeared that our entertainer, Pralong by name, had himself been one of the party to which the most recently deceased of these men belonged. They had started in the end of October last year (1841) to cross the Col into Piedmont, in all twelve men; but being overtaken by a tremendous storm, they at length resolved to return; but too late for three of their number, who, worn out with fatigue, and benumbed with cold, were left behind,—the imperious calls of self-preservation requiring their abandonment. Our informant assured us that he himself was the last to quit these unfortunate men in succession, when every effort to stimulate or assist them had been tried in vain. We understood that two of the bodies had already been recovered; the third was, no doubt, the one that we first saw. The articles which Bionaz had taken from the body were afterwards recognised in Evolena, and the money (which did not amount to more than three or four French francs) was faithfully paid over to the Curé, and measures were taken to have the body brought down for interment.

Our new acquaintance of Arolla gave us other information, which interested me as much. Having complimented us on the successful passage we had made, he asked if we were not desirous of attempting the more arduous passage from Evolena to

[1] [At a height of 6572 feet. Near them is the old hôtel, built in 1872, to succeed a chalet (constructed in 1865), and above them the new Kurhaus, both now much frequented by English visitors in summer. Forbes was probably the first native of Great Britain to visit this now well-known spot.]

Zermatt,[1] which, he assured us, that he and his father had more than once performed, and that they were indeed the only persons in the valley who had done so. Now this passage had long piqued my curiosity, having a sort of romantic interest, which attaches to what has been so seldom performed, as to render its possibility almost fabulous. It was certain that it must carry the traveller amongst some of the highest and most majestic peaks of this almost unknown district. Its elevation and character I had already studied in 1841 from the side of Zermatt, and had conceived the most lively curiosity to traverse these glaciers, and to ascertain the relations of a group of mountains 13,000 and 14,000 feet high, some of which are scarcely indicated on several of the latest maps. My great doubt had been as to the possibility of finding any guide in Evolena, and, therefore, that the first man whom we met with in the valley should be the very person who, I knew from Fröbel's work,[2] was reported to have some personal knowledge of this celebrated pass, seemed a piece of good fortune not to be lightly thrown away. After a short consultation with M. Studer, I found that the heavy marching trim of the worthy Glaus, and his own wish to visit the valley of Anniviers, would prevent him from undertaking this journey, although we were both eventually bound for Zermatt; therefore after a few minutes' arrangement I determined my plan, engaged Pralong to come down to Evolena next morning, and thence start with me in the afternoon for the foot of the Ferpècle Glacier, where we might sleep, and attempt the passage the following day. Pralong desired nothing better, and we soon started for Evolena. The walk to Haudères, where the valley of Arolla joins that of Ferpècle, the union of the two forming the Vallée d'Hérens, was very agreeable, and at times beautiful. At the hamlet of Chatorma[3] we noticed striated and polished rocks, of which, as has been already said, we saw none in the Valpelline. Below St. Barthélemi the way becomes steep, the torrent descends in rapids, and the banks are clothed with larch and pine wood; the ravine is altogether grand and picturesque. We then came to steep watered meadows, and at length, crossing first one stream and them another, we arrived at the hamlet of Haudères. Half an hour, which seemed a tedious while, over a

[1] [By the Col d'Hérens.]

[2] *Reise in die Penninische Alpen*, p. 73.

[3] [Satarma.]

fertile flat, divided into grass fields, and thickly studded with barns, brought us to the capital of the valley, the village of Evolena, which seemed to us the largest place which we had seen for some time. A nearer approach showed that the houses, which looked so imposing at a distance, were built of logs, and had dark and uninviting exteriors. But when we came to seek for accommodation, we found every anticipation we could possibly have made of discomfort and privation much exceeded.

CHAPTER XVI

FROM EVOLENA IN THE VALLEY OF HÉRENS TO ZERMATT IN THE VALLEY OF ST. NICOLAS, BY THE GLACIERS OF FERPÈCLE AND Z'MUTT.

A night at Evolena—Wretched accommodation—Departure for Bricolla—Aspect of the Glacier of Ferpècle—A night in the chalets—Ascent of the glacier—The Motta Rotta—The Stockhorn—Magnificent view of Monte Rosa and Mont Cervin—Dangerous descent—Precipices—The Bergschrund—Pralong returns—The Glacier of Z'Mutt—Structure of the Mont Cervin—Arrival at Zermatt.

We knew too well what accommodation might be expected even in the *capital* of a remote Vallaisan valley to anticipate any luxuries at Evolena. Indeed, M. Studer had already been there the previous year, and having lodged with the Curé, forewarned me that our accommodation would not be splendid. A change had, however, occurred in the establishment of the "Pfarrhaus," since 1841, by the introduction of the Curé's sister, who usually lived at Sion, a person of ungovernable temper and rude manners, who seemed to find pleasure in the arrival of strangers only as fresh subjects whereon to vent her spleen, and to show how heartily she despised the inhabitants of her brother's parish compared to the aristocratic burghers of the decayed town of Sion. Had this been all, and had our corporeal wants been reasonably attended to, we might have forgotten the ill-nature of expressions directed at random against ourselves and all mankind; but we experienced the greatest difficulty not only in procuring anything to eat, but even in being allowed to cook our own provisions. The Curé, a timid worldly man, gave us no comfort, and exercised no hospitality, evidently regarding our visit as an intrusion. Indeed, jaded by a fatiguing journey, without any prospect of beds (for we had been told at once that we could not lodge in the *Cure*), we wished ourselves a hundred times, in the course of the evening, at the deserted chalets of Prarayé, where we had spent the former night; whilst the amiable family of A—— at Valpelline seemed, by contrast, to belong to another race of beings. The faithful Glaus, too, had been taken unwell during the latter part of the day; but there was no alternative but to sit round a table, attired as we were, for two hours, before a soup, prepared with our own rice, was presented to us. At a late hour in the evening we were told that one bed could be had in the village; we gladly left the Pfarrhaus, shaking the dust from our feet, and went to the destined lodging, where we found civil, and tolerably cleanly people, whose jargon, however, it was quite impossible to understand. There was actually but one spare bed in the whole village.[1] We drew lots for the prize, which fell to me. It was clean, though neither soft nor even; but between two such journeys as I was undertaking, even to undress was a luxury, and I slept till late next morning, when I was awakened by M. Studer entering. Where he had slept never transpired. He had, however, spent a night of misery, and came to communicate his intention of departing immediately for the Val d'Anniviers, instead of passing the day in the neighbourhood of Evolena, as he had intended. I could not gainsay the propriety of his determination, although sorry to part. He left shortly afterwards, and we agreed to meet at Zermatt,—he going by Visp, I by Ferpècle.

Before I had finished dressing, our worthy guide from Valpelline came to bid me adieu. During the latter part of our yesterday's walk we had become well acquainted, and his simplicity of character had touched us both. He had more than once expressed a wish to accompany us farther, as well as to avoid returning to his own country the same way. He urged nothing of the kind now, but quietly bid me good-bye and took the road to Haudères. When I saw him fairly gone, I could not but regret having parted with him so easily. I thought that he might be very useful in the more difficult journey which awaited me, my own servant being inexperienced, and the guide of Arolla, though he promised well, being quite unknown to me.

[1] [Now there are two good mountain hôtels.]

I, therefore, ran after "l'habit rouge," and asked if he would accompany me to Zermatt, and return home by the Val Tournanche in Italy. To this he at once assented. There was no bargaining or hesitation, and he turned back with me.

In the forenoon Pralong joined me, according to promise. Having first dined, I started with my three men about two o'clock, with very fine weather, intending to sleep at the last chalets of Ferpècle, and to cross the glacier the following morning. Before quitting Evolena I shall say a few words respecting the valleys of which it is the centre and capital.

The group of valleys of which we speak, and of which Hérens is the chief, is situated between the Rhone and the great chain of Alps. Their openings into the valley of the Rhone are so small and unconspicuous that they are passed by the traveller, rolling along in his private carriage, or that of the Simplon courier, almost without perceiving their existence; yet opposite to three well known stages on that road, Sion, Sierre, and Tourtemagne, three several valleys proceed, the Val d'Erin or d'Hérens (Eringerthal), the Val d'Anniviers (Einfischthal), and the Vallée de Tourtemagne (Turtmannthal). Their magnitude and importance are in the order just stated. The Val d'Hérens divides into two branches, the valley of Evolena and that of Hérémence, both of which terminate in great glaciers, to wit, the Glaciers of Ferpècle, Arolla [Seilon], and Lendarey. The Val d'Anniviers divides into the Val de Torrent and Val de Zinal, with glaciers of the same names. The valley of Tourtemagne is uninhabited, except in summer, and terminates in a glacier at the foot of the Weisshorn.

These valleys have not only been hitherto unfrequented by *tourists*, but are almost unknown even to *travellers*[1] (to make a distinction commonly and not unjustly drawn in Switzerland). De Saussure says nothing of them. Bourrit[2] speaks of them so slightly that it may be doubted whether he ever was even so far as Evolena. Ebel mentions them only to acknowledge his want of information, and Simond is silent alike on their history and existence. Even at the time I am describing, although it was

[1] [Nowadays Evolena, Arolla, Ferpècle, St. Luc, and Zinal are much frequented by travellers, but the Turtmannthal is still known to comparatively few wanderers through the Alps.]

[2] [Vol. i. pp. 111-116; Bourrit describes the Val d'Hérens only, and that merely from hearsay.]

past the middle of August, the Curé informed us that we were the only strangers who had yet appeared that season at Evolena. A pleasant little work, by Julius Fröbel, entitled, *Reise in die weniger bekannten Thäler auf der Nordseite der Penninischen Alpen,*[1] has given the first and only detailed account of them worth notice, and even his visit was one of but a very few days, and directed only to the more accessible points. His work is valuable from an improved map which it contains, and which corrects many of the almost incredible errors of the best executed maps before that time—such as those of Weiss, Keller, and Wörl. I should add, that a work published at Basel, also in 1840, by C. M. Engelhardt, under the title of *Naturschilderungen aus den höchsten Schweizer-Alpen,* gives some account[2] of these valleys, and confirms the unanimous testimony of travellers respecting the discomfort and incivility experienced at Evolena.

It seems to be admitted by all who have mentioned these valleys, that their population is of a distinct race from their Swiss neighbours.[3] Very different origins have been assigned to them,—that they came from the east, and were originally tribes of Huns and Alani, and that they settled here in the fifth century, is the most prevalent theory; others pronounced them to be Saracenic, dating from the ninth century, whilst Fröbel inclines (chiefly upon etymological grounds, not perhaps very conclusive) to consider them a Celtic race. That they lived in a very independent manner, were heathens long after the conversion of their neighbours, became subject to the Bishop of Sion, and were christianised by his missionaries, is confidently stated. In modern times we know that they have shown a spirit of stubborn independence, and resisted, in their unapproachable fastnesses, the incursions of the French armies, at a time when the rest of the Vallais had submitted to the yoke of Bonaparte.

Their character does not appear to differ much from that of the Vallaisans, or, indeed, of the Swiss generally. Their hospitality, according to Fröbel (p. 92), is seldom disinterested, and an intense love of money predominates in all their transactions.

[1] Berlin, 1840.

[2] [The detailed account of Engelhardt's visit in 1837 to the Vals d'Hérens and d'Anniviers is given in his *Naturschilderungen*, pp. 100-132.]

[3] [This wild theory is entirely devoid of the slightest historical foundation.]

A dollar which once finds its way to Hérens is never changed, and never comes forth again. This feature, supposed generally to be an imported vice, conspicuous only on the great and frequented roads, is, therefore, not merely the result of English folly and extravagance; and my experience in other remote places confirms the opinion. The character of the people is, further, according to the same writer (p. 91), stiff and pedantic, not unfrequently producing a ludicrous appearance of self-importance amidst an utter neglect of the common comforts and almost decencies of life. Their food is not only coarse, but scanty, and even unwholesome; their houses and apartments are amongst the worst in the Alps: cleanliness is not amongst their virtues (p. 83). Much of this may be traced to laziness, which, Fröbel says, is the prevailing vice: mules are abundant for country uses, and no man walks who can possibly ride (even second) on a mule; still less will any one carry a common knapsack without complaint (p. 91). Glaus's *hotte* was the wonder of all who met us. Fröbel has, indeed, said so much about the impossibility of obtaining good guides in Evolena,[1] that I had despaired of undertaking any considerable expedition, but Pralong seemed to be rather an exception to the usual character, being active, civil, and far from exacting; he also displayed much personal courage and resolution.

The language is barbarous, but I doubt whether it is more so, or more decidedly national than in many other remote valleys of the Alps. The word "fläthig" for *cleanly*, which Fröbel has mentioned (p. 83) as distinctive, I have heard in the valley of Saas, where the population is, I believe, purely German. The name Evolena is said (p. 86) to mean, in the native dialect, "tepid water," and may be derived from a number of very beautiful springs, which rise from the fallen débris at the foot of the mountain slope immediately behind the town. *Borgne* means brook (p. 169); *biegno*, glacier (p. 52); and *pigno*, mountain top; which last Fröbel (p. 67 n. and p. 171) says is synonymous with the Spanish *peñon*, the French *pignon*, the mons *penninus* of the Romans, and the Gaelic *bein*.

These valleys, notwithstanding the seeming poverty of their

[1] "Die Männer von Evolena sind schlechte Bergleute." "Zehn bis funfzehn Pfund auf dem Rücken zu haben ist einem Manne von Evolena eine unerträgliche Unbequemlichkeit," p. 91.

inhabitants, annually export a great deal of produce. Evolena is eight hours distant from Sion.[1] Its neighbourhood presents a very lively and fertile appearance, the valley being broad and well watered, covered with pasture, and studded with barns and chalets up to a great height on both sides; for although the secondary ranges—those which divide Hérens from Hérémence and Anniviers,—are of considerable height, and of a fatiguing nature to climb, as those who have passed testify, they are fertile and grassy, affording excellent pasture. The cheerful appearance is indeed diminished when we approach, and find what seem to be villages to be mere barns, or rather hay-lofts, without a single inmate, and when, in the inhabited places, we find so much want of comfort and cleanliness. But as I have said, the exports of dairy produce to the low country are large, and probably very greatly exceed the imports, although these must include most of what are commonly considered as the necessaries of life.

Besides the natural entrances to these valleys from the valley of the Rhone, which, as we have said, are narrow and unconspicuous, there are various passes to and from the higher parts of these valleys. In former times the glaciers were, as we have also seen, undoubtedly much more accessible, and even the pass to Zermatt seems at one time, like the Col du Géant, to have been frequently used. From Hérémence there is said to exist a passage to the Glacier of Chermontane,[2] which may have been in the direction which we saw in crossing the Col de Fenêtre. There is also a long pass, but not over ice, into the Val de Bagnes, below Mont Pleureur, which M. Studer crossed in 1841.[3] From Anniviers, it is very doubtful whether any glacier-pass exists;[4] but from Tourtemagne, which is a valley inhabited only in summer, it is possible to cross the northern part of the Weisshorn into the valley of St. Nicolas above Stalden.[5]

But to resume our journey. Having quitted Evolena at 2 P.M.,[6] I walked to Haudères, where my guide, Jean Pralong,

[1] [Now it is 16 miles distant by a carriage road.]

[2] [Probably the Col de Seilon, which leads to the Giétroz Glacier, is meant. See p. 266.]

[3] [The Col du Crêt. See p. 257.]

[4] [Nowadays plenty are known to both the Zermatt and Hérens valleys.]

[5] [Either the Augstbord Pass, 9492 feet, or the Jung Pass, 9823 feet, is meant.]

[6] The height of Evolena is 4532 English feet above the sea by M. Studer's observation compared with the barometers at Geneva and St. Bernard. [It is really 4521 feet.

lived. This village is at the junction of the two *Borgnes*, three miles above Evolena. It was nearly deserted. Pralong took the key of his house from under a stone, and invited me into it. The entrance was rude and ill-furnished, the light and air coming in on all hands; but he conducted me up a trap-stair to a very tolerable apartment, with clean-looking beds, which we should have envied the night before. He offered me wine, and took a supply himself for the journey, candles for our use at night, and various other articles, including a rope to be used on the glacier. We then started, and followed the east side of the eastern rivulet, that descending from the Glacier of Ferpècle. We followed narrow water-courses to abridge our way, and during our ascent I was surprised to notice the oriental plane-tree and the currant both growing wild. The rocks exhibit traces of glacier friction, but neither here nor in the other branch of the valley towards Arolla are the transported blocks numerous.

After two hours' walk from Evolena, we reached the chalets of Ferpècle,[1] the only habitations of this part of the valley. Here we proposed to get some hay to form our bed at night, which we conjectured might be a scarce commodity at the still higher station, where we proposed sleeping. But this was not so easy a matter, for this seeming village contained not a single inhabitant; the greater part was composed merely of hay-lofts, which, upon examination, proved to be much better secured than at first sight seemed probable. But Pralong was not daunted by the resistance of wooden bars and iron shackles, and my geological hammer was unscrupulously applied to obtain an entrance with the deliberate purpose of pillage. At length one door was forced, and a good armful of dry clean hay was secured and carried off, and all else replaced as before. We had now the lower end of the Glacier of Ferpècle immediately before us. The valley is very deep, and the scene solitary and striking, but it is impossible to form here any idea of the extent of the ice. Keeping always to the left, we began a smart ascent at first over the moraine of the glacier, which here as elsewhere seems to have retreated of late years. At length we gained a better path, traversing high pastures, and crossing the beds of several vast torrents. Having now got considerably above the ice, we advanced nearly on a level.

[1] [Probably those of Salay are meant. Here there is now a pleasant little mountain inn.]

We also saw rising beyond groups of jagged summits,[1] which separate the Glaciers of Ferpècle and Arolla, of which the most conspicuous is a sharp pinnacle called Aiguille de la Za.[2] These terminate towards the great chain in a range called the Dents des Bouquetins.[3] This led us to speak of those animals, and I asked Pralong whether any were ever seen. He replied that they had long disappeared, and that the story went that long ago the Government of the Vallais, desirous to preserve the race, declared the shooting of a bouquetin to be a capital offence, from which time not one of these animals has been seen,—a practical proof, he probably meant to infer, of the impotence of extreme legislation. He also began spontaneously to talk about the glaciers, and the cause of their motion, and put several very pertinent questions. Amongst other things, he affirmed distinctly, that the glaciers advance indifferently in summer and in winter, and even that if the lower extremity be diminishing, it continues to do so—if advancing, to advance also—in winter as in summer.

As the evening fell we gradually approached—by a path which certainly seemed to lead to no human habitation, but to an endless wilderness of ice and rocks—the chalets of Bricolla, which we reached in an hour and a half from the chalets of Ferpècle. The first symptoms of human art were two pyramids of stone (*hommes de pierres*, as they are generally called), which directed us from a distance; then two stone huts near together, and one or two others a little beyond. We soon found that there were inhabitants, and we were received with simplicity, and with that composure and seeming absence of curiosity which I have already mentioned as remarkable amongst the *Pâtres* of the higher Alps. A visit even from Evolena is a rarity, but most likely none of them had before seen or lodged a traveller and his guides, prepared to cross the glacier to Zermatt. Nevertheless, as their reception was far from repelling or suspicious, I was well satisfied with their tranquillity about my concerns and objects; and preparing my arrangements for the evening, I left my guides, who all spoke different native tongues, to satisfy, as best they might, any latent curiosity of our hosts.

[1] [The Dent Perroc and the Dents de Veisivi, which are all grouped under the name of "Les Grandes Dents."]

[2] [12,051 feet. Although not conquered till 1868, it is now one of the favourite ascents from Arolla.]

[3] [12,625 feet.]

It was a charming evening, almost too mild to give quite a favourable prognostic for the weather. After sunset the moon, which was almost full, rose, and threw her light over a scene not to be surpassed. These chalets, placed on a broad grassy shelf of rich verdure, overhanging, at a height of several hundred feet, one of the noblest glaciers in the Alps, are not much less elevated than the Convent of the Great St. Bernard,[1]—a position sufficient in most cases to diminish the effect of the higher summits, but which here only increases it, so stupendous is the scale of nature at this spot. Rising abruptly from the glacier, at no great distance on the left, is the grand summit of the Dent Blanche,[2] which is called Hovenghorn as seen from Zermatt. Its height is probably unmeasured, but is marked in Keller's map 13,000 French feet, which, I believe, is rather under the mark.[3] To the south the view is bounded by the ridge which I proposed passing, from which the glacier descends in some places very steeply, and with a striking effect, breaking over a rock called Motta Rotta, which divides its current for a short space. To the west of this a narrow ridge of angular summits, very abrupt and bare, divides the glacier into two distinct branches. This is called the Mont Miné, and is reputed to contain indications of ancient mines. I was surprised to learn that sheep are usually conveyed across the glacier to graze upon what seems a mass of broken rock. Between the Mont Miné and the ridge formerly mentioned as separating the Glaciers of Arolla and Ferpècle, the western branch [4] of the Ferpècle glacier descends. This ridge is far higher, and more commanding than the Mont Miné. It has its origin at the Dents des Bouquetins, near the axis of the chain, and it descends to the Aiguille de la Za, and continues to its termination above Haudères, in the Dents de Veisivi. From the considerable height at which I stood, the glacier was seen (in its lower part at least) in plan, and presented a view of the same description, but more extensive and wild, than that of the Mer de Glace from the Montanvert. As now seen by moonlight, its appearance was indescribably grand and peaceful, and I stood

[1] [The Bricolla chalets are 7960 feet, and the Convent 8111 feet.]

[2] See the Topographical Sketch, No. VII., p. 297, for this route.

[3] [Its height is 14,318 English feet.]

[4] [It is now called the Mont Miné Glacier, the name Ferpècle Glacier being given to the east branch, which is really the main stream. Both flow from the great snow-fields that extend from the Dents des Bouquetins to the Dent Blanche.]

long in fixed admiration of the scene, the most striking of its kind which I have witnessed, unless, perhaps, I were to except a moonlight walk over the great Glacier of Aletsch under very similar circumstances. Amongst other things, I did not fail to remark the wave-like bands, or "dirt beds," at regular intervals on the surface of the glacier, in precise correspondence with what I had observed at Chamouni from the Charmoz. Here they were, if possible, more striking, more numerous, and not less regular. Instead of eighteen bands, I here counted thirty, at intervals sensibly equal, and in forms like those figured on the map of the Mer de Glace. The moonlight was very favourable to this observation.

I soon after returned to the hut to supper. As might be expected, the cheer was not great, but cheerfully given. There could not be much less comfort than at Evolena; but it was at least freely offered. There was no temptation to prolong a stay within doors, unless to sleep. I retired early with my guides to the lodging prepared for us with the aid of the hay which we had brought. It was a small shed, about six feet square, and four high, attached to the principal hut, entered by a doorway through which one could creep with difficulty, and which was shut up with a piece of cloth. I was placed next the wall, and the others slept beside me. The shepherds themselves slept in a separate hut a little way removed. Before we went to rest, it was agreed that they should call us at 3 A.M., that we might be on foot before day, for all reports agreed, that whatever might be the difficulties of the journey, it was, at least, a very long one. In order to awaken us at the right time, they begged to have my watch with them for the night, a request which, in some other countries, might have been suspicious (it was a valuable gold chronometer) but which here I granted as readily as it was undoubtingly asked. As we lay down I was struck by the conduct of Pralong, who knelt down on the hay and said his prayers shortly, and without form or pretension of any kind; and we had not been long composed to rest before we heard a solemn and not unmusical voice proceeding from the neighbouring apartment. On inquiry of Pralong, I found that the practice of evening prayer is kept up amongst the assembled shepherds; a rare but touching solemnity amongst men of the common ranks, —for no women usually live in the higher chalets,—separated during so large a part of the year from the means of public worship.

I passed a sleepless, though far from an uncomfortable night. Pralong had spoken doubtingly of the weather in the evening, and I well knew that any thing like uncertainty in that respect could not be hazarded on such an expedition, for which I felt more and more disposed as I got better acquainted with the scenery of this interesting chain. Every change of direction of the moon's rays falling through the open walls and roof of our shelter I mistook for a cloud, and felt fresh anxiety lest the hour of rising should be overpast, as it had been at Prarayé. I was up before the rest, and whilst the stars were shining bright, the moon having set, I performed my hasty toilet. It was some time before breakfast could be got ready, and, as usual, an hour and a quarter elapsed before we were fairly under way, exactly at a quarter to five.

It may not be out of place to mention here what was known respecting this pass, which has remained less celebrated than the Col du Géant, or the Strahleck (both of which it exceeds in height),[1] because the valleys between which it communicates are, I believe, little known. I first heard of it from a guide at Zermatt, Peter Damatter, who told me, in 1841, that he had passed it, and that the town of Sion was visible from the top. He represented the distance as excessively great, so as with difficulty to be accomplished in a day. Venetz, the able engineer, of the Vallais (to which canton this country belongs), wrote, in 1821, that this pass was so dangerous that he had never known but one man (Josef Perren) who had accomplished it;[2] whilst he mentions it as a proof of the great increase of the glaciers in modern times, that formerly it was in considerable use, and certainly, for the rare occasions that any one may be supposed to have business between Evolena and Zermatt, the circuit of three or four tedious days' journey by Sion and Visp is by no means cheering.[3] Fröbel mentions, that some years before he wrote, several gentlemen of Sion effected the passage under perilous

[1] [The Col d'Hérens is 11,418 feet, the Col du Géant 11,060 feet, and the Strahleck 10,995 feet.]

[2] *Mémoire sur les Variations de la Température dans les Alpes de la Suisse*, pp. 7, 8. I quote from a citation, not having the original by me. [See p. 42 above.]

[3] [Venetz also mentions the old procession from Zermatt to Sion by the Val d'Hérens. See p. 42 above.]

circumstances, having passed the entire day, from two in the morning until evening dusk, between the last chalets of Ferpècle, and the first of Z'Mutt.[1] Making all customary allowance for exaggeration, I had good reason to take all precautions, and to start with the early dawn; indeed we were scarcely off when Pralong intimated that he feared we were already somewhat too late.

It will be recollected that, besides Pralong, the guide of Evolena, I had the trusty Bionaz, of Val Bionaz, and Tairraz of Chamouni, as my attendants. The provisions, and my personal effects, made a burden so light for each, that even an Eringer could not reasonably complain; and taking leave of our hosts with thanks and remuneration, we hastened at a good pace to gain the glacier. But this was not the work of a moment. I have already said that the chalets of Bricolla stand on a shelf many hundred feet above the glacier; and, what is always disagreeable, our first step to mounting was a steep and uncomfortable descent. We had not left the chalets ten minutes when we found a foaming torrent to be crossed. Now, a plunge up to the knees in a river even ice-cold is a trifle in ordinary travelling, and might be considered a refreshing commencement of a long day's walk; but when that walk is to be of ten or twelve hours on a glacier, and over snows 11,000 or 12,000 feet high, such a freak might endanger life or limb. Accordingly, while Pralong and Bionaz spluttered through, I sought an easier passage higher up, which I at length found, and was followed by the wary Savoyard. Without difficulties worth mentioning we gained the surface of the ice, having lost, however, in level, a height of perhaps 1000 feet; we then patiently and warily proceeded on our march,—

[1] "Die Angaben über die Gangbarkeit dieses Passes sind sehr verschieden. Wie bei aller Gletscherpässen wird auch hier alles vom Jahrgange und von der Witterung abhangen. Der Herr Domherr Berchtold[1] in Sitten welcher ich über denselben befragte, bemerkte mir, es sei in jedem Falle 'eine Aventure,' über ihn zu gehen."—Fröbel, p. 73.[2]

[1] [Josef Anton Berchtold, born 1780, died 1859, was a Canon of Sion from 1816 and an eager student of applied mathematics. Between 1831 and 1834 at his own cost he had determined the heights of many spots in the Vallais. In 1834 he was entrusted by the Swiss military authorities with the triangulation of the Vallais for the "Dufour map," and completed his task by 1837. He continued his labours till 1844: the results are frequently given in Engelhardt's two books (1840 and 1852) and in that of Fröbel, etc.]

[2] [Pralong and his father (see p. 283 above) had already crossed it more than once. The day after Forbes's passage two men named Fullonier took over a Genevese, and a year later Mr. A. T. Malkin.]

> To climb steep hills
> Requires slow pace at first: anger is like
> A full-hot horse, who, being allow'd his way,
> Self-mettle tires him.[1]

But an unlooked for interruption occurred. My guides were all seized with sickness within a few minutes of one another. Their breakfast (boiled milk) had probably been prepared in a copper vessel, not cleaned overnight; and though all hardy men, with robust stomachs, and accustomed to the universal milk diet

Topographical Sketch N.° VII.

of the Alps, they suffered distressingly from the poison. For myself, long experience had made me almost wholly avoid these messes, and every preparation of milk. I had drunk tea both night and morning, prepared in my portable boiler, and had filled my gourd with some of the same invaluable stomachic, which I now administered with effect to Tairraz and Bionaz, whilst Pralong declared that his casket, or *keg* as it would be called in Scotland, of red wine, was worth all the tea in the universe. Happily, I suffered no uneasiness, and the others, being probably accustomed to the disorder, made light of it, and gradually recovered; meanwhile we pursued our way. We were now (see

[1] Shakspeare, Henry VIII., Act i. Scene 1.

the Topographical Sketch, No. VII.) close under the rocks which bordered the glacier on our left, beneath the lofty peak of the Dent Blanche. Before us was the Motta Rotta, the rocky precipice already described as rising through the ice. At length the glacier became much crevassed, and we had a choice of difficulties, either to skirt the precipitous rocks on our left, or to make for the centre of the glacier on our right, with the chance of crevasses yet more impassable. Pralong, indeed, broached the notion of attempting the ascent of the glacier between the Motta Rotta and the Mont Miné, which, he said, would lead us more directly to the Col; but he did not know that such a passage had been attempted, and as, upon examination with the telescope, I perceived an enormous *Bergschrund*, or well-defined crevasse, which separated the higher summits from the glacier steep, I preferred pursuing the direction in which he had already passed. We accordingly made for the rocks, and scrambled along and up them for a considerable way. We were preceded by a whole troop of chamois, eleven in number, which we startled upon the ice, and which took immediately to the cliffs. At length it became difficult to say whether the rock or the glacier was the more formidable opponent, and we regained, with some difficulty, the surface of the latter, being now more than on a level with the chalets which we had left.

The sun was only now rising behind the ridge of the Dent Blanche, the ice was still hard frozen and slippery. The glacier was very steep and rugged, but the crevasses were exposed and the walking was more difficult than dangerous, although once I was only withheld by my companions from slipping into a chasm. But the snow-line was soon gained, and the surface being still crisp, our footing was sure, and the bed of snow too thick to create any risk from crevasses. We were on the north or shady exposure, always the easiest to mount, and had a fatiguing climb up dazzling snow fields, about 30° of elevation abreast of the Motta Rotta, which was on our right.[1] Pralong took the lead manfully, and was now quite recovered from his indisposition. The heights of the Motta Rotta gained, the Col might be said to be reached, for although snow fields of great extent separated us from it, they evidently presented no difficulty. It is, perhaps,

[1] [Forbes thus passed to the east of the Motta Rotta, which is still the ordinary way.]

only in this part of the Alps that such a prodigious extent of comparative table-lands of snow are to be found at such an elevation. New peaks began to rise before us, and especially the Mont Cervin, or Matterhorn, and the Dent d'Hérens, whilst to the westward, the summits of Mont Collon, and the neighbouring chains peeped over the wilderness of snow and ice. The Col or pass, lay now, Pralong told me, considerably to the right, but seeing just before us a snowy summit, which alone concealed from us the view of Monte Rosa, and the great chain of Alps in that direction, I proposed, as we had gained this height at a very early hour, and with far less difficulty than I expected, to climb to the top of it to enjoy the view. Now, Pralong was not one of those teasing, pedantic guides who will never listen to any opinion, and who make it a point to thwart a proposition merely to show their consequence, the more so if it offer a chance of delay. I liked him for his confidence and good temper. He admitted that a traveller's opinion might be taken, at least as to the course which would please him best; accordingly, we walked right over towards the precipice marked on the Sketch as stretching from the Dent Blanche to the Stockhorn. As we approached it, I caught one of those glorious bursts of scenery of which all description must ever fail to realise the incommunicable grandeur, and one sight of which at once and instantly repays the traveller for days of toil and sleepless nights. Wandering on alone as near the verge of the snow-crowned precipice as I dared venture (for there an unseen fissure in the compacted snow, some yards from the very ledge, might readily occasion the detachment of a mass, by the traveller's weight, into the abyss), I gained the summit of the Stockhorn, of which I had considerably overrated the height from where I first proposed the deviation, and was seated on its top exactly at nine o'clock.

I wish I could convey an impression, however faint, of the view to the east. The morning was calm, the sky pure, and the sun bright; indeed, there was not a breath of wind, though I was here at a height of 11,760 feet above the sea, or 600 feet higher than the Col du Géant;[1] and this stillness, combined with the reflected sun heat, made the air feel perfectly mild, although, to my surprise, I found the thermometer to be only 34°. The whole range of Monte Rosa, including that proble-

[1] [The Stockhorn is 11,795 feet, or 735 feet higher than the Col du Géant.]

matical summit,[1] scarcely inferior to it in height, called by some Montagne de Fée, and by others Mittaghorn, filled the eastern distance. From the great height at which I stood, there could be no doubt about which was the highest point. Although between 3000 and 4000 feet higher, the distance was so great as to bring the eye apparently almost on a level, and in no direction is the relation of these much contested summits better seen. The summit which I thus judged to be the highest, is exactly the

VIEW OF MONTE ROSA FROM THE COL D'HÉRENS.

"Höchste Spitze" of von Welden, 15,158 English feet above the sea,[2] of which more hereafter.

The whole lustre of the morning sun shone shadowless upon these snowy heights, and upon the vast surface of the Glacier of Z'Mutt, of which only a portion can be included in the Topographical Sketch, and which lay completely, as in a map, at my feet, separated from me by stupendous precipices—"a vast vacuity." It is the cliff attempted to be shown in the Sketch, of which the Stockhorn on which I was seated forms at once the salient angle and the highest point. A branch of the glacier, it will be observed, comes close to the foot of the Dent Blanche, and to the base of the precipice. The Dent Blanche, thus seen in its precipitous height from top to bottom, had a magnificent appearance, and from the height which I afterwards ascertained of the point on which I stood, I cannot doubt that its reported height

[1] What von Welden (pp. 19, 29) has called "Berg X." [Undoubtedly the Mischabelhörner, of which the highest summit is the Dom, 14,942 feet, the second highest peak wholly in Switzerland. It dominates Fee on the east, while the name Mittaghorn is now given to a rocky point at the east edge of the great Fee Glacier.]

[2] [15,217 feet, the highest summit wholly in Switzerland.]

(nearly 14,000 feet)[1] is not overrated. Beyond the Dent Blanche appeared the elegant and commanding summit of the Weisshorn, whose height, recently determined by M. Berchtold of Sion, is 14,812 English feet,[2] and which sinks into comparative insignificance the Gabelhörner and other rugged mountains, which separate the head of the Val d'Anniviers from the Glacier of Z'Mutt. But amongst the objects nearer at hand, even the Dent Blanche was not the finest. Right opposite, separated from me just by the breadth of the Glacier of Z'Mutt, were the Mont Cervin and the Dent d'Hérens, the former of 14,766 feet,[3] the latter conjecturally 14,000 feet above the sea.[4] The unscaled and unscalable pyramid of the former is, beyond comparison, the most striking object in the Alps. The Dent d'Hérens forms distinctly a part of the same range, united by a continuous and inaccessible precipice, and they are not isolated and unconnected masses, as represented in Fröbel's map. To the westward were seen the mountain groups of the head of the Valpelline, —the Mont Collon, and the Pigno d'Arolla, the Dents des Bouquetins, and the seemingly interminable ice-fields over which (as I have said above[5]) a passage might possibly be effected to the Col de Collon, above which I thought that I perceived the Mont Gelé, near the Col de Fenêtre; but in this I might easily be mistaken. It is probable that the Mont Vélan and the Grand Combin might be seen in the same direction, but clouds rested on that part, and on that alone, of the horizon. I apprehend that Mont Blanc must be concealed by the mountains last named. To the north was the Glacier of Ferpècle, which we had ascended, stretched out in all its length, flanked by its aiguilles, and descending into the depth of the valley, in which we easily traced the village and church of Evolena, but Sion is certainly not visible.

Of all the views which I have seen in the higher Alps, none can compare with that from the Stockhorn[6] of the Col d'Hérens

[1] [It is really 14,318 feet.] [2] [It is really 14,804 feet.]

[3] De Saussure. M. Berchtold's measurement is not sensibly different—namely, 13,839 French, or 14,750 English feet, as stated by Engelhardt in the Proceedings of the Swiss naturalists for 1841. The numbers given in Engelhardt's *Naturschilderungen* are many of them inaccurate. [14,781 feet; it was not vanquished till 1865.]

[4] [13,715 feet.] [5] [See p. 278.]

[6] [Perhaps an even finer panorama may be gained from the easily accessible snowy pyramid of the Tête Blanche, 12,304 feet, to the south-west of the Col d'Hérens.]

(as I propose to call this pass, which has not yet received a name). The unequalled view of Monte Rosa, and the centrical position with respect to the three summits of the second (if not of the first) order, the Mont Cervin, Dent Blanche, and Dent d'Hérens, which seem all so near as almost to be tangible, are sufficient to mark its character. The Weisshorn and the Cima di Jazzi,[1] as well as Mont Cervin, all border on 15,000 feet; so that counting all the peaks of Monte Rosa but as one, we see at once at least five distinct mountains higher than the Finsteraarhorn, long esteemed the highest in Switzerland proper. Compared to the Col du Géant, the view is here more vast and savage, and the individual objects finer and closer; though the distant view of the chain of the Alps gives to the former a delightful and peculiar charm.

Before leaving this part of our description, I must say one word on the geography of this part of the chain. By Wörl's map, or that of Keller until the edition of 1842, it would appear impossible that such a pass can exist as that which I am now describing. The chain of Alps (I write with Wörl's map before me) is represented as turning from the Mont Cervin abruptly to the N.W.,—as including the Dent Blanche, at the southern foot of which the Valpelline is made to take its rise (!) and then, as bending back again towards the head of the Glacier of Arolla. Since the Dent Blanche is rightly[2] placed between the Glacier of Ferpècle and that of the Val de Torrent, it evidently would have been impossible to reach Zermatt from Evolena without crossing into Italy, and recrossing near the Mont Cervin. Now, without detailing other varieties of error, the reality is, that the main chain of Alps is here well defined, and nearly straight, extending from Mont Cervin through the Dent d'Hérens to the nameless[3] summits south of Mont Collon, and at the true head of Valpelline or Bionaz. The whole north face of Mont Cervin and the Dent d'Hérens is a united and inaccessible precipice,[4] which falls into the Glacier of Z'Mutt,

[1] [The Cima di Jazzi is but 12,527 feet; the Finsteraarhorn is 14,026 feet.]

[2] [Quite wrongly. The Dent Blanche rises between the Ferpècle and Zinal Glaciers; it is only the Grand Cornier (13,022 feet) to its north which overlooks the Val de Torrent.]

[3] [This refers to the range—the summit of which now possess so many names that great confusion has been caused—running from the Evêque towards the Mont Gelé. See p. 266.]

[4] [Both peaks have since been climbed from that direction, while two passes between them have been forced.]

which extends far to the westward of both,[1] not rising (as even Fröbel inaccurately represents it) immediately behind the Mont Cervin, but in the great ice-mass to the westward of the Dent d'Hérens. Now, just where the Glacier of Z'Mutt takes its rise, is the commencement of a great lateral chain on so stupendous a scale as to create little surprise that it has often been mistaken for the great chain. The Glacier of Ferpècle descends from its north-western flank, where it forms the Col d'Hérens and the Stockhorn, upon which we conceive ourselves stationed. It then expands itself into the mass of the Dent Blanche, which sends forth the ramifications of the Dents d'Abricolla and Zatalane,[2] which separate the valleys of Hérens and Anniviers. From the Dent Blanche the chain takes an easterly direction, forming the summit called Moming in Hérens, Triftenhorn at Zermatt (where the Dent Blanche is called Hovenghorn),[3] which separates the valley of Zinal and that of Z'Mutt. This part of the chain seemed to me quite impassable.[4] Then follow a range of peaks, called Gabelhörner,[5] which continue the chain in a north-easterly direction, parallel to the valley of St. Nicolas, until we reach the culminating point of the Weisshorn, a seemingly inaccessible peak of 14,812 English feet,[6] which is often mistaken for Monte Rosa, especially from the Gemmi Pass, whence it and the other parts of the chain just mentioned have been elaborately figured in von Welden's work (Plate IV.) as the *actual* chain of Monte Rosa, and received specific names accordingly, although the real Monte Rosa is some thirty miles distant, and wholly concealed![7]

It will thus be distinctly understood that the passage of the Col d'Hérens is not that of the great chain, but only of this ramification of it.

[1] [This is *not* so.]

[2] [The former summit is no doubt the Grand Cornier, 13,022 feet, and the latter the Zadelâno, 11,070 feet.]

[3] [*I.e.*, Hohwänghorn, a name now given to a neighbouring and lower point on the S. side of the ridge between the Dent Blanche and the Gabelhorn. Forbes probably took the name from Engelhardt's *Naturschilderungen* (pp. 225, 226), where it is applied to a far lower summit than the Dent Blanche, and is so marked on Engelhardt's 1840 map. Engelhardt, in his 1852 book (*Das Monte-Rosa Gebirg*, p. 185), says that Forbes really meant to give this name to the *lowest* slopes on the south towards the Dent Blanche, and marks it thus on his 1850 and 1856 maps.]

[4] [It is not so, however, in reality.]

[5] [The positions of the Gabelhorn, 13,364 feet, and the Moming or Zinal Rothhorn, 13,856 feet, are reversed, the former being the nearer to the Dent Blanche. There are *many* passes over the range between the Dent Blanche and the Rothhorn.]

[6] [14,804 feet, first scaled in 1861.]

[7] [*Not* from the Gemmi.]

M. Studer having taken his barometer with him to Anniviers, I had only the sympiesometer and the boiling-water apparatus to depend upon for the determination of the height. I consider the latter as the most certain, and as probably not erring more than 50 feet from the truth. It gave (by comparison with the barometer at Geneva) a height of 11,770 feet,[1] the temperature of boiling water being 192°·45 (or 191°·93 corrected), and that of the air 34°. I melted snow, and caused the water to boil with great ease, even at this height, and thus supplied the party with plenty of water to drink, which otherwise it would have been impossible to procure.

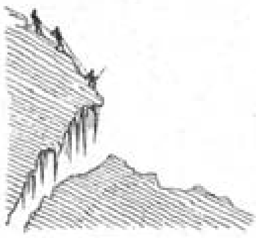
Stretched upon the snow, we made a hearty meal; and the hour and a half which I spent here in observing my instrument, taking magnetic bearings of the principal objects, sketching the outline of Monte Rosa, and trying effectually to impress upon my memory a scene which I scarcely expect ever to see equalled or under circumstances so favourable, went quickly by, when Pralong modestly invited me to depart, as our task was far from accomplished; indeed, as it appeared, the most difficult part was to come.

Our object was now to descend upon the Glacier of Z'Mutt, of which, as I have endeavoured to explain, and to represent upon the Topographical Sketch, No. VII., the lower or more level part swept along the base of the Mont Cervin and Dent d'Hérens, whilst a higher stage of it rose to the foot of the lofty precipice above which we stood. Now, whilst the *top* of this precipice sunk from the summit of the Stockhorn, westwards to the Col, and then rose a little, the glacier and the *foot* of the precipice rose rapidly and continuously to the westward, so that the top and bottom of the precipice became at length blended together, under a snowy sheet. To reach this point, however, would have been a long détour, and the glacier appeared dangerously crevassed. Having, therefore, descended from the Stockhorn [towards] the Col (which was not a great deal lower), Pralong proposed to attempt descending the cliff,[2] by which he recollected to have passed when he last crossed, and to have successfully reached the

[1] [Really 11,795 feet.]

[2] [This is probably the Wandfluhjoch, which was successfully forced *upwards* from the Z'Mutt Glacier by the present Editor's party in 1871. It is said that in 1851 this pass was made from Zermatt by the late Herr Alexandre Seiler (later the well-known innkeeper at Zermatt) the then Curé of Zermatt, and a young student from Sion: the party were without guides or local knowledge, and missed the right way over the Col d'Hérens owing to clouds (*Schweizer Alpen-Zeitung*, vol. i. p. 167).]

glacier below. We began cautiously to descend, for it was an absolute precipice: Pralong first, and I following, leaving the other guides to wait about the middle, until we should see whether or not a passage could be effected. The precipice was several hundred feet high. Some bad turns were passed, and I began to hope that no insurmountable difficulty would appear, when Pralong announced that the snow this year had melted so much more completely than on the former occasion, as to cut off all communication with the glacier, for there was a height of at least 30 vertical feet of rocky wall, which we could by no means circumvent. Thus, all was to do over again, and the cliff was reascended. We looked right and left for a more feasible spot, but descried none. Having regained the snows above, we cautiously skirted the precipice, until we should find a place favourable to the attempt.[1] At length, the rocks became mostly masked under steep snow slopes, and down one of these, Pralong, with no common courage, proposed to venture, and put himself at once in the place of danger. We were now separated by perhaps but 200 feet from the glacier beneath. The slope was chiefly of soft deep snow, lying at a high angle. There was no difficulty in securing our footing in it, but the danger was of producing an avalanche by our weight. This, it may be thought, was a small matter, if we were to alight on the glacier below; but such a surface of snow upon rock rarely connects with a glacier without a break, and we all knew very well that the formidable "Bergschrund," already mentioned, was open to receive the avalanche and its charge, if it should take place. We had no ladder, but a pretty long rope. Pralong was tied to it. We all held fast on the rope, having planted ourselves as well as we could on the slope of snow, and let him down by degrees, to ascertain the nature and breadth of the crevasse, of which the upper edge usually overhangs like the roof of a cave, dropping icicles. Were that covering to fail, he might be plunged, and drag us, into a chasm beneath. He, however, effected the passage with a coolness which I have never



PASSING THE BERGSCHRUND.

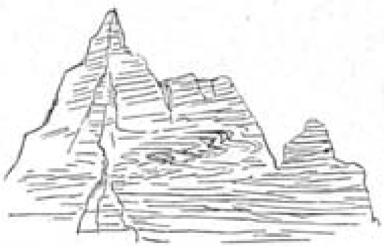
[1] Upon the rock whence we finally descended I left a bottle containing the names of the party.

seen surpassed, and shouted the intelligence that the chasm had been choked by previous *avalanches*, and that we might pass without danger. He then (having loosed himself from the rope) proceeded to explore the footing on the glacier, leaving me and the other two guides to extricate ourselves. I descended first by the rope, then Bionaz, and lastly Tairraz, who, being unsupported, did not at all like the slide, the termination of which it was quite impossible to see from above. We then followed Pralong, and proceeded with great precaution to sound our way down the upper Glacier of Z'Mutt, which is here sufficiently steep to be deeply fissured, and which is covered with perpetual snow; now soft with the heat of the morning sun. It was a dangerous passage, and required many wide circuits. But at length we reached in a slanting direction the second terrace or precipice of rock which separates the upper and lower Glacier of Z'Mutt,[1] and which terminates in the promontory marked Stockhi[2] in the map. When we were fairly on the débris we stopped to repose, and to congratulate ourselves on the success of this difficult passage. Pralong then said that he wished to ask a favour of me. To my astonishment, this was that he might be allowed to return to Hérens instead of descending the glacier to Zermatt. He was afraid, he said, of change of weather, and did not wish to lose time by going round by Visp. Of course I readily granted his request, and paid him the full sum agreed upon. To return all alone (and it was now afternoon) over the track we had just accomplished was a piece of spirit which would scarcely have entered the imagination of any of the corps of guides of Chamouni. I almost hesitated at allowing him to expose himself, but he was resolved and confident, and having given him most of the provisions, and all the wine, we saw him depart.

We had still a long, though not a dangerous, stretch of glacier before us. We had, in the first place, to descend the precipices behind the Stockhi to the lower level of the Glacier of Z'Mutt. Though steep, they were not dangerous like the last, and though the way was new to my companions as well as myself, we found no particular difficulty. We had now no alternative but to pursue the surface of the Glacier of Z'Mutt for several miles, which proved a fatiguing walk enough, the ice being intersected

[1] [The upper glacier now bears the name of Stock Glacier.]
[2] [The Stockje.]

by crevasses, and in many places almost covered with vast boulders. During this descent I had an opportunity of examining closely the structure of the Mont Cervin on this side, which probably no mineralogist has had before. There seems no reason to doubt that it is entirely composed of metamorphic secondary rocks. The lower part is of the system of *green slates,* which abound in this part of the Alps, and which here pass into serpentine and gabbro, as the moraines testify, the higher part of grey and *white slates,* remarkably contorted, and probably calcareous. The middle strata of the Mont Cervin appear to form, by their prolongation, the Stockhi on which I stood, and the Col d'Hérens and Stockhorn are composed of a repetition of the green slate, which contains so much felspar that it may be called gneiss. The whole height of the Mont Cervin, down to the level of the glacier, is one continuous precipice, which must be between 7000 and 8000 feet high.[1] The conformation of the Dent d'Hérens is similar to it.



MONT CERVIN FROM THE N.W.

The gradual appearance of the moraines upon the Glacier of Z'Mutt was very striking. I mean that they are slowly developed upon the surface of the ice, as I have described on the Mer de Glace of Chamouni. They come from many quarters, and with a prodigious volume; from the Dent d'Hérens, the Mont Cervin, the Stockhi, the Stockhorn, and from other promontories divided by glaciers which fall from the range of the Dent Blanche and Triftenhorn,[2] they accumulate at last upon so narrow a space of glacier as, from a distance, to appear to cover it entirely. The usual nearly longitudinal vertical structure was developed in the ice where we first descended upon it. Both banks of the glacier were too precipitous to attempt to climb them, and for a long way we had to pick our steps as we best could on the ice and among the moraines. At length we gained the right bank, not far above the first chalets of Z'Mutt,[3] with which I was already

[1] [It is really about 6200 feet.]
[2] [Really the Gabelhorn.]
[3] [Properly, the uppermost chalets on the Staffel Alp.]

acquainted by my visit of the previous year. Immediately after, we entered the larch woods, and crossed the river where a very deep ravine is spanned by a most picturesque and insecure bridge, which passes to the village of Z'Mutt on the left bank of the stream.[1] I walked very leisurely, enjoying the fine evening, and half an hour after reached Zermatt, where I took up my quarters in the clean house of the village doctor, named Lauber, which serves as an inn.[2] I arrived at half-past 5 P.M., or in somewhat less than thirteen hours, from Bricolla, including various halts.

[1] [The regular route now quits the Z'Mutt Glacier on the right bank, and passing by the Staffel Alp, joins the path from the St. Theódule.]

[2] [Early visitors to Zermatt—as to most other mountain villages—were received by the Curé; but in 1839 the local doctor—or rather bone-setter—opened a modest little inn, which was the sole resort of travellers in Zermatt till the Hôtel du Mont Cervin was opened in 1852. In 1854 he sold his house to M. Alexandre Seiler—who thus became closely connected with Zermatt, and the first inn at Zermatt still forms the nucleus of the Monte Rosa Hôtel, so well known to many generations of mountaineers.]

CHAPTER XVII

THE ENVIRONS OF ZERMATT

Valley of St. Nicolas from Visp to Zermatt—Torrents—The Bies Glacier—Position of Zermatt—Glacier marks on the rocks—Glacier of Gorner—The Riffelberg—View and bearings from it—Sketch of the geology of this part of the Alps—Simple minerals.

In 1841 I visited Zermatt, in company with Mr. Heath, by the usual route from Visp in the Rhone valley. It is about eight hours' walk; one and a half hours to Stalden, where the valleys of Saas and St. Nicolas separate (see the general map); two and half to St. Nicolas; two to Randa, and two to Zermatt.[1] Between Visp and Stalden the country is very pleasing, especially where the river is crossed at Neubrücke, whence there is a very fine view of a small portion of the snowy range which separates the valleys of Saas and St. Nicolas. Near Stalden are earth pillars, capped by boulders which have protected the soil beneath from the rain, which has washed all the neighbouring parts away, and left these standing, not unlike the marks left by workmen to show the extent of an excavation. Similar columns are likewise to be found near Useigne in the Val d'Hérens, at St. Gervais, at Botzen in the Tyrol, and near Molines in Dauphiné.[2] The

[1] By some strange oversight it is represented, as a feasible excursion, in both editions (1838 and 1842)[1] of Mr. Murray's valuable Hand-Book for Switzerland, to leave Visp in the morning and to cross the Pass of Mont Cervin (Col de St. Théodule) into Piedmont the same day. Now, the ascent of the St. Théodule from Zermatt is alone nearly five hours' heavy work (a rise of above 6000 feet[2]), so that were any luckless traveller to take this advice he would find himself, *after thirteen hours' walking*, in the midst of a vast glacier, 11,000 feet above the sea.[3]

[2] [Also in many other spots. There is a quaint view of the earth pillars of Useigne at the end of Fröbel's book.]

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[1] [The text is altered in the next edition, 1846.]

[2] [Precisely 5584 feet.]

[3] [Before 1891 this would certainly have been a *very* long day, but in that year a railway was opened from Visp to Zermatt (2½ hrs.), and this has increased the possibility of covering this considerable distance in a single day.]

boulders here seemed to be gabbro or diallage rock. From Stalden to St. Nicolas the valley is somewhat monotonous; but the Weisshorn is a striking object. I did not trace here any decided marks of glacier action.

Between St. Nicolas and Randa several wild and bridgeless torrents have to be crossed, which, in bad weather, must make this route nearly impassable. I noticed particularly the mode in which a violent torrent accumulates boulders, forming a mound of blocks on either hand, which serves, in some measure, to restrain its fury, whilst the level of its bed is continually raised by the detritus which it accumulates; and when, by extraordinary freshes, the barrier is broken, the country on either side is, of course, deluged. I only speak now of the wildest and most powerful torrents descending at a great angle, and which act sufficiently on blocks to roll them with the aid of gravity for a great way, and chafe them into irregularly rounded masses, with a noise which every one who has visited the Alps recalls as one of the most striking of natural sounds, accompanied, as it always is, with an impression of irresistible force. Now these rocky accumulations have a very striking resemblance to the moraines of glaciers, and this is a circumstance which it is well to be aware of, and which has not, I think, been prominently stated. In *form*, these mounds resemble moraines, the external, and even the internal, slope being in both cases usually determined by the *angle of repose* of the blocks. The *materials* of both are also alike;—angular blocks, more or less rounded by friction, never quite smooth or polished, angular gravel, and sharp sand. In the *disposition* of the materials, I have not observed that regularity of arrangement which is said to distinguish water-action from that of glaciers. On the contrary, the deposit of these torrents seems to be wholly devoid of layers of coarser or finer materials, and, as in true moraines, the largest blocks often lie uppermost. I may mention the great torrent descending from the Dent du Midi, which devastates the country above St. Maurice,[1] as another example of this.

The village of Randa lies amongst extensive meadows, and

[1] [This is probably an allusion to the great mud avalanche that descended from the Dent du Midi in 1835, and laid waste the region between St. Maurice and Evionnaz. But this had nothing to do with a torrent. Forbes perhaps means the St. Barthélemi torrent which descends from the Dent du Midi to the Rhone valley close to Evionnaz.]

although on the opposite side of the valley from the Bies Gletscher, descending from the Weisshorn (which is now left behind on the right), it has twice materially suffered from the lower part of that glacier giving way and filling up the whole bottom of the valley, in 1737 and 1819.[1] Above the village of Täsch the valley contracts, and a rocky barrier has to be surmounted. From thence a grand view of the Mont Cervin opens; and soon after the village of Zermatt, charmingly situated in a green hollow, well flanked with wood, and enclosed by snowy summits, comes into view. It is at the rocky barrier just mentioned that I noticed the first clear traces in this valley of ancient glacier action in the polishing and striating of the surfaces,—a remarkably well defined result, which may be traced at intervals up to the very foot of the glacier. These striæ were distinctly found by M. Agassiz in 1839, under the glacier itself. This is one of those cases in which it seems impossible to deny this to be a conclusive proof of the ancient extension of the ice.

The village of Zermatt (called Praborgne, in Piedmont) is near the union of three glacier-bearing valleys,—the main valley, at the head of which is the great Glacier of Monte Rosa, called also the Glacier of Gorner, or Glacier of Zermatt; the valley immediately to the east, which contains the Glacier of Findelen, descending from the Saasgrat; and that on the right, or to the west, headed by the Glacier of Z'Mutt.

The river Visp takes its rise in these several valleys, and especially from the great Glacier of Monte Rosa, where it issues, as usual, from a cavern in the ice. I measured its temperature in 1841, at different points of its length, which I found to be:—

Under the glacier	33·3° F.
At Zermatt	35·5
One hour below S. Nicolas	41·0
Half an hour below Stalden	43·0

The great Glacier of Monte Rosa terminates at present about three miles above Zermatt. The lower part is too steep to be ascended,[2] and it presents the phenomenon of conoidal bands, not only falling forwards until the frontal dip is nothing, but actually sloping outwards as in glaciers of the second order. It rests on

[1] Engelhardt, *Naturschilderungen*, pp. 175, 176; and Agassiz, *Études*, p. 158.

[2] [The icefall *can* be forced, but the glacier has retreated much since Forbes's time.]

serpentine and talc slates, and these rocks present exquisite proofs of glacier polish on the sides of the Riffelberg up to a very considerable height above the western bank of the glacier. Its breadth is here not great, and the surface is crevassed in a remarkable manner, as it rounds the promontory of the Riffel, like the rays of a fan, which M. Agassiz has well represented in his Atlas, as well as the medial moraines on its surface (which are numerous and well defined), and their origin at the rocky promontories separating the glacier streams which descend from the Breithorn, the Lyskamm, and Monte Rosa. It is difficult to ascend the rocks on the eastern bank of the glacier, but it is possible; and when the upper surface of the ice begins to be commanded, there are one or two ruined huts in which a shepherd seeks a temporary shelter, and which may serve as a landmark. Near this the serpentine rocks are beautifully excavated in nearly horizontal striæ, whilst below, in the immediate neighbourhood of the ice, I found not only grooves but scratches well marked on the serpentine and talc slates. These scratches visibly crossed one another in two series, *under a considerable* angle, and this must be recent work, because the weather soon wears this rock.

When the upper level of the glacier is viewed, either from the Riffel or from the path up to the Col of Mont Cervin, it presents a noble scene. It is a very vast ice river, whose surface, at the height from which it can be most conveniently observed, appears nearly even, though diversified by fissures and by structural bands like those on the Mer de Glace, which, so far as I can judge from the general view which I obtained without walking over it, are most distinct upon the southern half, and present complete loops bounded by the medial moraine, whilst the northern half (I mean of the breadth of the glacier) has probably a similar structure, although less distinct, and in one part, near the foot of Monte Rosa, is evidently much contorted. The tributary glaciers descending from the Breithorn have also a well-developed system of bands, quite normal.

But the Riffelberg may be more easily ascended by its northern slope; there are, indeed, several paths, but it is a stiff walk of nearly three hours from Zermatt.[1] The view corresponds

[1] [Now there is a railway from Zermatt past the Riffel—with its two inns, built in 1854 (Riffelhaus) and 1884 (Riffelhalp) respectively—to the Gornergrat. It should be remembered that early travellers did not go beyond the ridge at the east

to that of the Montanvert of Chamouni. Though much more vast, I doubt whether the impression of this glacier, and the chain beyond, is altogether so interesting as the other. Monte Rosa is, indeed, very high, and very large, but it presents too many points and too many masses of nearly equal height; the view wants concentration and variety of form to make a picture. I except, however, the Mont Cervin or Matterhorn, which is seen from hence, but in an opposite direction from Monte Rosa, and which I have already noticed as beyond comparison the most striking natural object I have seen—an inaccessible obelisk of rock, not a thousand feet lower than Mont Blanc![1] The summits of Monte Rosa, distinctly seen from the Riffelberg, are the "Nord End" and "Höchste Spitze" of von Welden's map; then follow to the westward the somewhat heavy looking range of the Lyskamm and Breithorn,[2] terminating in the Petit Mont Cervin and Col de St. Théodule, a snowy chain of 11,000 feet, which is connected with the Mont Cervin. To the west is perfectly well seen the Glacier of Z'Mutt, the Col d'Hérens, and the range of the Hovenghorn (Dent Blanche), and Gabelhörner as far as the Weisshorn.[3] To the north is the lateral, though very elevated and all but impassable, range which separates the Valley of Saas from that of St. Nicolas, which is called the Saasgrat, and of which the culminating point is (according to Berchtold of Sion) no less than 14,574 feet above the sea.[4] It is, I believe, variously called by different writers and guides, the Dom, Montagne de Fée, Mittaghorn, and perhaps by some erroneously, Cima di Jazzi. Nearer at hand are the Strahlhörner, and close to the north foot of the Riffel is the Glacier of Findelen, already mentioned, which unites to the eastward with the great Glacier of Monte Rosa, and which must be ascended in order to reach the Weiss Thor, a very remarkable pass leading to Macugnaga, which I shall mention later. Though the

foot of the Riffelhorn, the first to push on to the summit of the Gornergrat being apparently Sir John Forbes in 1848.]

[1] [The Matterhorn is 1001 feet lower than Mont Blanc. It was first conquered in 1865, and is now often scaled. There is a wild idea of constructing a railway to the summit.]

[2] [The Twins, between these two summits, are omitted.]

[3] [The Zinal Rothhorn rises between the Gabelhorn and the Weisshorn. For the Hohwänghorn see p. 303 above.]

[4] [The Dom is really 14,942 feet. For the Mittaghorn see p. 300 above. Of course the Saasgrat has nothing to do with the distant Cima di Jazzi.]

Glaciers of Findelen and Gorner have thus a common origin, the former has been retreating (at its lower end), the latter advancing for many years; this is a difficulty of which I know no plausible explanation. Peter Damatter, my guide both in 1841 and 1842, asserts positively that the Glacier of Gorner advances in winter, and *more* in winter than in summer; but by this is to be understood that the lower extremity advances faster into the valley; being, of course, protected from thawing influences, its advance would be more perceptible. Upon questioning him closely, he declared that he had seen the glacier press on the snow before it; and that, in January, 1840, in particular, it had advanced towards a fixed mark no less than 50 *Klafter* (fathoms) in three weeks; a result, however, which we must be allowed to doubt.

The top of the Riffelberg is a peak, or "horn,"[1] as it is called in German[-speaking] Switzerland, which long passed for inaccessible, as no guide at Zermatt had attained it. In 1841 I attempted it by the western side, and arrived within a few fathoms of the top, when I was stopped by a cleft and a precipice, which was not to be ascended without incurring a needless risk. In 1842, however, some English students at Hofwyl,[2] clambering about the rocks, found a circuitous path on the eastern side, by which the top may be gained without much difficulty. I, accordingly, mounted it with Damatter, who had learned the way, and proceeded to take some bearings from the summit, which is a narrow rugged space. At first I thought Kater's compass pointed wrong; the sun, which was near setting, appeared due north. Then I took another compass and got the same result. It was clear that there was an enormous local attraction of the hill on the needle. We would charitably wish this to be considered as a possible explanation of some portion of the inconceivable errors of the more esteemed maps of this part of the Alps; errors which something like an oversight of 60°, as in the present case, would alone seem capable of accounting for. I shall, however, preserve the bearings I took, including an azimuth of the sun, which may serve to correct the others, and

[1] [The Riffelhorn, 9617 feet.]

[2] [Fellenberg's famous school, near Münchenbuchsee, not far from Bern. But in Part III. below, p. 497, Forbes gives a different account of the conquest of this summit.]

which may possibly be of use. They are expressed in degrees, round the circle, from N. by E.

BEARINGS FROM RIFFELHORN.

Stockhorn (Col d'Hérens)	$5\frac{1}{2}$°
Dent Blanche (Hovenghorn)	23
Triftenhorn (Moming)[1]	54
Weisshorn	70
Mont Fée ? (Saasgrat)[2]	139
Monte Rosa (Höchste Spitze)	204
Petit Mont Cervin	$289\frac{1}{2}$
Sun's azimuth, 21st Aug. 1842, 4 h. 34 m.	349
Mont Cervin	351

Now, the Riffelhorn bore $120\frac{1}{2}$° from the Stockhorn. Supposing that observation correct, the Stockhorn ought to have borne $300\frac{1}{2}$° from the Riffel; but it appeared to bear $5\frac{1}{2}$° (or $365\frac{1}{2}$°), consequently the local error was 65°! It appears, therefore, that the slaty beds of the Riffel are highly magnetic, probably from octohedral iron, which is found in large crystals on the neighbouring Glacier of Findelen.

I take this occasion of adding a few remarks upon the relations of the rocks in this part of the Alps, which have been only incidentally mentioned. In doing so we must carefully distinguish statements of facts from theoretical statements. The former include the general distribution of rocks of certain mineralogical characters throughout the chain, as for instance granites, and the position and arrangement of the stratified rocks connected with them. The nomenclature of these rocks, and the limits of formations, may at present be considered as in some degree hypothetical.

The granite of the Alps appears at intervals along the chain as if it were continuous below, but breaking forth only here and there, and affecting various other rocks with which it is intermingled, constituting, as M. Studer has most prominently brought into notice, a series of distinct centres, rather than long lines or axes of elevation. At the same time, we undoubtedly find a linear arrangement amongst these granitic groups, and frequently indications of true granite where the rock does not occur in mass, as in the granite veins of the higher part of the Valpelline, and of the valley of Arolla, and at Vallorcine. It is

[1] [The Zinal or Moming Rothhorn.]
[2] [The Dom, the highest point of the Mischabelhörner.]

not unfrequent that a secondary or parallel outburst of granite takes place, so that the chain appears to have two if not three axes. This is well marked in the range of the Aiguilles Rouges, near Chamouni, and something of the same kind will probably be found in the Val de Bagnes, the head of the Val d'Anniviers, and in the valley of Saas. M. Studer has indeed mentioned the Dent Blanche as a granitic centre. I do not recollect to have seen granite blocks on the Glacier of Ferpècle, but I cannot be certain. The Stockhorn is certainly slaty. Now, though slaty rocks containing felspar are often in contact with Alpine granite, it is impossible to consider them as representing universally the gneiss formation of other countries. In the first place, the granite as often, or oftener, *overlies* the slate than the contrary. These slaty rocks may be distinguished by mineralogical character, but scarcely by any other. They are quartzose, or micaceous, or calcareous, or contain serpentine, and are in colour white, grey, black, or green, and these colours are amongst the most distinctive characters which they present. Thus, there are the black-slates of Fiz and the Bonhomme, near Chamouni, while the greater part of the mountains we have lately been describing are composed of regularly stratified alternations—felspar-slate, (gneiss), quartz-slate passing into quartz-rock, talc-slate (*schistes verts*), passing into serpentine and diallage, and calcareous slates passing into dolomite, which last occurs in several repetitions in the section of strata formed by the valley of the Visp (or Viège). The talc-slate also passes into pot-stone, which is worked near the town of Viège (Visp), and above Evolena. The Col d'Hérens is a felspathose slate or gneiss; the Stockje is a white quartzose slate, probably containing lime, and this appears to constitute the whole of the higher part of the Mont Cervin, whose unapproachable precipices will for ever prevent the geologist from a nearer survey. I have already said that the middle strata are contorted, and probably calcareous, and that the lower part, together with the Hirli[1]—an accessible promontory at the foot of the pyramidical part on the side of Zermatt—is composed of the green slates passing into serpentine and gabbro. The mineralogical descriptions of De Saussure of this part of the Alps are intelligible and exact, and, with the exception of his attempt to classify the rocks amongst the regular primary deposits, may be

[1] [The Hörnli, 9492 feet. The name Hirli appears on Engelhardt's 1840 map.]

considered to be nearly as precise as any that could now be given. For the sake of condensation, I may add that the Riffel, and nearly all the chain of Monte Rosa, are composed of similar beds, which generally rise towards the eastern points, on the north side to the south-east, on the south side to the north-east. De Saussure says distinctly that the beds of the Mont Cervin rise to the north-east at an angle of 45°; my impression was that they are less inclined or nearly horizontal—but De Saussure is no doubt correct.[1] His opinion of the arrangement and materials of the beds composing it I find to coincide accurately with my own observations on the spot.

The highest part of Monte Rosa, judging from specimens brought from the last accessible point by M. Zumstein, is mica-slate. The whole system of Monte Rosa, as already said, rises to the east, and the first regularly crystalline rocks we meet with are near the Pizzo Bianco, above Macugnaga, which will be mentioned farther on. With respect to the age of these various rocks, few geologists are as yet disposed to decide with much confidence. I have already observed[2] that the division between true primitive gneiss and mica-slate, and rocks of the same mineral character, which may be traced continuously into beds containing lias fossils, seems to be an arbitrary distinction, and one upon which no two observers could exactly agree. The age of the felaspathic and micaceous slaty rocks may be considered as open to discussion. The others—namely, the grey and green slates which I have described, are included by M. Studer under the general name of *Flysch*, a widely spread formation in Switzerland, but whose superposition is too irregular and uncertain, and the series of formations too imperfect to afford any clue to its age, whilst the one or two fossils which have been found in it seem to point to an age newer than the lias, and older than the medium chalk formation. What an overturn of all ancient ideas in geology, to find a pinnacle of 15,000 feet high,[3] sharp as a pyramid, and with perpendicular precipices of thousands of feet on every hand, to be a representative of the older chalk formation! and what a difficulty, to conceive the nature of a convulsion (even with unlimited power) which could produce a configuration like the Mont Cervin rising from the Glacier of Z'Mutt.[4]

[1] *Voyages*, § 2243. [2] Page 273. [3] [14,781 feet.]
[4] I am happy to learn from M. Studer, that he has at length completed a first

Some pretty minerals are collected near Zermatt, principally from the moraines of the Glacier of Findelen. The most remarkable is one of the talc family, a silicate of magnesia called *Pennine*, which occurs well crystallised in talc-slate. It is blackish green by reflected light, and by transmitted light it is dichroitic, being of a brown orange in one direction, and of a bright green in another. On the Riffel, I found a large vein of an imperfectly characterised mineral, which M. Studer considers to be a variety of kyanite. A considerable variety of garnets, particularly the black kind, are found at Findelen, as well as octohedral iron.

approximation to a geological map of the Swiss Alps, the result of twenty years' observation. [This map (scale 1/380,000) appeared at Winterthur in 1853, and a second edition in 1867. Studer was aided by A. Escher.]

CHAPTER XVIII

FROM ZERMATT TO GRESSONEY BY THE COL OF MONT CERVIN (1842)

Detainment at Zermatt—Ascent to the pass of Mont Cervin—The Col—Fortifications—The descent—Highly electric state of the atmosphere—Custom-house officers—Breuil—Val Tournanche—Chamois—Col de Portola—Val d'Ayas—Brusson—Col del la Ranzola—Arrival at Gressoney—M. Zumstein.

Never till now,
Did I go through a tempest dropping fire.
* * * * * * *
A common slave—you know him well by sight—
Held up his left hand, which did flame and burn
Like twenty torches join'd, and yet his hand,
Not sensible of fire, remain'd unscorch'd.
Julius Cæsar, Act i. Scene 3.

IN 1841 I had been prevented from crossing the celebrated pass of Mont Cervin along with my friend, Mr. Heath, and in 1842 another accident threatened again to make Zermatt the limit of my journey. A trifling injury to my foot, received on the Mer de Glace at Chamouni, and which had not appeared to get worse during the severe walking which I had since performed, assumed a more serious appearance during a day or two of comparative repose which I passed at Zermatt, waiting for M. Studer's arrival from Visp. I became a close prisoner, for nearly a week, at the little inn at Zermatt, where I was fortunate in finding much comfort and attention from the worthy Madame Lauber. The weather had altered for the worse, which diminished my regret at the detention, and I had the advantage of M. Studer's company. My friend was, however, resolved to lose no more time than the weather rendered necessary in resuming his journey, and as my foot was now convalescent, I consented to accompany him, on a morning of somewhat doubtful promise, when we were called by the faithful Glaus, whilst the stars were still shining bright through the wild drift of cloud. The impatience of the guides on such occasions is not the least of the evils of detention. My Savoyard, who spoke not a word of German, pure or impure (and nothing else was understood at Zermatt[1]), suffered the horrors of *ennui* to an extent which might be thought to belong exclusively to the loungers of our great cities; and but for a small speculation in the minerals of Findelen, which he fully counted upon disposing of with a profit of 200 per cent at Chamouni, he very probably would have insisted on walking off to enjoy the daily fund of summer's gossip of his native valley.

We set forth about half-past 4 A.M., and having crossed the torrent of Z'Mutt, wound slowly up the steep pastures which skirt the western edge of the Gorner Glacier. We gradually attained a considerable elevation above its surface, before crossing another torrent, which descends from the Boden-Gletscher,[2] which we left upon our right. In the preceding year I had ascended thus far, and crossed the Boden Gletscher to the foot of the Hirli,[3] where there is a gloomy *tarn* called the Schwarz See, beyond which is a fine view of the northern precipice of the Mont Cervin, and of the Glacier of Z'Mutt. Those who do not propose to pass the Col of St Théodule may thus make a very interesting excursion, and return by the chalets of Z'Mutt. Now, however, we kept right onwards, and a little after seven we reached the edge of the glacier which we had to traverse. Its surface is tolerably level, it is very extensive and desolate, not being included between bold walls as in the lower glaciers, but occupying a sort of vast table-land, at an average height of nearly 10,000 English feet above the sea. We had an opportunity of appreciating its desolation, for we were repeatedly enveloped in the rolling mists which swept over the Col, and which appeared to boil up tumultuously from the side of Italy, which we were approaching, and to be repelled on the Swiss side by the north wind. This wind secured us a fine view of Monte Rosa, and of the chain of the Weisshorn; but I learned nothing new of the topography of either from this point, nor does the panorama admit of comparison with that from the Col d'Hérens. Even the Matterhorn (Mont Cervin), which, however, we saw imperfectly,

[1] [This is very far from being the case now.]
[2] [Now known as the Furgg Glacier.] [3] [The Hörnli.]

loses its apparent height, since here it rises only from the ridge, already at a height of 11,000 feet. Having walked already for a long time over snowy flats, we entered a kind of defile as we approached the Col. The mists closed round us, and a stranger might very easily have entirely lost his way, for the defile presented many accessible points; our guide, Damatter, however, took the matter very coolly, and brought us safely to the Col. The weather was damp and raw, and we had no view. We had been five hours and a quarter constantly ascending from Zermatt. We hastened to observe our instruments. The temperature of the air was 35° Fahrenheit, and the barometer stood at 511·53 millimètres, $3\frac{1}{2}$ millimètres above what I had observed it at the Col du Géant. The height above the sea comes out 10,938 English feet,[1] by a comparison with the barometer, both at Geneva and St. Bernard.

The Col du Mont Cervin, or St. Théodule, consists of felspar slate or gneiss, and exhibits well preserved traces of a rude fortification, called "Fort du Saint Théodule."[2] De Saussure says (§ 2220) that it was erected two or three centuries ago by the inhabitants of Aosta, to prevent an invasion of the Vallaisans. "Ce sont," he adds, "vraisemblablement les ouvrages de fortification les plus élevés de notre planète. Mais pourquoi faut-il que les hommes n'aient érigé dans ces hautes régions un ouvrage aussi durable que pour y laisser un monument de leur haine et de leurs passions destructives?" Certainly there is nothing more jarring to the impressions of stern grandeur and vast solitude than the not unfrequent occurrence of military works in any parts of the Alps,—

> "High heaven itself our impious rage assails;"
>
> [HORACE, *Odes*, i. 3.]

the pass of the Col de la Seigne, at the head of the Allée Blanche, and more than one of the very savage Cols near Monte Viso, bear witness to this strange anomaly.[3]

We were disappointed of the fine view which we ought to have seen towards Aosta. Fortunately the clouds cleared so far

[1] [Really 10,899 feet. There is now an inn on the rocks of the pass itself.]

[2] [St. Théodule is the patron saint of the Vallais, and the pass is now commonly called the "Col de St. Théodule." The fortifications were really erected in 1688, by order of the Duke of Savoy, who was endeavouring to prevent the "Glorieuse Rentrée" of the Waldensians from Switzerland into their native valleys.]

[3] [Since 1842 many Alpine passes have been disfigured in this hideous fashion.]

as to let us see our way across the remaining part of the glacier on the Italian side, which is much steeper than the other, and consequently traversed by extensive rents, which being covered knee-deep with snow freshly fallen during the last few days of bad weather, were, in some places, not a little dangerous. The pass of the Mont Cervin appeared to me, on the whole, a more considerable undertaking than I had expected. Knowing that it is frequently traversed in favourable seasons by horses and mules, I expected to have found the glacier both shorter and easier. This season, indeed, no beast of burden had crossed, and it appeared almost inconceivable how they ever could; but such is certainly the fact, and we saw more than one trace of animals which had perished in the passage. Another circumstance which led me to expect an easier passage than we found it, was the ludicrous outfit of our friend Peter Damatter, the guide of Zermatt, who, instead of bringing a good ice-pole and cord, as he ought to have done, being aware of the fresh snow, had provided himself merely with an umbrella. He was glad to borrow a stick from one of the party to sound his way on the Italian side, although we alleged that he used it with little dexterity; but the snow was literally knee-deep, and we encountered several wide crevasses, into one of which Tairraz had almost fallen, although he was the last of the party who had trodden in the guide's footsteps. Had he unfortunately done so, we should have had difficulty in extricating him for want of a rope. When he recovered his footing, he looked as pale as a sheet, but proceeded quietly.

At length we were free of the glacier, and recovered a track by no means obvious, which leads to the chalets of Breuil, leaving upon our left hand the longer and more difficult route by the Cimes Blanches, conducting to St. Giacomo d'Ayas. The atmosphere was very turbid, the ground was covered with half melted snow, and some hail began to fall. We were, perhaps, 1500 feet below the Col, or still above 9000 feet above the sea, when I noticed a curious sound, which seemed to proceed from the Alpine pole with which I was walking. I asked the guide next me whether he heard it, and what he thought it was. The members of that fraternity are very hard pushed indeed, when they have not an answer ready for any emergency. He therefore replied with great coolness, that the rustling of the stick no doubt proceeded from a worm eating the wood in the interior! This answer did not appear to me satisfactory, and I therefore applied the *experimentum crucis* of reversing the stick, so that the point was now uppermost. The worm was already at the other end! I next held my hand above my head, and my fingers yielded a fizzing sound. There could be but one explanation — we were so near a thunder cloud as to be highly electrified by induction. I soon perceived that all the angular stones were hissing round us like points near a powerful electrical machine. I told my companions of our situation, and begged Damatter to lower his umbrella, which he had now resumed, and hoisted against the hail shower, and whose gay brass point was likely to become the *paratonnerre* of the party. The words were scarcely out of my mouth when a clap of thunder, unaccompanied by lightning, justified my precaution.

At length we got below the level of the clouds, and the first shelter we reached was the wretched retreat of two Sardinian *douaniers*, who had lighted a fire under a portion of the remaining arch of what had once been a pretty solid edifice, probably a cowhouse; stones being plentiful, and wood the reverse, this mode of roofing had been adopted. They received us with civility, and allowed us to dine by their fire; and as we had been on foot for eight hours, we were entitled to some repose. The absolute discomfort in which this class of men live is greater than in almost any other profession, Hard diet, constant exposure, sleepless nights, combined with personal risk, and still more galling unpopularity, great fatigue, and perpetual surveillance, are the ordinary accidents of their life. Liable to suspicion when they quit the wildest and most inaccessible parts of the chain where a smuggler may by possibility pass, posted for hours together on a glacier 9000 feet above the sea, and, like animals of prey, taking repose during daylight in some deserted hovel— one cannot but conclude the smuggler's life to be luxury compared to the protracted sufferings of their detectors. On many frontiers the *douaniers* are a slovenly and self-indulgent race; but on others I know that this is no exaggerated picture of their lives, even in the finest season of the year.

We descended to Breuil, a group of chalets[1] pleasingly situated at the first green level in the valley, where we arrived

[1] [Rather above them there is now an excellent hotel.]

at two o'clock, having stayed an hour with the *douaniers.* The scenery of the head of the Val Tournanche, in which we now found ourselves, is very striking. The Mont Cervin, which owing to the clouds we saw imperfectly, is the most conspicuous object, and next to that the excessively rugged range which stretches away from the Dent d'Hérens as a centre, and forms the boundary between the Valpelline and Val Tournanche; the Dent d'Hérens itself rose in terrible majesty. We noticed what appeared to be an ancient moraine descending from between the Mont Cervin and the Col we had passed, exactly where, according to the general belief, the former passage existed,—namely, close under the Mont Cervin itself.

We performed the road from Breuil to the village of Val Tournanche leisurely, having the afternoon before us. In one place the valley becomes contracted, and the torrent dashes through a picturesque ravine,[1] which exhibits distinct traces of glacier action as well as the friction due to water. Transported blocks are not numerous. Below this occur the first permanent habitations, and Val Tournanche itself, which would be a pretty village anywhere, seems a paradise to one descending from such savage scenery as we had left. The valley, though narrow, and partly bordered by precipices, has yet an undulating grassy bottom, with well watered meadows. The heights are clothed with pines, and the cottages peep out through walnut trees, as well as the spire of the village church, which has an Italian character. There is no inn,[2] but we were received and hospitably entertained by the Receveur des Douanes, with whose subordinates we had dined.

Next morning we proceeded to cross the lateral chain which separates the Val Tournanche from the valley of Ayas or Val Challant,[3] to which, as has been already said, there is a direct passage from the Col of St. Théodule. This is the first of a series of ridges which require to be passed in succession by one who would make the circuit of Monte Rosa. These lateral passes, though none of them difficult, are generally steep and fatiguing, and render this expedition a far more serious one than

[1] [The "Gouffre des Busserailles," which has now been made accessible.]

[2] [There is now a very pleasant little mountain inn here. The village is just 5000 feet in height.]

[3] [Properly the Ayas valley is called "Val Challant" only below Brusson.]

the circuit of Mont Blanc. There are usually several passes of these ridges: in the present case, having accidentally met with the Curé of a parish which lay in the way of the pass to Ayas, we left Val Tournanche, in company with him, at seven o'clock A.M., and descended the valley a little way farther; we then took a footpath to the left, and soon found ourselves in a wood, which covers the precipices of that part of the valley. Our Curé was a stout walker, and a useful guide, for our footpath (which was a *short-cut*) soon split into numberless tracks, and as we gradually got amongst the rocks, we were glad that we were not left to waste time by discovering a way for ourselves. We ascended gradually higher and higher, and all the while, as we walked parallel to the course of the valley, the torrent was working itself deeper and deeper, so that from each fresh crag we found a greater interval between us and it, until at last, turning a rock, we stood above a precipice at least 2000 feet high, to which here and there a clinging pine seemed to give more steepness, by offering a scale for measuring the abyss. This point gained, we rejoiced in the beauty of the morning, and of the herbage spangled with drops from the early mists; and as we turned round we saw behind us the Mont Cervin rising in unclouded grandeur. We then passed from rock and wood to an open Alpine pasturage, which seemed cut off by these precipices from the world beneath, and here was the home of our Curé, a little village, appropriately named Chamois, one and half hour distant from Val Tournanche.

From thence, a gentle though pretty long ascent took us to the Col de Portola, composed of limestone, and very precipitous on the eastern side, where it immediately overlooks the village of Ayas. The height of the Col, by M. Studer's observation, is 7995 feet, and that of Chamois 6004 feet above the sea.[1] The descent presented no difficulty, and from Ayas two hours' pleasant walk took us to Brusson. In the course of it we crossed a singular tract of country. It was evidently the site of a lake which had been formed by the damming of the waters by a tremendous landslip which had taken place from a mountain on the right. At first we thought it a moraine, but we saw evidently that it was but a current of débris which had descended from the neighbouring hill, disengaged, like that of

[1] [The Col is really 7924 feet, and Chamois 5955 feet.]

Goldau, probably by the force of water. The scale of it is immense.

We arrived at Brusson soon after three, and thought of going on to Gressoney, which would have been quite practicable. The beauty of the spot, however, tempted us to remain, notwithstanding the indifferent accommodation which the Lion d'Or offered; but, after all, we might have been much worse lodged. The village is beautifully situated on a frequented mule road from Châtillon to Gressoney, by the Cols of Joux and Ranzola; the lower part of the valley also communicates with the valley of the Doire at Verrès. It appears, however, to be shut in by the highly picturesque mass of Mont Néri,[1] a dark mountain, with snow lying in its higher ravines, and which, from its general character, is probably in geological relation with the mountains of Champorcher on the other side of the great valley.

The next morning was beautiful. It was Sunday, and as we slowly ascended the heights above Brusson, we met numbers of peasants descending to church, who greeted us in French patois. After $2\frac{1}{2}$ hours we reached the Col della Ranzola, which was higher than we expected, being 7136 feet above the sea, whilst the level of Brusson is 4431.[2] It is a narrow opening in the ridge, from whence we suddenly obtain a view of the deep and narrow Val de Lys, and, soon after, of the village of Gressoney. As usual (owing to the general western dip of the strata), the east side of the Col is steep. Right opposite we observed the Col of Valdobbia leading from the Val de Lys to the Val Sesia. We ought to have enjoyed a view of Monte Rosa; but though the weather was fine, the mountain remained veiled in clouds. A rapid descent brought us, in about an hour, to the village of St. Jean de Gressoney, the principal place in the valley, where we at once perceived, by the appearance of the people in their Sunday costume, as well as their language, that we were amongst a new race. In fact the Val de Lys, and part of the neighbouring ones, are inhabited by a German-speaking colony. We arrived at comfortable quarters, *chez* Luscoz, in good time for the mid-day meal, and disposed ourselves to remain

[1] [Also called the Bec de Frudière, 10,073 feet. It commands a very fine panorama.]

[2] [The Col is 7123 feet, and Brusson 4370 feet.]

there for the rest of the day. Everything betokened German neatness and order, and in a very short time what appeared to us a sumptuous meal was set on the table, at which sat our host, himself the representative of one branch of the family of Luscoz, one of the most dignified of the valley, and whose stately portraits, mingled with those of the reigning sovereigns of their time, graced the walls of the old baronial-looking hall with huge stone-arched fireplace, and numberless windows, in which we sat. The women, as usual, wore the more characteristic costume, and especially the caps of gold tissue, so common in some parts of Germany. The familiar language talked at table was German, though probably all the natives present could talk more or less French and Piedmontese. We were received with courtesy, and entertained less as guests at an inn than as at a private house, and we found that the charges bore a proportion to the favour thus conferred on us. Nevertheless, in such situations a traveller is generally willing to purchase unusual comforts at a higher rate. An intelligent old man sat next M. Studer, and, after a little conversation, he turned out to be M. Zumstein, the well-known ascender of Monte Rosa,[1] whose acquaintance we had been prepared to make. He entered readily into conversation. When, after dinner, I handed him a letter which had been sent to me by the ever friendly care of the Chevalier Plana of Turin, he at once offered to devote himself to our service during our stay in the Val de Lys, and to accompany us to the glacier.

In pursuance of this plan, we proceeded next morning to Noversch, where M. Zumstein lives, forty minutes' walk above St. Jean, proposing to visit the glacier at the head of the valley, and to cross the Col d'Olen to the Val Sesia next day. But the weather was too unfavourable. The clouds which had hung over Monte Rosa for two days now descended into the valley, and by the time we reached M. Zumstein's house, it rained heavily. We therefore paid him a long visit, and obtained some particulars respecting his journeys. His barometer, compared with M. Studer's, gave (29th August, 11 A.M.)—

[1] [This refers of course only to the *third* peak of Monte Rosa, the Zumsteinspitze, 15,004 feet, first reached by Zumstein in 1820. The highest summit of Monte Rosa, the Dufourspitze, 15,217 feet, was not attained till 1855, and the second, Nord End, 15,132 feet, not till 1861. In 1842, therefore, no one had been higher on Monte Rosa than Zumstein.]

	Fr. inch.	Lines.		Millimètres.
M. Zumstein's	23	7·8	=	640·5
M. Studer's				640·4
Temperature of boiling water (uncorrected) . .				204°·20 F.

In the afternoon M. Studer and I walked down the Val de Lys about five miles below St. Jean. We quitted the green slates and serpentine, which are the prevailing rocks of Gressoney, and found hornblende slate with granite veins; the hornblende contains garnets, which are very characteristic of the mountains of Cogne, with which probably the Mont Néri is geologically connected. We also observed well-characterised *roches moutonnées*, where the valley contracts into a narrow ravine, and its level suddenly falls. In general, blocks transported from any considerable distance are rare in this valley. We returned to St. Jean to dinner, and M. Zumstein spent the evening with us. M. Studer resolved not to wait any longer for fine weather, and to cross at once to the Val Sesia. I was unwilling, however, to omit examining the Glacier of Lys, and as our routes were to separate, at all events, very shortly, he keeping the southern side of the Alps, and I returning by Monte Moro into Switzerland, we determined, though with regret, to part here. The day was finer than the preceding ones, though clouds still lowered. M. Studer crossed the Col de Valdobbia, whilst I reascended the valley to Noversch to join M. Zumstein, who good-naturedly accompanied me to the glacier, though the day was far from fine.

CHAPTER XIX

GRESSONEY—MONTE ROSA

The German valleys of Monte Rosa—Peculiar race, of questionable origin—Their manners and dialect—Topography of Monte Rosa—Attempts to ascend it by Vincent and Zumstein—The highest point still unattained—An excursion to the Glacier of Lys—Its retreat—Its structure—Return to Stavel

THE valleys of Gressoney, Sesia, and Anzasca, all in the Sardinian dominions, and to the south of the great chain of Alps, are inhabited, *in their higher parts only*, by a race of men whose physiognomy, dress, and language alike bespeak a German origin.

Were the heads of these valleys in immediate communication with those of German[-speaking] Switzerland by easy passes, this would occasion little surprise, accustomed as we every day are to see national limits transgress natural or geographical boundaries, and the peculiarities of conterminous races to be softened by an imperceptible gradation. But in the Piedmontese valleys of Monte Rosa, the case is quite otherwise: the chain of Alps is their prison, not their portal; for from two out of three of them, certainly no human foot has ever passed directly from Italy to Switzerland, or the reverse. The German colony must, therefore, have been introduced through the Italian territory, and their choice, or their necessities, have driven them to the mountain fastnesses, which, perhaps, reminded them of those of their native land.

De Saussure has, as usual, nearly exhausted what it is of importance to say respecting the possible origin of these mountaineers. He has classed the existence of the German colony as one of the nine peculiarities of the district;[1] he has stated, in a few sentences, what may be conjectured as to their origin, and in a few more he has adroitly sketched their character.

De Saussure supposes that they were Vallaisans who crossed the Monte Moro (a pass from the Val Anzasca into Switzerland) at a remote period, in order to occupy the higher valleys of Monte Rosa, whose rough surface and rude climate had repelled the more delicate Italians. He describes the people as simple, timid, and even rude, but honest; their greatest fault, a want of hospitality, which he found embarrassing at a time when inns were even rarer than at present.

It may be affirmed that the manners of the German settlers have improved since the time of De Saussure, which leads us to believe that their fault arose from their ignorance and isolation. I met everywhere with respectful, and even touching attention. Any traveller speaking the German language is certain to be well received; and it is interesting to observe the tenacity with which these descendants of an unknown stock cling to the usages and the speech which form the only evidence of their birth, for history and tradition are both silent on the subject. Though most of the inhabitants—at least the men—speak several languages, acquired during their earlier years of expatriation, they invariably prefer speaking German, which many of them do with fluency, and without accent; far better, in short, than most persons of a similar class in German[-speaking] Switzerland. The expatriation to which I have alluded arises from their practice of going forth from their valleys at an early age to push their fortunes in wealthier lands, and especially in southern Germany. But, almost invariably, they at last return to marry,[2] and to settle in comfort at home. Hence, ease and independence is still more marked here than in Switzerland. Some of the earlier writers, as Scheuchzer,[3] distinguish Gressoney as the "Merchant Valley,"[4] *par excellence;* and at one time the race

[1] *Voyages*, §§ 2243, 2244.

[2] They have an expressive proverb to this effect:—"Weiber und Steine muss man lassen wo sie wachsen" (Schott, p. 96).

[3] [Schott (p. 94)—on whom Forbes is relying—quite misunderstands Scheuchzer's phrase (p. 303); it is quite clear that Scheuchzer means the Val Tournanche by the expression "Krämerthal," which is nowadays the German name of the valley. Hence the name has nothing whatever to do with Gressoney, though of course many small merchants and pedlars emigrate from that valley, as from nearly all the Alpine valleys on the south side of the chain of the Alps.]

[4] Krämer-Thal.

of pedlars in southern Germany were termed "Gressoneyer" collectively.

Their habits are cleanly and active, and their houses, built in the true German taste, would alone, and at once, distinguish them from their Italian neighbours. I spent a Sunday at Gressoney, as already mentioned, which gave me an opportunity of seeing the holiday costume of the women, which resembles some of the gayest in Switzerland, especially the abundance of gold and silver lace, and the metallic helmet-caps. In religion they are strictly Roman Catholics: their churches are adorned with frescos in the Italian taste.

Since De Saussure called particular attention to the German settlers of Monte Rosa, several German authors have written respecting them. Of these the chief are Hirzel-Escher,[1] von Welden, and Schott. Of these works now before me, the last[2] is the most elaborate as respects the question of population; but it is tedious from its detail, and disagreeable to read, from an affectation of singularity in the spelling and printing of the German language.[3]

Schott has given (in chap. vii. of his work) specimens of the patois of each of the various *communes* of the German valleys—namely, Issime and Gressoney in the Val de Lys; Alagna, the highest village, which alone is German, in the Val Sesia; Rima in the Val Sermenza; Rimella in the Val Mastallone; and Macugnaga in the Val Anzasca. That of Gressoney appears to be the least impure German; and indeed it is there alone that the striking externals of the German race are to be found in perfection: nearest to it in this respect is the valley of Anzasca. In every case the patois is a corrupt mixture of Roman and Teutonic roots, of which the author has given an elaborate vocabulary. It is curious to observe that in the proper names of these valleys the family names have preserved pretty

[1] [Hirzel-Escher, *Wanderungen in weniger besuchte Alpengegenden der Schweiz*, Zurich, 1829, pp. 46-49.]

[2] *Die Deutschen Colonien in Piemont, ihr Land, ihre Mundart, und Herkunft*, Von Albert Schott, Stuttgart, 1842.

[3] [Much has been since written on the subject. It seems probable that the Gressoney colony was brought over the St. Théodule by the Bishop of Sion—who had lands in the Lys valley—probably in the twelfth or thirteenth century; the other colonies probably came from Visp over the Monte Moro and other passes. See pp. 493 and 524 of the new edition (1898) of vol. i. of Mr. John Ball's *Alpine Guide*, and the references in the index of that work to the various villages named.]

generally their German character, as Achermann, Beck, Schwarz, Zimmermann, Zumstein, whilst the Christian names are chiefly Italian.[1]

The second of the works above named, that of von Welden, is interesting from the topographical details which it gives of the complicated environs of Monte Rosa, which, till then, were very imperfectly understood,—and not less so from the details of successive attempts to reach its highest summit, made by M. Zumstein (a native of these valleys), and described in his own words.

The vexed question of the comparative height of Mont Blanc and Monte Rosa was undecided before the survey of von Welden, which was published in 1824.[2] It required an elaborate operation to determine its absolute height, on account of the complication of peaks of nearly equal elevation which form its summit, all of which cannot be seen from perhaps any point external to them, and which must nevertheless be separately and minutely observed, in order to ascertain which is really the highest. Thus De Saussure, as appears evidently from his own view (*Voyages*, tome iv., Pl. V.), measured not the highest peak, but only the third in height, now called the Zumsteinspitze. He made it 2430 toises, or 15,540 English feet above the sea.[3] This was within 200 feet of the height of Mont Blanc; but later and more precise observations all agree in making even the highest point considerably lower.[4] Von Welden (pp. 12-20) finds it to be 14,222 French or 15,158 English feet, which agrees nearly with the mean of the results of Carlini, Oriani, and Corabœuf.[5]

Monte Rosa is a union of several mountain chains rather than one summit. The map will give an idea of their arrangement. From it, or from any map based upon von Welden's, it will be seen that a vast inaccessible [6] ridge stretches nearly east

[1] Schott, pp. 212, 213.

[2] *Der Monte Rosa, eine topographische und naturhistorische Skizze*, Vienna, 1824.

[3] *Voyages*, § 2135.

[4] [The Dufourspitze is 15,217 feet, the Nord End 15,132 feet, and the Zumsteinspitze 15,004 feet. Mont Blanc is 15,782 feet.]

[5]
Carlini,	2387	toises.
Oriani,	2385	,,
von Welden,	2370	,,
Corabœuf,	2379	,,

Brugière, *Orographie de l'Europe*, p. 208.

[6] [All the peaks have since been climbed and many passes made between them.]

and west, commencing at the Col du Mont Cervin, between Zermatt and Breuil, and terminating in the Cima della Pissa, to the east of Monte Rosa. This chain includes the Petit Mont Cervin, the Breithorn, [the Twins], and the Lyskamm. Another vast ridge, though a shorter one, meets this nearly at right angles, stretching from Monte Rosa, northwards, towards the Cima di Jazzi. It also crosses the chain to the south, so as to form the ridge of the Col d'Olen between the Val de Lys and Val Sesia. The union or *knot* formed by these two chains is the locality of the elevated summits properly called Monte Rosa. Of course four cavities or angles are left when the traverse chain meets the longitudinal one. The one of these to the north-eastward, which is the most precipitous, and which, indeed, has been compared by De Saussure to a crater, forms the head of the Val Anzasca, and embosoms the Glacier of Macugnaga; the north-western one, vaster, but less precipitous, gives birth to the great glacier of Gorner, or of Zermatt; the south-western angle contains the glacier of Lys, which descends from the Lyskamm [1] into the valley of Gressoney; the fourth, or south-eastern cavity, is occupied by the head of the Val Sesia, and has also extensive, though less prominent glaciers.

Thus Monte Rosa is in ground plan like a four-rayed star or cross. All the highest summits are ranged along the northern and southern rays, especially the former. The point of union of the rays is not the most elevated, though, in some respects, it is the most generally commanding top. It is the most conspicuous from the Italian side of the Alps; it has been called by von Welden "Signal Kuppe." It is the fourth in point of height.[2] The three higher lie all immediately north from it; the first in order is the "Zumsteinspitze," the highest which has been ascended, which is a snowy blunt summit, mistaken by De Saussure for the highest. Next follows the highest; a sharp rocky obelisk, well seen from the Col d'Hérens (see p. 300), and from Monte Moro (see next chapter). It is connected with the Zumsteinspitze by a longitudinal very sharp icy ridge like a house roof, which, on the eastern side,[3] descends with appalling

[1] *Kamm*, a comb-shaped or jagged mountain ridge.

[2] [14,965 feet. It is also called Punta Gnifetti, from the Curé of Alagna, who first vanquished it on August 9, 1842, just three weeks before Forbes's visit to Alagna. See p. 341 below. There is now a large club hut close to the summit.]

[3] [Strictly speaking, the Höchste Spitze, 15,217 feet—conquered in 1855—

rapidity to an abyss which is scarcely equalled in the Alps for depth and steepness. Beyond the highest, or "Höchste Spitze," is the second highest, called by von Welden "Nord End," which, like the last, has never been scaled.[1] The difference of height of these four summits is trifling, amounting to only 34 toises, or little more than 200 feet, from the highest to the lowest. Three other summits of somewhat less height form the southern arm of the Cross, namely, the "Parrotspitze," "Ludwigshöhe," and "Vincent Pyramide," the last of which, and also the lowest, was the first ascended of the group.[2]

Having now endeavoured to give a distinct geographical idea of the position of this group of mountains (which I have seen and sketched in almost every direction from whence they are visible), I shall add a very few words respecting the attempts which have been made to ascend it, which have excited far less interest than those upon Mont Blanc; and such is the confusion prevalent on the subject, that some guides of Chamouni maintain that they have ascended the summit of Monte Rosa from the Col of Mont Cervin,[3] which is a good deal more ridiculous than if they proposed to scale Mont Blanc by ascending the Glacier of Argentière.

The explorers of Monte Rosa, in its wilder recesses, were MM. Vincent and Zumstein, the former the earlier, the latter the more persevering and successful. I can only mention briefly the results of their journeys, which may be found contained in an interesting series of papers by M. Zumstein in von Welden's work (p. 97 *sqq.*).

The first ascent of the lowest summit was by M. Vincent alone, in August, 1819, whence his name was justly given to it.

rises altogether in Switzerland on a promontory that detaches itself from the Grenzgipfel, 15,194 feet, which, like the Signal Kuppe, Zumsteinspitze, and Nord End, is on the watershed that also forms the political frontier.]

[1] [The Nord End is 15,132 feet, and was first climbed in 1861.]

[2] [The Parrotspitze, 14,643 feet, was first climbed in 1863; the Ludwigshöhe, 14,259 feet, in 1822; and the Vincent Pyramide in 1819. There are two or three other minor points.]

[3] [This is probably an allusion to the first ascent of the Breithorn, effected in 1813 from the St. Théodule Pass by Monsieur Henri Maynard, a Frenchman, accompanied by several guides, among whom was J. M. Couttet, who in 1792 had ascended the neighbouring Petit Mont Cervin with Saussure. The original account states expressly that it was an ascent of Monte Rosa. See von Welden, p. 7; *Alpine Journal*, vol. xv. pp. 437, 438; Durier's *Le Mont Blanc*, p. 243, note; and Dollfus-Ausset's *Ascensions dans les Hautes Régions des Alpes* (1864), p. 109.]

Then he and M. Zumstein together repeated the ascent a week later, with more favourable weather. The chief difficulties experienced were from a huge ice cleft, or *Bergschrund*, and from the labour of cutting 600 steps with a hatchet on a steep ice slope. The ascent on this, as on all other occasions, was made from the side of Gressoney, near the Col d'Olen, where gold mines are worked above the limits of perpetual snow, and where, therefore, a shelter, however rude, could be obtained, at a height of 10,800 feet, certainly the highest temporary habitation in Europe.

The second journey, that of 1820, was performed by Zumstein alone, with the purpose of making for the summits farther to the north, and also the highest. He was accompanied by a surveyor, with a theodolite, who was commissioned by the Turin Academy to make observations for the improvement of the maps of Monte Rosa; but the Italian surveyor being unused to such excursions, the labour and expense of the journey were unavailing, although it clearly appears from the narrative, that had Zumstein himself been able to make the observations, he would have had ample time and opportunity for doing so,—one proof amongst many of the necessity (which De Saussure saw and acted on) of the director and chief of such an expedition being not only an experienced mountaineer, but himself capable of undertaking all the experiments and observations which he desires to be made. Under such circumstances, the zeal and sense of responsibility of the traveller and discoverer himself, are alone equal to the task of making observations of any value, or rather, not positively mischievous by their inaccuracy. The most perfect land-measurer, the most experienced laboratory assistant, are alike thrown out when they are expected to make their contacts, verify their zero points, record degrees, minutes, and seconds with as much deliberation balanced on a dizzy pinnacle or exposed to a pinching frosty gale, as in their ordinary localities, and with the usual appliances.

M. Zumstein left the peak which he had before ascended, and several others, on his right hand, following the elevated snow valley which separates the high range of Monte Rosa from the Lyskamm. It appears that these vast snow-fields may be traversed without danger, unless from the chance of being overtaken by night or bad weather at so great a distance from shelter. The valley of Zermatt is visible from them; and we find that some peasants of Gressoney, who reached this point [in 1778], brought back startling reports of an unknown pastoral valley [1] discovered by them amidst the wilds of Monte Rosa; [2] the fact being merely that they saw the woods and meadows [towards Zermatt], backed by the icy chains of the Dent Blanche and Weisshorn.

So distant are the higher summits of Monte Rosa from the gold-miner's hut whence the party had started in the morning, that the day was spent before the loaded guides and the timid surveyor could be got forward to the foot of the higher peaks. Here Zumstein had the courage to determine upon passing the night in a cleft of the ice at the height of 13,128 French, or 13,992 English feet above the sea,—undoubtedly the greatest height at which any one has passed a night in Europe.[3]

The next morning the summit bearing the name of Zumstein was attained without much difficulty. Here, too, the opportunity of making observations was lost, for whilst waiting for the ever-tardy engineer, the horizon became clouded. The party perceived, however, that they were not, as they expected, upon the highest point, which was 750 yards farther north, and 200 feet higher. It appeared to them to be inaccessible in this direction.[4] The barometer stood at $16\frac{1}{3}$ French inches. None of the party experienced the exhaustion and other symptoms so often felt on Mont Blanc. They returned to the huts after having been forty hours on the snow. Twice afterwards M. Zumstein repeated his visits to this peak, but without succeeding in making farther progress.

I shall conclude this chapter with some account of an excursion in the valley of Gressoney, where we stopped at the close of the last chapter, in the friendly company of M. Zum-

[1] [Or the "Valleé Perdue." The seven young men — among whom was Vincent's father—reached a rocky tooth just west of the present Lysjoch between the Lyskamm and the main mass of Monte Rosa; this tooth was named by them the "Entdeckungfels" or "Discovery Rock." Sir Martin Conway visited it in 1884, and has described the prospect thence. See *Alpine Journal*, vol. xii. p. 73.]

[2] Compare De Saussure, *Voyages*, § 2156, and Zumstein in von Welden, p. 124.

[3] [Of course since 1842 some persons have spent the night on the summit of Mont Blanc itself.]

[4] [Yet the climb was achieved in 1874, and did not prove so very difficult.]

stein, the mention of whose name naturally suggested this digression.

The valley of Gressoney, or Lys-Thal, is more contracted and mountainous than I had expected to find it, and this is characteristic of several of the valleys which diverge from Monte Rosa, which seem to be mere cracks or rents, without diverging branches of any extent. The sides are steep without being precipitously grand. Near St. Jean the valley is flat and fertile: at Castell, half an hour's walk above, it rises suddenly amongst rocks to a higher level. The distant view of Monte Rosa, which ought to be the centre of interest, was indeed wanting, for it remained impenetrably covered with clouds. Nevertheless, with M. Zumstein for my guide, I left Noversch, forty minutes' walk above St. Jean, for the Glacier of Lys. At the hamlet of La Trinité, which is situated in the midst of a little plain, one hour from St. Jean, a small valley branches to the right, which affords the easiest road to the Col d'Olen leading to the Val Sesia on the east. We continued a due northerly course, passing several cottages, which, though small, were clean and cheerful. In the lower part of the valley are many houses of considerable pretension, and at least three storeys high, which are all built of wood, and inhabited by the wealthier natives, who have returned with fortunes acquired in foreign countries, to pass the remainder of their days at home. Amongst these is Baron Peccoz, who acquired his nobility from the King of Bavaria, and who, having made money in trade in Germany, passes the greater part of the year at the very head of the valley of Lys, where he can indulge what is, with him, an insatiable passion for chamois hunting. His substantial dwelling is the very last permanent habitation in the valley, at a spot called *Am Bett*,[1] and within half an hour's walk of the glacier. He entertained the sons of the King of Sardinia, and their suite, on a visit which they made some years since to Monte Rosa. Having an introduction to him, through M. Plana's kindness, I might have availed myself of his hospitality, but he was absent upon his favourite sport, and M. Zumstein was good enough to secure for me humbler, but most comfortable, quarters for the night, in the

[1] [The Betta huts are half way between La Trinité and Cortlis. Forbes probably confused the spot with Stavel.]

cottage of a worthy peasant of the valley. At a place called Stavel,[1] the serpentine unites with the chlorite slate, and higher up is replaced by red gneiss. At a spot called Cortlis are some traces of glacier action, namely, polished rocks, which, it has been observed, are rather rare in this valley. At Castell there are some blocks which appear to have been transported; but this evidence is doubtful where the geology is so monotonous.

At length we reached the glacier, at a distance of not more than two and a half hours' walk from St. Jean. It has retreated continually since 1820, and has left a vast enclosure—sharply defined by its moraine—a perfect waste, having (as I judged) not less than a square mile of area. Within this area is a kind of rocky precipice, above which the glacier has now retired: it is composed of gneiss, including quartz veins, and though these have never before been uncovered by the ice in the memory of man, M. Zumstein assures me that he has found marks of blast holes where metallic veins had been sought for, probably gold, which is still worked in the neighbourhood.

We ascended on our right the eastern moraine of the glacier, I mean its *ancient* moraine, which extends yet far beyond that of 1820, and with some labour and fatigue we gained the level of a kind of *plateau*, which intervenes between the crevassed ice descending from Monte Rosa and the final slope of the glacier, at its lower end. Here the view ought to have been very grand, but we were now completely in the clouds, with a drizzling rain. I wished to cross the glacier, in order to examine its structure, and a rise in the mist favoured us. The glacier stream is here composed of two great ice flows, derived from the two sides of a promontory, called *die Nase*, or the Nose, and the eastern one is itself the result of two others, so that three streams of ice appear distinct where we crossed the glacier, with the usual belted structure, vertical near the sides, and under the medial moraine, and presenting a threefold convexity in its front, as I have observed in other very wide glaciers, where the individual structure is not immediately lost. The bands were very well developed. I pointed them out to M. Zumstein, who candidly

[1] ["Stavel" is the local patois form of "Staffel." Here the late M. de Peccoz owned a villa which has been used several times as a summer residence by the Queen of Italy.]

admitted that, much as he had been amongst glaciers, he had never noticed them before.

The moraines of the Glacier de Lys are composed exclusively of gneiss and syenite, without a trace of green slate or serpentine, so abundant below.

Having crossed the glacier, we took refuge for a while from the weather in one of the rude cabins constructed by the shepherds amongst the blocks of the ancient moraine. We then descended the west side; and I observed, in the moraine of 1820, several bands or heaps of stones, arranged transversely to the glacier, and parallel, like the ridges of a ploughed field. I am uncertain whether or not these were deposited in the *last* crevasses of the glacier before it disappeared.

We returned somewhat wet to the village of Stavel, and slept in the clean beds which had been provided for us. The guide whom I had desired to follow me from St. Jean to cross the Col d'Olen next day, and to bring provisions, did not appear, and indeed the guides of this country seem to be not altogether sure. I eat cheerfully, however, the rye bread of the house, baked at Christmas, 1841, and cut with a hatchet into morsels like sugar, of a size which could be put into the mouth at once. I found it not unpalatable, and even preferred it to fresh bread of the same kind.

(1842.)

CHAPTER XX

TOUR OF MONTE ROSA CONCLUDED—FROM GRESSONEY TO VISP, BY MACUGNAGA AND MONTE MORÒ

Passage of the Col d'Olen—Alagna—Riva—The Turlo Pass—Val Quarazza—Its polished rocks—Macugnaga—The people and their habitations—Excursion to the glacier of Macugnaga—The Weiss Thor, a remarkable pass—Structure of the glacier—Glaciers of the second order—Geology of the chain of Monte Rosa—Petriolo—Gigantic fragments of rock—Return to Macugnaga—Pass of Monte Moro—View of Monte Rosa—Descent to Saas—Glaciers of Schwarzberg and Allalin—Gabbro—Saas—Stalden—Peasants' theatricals—Visp.

NEXT morning, after taking a cordial leave of M. Zumstein, I started soon after dawn from the hospitable roof of my entertainer at Stavel, with dull but fair weather, to cross the Col d'Olen to Alagna, in the Val Sesia. A cheerful well-mannered peasant, named Joseph Skinoball,[1] replaced my faithless guide as far as the Col, whence he turned back. During the ascent we left upon the left hand the gold mines of Indren, and the spot named "Die hohe Licht," so often referred to in Zumstein's ascents of Monte Rosa. The Col d'Olen might be reached either from La Trinité or from Stavel, or direct from the Glacier of Lys. In fine weather it would not be too long a day's work to go from St. Jean to the glacier, and then to Alagna or Riva, to sleep. The Col is wild, and composed of jagged rock mingled with snow. I ascended in two hours and a quarter from Stavel. Water boiled at 195°·70, by the thermometer, whence I find the height to be 9758 feet [2] above the sea. Keller makes it 1000 feet less.

[1] [The name looks odd, but the right form is not obvious.]

[2] [Really 9420 feet. Just below the pass on the Alagna side there is now a comfortable mountain inn.]

From a little way beyond the Col there is a fine view eastwards, including part of the Lago Maggiore and the hills beyond. The descent to Alagna is very steep and long (as it lies much lower than Gressoney), but, at the same time, interesting. The Val Sesia is here very narrow, and is included between two serrated chains of mountains, of which the Zuber [1] on the western, and the Tagliaferro and Monte Turlo [2] on the eastern side, are conspicuous. The lower part of the descent to Alagna is through beautiful wood and green pastures. Alagna itself has a pretty church, in the Italian taste, and is most agreeably situated. I called on the Curé, who had ascended the Signal Kuppe (one of the summits of Monte Rosa) a month before.[3] Alagna is a very poor place. A much more barbarous German is spoken than at Gressoney, and it is so completely on the German boundary that at Riva, only half an hour's walk farther down the valley, Piedmontese is exclusively spoken, so that I was assured that a great part of the whole inhabitants of these two *communes*, especially the women, are incapable of understanding one another. There being no inn at Alagna,[4] I descended the valley to Riva to sleep, although I should have to retrace my steps. I had, indeed, intended walking farther down the Val Sesia, which is more pleasing than the Val de Lys—for I arrived at Riva before noon; but a violent thunder-storm, which lasted all afternoon and part of the night, prevented me. The result, however, was happy. It put an end to the recent uncomfortable weather, and the wind having changed, some of the finest days of the season succeeded, commencing with the 1st September. It is a singular, and not unimportant fact, which every native of these valleys whom I consulted agreed in stating, that the N.W. and N.N.W. wind brings fine weather, and that the E. wind, which in Switzerland (and even at Courmayeur) is dry, is here the wet wind. M. Plana mentioned the same as being true at Turin.

The following morning I was up before daylight, and left

[1] [The Punta di Starling, south of the Zubé Pass, is probably meant.]

[2] [Now called the Fallerhorn, to the north-west of the Turlo Pass.]

[3] [Giovanni Gnifetti, who, on August 9, 1842, ascended the Signal Kuppe, now also called the "Punta Gnifetti." See the narrative of his attempts and final success in his little book, *Nozioni Topografiche del Monte Rosa, ed Ascensioni su di esso* (Novara, 1858), pp. 40-87.]

[4] [There are now several, one of which is excellent.]

Riva at a quarter past five. The weather was beautifully clear, and the summits of Monte Rosa showed finally, with the morning sun above the deep wooded valley. Riva is situated at the foot of the Col de Valdobbia, and is, therefore, nearly opposite to St. Jean de Gressoney. The church contains some paintings of a rude kind. I had soon retraced my steps to Alagna, and there was introduced by the Curé to a shepherd of Biella, who was going to cross the Turlo Pass, and who offered to show the way. He was a merry fellow of the true Italian cast, with a broad brimmed hat, and spoke only the Piedmontese jargon. He had spent the night over the wine-skin, and pathetically lamented the fatigues of the ascent, for which, indeed, he was not in very good training, and before we reached the top he declared himself to be "prope della morte." About three quarters of an hour's walk above Alagna we passed an extensive establishment connected with a gold mine, the property of the Sardinian Government; but, like most of the others in this neighbourhood, it has fallen completely into decay.[1] The only gold mines which I believe are now worked to any extent are those of Pestarena, in the Val Anzasca. We crossed the stream soon after, and commenced the ascent of the Turlo. At a little height, Monte Rosa had a grand appearance, the chief summits visible being (as I judged by the map) Vincent's Pyramide, Ludwig's Höhe, [Parrotspitze], and the Signal Kuppe. A steep zigzag leads to the higher chalets seated in an extensive hollow in the hill. From hence, a seemingly endless ascent over smoothish rocks mixed with turf leads to the Col, which remains in view the whole way. Monte Rosa is hid, and there is no variety of view. All travellers consider this, and justly, as one of the most tedious passes in the Alps, although it presents no kind of difficulty. The last part of the ascent is over fallen masses of rock. I observed a group of chamois to the right. The summit is marked by a cross. Here I found the temperature of boiling water to be by my thermometer 196°·68, that of the air being 36° at 11 A.M.; from which I conclude the height to be 9141 English feet, instead of 8400 as marked by Keller.[2]

[1] [These are now worked again by an English Company like that at Pestarena.]

[2] [Really 8977 feet. The name Turlo is an Italianised form of the German "das Thürle" or wicket.]

The view from the Turlo Pass is a wild one. The ridge is itself jagged and pinnacled in fantastic forms, on the eastern side the ground falls (as usual) much more steeply, and the bottom of the Val Quarazza seems at an immeasurable depth, separated by an extensive snow-field. Monte Rosa is still concealed by the mass of the Pizzo Bianco, which rises on the left. A very steep descent, first over snow, and then over fallen rocks, brought us, not without fatigue, down a height of several thousand feet. When we had reached the level of the highest sheep pastures, my guide took his leave; he gratefully accepted the trifle which I gave him for his safe conduct, and then he started off with the half-cheerful, half-plaintive exclamation—"We shall meet no more but in Paradise;" and so we separated.

Not long after I reached the chalets of La Piana, which, like most of those in the neighbourhood, are inhabited by Piedmontese, and not by the German settlers, and consequently are very filthy. I rested awhile on the rocks between the chalets and the river, which were very beautifully rounded and striated, I have no doubt by glacier action. The forms were smooth, undulating ones, and the polish fine; the rock is a gneiss, approaching nearly to granite. I may mention that, in the Val Sesia—that is, in the very small space of it which I traversed—I observed no glacier marks on the rocks. In the higher part above Alagna I noticed a very beautiful syenite in blocks; I also observed quartz-rock *in situ*, near the gold works. Near the Turlo Pass there occurs a beautiful mica slate, with crystals of schorl (which mineral I also found on the Glacier de Lys), succeeded by a granitoid gneiss with large felspar crystals. The Val Quarazza, which is a tributary of the Val Anzasca, contains in its lower part granitoid blocks, probably transported by glaciers. I crossed the torrent a little below the chalets of Piana; the valley there becomes picturesque and wooded, and a series of cascades occur near the junction of the valleys. Turning to the left, by the village of Isella, I reached Macugnaga about 4 P.M., having travelled very quietly. This valley is very pleasing in its appearance, the houses are dispersed over its surface rather than grouped in villages, but Macugnaga is the last Commune. The people are agreeable, talking German; the houses neat, and the hay-harvest gave a lively appearance to the scene. For a while I could not get access to the inn, until the landlord, a decrepit, hunchbacked, and blind man, though still below middle age, made his appearance from labouring in the hayfield, and by his pleasing manner, and his attention, soon gained my interest, and made me well satisfied with what his house afforded, which, indeed, was more than average comfort, considering the remoteness of the spot. There was a visitor's book, and I do not think that a dozen travellers of all countries had entered their names since the previous year. The landlord's name is [Gaspard] Verra, and his wife is an obliging person.[1]

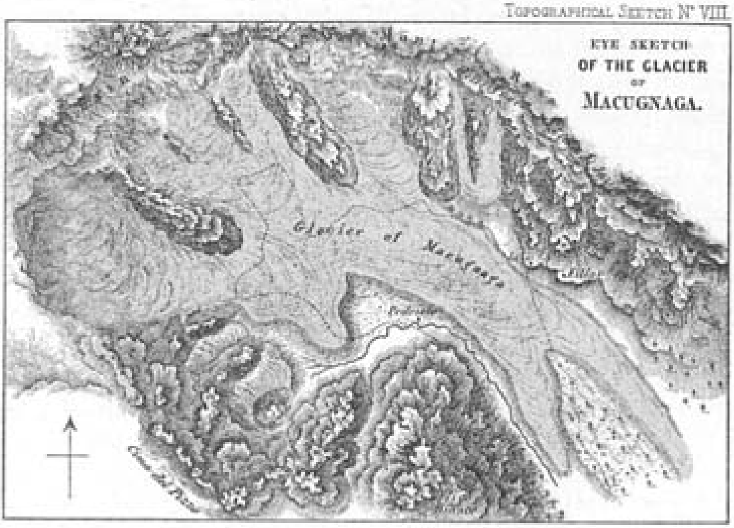
On the 2nd September I rose at five, intending to cross the Monte Moro into the Vallais. The weather was superb, and Monte Rosa clear. Whilst I dressed I began to regret my purpose; and when I descended to breakfast, and got a view of the head of the Valley of Macugnaga, in all its magnificence, I called to mind that I had seldom, if ever, regretted a day's delay in the midst of fine scenery, and had often repented over the infectious haste of travellers. Therefore, although I had lost two days at Gressoney, I called my Savoyard [Victor Tairraz], and desired him to prepare for a trip to the neighbouring glacier. We were soon on foot, with an enchanting morning, the sun was not yet risen on the valley, which had a freshness very symptomatic of fine weather, and which I had not enjoyed for some time; the north-west wind had established itself. A little above the village stands the church of Macugnaga, and beside it a noble and thriving lime-tree, forming an excellent foreground to the vast scenery behind, which is, beyond all comparison, the finest view of Monte Rosa itself. From thence I passed to the village of Pecetto, with its church, which is the last in the valley, and both here and at Macugnaga I was struck with the unusual taste displayed in ornamental gardens at the cottage doors, and with the great beauty and luxuriance of some of the choice flowers, especially carnations. The inhabitants I met, and who greeted me in German, were chiefly females and old men. All the young men leave the valley to seek their fortune in France, or elsewhere, as merchants. The inhabitants of the Val Sesia are, in like manner, chiefly *colporteurs* or hawkers. This circumstance explains a curious remark of De Saussure, who, wishing to have a heavy case of minerals transported to Vanzone from

[1] [For an account of this inn see Mr. Coolidge's *Swiss Travel and Swiss Guide-Books* (1889), pp. 232, 233.]

Macugnaga, inquired for a man who could carry them. He was answered that no man in the valley was equal to the task, but that a *woman* could easily do it, if it was the same to him. And it is certain, he adds, that two women can carry a mule's burden.[1]

Beyond Pecetto a charming path lay through fields and woods, without habitations, but interspersed with barns; and the great glacier which occupies the head of the valley appears conspicuously. I ascended a steep wooded slope, which separates

Topographical Sketch Nº VIII.



the lower end of the glacier into two, of which, however, by far the larger is on the right hand, the other being only a little overflow. This slope is very high and steep; the upper part is entirely composed of the ancient moraines of the glacier, which have a singular figure like artificial mounds (see the Topographical Sketch, No. VIII.), and embrace a charming well-watered pasture ground. From its upper part I crossed the main branch of the glacier on the right to the Chalets de Jazzi at the foot of the mountain of that name.[2] From thence the view of the precipitous amphitheatre of Monte Rosa is very fine. Nearly above

[1] *Voyages*, § 2224.

[2] The Cima di Jazzi appears to correspond with the Strahlhörner, when seen from Zermatt. [They are neighbours, but quite distinct, and separated by two of the Weissthors.]

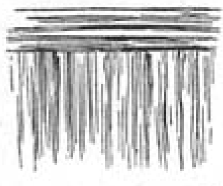
these chalets I knew must be the celebrated pass of the Weiss Thor from Zermatt to Macugnaga. The Piedmontese shepherd who occupies the chalet could give me no information respecting it, and the range appears on this side so absolutely precipitous, that I could hardly convince myself that any track could be found accessible to human foot. It is certain, however, that occasionally precipices are more practicable than they appear at a distance, and generally less vertical; and after a very careful examination I detected a passage of the rocks, and only one, which it seemed possible to pursue. This pass is mentioned by almost every writer on Monte Rosa. De Saussure says that it is very dangerous, but does not state that he conversed with any one who had performed it.[1] In Hirzel-Escher[2] and von Welden,[3] I find no particular addition from personal knowledge. Engelhardt[4] relates the account of the passage of the Weiss Thor by his guide at Zermatt, no doubt Damatter, who has repeatedly assured me that he once passed it, [and] that it is very dangerous, much more so than the Col d'Hérens. Schott[5] states that this pass was formerly more used than at present, and almost exclusively for the purpose of pilgrimage from the Vallais to the Sacro Monte at Varallo, and this corresponds accurately with what I learned from the host Verra at Macugnaga. It is pretty certain that it has been crossed but once in the memory of men now living, and then by a pretty numerous company. I believe that no one in the Val Anzasca has passed it.[6]

I continued along the western moraine of the glacier for some way above the chalets, and crossed the foot of the first tributary glacier descending from the Monte Rosa, or rather that part of it next the Weiss Thor called the Nord End. It has the usual scallop-shell structure of steep glaciers. I then crossed to the centre of the glacier to examine its structure, and ascended the axis of it up to the limit of perpetual snow (or

[1] *Voyages*, § 2145. [2] *Wanderungen*, p. 32. [3] *Der Monte Rosa*, p. 38.
[4] *Naturschilderungen*, p. 195. [5] *Die Deutschen Colonien in Piemont*, p. 61.
[6] [The pilgrims' pass is now called the "Schwarzberg Weissthor," and was crossed in 1825 by Brantschen of Zermatt, with other pilgrims. South of it and north of the Cima di Jazzi is the "New Weissthor," certainly crossed in 1848, and south of the Cima di Jazzi the "Old Weissthor," certainly crossed in 1851. The pilgrims' pass was traversed certainly in the sixteenth century and probably earlier. The history of these passes is very intricate. See the new edition (1898) of vol. i. of Mr. Ball's *Alpine Guide*, p. 523, and (for references) pp. 67, 68 of Sir Martin Conway's *Climbers' Guide to the Eastern Pennines* (1891).]

névé), having sent my companion to await my return on the eastern moraine.

The general structure of the Macugnaga glacier is quite normal, in single waves, as shown in the sketch of a Ground Plan, No. VIII. Higher up, the glacier descends steeply on a twisted inclined plane, occasioned by the barrier which it has itself raised to its advance on the eastern side, by a stupendous moraine several hundred feet high, composed of huge blocks. The structure of the ice is beautifully developed as it sweeps round this spiral inclined plane, and is quite conformable to the cause which I have elsewhere assigned to it. Above this the glacier becomes more level. Its surface is thickly covered with snow, and this snow is evidently, in many cases, the result of avalanches which fall from the steeps of Monte Rosa upon the glacier, which De Saussure has stated (§ 527) to be one source whence glaciers derive their sustenance,—a fact which has been rather strangely denied. The snow, or névé, is usually disposed in bands or layers horizontally deposited, which most likely owe their origin to successive avalanches or successive snow falls. I wish distinctly to state that I attribute this stratification to nothing like the cause of the veined structure of glacier ice. I got some excellent sections of the glacier and névé together; the former underneath, presenting the usual vertical bands; the latter superimposed in true horizontal strata. On the surface of the ice I found the remains of a gravel cone of vast extent (see pp. 25, 26). I mention this as a glacier phenomenon of rather unfrequent occurrence.



SUPERPOSITION OF THE NÉVÉ ON THE GLACIER OF MACUGNAGA.

From the higher plateau, at the summit of a stupendous precipice, several thousand feet in height, to which the snow clings difficultly, is seen the principal range of summits of Monte Rosa; first, on the left, the *Signal Kuppe*, then the *Zumsteinspitze*, marked in De Saussure's view from Macugnaga as the highest. From this to the *Nord End*, a very considerable distance, there runs a sharp snowy ridge, which is broken at several points by projecting rocks; the first is a trifling pinnacle,[1]

[1] [The Grenzgipfel, 15,194 feet, or point at which the promontory on which rises the Höchste Spitze joins the watershed.]

but the second is a tremendous rocky tooth, the *Höchste Spitze*, or highest summit, which appears to join on to the snowy ridge before mentioned in such a way as to leave great doubt whether, even supposing the foot of it to be attainable, it could be ascended.[1] East from the Signal Kuppe is a secondary ridge, connecting Monte Rosa with the Cima della Pissa of von Welden, and which, at the same time, separates the valleys of Anzasca and Alagna. From this several secondary glaciers descend, and have a short course, with great moraines. I sketched them, as illustrating well the clam-shell structure, and this form of glacier. From the Cima della Pissa the ridge turns N.E., and [rises in] the Pizzo Bianco, ascended by De Saussure. I had an opportunity of examining undoubted specimens of rocks, which had descended with the glaciers from different parts of the chain. From the highest ridge (*Zumsteinspitze* to *Nord End*) the rocks are a fine-grained gneiss, and a beautiful silvery mica slate. This latter rock was shown to M. Studer and myself at Gressoney by M. Zumstein as the highest attainable one. From the Signal Kuppe and Cima della Pissa there descends a gneiss, with large felspar crystals, such as I observed on the Turlo Pass. In general there is little chlorite, and no trace of serpentine or green slate on this side of Monte Rosa.

I descended the steep moraine before alluded to, and at length perceived the smoke of a fire, which Victor had lighted below for his amusement. Nothing gave me so great an idea of the vast magnitude of the scene by which I was surrounded as the difficulty of distinguishing a human figure, and the apparent insignificance of the blocks of stone, or, to speak more properly, fragments of mountains with which the ground at the foot of the moraine was strewed. These masses which, as seen from a distance, lay in indistinguishable heaps, were, I am confident, the largest detached blocks of stone which I have ever seen in any position,—I mean, which had rolled or been carried altogether from their native bed. That beneath which Victor had prepared our dinner was, I suppose, 500 feet in circumference, and it was 120 feet high. From lying on an irregular

[1] [The Höchste Spitze is best reached from the Gorner Glacier on the north, but has been attained a few times direct from the Macugnaga Glacier *viâ* the extremely steep slopes and the Grenzgipfel.]

bed, it had broken, since its deposition, through the middle, and left a serrated gap in the upper part. It was surrounded by several others scarcely less gigantic. These blocks are described by De Saussure (§ 2144), and by Engelhardt (page 305), who discusses whether they were brought down by the glacier, and form part of the moraine. I incline rather to believe that they fell from the slope of the Pizzo Bianco. The scene was beautiful, and interesting, and intensely solitary. These masses rest upon an alluvial well-watered flat between the edge of the glacier and the natural side of the valley. It is protected from the glacier by the vast barrier of débris already alluded to, which checks its progress, and, in fact, forms the little valley in question, which is covered with the most vivid green, and which forms the pasture or *Alp* of Petriolo, the name of a few huts farther down, and already deserted for the season. With these stones as a foreground,—which, recalling past times and physical power, might be termed the Druidical monuments of nature,—the extent of glacier behind, and the chain of Monte Rosa in the distance, all seems harmonised to one scale of immensity, and the eye is satisfied.

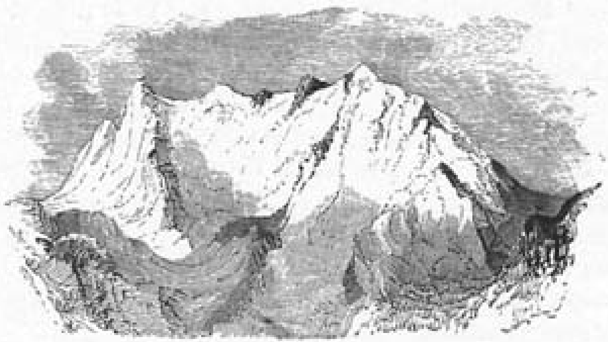
I returned to Macugnaga by the track which leads over the rocks at a great height above the glacier, from the Alp of Petriolo, and having passed two groups of wretched hovels by the way, I descended a steep and intricate path, which brought me back to that which I had left between Pecetto and the glacier.

The Glacier of Macugnaga (called also *Anza Gletscher*, or the eastern Glacier of Monte Rosa) appears to be as large as it has been for a long time: it has not shrunk like the Glacier de Lys.

The following morning, at half-past five, I was on my way to the Monte Moro, the easiest passage of the great chain of Alps between the Great St. Bernard and the Simplon, but yet impracticable for horses or mules. Still it appears formerly to have been passed by beasts of burden, for there is a carefully constructed pavement visible at various parts of the ascent, especially towards the top, which has been noticed by De Saussure[1] and other writers, and which it is impossible to mis-

[1] *Voyages*, § 2145. De Saussure seems never to have crossed the Monte Moro himself.

take. It is on record that this pass was in frequent use in the fifteenth and sixteenth centuries, and the road was maintained at the joint expense of the inhabitants of Saas and Antrona.[1] Although the absolute height of the Moro is greater than that of the Turlo Pass, it is incomparably less fatiguing, being both shorter and more interesting. Indeed, I could not refrain from turning round continually to admire the magnificence of the



MONTE ROSA FROM THE PASS OF MONTE MORO.

view of Monte Rosa, which, though the point of view never altered, seemed to rise to a greater height in proportion as I ascended. In four hours I gained the top, and having melted some snow, I observed the boiling-point, which was 196°·30 by my thermometer, having been 205°·35 at Macugnaga the evening before. The temperature of the air was 41°. Compared with the barometer at Geneva and St. Bernard, the height of Macugnaga above the sea appears to be 4369 feet, and of Monte Moro 9641 feet.[2]

The descent to Saas is singularly easy and pleasant. There is a steep bed of snow crossed at first, but afterwards a gentle fall leads the whole way down to Visp in the Vallais. On the right hand is the great chain of Alps stretching away towards

[1] Schott, p. 63; Engelhardt, p. 298; and Venetz, p. 9.[1]
[2] [Macugnaga is 4254 feet, and the pass 9390 feet.]

[1] [The German-speaking colony at Macugnaga probably crossed Monte Moro between 1262 and 1291. The path over it is first mentioned in 1403. The pass was much used by pilgrims on the way to Varallo, or persons bound for the fair at Macugnaga or later at Vogogna. The origin of the name "Moro" has not yet been satisfactorily explained. Forbes is wrong in thinking that the decision of 1515 referred to the Monte Moro; it really relates to the Antrona Pass, another equally ancient pass that leads from Saas to the Val Antrona.]

the Simplon. On the left is the redoubtable Saasgrat, a lofty chain of inaccessible[1] snowy peaks, separating the valley of Saas from that of Zermatt or St. Nicolas, and from which a series of glaciers descend into the former. There is said to be a passage[2] from the one valley to the other from the top of the Findelen Glacier to the north of the Strahlhorn, which must enter the Saaserthal near Distel, the highest group of chalets. Damatter assured me, at Zermatt, that there is no other practicable pass across the Saasgrat.[3]

I must say a word here respecting the maps of this country,[4] which are worse than those of perhaps any other part of the Alps, and are all nearly equally bad, though with a great diversity of errors, which, showing that the artists have copied neither nature nor one another, leaves us to consider them as pure fabrications. Thus, in the map of apparently most authority of any—von Welden's—attached to a work professedly geodetical and topographical, whilst the Italian side of the mountain and its valleys are neatly and well laid down, the northern or Swiss side is a mass of pure invention, in which the most obvious features are nowhere to be found, and villages and glaciers, lakes and mountains, are jumbled into inextricable confusion. Take the easily accessible neighbourhood of Zermatt: the great Glacier of Gorner is to be recognised only by its name (Zermatt Gletscher), and *debouches* on a lake which has no existence; the Riffelberg and the Glacier of Z'Mutt are nowhere! Nor is the valley of Saas better. The Mattmark See, a lake below Distel, is supplanted by an imaginary glacier, composed of tributaries from all sides, and across which the path of the Moro is carried. A very pretty and detailed map of the Simplon pass and its neighbourhood, published by authority, replaces the great Glacier of Macugnaga by a great lake! Wörl, in his map, has copied von Welden's errors. Even the new Government map of Sardinia, of which a sheet has lately appeared, has perpetuated blunders even worse than von Welden's, in exquisite engraving. Lakes are

1 [*All* since climbed from both sides.]

2 [The Allalin Pass, 11,713 feet, is meant, the Strahlhorn being confounded with the higher Rimpfischhorn. The route reaches the valley at Mattmark.]

3 [Now there are a number of passes over the Saasgrat; among them is the lofty Domjoch, 14,062 feet, between the two highest summits, the Dom and the Täschhorn.]

4 [Nowadays there are excellent large scale (1/50,000) maps published by the Swiss and Italian Governments.]

created, villages are displaced, and others which have no existence inserted where glaciers should be! The Italian side is, however, admirably executed, even though not quite precise in the details of roads and villages. On the whole, the most careful map of the Swiss part of the chain is that in Engelhardt's work;[1] but the author has unfortunately adopted a complex and impracticable system of projection, partly picturesque, partly geometrical, which greatly diminishes its value. I cannot help thinking also that in this, as in other maps, the breadth of the Saasgrat is underrated at its upper part. It is a very pretty, though certainly not an easy topographical problem, to unravel the complication of this chain, of which the mountains are so inaccessible, so varying in their forms, and each called by several different names. But to resume the descent to Saas.

Four glaciers are passed by the way. The first is of small size, on the right hand, and near the pass.[2] It is steep, but even, and exquisitely ribboned in the usual manner. The second glacier is on the left, descending from the summit called on the Sardinian map Monte Moro.[3] It chiefly struck me, from the small stream of *pure* water which flowed from under it, as was also the case in the last glacier.

The third glacier is below the chalets of Distel on the left. It is called Schwarzberg. It is very remarkable, from its shrunk and wasted appearance. The limits of a moraine of recent date stretch quite to the eastern side of the valley (which is here wide), where it has left one enormous block of green-slate, a cube of about sixty feet, slightly rounded on the edges.[4] As far as I could learn from some peasants who were passing, this block was deposited about twenty years ago. The glacier has now retreated quite to the other side of the valley.

The fourth glacier, called Allalin, is the most remarkable of any. It completely crosses the valley (which is here rather narrower) with its moraine, which, damming up the river, forms a lake called the Mattmark See. The moraine supplies the well-known blocks of gabbro, containing Smaragdite, which are

[1] *Naturschilderungen aus den höchsten Schweizer-Alpen*, 1840.

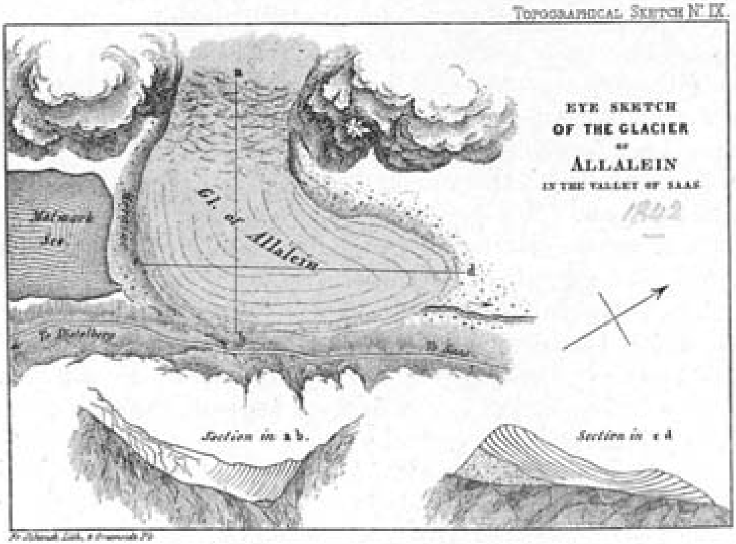
[2] [The Thälliboden Glacier, along the west edge of which the Moro track is carried.]

[3] [The Seewinen Glacier, practically a portion of No. 3.]

[4] This is mentioned by De Charpentier (p. 41) under the name of the Blaustein; he describes it as deposited in 1818, and as having 244,000 cubic feet of contents.

recognised so extensively over the plains of Switzerland, and which have no native locality in the Alps but here. They are brought down by the glacier from the inaccessible[1] heights of the Saasgrat, which near this place rises to about 15,000 feet, so that the rock may probably never be found *in situ.* These masses are usually much rounded by attrition, notwithstanding their excessive hardness. The structure of the glacier of Allalin is well developed, and quite regular. It resembles generally the

Topographical Sketch No. IX.



Glacier of La Brenva in the Allée Blanche, and as in that case the river passes under it. It also resembles the Glacier of the Rhone in the way in which it pours into the valley, and its subsequent structure, which is represented both in Plan and Section in the Topographical Sketch, No. IX. The veined structure is especially developed *in front, i.e.*, against the opposing side of the valley, where the pressure is greater than laterally, and consequently the ice, seeking the direction of least resistance, is gradually swayed down the valley, and takes the particular form shown in the map, which, together with the sections, will give a clear idea of its whole structure. The direction of the crevasses is generally radial, or perpendicular to the struc-

[1] [No longer so; the highest point, the Dom, is 14,942 feet.]

tural bands. I walked over a part of the glacier, but it is not easy to advance far. The front of it is, as I have said, pushed by the general mass against the eastern wall of the valley. The rock, which is here soft, is disintegrated and clayey, and it was interesting to see that the glacier had left vertical markings or striæ upon the clay which had lately been uncovered by its melting, exactly as it would have done on rock, and in the very same direction as I observed them in similar circumstances against fixed rock at La Brenva [pp. 197, 198 above].

Below the Allalin glacier the road falls more rapidly, and a very wild gorge is entered, which continues for a mile or two. The little village of Almagell is the first reached. Here a path on the right leads into the Val Antrona.[1] In half an hour longer I was at Saas, where I received a hearty welcome from Moritz Zurbrücken, the worthy host in whose house I spent a night last year. The journey had been a short and interesting one, and its fatigues were soon forgotten over a roast leg of chamois, and a bottle of good wine.

The neighbourhood of Saas presents one interesting excursion, which I made in 1841, to the valley of Fee, which is a small branch of the Saasthal, descending from the mountains to the west. The easiest ascent is by a footpath, exactly opposite to the village of Saas, and which is distinguished at intervals by a series of station chapels. The valley of Fee, like most of those in this neighbourhood, joins the principal valley at a higher level, and when that level is gained the view is very striking. The entire head of the valley is bounded by a vast glacier, descending from the three lofty mountains, marked in Engelhardt's map, Schwarzhorn, Fehorn, and Stuffen or Dom.[2] The village of Fee,[3] which is inhabited all the year, lies in a beautiful green hollow, amidst meadows and trees, which seem to touch the regions of ice. Indeed, a few years ago, the glacier descended so as to threaten the destruction of the higher chalets and trees, and completely to obstruct the passages to an *alp* or pasture between two branches of the glacier which then closed round it. About 1834 the glacier began to retreat, and

[1] [The Antrona Pass (9331 feet), mentioned in a note on p. 350.]

[2] [Probably the Nadelhorn, the Alphubel, and the Dom respectively; but Engelhardt's map is very wild in this region.]

[3] [5899 feet. It is now provided with excellent hotels, and a much frequented resort in summer.]

has continued to do so since, so that it is now at a very considerable distance from the chalets, which it had almost touched. But what interested me most in the valley of Fee were the admirable traces of former glacier action throughout its length. *Roches moutonnées* of gneiss occur in the whole of the lower part of the valley, scooped out by horizontal grooves, perfectly continuous for some yards or fathoms, and which it is impossible to contend for a moment that water, however charged with stones, is capable of producing. Some of these grooves are like elaborate chiselling, and, on the whole, it would be difficult to find a better specimen of the phenomenon in question. It is remarkable, that in the valley of Saas, *above* the entrance of the valley of Fee, I perceived no such traces, which, however, appear at several points between Saas and Stalden. The rock of the higher valley, which is slaty and often friable, is certainly not favourable to the preservation of such surfaces. By continuing from Fee, along the western side of the valley of Saas, a beautiful walk may be followed through the wood, nearly as far as Almagell. The annual *fête* of the valley is held at Fee, on the 8th September.[1]

From Saas to Stalden there is a great variety of scenery; and in this respect the Saas valley is much more interesting than the neighbouring one of St. Nicolas. There is a series of green flats of small extent, separated by gorges of greater or less depth; one of these in particular, about an hour's walk above Stalden, is extremely fine. The river rushes through a very deep, narrow chasm, overhung with magnificent larch trees, amongst the finest which I have seen in the Alps, and the head of the valley is closed by a snowy peak, perhaps the Monte Moro. It is also crossed by a little foot-bridge, upon which the traveller may stand to view the scene, if he wish to increase its sublimity by no visionary sense of danger in his own position; for the bridge is so weak that a heavy man might break it, and beneath is a furious torrent at a depth of perhaps 200 feet. The view *down* the valley is fine, as well as up; the Bietschhorn, a very elegant mountain north of the Rhone, stands in the opening. Where the valley of Saas is most contracted, the gneiss rocks, which form mural precipices, are striated horizontally to a great height—probably 800 feet. Glaciers

[1] [The festival of the Nativity of our Lady.]

peep through the ravines on the western side, but none of them reach the valley.

Stalden is beautifully situated, as already mentioned, at the junction of the valleys of Saas and St. Nicolas. I had an opportunity of witnessing here a remarkable scene on my last visit. A comedy was to be acted by peasants dressed in costume, who were to perform on a stage erected in the open air. There were not less than forty actors, the female parts being performed by men, and the costumes were elaborately and ingeniously devised—in some cases not without propriety and taste. I was able to remain long enough to see only the opening of the piece named *Rosa von Tannenburg,* which was preluded by a procession of the actors, amongst the most conspicuous of whom were three devils attired in tight suits of black, with horns and tails, the senior wearing goat's horns and the subordinates those of the chamois. The entertainment was under the immediate patronage, and even direction, of the clergy. The morning mass at Saas was said that day at four instead of five o'clock, in order to allow the pastor and his flock to reach Stalden in good time, and one of the *vicaires* (who correspond to our curates) of Stalden seemed to be the master of ceremonies, for he was frequently seen in earnest conversation with the junior devil with the chamois horns. I must add, that the scene was one of the most romantic which can be conceived. Behind the village was a truly natural theatre, with a green meadow for the pit, whilst a range of low cliffs, with a concave front festooned with ivy and brushwood, represented the boxes and gallery, and an audience of not less than two thousand persons, almost entirely peasants, with their gay costume, filled the allotted spaces. The sky was intensely blue, and the summits of the Weisshorn and other snowy Alps completed the picture.

I was obliged to withdraw sooner than I wished, in order to reach Visp in time for the diligence which was to take me to Sion. Thus closed one of the most interesting journeys which I have had the good fortune to make. Since leaving Orsières three weeks before, I had not even crossed a road which admitted of the passage of a wheeled carriage.

CHAPTER XXI

AN ATTEMPT TO EXPLAIN THE LEADING PHENOMENA OF GLACIERS

The Dilatation theory considered, and compared with observation—The Gravitation theory examined—The author's theory proposed—Glaciers really plastic—Conditions of fluid motion—Compared with those of a glacier—Effect of viscosity—The veined structure of the ice a consequence of the viscous theory—Illustrated by experiments—Comparison of a glacier to a river—Conclusion.

"Rien ne me parait plus clairement démontré que le mouvement progressif des glaciers vers le bas de la vallée, et rien en même temps ne me semble plus difficile à concevoir que la manière dont s'exécute ce mouvement si lent, si inégal, qui s'exécute sur des pentes différentes, sur un sol garni d'aspérités, et dans des canaux dont la largeur varie à chaque instant. C'est là, selon moi, le phénomène le moins explicable des glaciers. Marche-t-il ensemble comme un bloc de marbre sur un plan incliné? Avance-t-il par parties brisées comme les cailloux qui se suivent dans les couloirs des montagnes? S'affaisse-t-il sur lui-même pour couler le long des pentes, comme le ferait une lave à la fois ductile et liquide? Les parties qui se détachent vers les pentes rapides suffisent-elles à imprimer du mouvement à celles qui reposent sur une surface horizontale? Je l'ignore. Peut-être encore pourrait-on dire que dans les grands froids l'eau qui remplit les nombreuses crevasses transversales du glacier venant à se congeler, prend son accroissement de volume ordinaire, pousse les parois qui la contiennent, et produit ainsi un mouvement vers le bas du canal d'écoulement."

RENDU, *Théorie des Glaciers*, p. 93.[1]

In the second chapter of this work I stated the usually received opinions as to the cause of the formation and maintenance of glaciers. We found that authors are pretty well agreed in considering that the snow which falls on the summits of the Alps becomes converted into ice by successive thaws and congelations, but that the details of the process are by no means so well understood, and that the immediate cause of the descent of these frozen masses towards the valleys has been very differently explained.

[1] [Pp. 81, 82 of the 1874 reprint.]

The chief theories we reduced to two: the theory of DILATATION and that of GRAVITATION.[1] On the former, the ice is supposed to be pressed onwards by an internal swelling of its parts, occasioned by *rapid* alternations of freezing and thawing of its parts, or rather by the continual formation of minute crevices, into which water, derived from the warmth of the sun, and the action of the air on the surface, is introduced, and where it is frozen by the cold of the glacier, whose bulk it thus increases. On the theory that gravity or weight is the sole cause of glacier motion, the ice lying on an inclined plane of rock is supposed to slide over it, by its natural tendency to descend, aided by the action of the earth's warmth, which, on the hypothesis of De Saussure, prevents it from being frozen to the bottom.

It may be proper now to inquire shortly what light has been thrown upon these two theories by the observations detailed in a former part of this work.

Of the facts which have been established in Chaps. VII. and VIII., with respect to the motion and structure of the ice of glaciers, two seem at least to be not opposed to the theory of DILATATION. I mean the *more rapid movement of the glacier at its centre* (p. 139), and the *infiltration of its mass* by water permeating the capillary fissures (p. 167). The former fact having been unknown to the supporters of the dilatation theory, has not been adduced by them in its favour; which it is, indeed, only thus much, that a body having a certain consistence and variability of form, when subjected to *any* pressure, whether internal or external, will yield soonest in those parts which are least retarded by friction. This fact, however, has no direct bearing on the *cause* of the pressure.

The latter fact would be entirely favourable to the theory of De Charpentier and Agassiz, could it be carried out in its consequences, in the manner which they suppose. But it is not enough that there be capillary fissures and crevices, and that these be filled with water,—*that* does not help the matter at all, —it must also be shown that that water undergoes conversion into ice, so as to dilate it at the time, and to the extent, required for the motion. I conceive that the observations which I have made show such a cause of motion to be inconsistent with the phenomena; and this inconsistency is twofold, first,

[1] [See p. 34 above.]

from the direct evidence that, though the ice is permeated by water, yet the water freezes rarely, and to an insignificant extent; and, secondly, from the motion of the glacier in its different parts, and at different times, being at variance with what must have held true upon the theory in question.

1. The water included in a glacier is rarely in a freezing condition. I need not now repeat the arguments which have been adduced (pp. 35, 36) to show that upon every principle of the doctrine of heat, especially the doctrine of latent heat, it is impossible that the transient cold of the night should in any circumstances produce more than a superficial and most imperfect congelation,—that to suppose anything else would be to suppose in a glacier an indefinite supply of cold,[1] contrary to first principles, and to direct observations with the thermometer on the temperature of the ice, which has been found by M. Agassiz himself to be constantly, and at all depths, within a fraction of a degree of 32°. But besides this, the most direct observation shows that the nocturnal congelation, which is so visible at the surface, drying up the streamlets of water, and glazing the ice with a slippery crust, extends to but the most trifling depth into the mass of the glacier. This is so evident, upon consideration, that when fairly placed before him, M. de Charpentier has been obliged to abandon the idea that the diurnal variations of temperature produce any effect. In truth, there is positive evidence that no internal congelation takes place during the summer season, when the motion is most rapid, and when, therefore, the cause of motion must be most energetic. Of this I will give one striking example.

Towards the end of September, 1842, when, it has been already mentioned, a premature winter had covered the Mer de Glace with snow, and lowered the temperature of the air to 22° Fahrenheit, I had occasion to make an expedition over nearly its whole extent, in the direction of the Glacier de Léchaud, in order to observe the marks which had been placed in that direction, and to determine the motion of the higher parts of the ice. The excursion promised to be far from agreeable. The sky was lowering when I started from the Montanvert, and it soon began to snow, and continued to do so with little intermission during

[1] This argument has been well put by M. Elie de Beaumont, with his accustomed clearness.

the day. The Mer de Glace had been covered with snow *for a week*, at the Montanvert to a depth of six inches, but in its higher parts of not less than a foot and a half. I was not sorry, however, to have an opportunity of ascertaining the conditions of the ice, under circumstances so critical for the theory of dilatation, for now, if at any time, the freezing and expansive effects of cold ought to be visible, the ice having been completely saturated by the preceding wet weather, and, it might be supposed, effectually cooled by five days of frost. As the walk promised to be laborious, if not difficult, owing to the thick coating of snow, I took with me David Couttet of the Montanvert, and Auguste Balmat, as usual, with the instruments and provisions. We started in a lowering morning at half-past six, and in less than an hour it began to snow, with a drifting wind, though fortunately without cold. To most persons the journey would have been an alarming one, but we were all three so intimately acquainted with the surface of the ice, and the direction of the moraines, that we had no fear of losing ourselves. It required, however, all Auguste's intimate knowledge of the glacier to keep us clear of dangerous crevasses and holes; for the snow was often knee-deep, and the glacier and moraines alike filled with innumerable pitfalls. We crossed the moraines, as usual, near the Moulins, and visited the stations B1 and C. We then kept nearly under the ice-fall of the Glacier de Talèfre, and reached with precaution the higher glacier of Léchaud, on our way to station E, where I anxiously wished to make an observation of the progress of the glacier. But now the bad weather increased so much that we were glad to get behind a great stone and eat our breakfast, waiting for a favourable change. The wind blew in strong gusts from the Grandes Jorasses, tossing the snow about so as to render all objects at a distance undistinguishable, thus threatening to make our expedition ineffectual, for the rock called the Capucin du Tacul, which was my index for the bearings on the glacier from station E, was hopelessly invisible. After some delay the storm abated, and the Pierre à Béranger, whose azimuth I had fortunately taken as a check, showed itself. We therefore advanced up the glacier, but again the storm thickened, and as we got to the foot of the rock on which station E was fixed, David Couttet (who had hitherto been the chief encourager of the expedition) said quietly, "Nous allons faire une bêtise," and proposed to return, for we were half blinded by the snow. I begged, however, that we might at least stop and take shelter as before. We did so, and, profiting by a few minutes' pause in the drift, I fitted up my theodolite, and took an observation of the motion of the glacier since my last visit, with due care and deliberation. We then returned nearly as we had come, fortunately without accident, and reached the Montanvert after nine hours' absence. What struck me most in this expedition was, that even at the highest station, which is 7900 feet above the sea, and in this severe weather, the ice, far from being frozen to a great depth, appeared charged with water as usual, except at the surface. The stick which marked the point of the glacier observed, and which I expected to find firmly frozen into its place, was *standing in water* in its hole in the ice, and of course quite loose. The *surface* of the glacier generally was dry,—there was not a rill of water in the Moulins, or elsewhere: yet the congelation had scarcely penetrated at all. Couttet and Balmat were all the time afraid of treading into a watery hole, and thus getting their feet frozen, an accident which I thought very unlikely to happen; but they both did get their feet wet in the course of the day. Hence there can be no doubt that, as Couttet very distinctly expressed it, the snowy covering kept the glacier warm, just as it does the ground, and that the cold penetrates extremely slowly even when winter arrives. I may add that near the Tacul I found no difficulty in obtaining a draught of water by breaking the crust of ice formed on a pool in the glacier under a stone. It was on this excursion that I observed the blue colour of snow, mentioned on p. 69, which was most distinctly perceptible by transmitted light, whenever the snow was pierced by a stick to a depth of six inches or more. It was at one part of the glacier that this was most evident, which I attributed to the particular degree of aggregation which it had there, neither very dry nor very moist.

From the incidents just related, I think it seems to be demonstrated beyond a doubt that, at least, any *transient* impression of cold is quite incapable of converting the infiltrated water into ice at any depth in the glacier.

2. At the same time that the preceding observations were made, the rate of motion of the glacier was carefully observed; for I concluded, as a matter of certainty, that, if the dilatation

theory were true, a sudden frost succeeding wet weather must inevitably cause the glacier to advance far more rapidly than in summer, or, indeed, at any other season; for there could never possibly be more water to be frozen, nor could cold ever act with more energy than at the time in question. What the facts were, we have already seen in the seventh chapter, where it appears, both from the tables and figures (pp. 132-134), that the progress of the glacier was retarded during the cold weather which prevailed from the 20th to the 25th September, and that it re-advanced when the thaw had taken place some days later.

3. The motion of the glaciers during winter, established in the same chapter (pp. 144, 145), is directly contrary to the conclusions invariably drawn by the glacier theorists from their supposed immobility; since they consider, that while the glacier is completely frozen, and has no alternations of congelation and thaw, there can be no dilatation.

4. The experiments mentioned on pp. 126, 127 show, that the motion of a glacier during the day and night is sensibly uniform, which is contrary to the same view.

5. The rate of motion of the glacier at different parts of its length has been shown (p. 137) to be by no means such as the expansion of an elongated body, supported at one end, and pushed along its bed, would occasion.[1]

6. The advocates of the theory of dilatation have rightly maintained, as a consequence of the theory, that the ice will expand in *all* directions, and consequently upwards, that being the direction in which the resistance is least of all. They thence conclude that whilst the ice wastes by melting at the surface, the surface will be raised by the inflation of the interior mass by the expansion of freezing water, and that its absolute level will thus be maintained, or will even rise, notwithstanding the daily waste. They profess to have made experiments which confirm this view; but I have already stated (p. 146) that my own are entirely at variance with it, the absolute level of the ice lowering with great rapidity during the season of most rapid motion; a conclusion which is entirely confirmed by the observations of MM. Martins and Bravais, lately published.[2]

On these, amongst other grounds deduced from direct obser-

[1] [See especially, on this point, *Occasional Papers*, pp. 68-77.]
[2] *Annales des Sciences Géologiques*, par Rivière, 1842.

vation, I consider the dilatation theory maintained by Scheuchzer, De Charpentier,[1] and Agassiz as untenable.

In the next place, let us consider the sliding theory of Gruner and De Saussure, of which a sufficient account has been given in Chapter III.

As I understand the GRAVITATION theory, it supposes the mass of the glacier to be a *rigid* one, sliding over its trough or bed in the manner of solid bodies, assisted, it may be, by the melting of the ice in contact with the soil, which possesses a proper heat of its own, and which lubricates in some degree the slope, as grease or soap does when interposed between a sliding body and an inclined plane. It is only in so far as the theory is considered as applicable to a rigid body that I have objections to state to it.

1. In the case of the greater number of extensive glaciers, there are notable contractions and enlargements of the channel or bed down which they are urged. Let any one glance at the Mer de Glace, and see two extensive glaciers meeting at the Tacul, forming a vast basin or pool, from which the only outlet has a less breadth than the narrowest of the tributaries; the idea of *sliding*, in the common legitimate sense of the word, is wholly out of the question.

2. We have already seen that the ice does not move as a solid body—that it does not slide down with uniformity in different parts of its section—that the sides, which might be imagined to be most completely detached from their rocky walls during summer, move slowest, and are, as it were, dragged down by the central parts. All this is consistent with motion due to weight or gravitation; but not with the sliding of a rigid mass over its bed.

3. The inclination of the bed is seldom such as to render the overcoming of such obstacles as the elbows and prominences, contractions and irregularities of the bed of glaciers, even conceivable, being, on an average of the entire Mer de Glace, only 9°, a slope practicable for loaded carts; but the greater part of the surface inclines less than 5°, which is below the steepest slope on the great highway of the Simplon, an artillery road.

[1] [M. de Charpentier became converted in 1844 after reading Forbes's book. See *Life and Letters*, p. 162.]

4. It has been convincingly proved in Chapter VII. that the motion of the glacier varies not only from one season to another, but that it has definite (though continuous) changes of motion, simultaneous throughout the whole, or a great part of its extent, and therefore due to some general external change. This change has been shown to be principally or solely the effect of the temperature of the air, and the condition of wetness or dryness of the ice. In order to reconcile this to the sliding theory, it should be shown that the disengagement of the glacier from its bed depends on the kind of weather which affects its surface and temperature. In no part of the summer is the glacier actually frozen to its lateral walls; the difference, then, must be due to the action of the earth's heat in gradually melting away the irregularities of the inferior surface of the ice, in contact with the rocky bed on which it reposes. I have already said that I consider such an influence of the proper heat of the earth to be distinctly included in De Saussure's theory, as it has been stated by himself, and understood by his successors.[1] It was, however, suggested to me very distinctly by M. Studer last summer, as not inconsistent with a motion by gravity without acceleration; and I admit the ingenuity of the thought, which, as it will be seen in the sequel, I am disposed to allow, may be one *way* of glacier motion, though not exactly the *cause* of it. The same thought was afterwards suggested to me by Sir John Herschel, and more lately Mr. Hopkins of Cambridge, the author of an ingenious pamphlet on the theory of glacier motion, has illustrated it by experiment. But this is an effect which must remain nearly the same at all seasons, being due to the constant flow of heat from the interior.

5. The flow of heat from the interior is so *very* trifling that it may be doubted whether it is adequate to produce the particular effect of wearing off the prominences of the descending ice, or of moulding it to the form of the channel. In order to do so to any effectual extent, it would be necessary that prominences of many feet or yards in extent should be melted away in a moderately short space of time. Now, what is the fact?

[1] Any one who carefully reads De Saussure's § 535 in connection with § 533, will be convinced that he gives all due weight (we should be inclined to say *more* than due weight) to the effects of subterranean heat in *detaching* the ice from its bed, *lubricating* it on its bed, and even *elevating* it over obstacles by the hydrostatic pressure of confined water.

M. de Beaumont has estimated,[1] by the theory of Fourier, from the observations of Arago on the earth's temperature, that the quantity of central heat which reaches the surface of the earth, is capable of melting $6\frac{1}{2}$ millimètres of ice, or exactly *a quarter of an English inch in the space of a year.* Now, even admitting (as I think we may) that if the surface of the earth were covered with ice, the flow of heat would be somewhat greater, still it must be admitted to be capable of disposing of portions of ice insignificant compared to the inequalities which oppose its downward progress.

6. This small quantity of heat is not always applied (as Professor Bischoff[2] and M. Elie de Beaumont have justly remarked) to *melt* the ice of glaciers. Below 32° it will simply tend to raise the temperature of the ice in contact with the soil, and powerfully adhering to it. The almost *pendant* glaciers of the second order, which are seen only at great heights, those, for instance, on the precipices of the Mont Mallet (see p. 76), must remain permanently frozen to the rock. Nevertheless they do actually descend over it, for they continually break off in fresh avalanches. This is a fact which neither the theory of dilatation nor that of gravity, as commonly stated, is capable of explaining.

After the detailed though scattered deductions which have been made in the course of this work, from observations on the movement and structure of glaciers, as to the cause of these phenomena, little remains to be done but to gather together the fragments of a theory for which I have endeavoured gradually to prepare the reader, and by stating it in a somewhat more connected and precise form, whilst I shall no doubt make its incompleteness more apparent, I may also hope that the candid reader will find a general consistency in the whole, which, if it does not command his unhesitating assent to the theory proposed, may induce him to consider it as not unworthy of being farther entertained.

My theory of glacier motion then is this:—A GLACIER IS AN IMPERFECT FLUID, OR A VISCOUS BODY, WHICH IS URGED DOWN

[1] *Annales des Sciences Géologiques*, par Rivière, 1842.
[2] *Wärmelehre*, p. 101, etc.

SLOPES OF A CERTAIN INCLINATION BY THE MUTUAL PRESSURE OF ITS PARTS.[1]

The sort of consistency to which we refer may be illustrated by that of moderately thick mortar, or of the contents of a tar-barrel, poured into a sloping channel. Either of these substances, without actually assuming a level surface, will *tend* to do so. They will descend with different degrees of velocity, depending on the *pressure* to which they are respectively subjected—the *friction* occasioned by the nature of the channel or surface over which they move—and the *viscosity*, or mutual adhesiveness, of the particles of the semi-fluid, which prevents each from taking its own course, but subjects all to a mutual constraint. To determine completely the motion of such a semi-fluid is a most arduous, or rather, in our present state of knowledge, an impracticable investigation. Instead, therefore, of aiming at a cumbrous mathematical precision, where the first data required for calculation are themselves unknown with any kind of numerical exactness, I shall endeavour to keep generally in view such plain mechanical principles as are, for the most part, sufficient to enable us to judge of the comparability of the facts of Glacier motion with the conditions of viscous or semi-fluid substances.

That Glaciers are Semi-fluids is not an Absurdity

The quantity of viscidity, or imperfect mobility in the particles of fluids, may have every conceivable variation; the extremes are perfect fluidity on the one hand, and perfect rigidity on the other. A good example is seen in the process of consolidation of common plaster of Paris, which, from a consistency not thicker than that of milk, gradually assumes the solid state, through every possible intermediate gradation. Even water is not quite mobile; it does not run through capillary tubes; and a certain inclination or *fall* is necessary to make it *flow*. This may be roughly taken as an index of the quality of viscidity in a body. Water will run freely on a slope of 6 inches in a mile,

[1] [It may be interesting to cite here the criticism made on Forbes's theory by Professor Heim (p. 312 of his great work, *Handbuch der Gletscherkunde*). "Forbes speaks of his 'Theory of Plasticity,' but it is rather a case of abstraction from the facts than an explanation of the physical properties of ice. He says, in fact, little more than that 'the glacier moves like a stream because it is viscous.' . . . His error consisted in always comparing viscous (*zähflüssige*) substances with the glacier, instead of those whose inner cohesion is less than their internal friction (*dickflüssige*)."]

or a fall of 1-10,000 part,[1] another fluid might require a fall of 1 in 1000; whilst many bodies may be heaped up to an angle of several degrees before their parts begin to slide over one another.

Thus, a substance apparently solid may, under great pressure, begin to yield; yet that yielding, or sliding of the parts over one another, may be quite imperceptible upon the small scale, or under any but enormous pressure.[2] A column of the body itself is the source of the pressure of which we have now to speak.

Even if the ice of glaciers were admitted to be of a nature perfectly inflexible, so far as we can make any attempt to bend it by artificial force, it would not at all follow that such ice is rigid when it is acted on by a column of its own material several hundred feet in height. Pure fluid pressure, or what is commonly called hydrostatical pressure, depends not at all for its energy upon the *slope* of the fluid, but merely upon the *difference of level* of the two connected parts or ends of the mass under consideration. If the body be only semi-fluid, this will no longer be the case; at least the pressure communicated from one portion (say of a sloping canal) to the other will not be the *whole* pressure of a vertical column of the material, equal in height to the difference of level of the parts of the fluid considered; the consistency or mutual support of the parts opposes a certain resistance to the pressure, and prevents its indefinite transmission. It must be recollected that, in the case of glaciers, the pressing columns are enormous, the origin and termination of many of the largest having not less than 4000 feet of difference of level; were they, therefore, perfectly fluid, or suddenly converted into water, the lower end would begin to move with the enormous velocity of 506 feet a second, or would move over 44 *millions of feet* in 24 hours. Now, the velocity of the Mer de Glace is only about 2 feet in that time, a difference so enormous that the fluidity of a glacier compared to water will not appear

[1] According to Dubuat (*Hydraulique*, tome i. p. 64, edit. 1816), at a slope a great deal lower; but its exact value does not now concern us.

[2] This has been illustrated in a very interesting and apposite manner by Professor Lewis Gordon of Glasgow, who has shown that Stockholm pitch, whilst so completely solid as to admit of being broken into angular fragments, yet moves under its own weight with extreme slowness, but after the manner of a fluid. See *Philosophical Magazine*, March, 1845. See also the Fourth Letter on Glaciers in *Occasional Papers* (p. 35), where the case of sealing-wax is referred to (1845).

so preposterous as it might at first sight do, considering the small degree of transmitted pressure required to be effectual.

Again, it has been attempted to show (pp. 168, 169) that a glacier is not coherent ice, but is a granular compound of ice and water, possessing, under certain circumstances, especially when much saturated with moisture, a rude flexibility sensible even to the hand.

Further, it has been shown that the glacier *does* fall together and chokes its own crevasses with its plastic substance (pp. 166, 167).

When a glacier passes from a narrow gorge into a wide valley it spreads itself, in accommodation to its new circumstances, as a viscous substance would do, and when embayed between rocks, it finds its outlet through a narrower channel than that by which it entered. This remarkable feature of Glacier motion, already several times adverted to, had not been brought prominently forward until stated by M. Rendu, now Bishop of Annecy, who has described it very clearly in these words: "Il y a une foule de faits qui sembleraient faire croire que la substance des glaciers jouit d'une espèce de ductilité qui lui permet de se modeler sur la localité qu'elle occupe, de s'amincir, de se renfler, de se rétrécir et de s'étendre, comme le ferait une pâte molle. Cependant, quand on agit sur un morceau de glace, qu'on le frappe, on lui trouve une rigidité qui est en opposition directe avec les apparences dont nous venons de parler. Peut-être que les expériences faites sur de plus grandes masses donneraient d'autres résultats." [1]

Now, it is by observations on the glacier itself that we can best make experiments on *great masses* of ice as here suggested.

The Motion of a Glacier resembles that of a Viscous Fluid

All experimental philosophers are agreed as to the facts, that a fluid like water, heavy and slightly *viscid*, moves down an

[1] *Théorie des Glaciers de la Savoie*, p. 84 [p. 71 of the 1874 reprint]. Whilst I am anxious to show how far the sagacious views of M. Rendu coincide with, as they also preceded my own, it is fair to mention, that all my experiments were made, and indeed by far the greater part of the present volume was written, before I succeeded in obtaining access to M. Rendu's work, in the 10th volume of the *Memoirs of the Academy of Savoy*, which I owe at length to the kindness of the right reverend author. [Forbes visited the Bishop at Annecy in July, 1846. He had received a letter of congratulation and invitation in August, 1844, from the Bishop, who at the end of 1842 had sent Forbes a copy of this Memoir. See *Life and Letters*, pp. 316, 494, and 528.]

inclined plane or canal, with a velocity which varies according to the slope, and which varies also from point to point of the section of the stream. The part of the stream which moves fastest is the surface, and especially the *central part* of the surface. The velocity of motion diminishes *on* the surface from the centre to the sides, and *from* the surface towards the bottom.

The cause of these variations is admitted to be the *friction* of the sides and bottom of the canal or bed, which retards the fluid particles immediately in contact with them, and the adhesion of these particles to their neighbours, that is, their *viscosity*, communicates this retardation by certain gradations, which are not correctly known, to the interior mass of the fluid. Hence—

I. The centre and top of the stream move faster than the sides and bottom, especially if *the friction of the fluid particles over one another be less than their friction against the sides of the canal.* If this be not the case—if the friction of the contained mass against the containing or supporting walls be *less* than the friction which exists amongst its own particles, the mass will *slide out of its bed,* and will so far act as a solid body. If it have a certain mobility amongst its own particles, it will, whilst sliding over its bed, alter, at the same time, the relative position of its own particles—it will move partly as a solid, partly as a fluid. We may then fairly call it a *semi-fluid* or a *semi-solid.*

II. From this it also evidently appears, that the greater the viscosity of the fluid, the farther will the lateral and fundamental retardations be communicated towards its centre, and the general velocity of the stream will be more nearly regulated by the limit of the mobility of its parts.

III. In every case the greatest variation of the velocity of such a stream will take place near the sides and bottom, whilst the higher and the central parts will move most nearly together.[1] The position of any particle moving with the mean velocity of the entire stream, has not, I believe, been determined;

[1] A slight consideration will show, that this might naturally be anticipated, yet some eminent writers have supposed the velocity to increase *uniformly* from the bottom to the surface of a stream. The doctrine of the text is fully confirmed by direct experiments upon the river Rhine, quoted in Mr. Rennie's *Report on Hydraulics*, Part II., *British Association Report* (1834), p. 467, as well as by the models presently to be described.

but Dubuat has practically found this singularly simple result, that the velocity of the top and bottom of a stream being known, the mean velocity of the entire stream is the arithmetical mean of these two velocities.

IV. The difference of the velocities of a stream at the top and bottom depends upon the actual velocity of the stream, and increases as that velocity increases. The rate of increase appears to be as the square root of the velocity, and is independent of the depth.[1]

V. The velocity of the water in a stream increases with its declivity. If the bed of a river be highly inclined, the water flows rapidly; and again, if the embaying of a river by a strait accumulates the water above, there its declivity will be diminished.

VI. If any circumstance causes the viscosity or consistency of a fluid to vary, all these phenomena will vary proportionally. Thus, warm water is less viscid than cold, and a vessel will be sooner emptied through a narrow aperture the higher the temperature of the liquid.[2]

Now, in all these respects, we have an exact analogy with the *facts* of motion of a glacier, as observed on the Mer de Glace.

First, we have seen that the centre of the glacier moves faster than the sides (p. 139). We have not, indeed, extended the proof to the top and bottom of the ice-stream, for it seems difficult to make this experiment in a satisfactory manner. In the case of a glacier 600 feet deep, the upper hundred feet will move nearly uniform, on the principles already mentioned;[3] hence, crevasses formed from year to year will not incline sensibly forwards on this account, especially as the action of trickling water is to maintain the verticality of the sides. I conceive that this is a perfectly sufficient answer to an objection which, at one time, I myself urged against the hypothesis of the surface of the glacier moving most rapidly. Of the fact I entertain no doubt, though I see much difficulty in obtaining a satisfactory proof of it.

I have no doubt that glaciers slide over their beds, as well as that the particles of ice rub over one another, and change

[1] Dubuat, Arts. 37, 49, 65. [2] *Ib.* Art. 3.

[3] See *Occasional Papers*, pp. 50-54 (1845).

their mutual positions; but I maintain that the former motion is caused by the latter, and that the motion impressed by gravity upon the superficial and central parts of a glacier (especially near its lower end) enables them to pull the lateral and inferior parts along with them. One proof, if I mistake not, of such an action is, that a deep current of water will flow under a smaller declivity than a shallow one of the same fluid.[1] And this consideration derives no slight confirmation in its application to glaciers, from a circumstance mentioned by M. Elie de Beaumont, which is so true that one wonders it has not been more insisted on—namely, that a glacier, where it descends into a valley, is like a body pulled asunder or stretched, and not like a body forced on by superior pressure alone.[2]

Secondly, we have already seen (p. 367) how enormous would be the velocity of a glacier if suddenly converted into a fluid, and how prodigious a force is absorbed, as it were, by the consistency or solidity of the ice. The moderate, though marked difference, found (p. 139) between the lateral and central velocity of a glacier is in conformity to the second principle stated above, that the retardation due to friction will be more completely distributed over the whole section in proportion as the matter is less yielding.

Thirdly, the chief variation of velocity is, we have seen (p. 139), near the sides.

Fourthly, we have found on page 140 a most remarkable confirmation of Dubuat's principle, that the amount of lateral retardation depends upon the actual velocity of the stream under

[1] It is well known that the mean hydraulic depth, or the ratio of the section of a stream to the perimeter of contact with its bed, is the most important element (together with the declivity) in determining its velocity, or the effectual moving force which acts upon it. Now, in the case of common friction, that of a solid body, neither the absolute nor the relative depth of the sliding body can have any influence in determining its motion.

[2] It has been erroneously supposed by some, that in this and other passages of the first edition of this work, I have overlooked the opposition between the extension of the ice here spoken of, and the pressure *a tergo* subsequently mentioned, as necessary to produce the phenomena of the veined structure. The fact is, that a state of universal distension, or a state of universal compression, is equally incompatible with the existing phenomena of most glaciers; and that compression in some parts, and distension in others, are plainly indicated by their natural features. That a state of general compression is not, as has likewise been alleged, incompatible with the existence of crevasses, is shown in the Ninth Letter on Glaciers; see *Occasional Papers*, pp. 70-72 (1845).

experiment; whether we consider different points of the glacier or the same point at different times.[1]

Fifthly, the glacier, we have seen, like a stream, has its still pools and its rapids. Where it is embayed by rocks, it accumulates—*its declivity diminishes, and its velocity at the same time*;—when it passes down a steep, or issues by a narrow outlet, its velocity increases (p. 138).

The *central* velocities of the lower, middle, and higher regions of the Mer de Glace are (p. 137)—

1·398	·574	·925

And if we divide the length of the glacier into three parts, we shall find (pp. 112, 113) something like these numbers for its declivity[2]—

15°	$4\frac{1}{2}$°	8°

Lastly, when the semi-fluid ice inclines to solidity during a frost, its motion is checked; if its fluidity is increased by a thaw, the motion is instantly accelerated (p. 141). Its motion is greater in summer than in winter, because the fluidity is more complete at the former than at the latter time. The motion does not cease in winter (p. 144), because the winter's cold penetrates the ice as it does the ground, only to a limited extent (pp. 227, 361). It is greater in hot weather than in cold, because the sun's heat affords water to saturate the crevices; but the proportion of velocity does not follow the proportion of heat (pp. 134, 142, 143), because any cause, such as the melting of a coating of snow by a sudden thaw, as in the end of September, 1842, produces the same effect as great heat would do. Also, whatever cause accelerates the movement of the centre of the ice increases the difference of central and lateral motion (p. 140).

The Veined Structure of the Ice is a consequence of the Viscous Theory

We have now to complete what was partly said in Chap. VIII., where we endeavoured to illustrate the phenomena of the veined or ribboned structure of the ice, and to explain its cause.

[1] Une chose étonnante, c'est que ni la grandeur du lit, ni celle de la pente n'influent en rien sur le rapport des différentes vitesses dont nous parlons, *tant que les vitesses moyennes restent les mêmes* où celle de la surface est constante." . . . Dubuat, Art. 65.

[2] These numbers do not express the actual slopes at the points where the velocities were measured, but the slope of the inferior, middle, and superior regions of the glacier.

This structure we have seen to consist in the recurrence of alternations of blue and white, or compact and aërated ice in a glacier resembling the veins in chalcedony, the parts being thin and delicately subdivided.

We have seen (pp. 170, 174) that the structure has all the appearance of being due to the formation of fissures in the aërated ice or consolidated névé, which fissures having been filled with water drained from the glacier, and frozen during winter, have produced the compact blue bands.

We have further seen (p. 153, etc.) that this ribboned structure follows a very peculiar course in the interior of the ice, of which the general type is the appearance of a succession of oval waves on the surface, passing into hyperbolas with the greater axis directed along the glacier. That this structure is also developed throughout the thickness of a glacier, as well as from the centre to the side, and that the structural surfaces are twisted round in such a manner that the *frontal dip*, as we have called it, of the veins, as exhibited on a vertical plane cutting the axis of a glacier, occurs at a small angle at its lower extremity, and increases rapidly as we advance towards the origin of the glacier, as shown in Fig. 1.

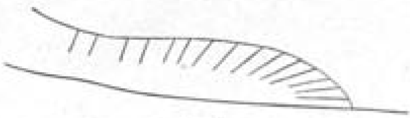


FIG. 1.

We have also considered glaciers generally as of three kinds, which, having a common structure, yet exhibit it in different forms or modifications. These three glacier forms may be termed the *canal-shaped*, the *oval*, and the glaciers of the *second order*. Picturesque views of these [were] given in Plates II., IV., and IX., representing the *Mer de Glace*, the

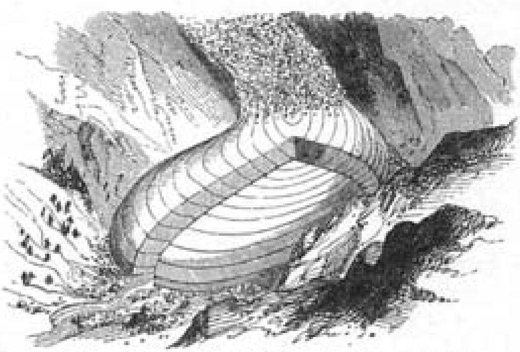


FIG. 2.—SHOWING THE STRUCTURE OF AN OVAL GLACIER BY IDEAL SECTIONS.

Glacier of *La Brenva*, and the secondary glaciers near *Macugnaga*. The annexed figures (one of which has been already used) show by means of views with ideal sections of such glaciers, the manner in which the structural surfaces traverse the mass of the ice. Fig. 2 shows the conoidal structure of a glacier of the oval kind. Fig. 3 shows this drawn out, as it were, into a canal-shaped glacier. On the right hand, in the upper part of the figure, a small glacier of the second order is shown, where it appears that its structure consists of a series of superimposed shells, nearly parallel to the soil, which might easily be confounded with the annual layers of the névé.

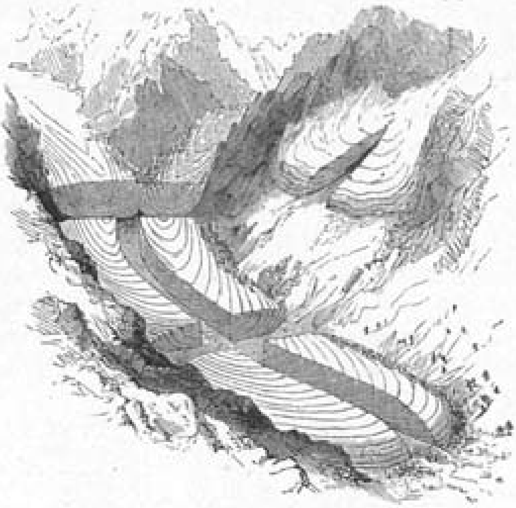


FIG. 3.—SHOWING THE STRUCTURE OF A CANAL-SHAPED GLACIER BY IDEAL SECTIONS.

All these structures I explain on the common principle of the difference of velocity of the higher and lower, as well as of the central and lateral parts of the ice; for wherever the parts of a stream, whether liquid or semi-solid, move with different velocities, there must be a force applied to separate them from one another, as I have fully explained at page 170.

But hear Dubuat, an eminent hydrostatical writer. Speaking of ordinary rivers, he says, "La viscosité de l'eau ou l'adhérence que ses particules ont entre elles, occasionne une résistance très petite, mais finie, qui s'oppose sans cesse à leur séparation : or, il ne peut y avoir de mouvement uniforme dans l'eau, sans que ses filets ne prennent différentes vitesses, selon qu'ils sont plus ou moins proches de la paroi qui retarde et rend uniforme le mouvement de toute la masse. Cette inégalité de vitesses ne peut avoir lieu sans une séparation mutuelle des parties contiguës. La viscosité, ou, si l'on veut, la force avec laquelle ces parties s'attirent, s'oppose à cette séparation ; il faut donc qu'il y ait constamment une partie de la force accélératrice destinée à vaincre cette résistance ; et lorsque la force accélératrice est assez petite pour lui être seulement égale, le mouvement doit cesser, quoique la pente soit finie. S'il existait un fluide dont les parties n'eussent aucune adhérence entre elles, la plus petite pente possible suffirait pour lui imprimer un mouvement ; mais les différents liquides connus éprouvant plus ou moins l'effet de la viscosité, la pente à laquelle ils commencent à couler est d'autant plus grande que l'adhérence de leurs parties les éloigne moins de la nature des solides." [1]

From this we might expect that we should have a separation of the icy particles, a rupture or fissuring of the substance of the glacier everywhere parallel to the resisting walls or bottom, producing a cross section, as in the annexed figure, for it cannot, I think, be doubted, after what has been stated, that the motion of the ice is more rapid at the surface than at the bottom, for the very same reason that it is more rapid at the centre than at the side. Indeed, from the form of the bed, it is impossible to say where the side ends and where the bottom begins. In glaciers of the second order, where the retardation is almost entirely due to the action of the bottom, the successive layers slip over one another with an increasing velocity towards the surface. See the upper part of Fig. 3.

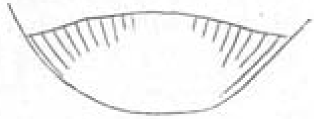


Fig. 4.

In consequence of this it is conceivable that a glacier should remain permanently frozen to its bed, and yet that the strata should move over one another, and the highest most rapidly. I am far from saying that this is actually the case ; for I believe that in most instances the glacier is detached from its bed by the natural warmth of the earth,—yet when the friction is so enormous, as when ice moves over a channel of rough rock,—and when, what is far more important and unanswerable, a glacier accumulating in an icy basin (as that of Talèfre, for example) flows out by a narrower aperture than that by which it entered, motion as a *solid* body is out of the question—it can only move by its parts yielding—in other words it is plastic.

[1] Dubuat, vol. i. p. 58.

But the question arises, how does this retarding action of the sides and bottom produce the *frontal dip* of Fig. 1? why does not the canal-shaped glacier present a series of trough-shaped layers, as in Fig. 4, whose bottom remains parallel to the bottom or bed of the glacier? The reason appears to be this. The fluid is urged on (in the centre of the glacier especially) by its own *weight*. It is falling down an inclined plane by the force of gravity. It is, however, prevented from moving by the intense friction of the whole of the lower part of the glacier (*i.e.*, the part lying farthest from the origin of the glacier) upon its bed. If the glacier be solid, there can be no motion, unless there be sufficient force to overcome this friction;[1] and this we have seen to be one great (and we think insurmountable) difficulty, both of the hypothesis of De Saussure and that of De Charpentier. But the semi-fluid has another mode of progression,—the pressure *may* not overcome the friction of the bed, or else the fluid pressure at the lower end *may* drag the whole glacier over its bed, *that* is immaterial; but any particle in a fluid or semi-fluid mass, urged by force from above, does not necessarily move in the direction in which the force impels it, it moves *diagonally;* forwards, in consequence of the impulse; upwards, in consequence of the resistance directly in front. Hence a series of surfaces of separation shaped (to use familiar illustrations) somewhat like the mouth of a coal-scuttle, or of a sugar-scoop, will rise towards the surface, varied in curvature by the law of velocity of the different layers of the glacier. Near the head or origin of the glacier, where the resistance in front is *enormous,* the tendency of the *separation planes,* which are those of apparent cleavage, will be very highly inclined. As the lower end of the glacier is approached, the resistance continually diminishes, the line of least resistance becomes more and more nearly horizontal; and finally, when the lower end of the glacier is reached, the planes fall away altogether, and the upper layers roll over the lower ones, now wholly unsupported. Such we have seen to be the actual phenomena of the Mer de Glace.

Imagine a long narrow trough or canal stopped at both ends, and filled to a considerable depth with treacle, honey, tar, or any such viscid fluid. Imagine one end of the trough to give way,

[1] By friction is here intended to be included all the resistances arising from the inequalities of the bed (1845).

the bottom still remaining horizontal, if the friction of the fluid against the bottom be greater than the friction against its own particles, the upper strata will roll over the lower ones, and protrude in a convex slope, which will be propagated backwards towards the other or closed end of the trough. Had the matter been quite fluid the whole would have run out and spread itself on a level; as it is, it assumes precisely the conditions which we suppose to exist in a glacier. The greatest disturbance or maximum separation of the parts takes place at the lower end, and there (the retardation at the sides being proportional to the *absolute* velocity, see p. 140) the separation will be most violent, and the loops on the surface will be most elongated. Near the origin the declivity is less, and the loops are more transverse. This is true of the glacier (see p. 159).

Fig. 5.

Now, let the trough be a little inclined, so as to aid the gravitating force derived from the mere depth of the fluid. Each particle will be urged on by a force due to the slope, diminished by the resistance opposed to it. The particles near the lower termination of the stream have no resistances, except their attachment to those behind them,—they, therefore, roll straight on; but those in the middle of the glacier will easier raise the weight of a certain superincumbent stratum of ice, than push the entire glacier before them; they may do part of both, but will undoubtedly rise towards the surface, and thus *slide upwards and forwards* over the particles immediately in advance. Though I am not aware that this form of fluid motion has been pointed out, its existence is scarcely to be doubted from very ordinary mechanical considerations, and several obvious phenomena also indicate it.

I have succeeded in illustrating these assertions and theories by an appeal to experiment—by constructing models of a viscid material (a mixture of plaster of Paris and glue, which does not *set* readily) poured down channels more or less irregular, representing Alpine valleys. In order to trace the motions better, I at first composed the streams of alternate doses of white and blue fluid, poured in successively from the head of the mimic valleys. In others the stream was of uniform material, but the surface was covered with coloured powder, and the distortion in each case, arising from the resisted motion and the mutual pressure of the parts, was observed. Models of the former description were shown to the Royal Society of Edinburgh in March, 1843, and were described in their Proceedings; the last were made about two months later.

Each of these models illustrates something important in this theory. Those composed of successive layers of coloured paste, when consolidated after having flowed under their own weight, and when cut up by longitudinal and transverse sections, exhibit, as in the annexed figure, the exact results of retarded fluid

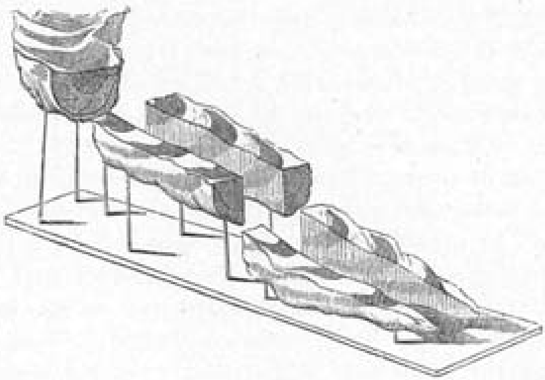


FIG. 6.—VIEW OF A MODEL, SHOWING THE CURVES GENERATED (EXPERIMENTALLY) BY THE MOTION OF A VISCOUS FLUID.

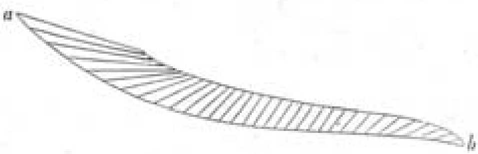
motion in modifying the arrangement and rate of motion of the parts. An arrangement so conformable to the measures of the surface-velocity of different parts of the glacier, to the expanding forms of the dirt bands (see Fig. 5, *Occasional Papers*, Third Letter, pp. 17-25), and to the diminishing measure of the frontal dip at the lower end of the glacier, as to confirm in a satisfactory manner my theoretical anticipations, which long preceded the construction of these models. The mere inspection of the extremely elongated curves presented by these coloured pastes, both on the surface and in the vertical longitudinal section, proves the excessive retardation of the sides and the rapid transfer of the central past the lateral portions continually repeated, evidently producing a continual separation of parts once in union in a manner consistent only with the semi-fluid or plastic condition; and this separation, or mutual tearing (see

p. 170), must have taken place nearly in the direction of the very elongated branches of the looped curves on the surface of the stream; whilst the continuity of the distorted layer of paste of any colour, which often extended over half the length of the model, recalled the fact of the force which must have been exerted to extenuate its parts to such a degree.[1] This continuity, arising from the cohering texture of the parts, demonstrates that the surfaces of tearing or differential motion, producing the ribboned structure, will not be parallel to the sides of the glacier on account of the *drag* towards the centre, arising from its superior velocity.

It was objected by M. Agassiz[2] to this theory of the veins,

[1] In the first edition I had too hastily inferred that the directions of the bounding surfaces of the layers of viscous fluid defined accurately the directions of *greatest* tension of the particles under their mutual actions. That this was an error, as Mr. Hopkins has observed, I readily admit, although practically the approximation to the lines of greatest tension, and consequent disseverment by tearing, is so close as probably to render the mistake inappreciable. The same observation applies to the phenomenon of *frontal dip*, which cannot be said to be actually represented in this kind of model, but rather that the causes which determine and modify it are so clearly exhibited as to leave no doubt in the correct application of them to the true phenomena, which it is difficult to reproduce in a manner quite analogous to nature in any model which shall retain the trace of it. In the second kind of model described farther on, and which was only contrived and made after the text in the first edition was completed, the lines of tearing are correctly shown, but only for differential motions in the horizontal plane (1845).

[2] Proceedings of the Ashmolean Society, *Athenæum*, February, 1843. In this communication M. Agassiz confirms my observation of the "dirt bands," adopts the name of "annual rings" (*Edin. Phil. Journal*, October, 1842), and endeavours to prove the conformity of their intervals to the actual motion of the Unteraar Glacier, as I had already done on the Mer de Glace. M. Agassiz still insists that glaciers are *stratified* (see p. 31 of this volume), and he distinguishes these strata, as he calls the annual rings, from the proper veined structure of the ice. He supposes, too, that the discoloration of the dirt bands arises from impurities actually interstratified with the ice at the névé, whereas it has been shown (p.156) that the discoloration is an entirely superficial phenomenon, arising from the peculiar texture of the ice, but which is quite as pure, internally, there as elsewhere. Having maintained in all his earlier writings that a glacier is horizontally stratified throughout its whole extent (*Études*, p. 40), M. Agassiz now adopts my figure 1 of page 373 (first published in the *Edin. Phil. Journal* for October, 1842) for the



lower end of his glacier, and connects it with the névé by a convenient series of interposed strata, first rising and then falling, as represented in the annexed cut, that, were it true, so soon as two glaciers united they would each lose their individual structure, and have single loops due to the union of their streams, whereas his observations led him to conclude that the loops of two united glaciers remain distinct. Now, in the first place, I reply that though the distinct structure of the double stream is maintained for a time, it is always finally *worn out* if the glacier be long enough, and the structure then forms single loops, *cutting at an angle* the medial moraines of the two glaciers (pp. 160, 161, and *Occasional Papers*, pp. 38, 39), and secondly, I maintain that this is precisely what a semi-fluid body might be expected to do. For the structure near the centre is always imperfectly developed, exactly because *there* the differential motion is least; I mean that there is least discontinuity of parts, because the velocity is nearly the same throughout a considerable space (p. 139); and if two glaciers unite and move tolerably uniformly together, they will preserve for a long way the structure which they had already acquired before the new one (representing a single united stream) is superinduced upon it. Now this, as we have seen in Chap. VIII., is exactly what takes place at the union of the Glaciers of Léchaud and Géant—of the two branches of the Glacier of Talèfre, and of the Glaciers of La Noire and the Géant, all of which, originally double in structure, finally become single, and cut the separating moraine at an angle. But I appealed here also to experiment, and found that by pouring double streams of viscid plaster down a single channel the separate forms were *very slowly* worn out indeed, and perpetuated far beyond the point of union of the streams. Thus the proposed objection became a strong confirmation of my theory. One of these

which is accurately copied from the original in Leonhard and Bronns' Journal, 1843, Heft 1. I can only simply but distinctly deny the resemblance to nature of this scheme, and reiterate the observation already several times made in this work, that the structure of a glacier is and must be formed in the glacier itself, not in the névé, from which it is often separated by an ice-fall, *which has ground the integrant parts of the névé to powder*, as in the Glacier of La Brenva (p. 195), the Glacier of Miage (p. 190), the Glacier of Talèfre (p. 162), and of Allalin (p. 352), with many others. Not to mention the section, page 347, of the Glacier of Macugnaga, where the two structures are seen at once, and perpendicular to each other.

Yet more extraordinary is the assumption made by M. Agassiz in order to account for this supposed prolongation of the beds of the névé into the inferior glacier. In order to explain the alternate rise and fall of the strata, he affirms that near the origin of the glacier the ice in contact with the bed moves faster than at the surface, but everywhere else slower!

models, also shown to the Royal Society, is represented in the annexed figure.

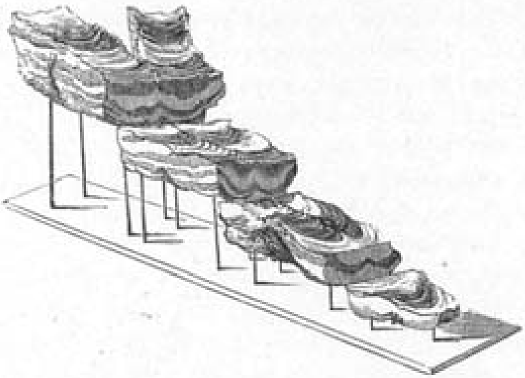


FIG. 7.—VIEW OF A MODEL SHOWING THE EFFECT OF THE UNION OF TWO STREAMS ON THE MOTION OF A VISCID FLUID.

As the models just described exhibit geometrically the rates of motion of each point of a viscous fluid retarded by the channel in which it moves, it becomes a determinate problem to find the measure of separation or tearing between any set of adjoining particles due to the differential velocity; but this separation may be correctly exhibited by an experiment such as that supposed in page 376, and which is thus performed. A mixture of plaster of Paris and glue is poured into one end of a narrow rectangular box, placed horizontally, where it is sluiced up by a bit of wood, removable at pleasure. The surface of the viscid mass is then strewed whilst level with a coloured powder sifted upon it as uniformly as possible, and the sluice withdrawn. The liquid flows exactly as I have described, and the colouring matter is drawn out into threads precisely resembling, in delicacy and continuity, on a minute scale, the veined appearance of the glacier surface. The explanation appears to be this, that the velocity of the central portion tends to pull the lateral portion towards the centre as well as parallel to the length of the glacier; this produces a slight lateral as well as longitudinal discontinuity, for the actual motion of the side portions towards the centre is exceedingly small, and does not sensibly disturb the parallelism of motion of the parts of the ice. This is, indeed, certain from the phenomenon of moraines, and corresponds to what may be familiarly observed in any stream, like a mill-race, moving slowly in a uniform channel, which, being strewed with a powder, that powder will be divided into streaks inclined to the side of the canal, whilst the motion of a floating cork will be sensibly parallel to it. In short the internal movements are of an order so inferior to the general movement of the stream that they may probably be left out of account in describing that general movement, although by the fissured structure which they induce they leave sufficient evidence of their existence. But if the slope be great, the movement towards the centre may be of an order to modify appreciably the direction of movement of a particle. This is probably the cause of the spread of the lateral moraines over the terminal part of many glaciers. (See the figure of the Glacier of Bossons, p. 165, note.) In an ordinary liquid like water the direction of the ripple-marks occasioned by the friction of a stream proceeding from a wider to a narrower channel points out lines of a maximum mutual friction of the particles against one another. They converge rapidly towards the centre of the stream, whilst the motion of the fluid, indicated by a floating body, deviates but little from the direction of the axis of the channel, but when the slope is rapid the drag towards the centre is manifest, and the amount of the differential velocities produces eddies and broken surfaces.[1]

The annexed figure shows the result of one of these experiments on the second class of plastic models. But it also reveals another striking confirmation of the theory which we maintain. In a perfect fluid there can never be a discontinuity of the mass such as may leave an unfilled separation or crack. The result of all the pressures and tensions must be resolvable into a sliding of one particle past another. As the body passes from the fluid, through the viscous or plastic state, into that of a solid, the sliding separation is combined with the formation of open fissures transverse to the lines of tension along which the sliding separation had taken place; and ultimately in the solid form, the division is usually entirely due to simple fracture. The models now described *invariably present both systems,* and in conformity with the empirical law already announced (see p.

[1] The mechanical theory of the veined structure (including the forces producing the Frontal Dip) is fully illustrated in a letter to Dr. Whewell. See *Occasional Papers*, pp. 55-60 (1845).

169, p. 170 note, and p. 29, Fig. 3, where the lines marked *a* represent crevasses; and *Occasional Papers*, p. 7), the open crevasses are invariably perpendicular to the veined structure, whether the former be transverse or radiating.

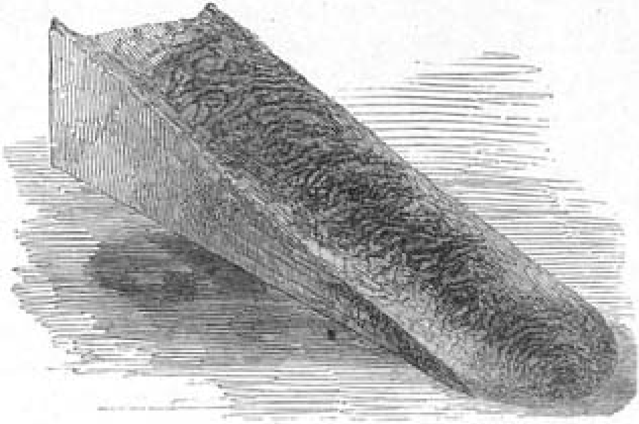


Fig. 8.

The whole phenomena then are such as—combined with the evidence which I have formerly given, that the motion of a glacier is actually such as I have described that of a viscid fluid to be—can leave, I think, no reasonable doubt that *the crevices formed by the forced separation of a half rigid mass, whose parts are compelled to move with different velocities, becoming infiltrated with water and subsequently frozen, produce the bands which we have described.*

The illustrations now given will, it is hoped, show that there is a striking conformity between the *facts of motion* and the *facts of structure* in a glacier, and that the two, mutually supporting and confirming one another, lend strong countenance to a theory which includes both. It would be very easy to enlarge upon and multiply these illustrations and coincidences, but I am satisfied that I have said enough to put the intelligent reader in possession of the strong points of the theory, whilst to many this chapter will appear already too long. A few circumstances which have not been here insisted on, appear in the Letters on Glaciers, Nos. 1-4, 8, 9 (see *Occasional Papers*).

The idea of comparing a glacier to a river is anything but new, and I would not be supposed to claim that comparison or analogy as an original one. Something very like the conception of fluid motion seems to have been in the minds of several writers, although I was not aware of it at the time that I made my theory. In particular, M. Rendu, whose mechanical views are in many respects more precise than those of his predecessors or contemporaries, speaks [pp. 24 and 67 of the 1874 reprint] of "glaciers d'écoulement" as distinct from "glaciers réservoirs"; and in the quotation at the head of this chapter, he evidently contemplates the *possibility* of the mutual pressures of the parts overcoming the rigidity.[1] He is the only writer of the glacier school who has insisted upon the plasticity of the ice shown by moulding itself to the endlessly varying form and section of its bed, and he is also opposed to his leading contemporaries in his conjecture that the centre of the ice-stream would be found to move fastest. But M. Rendu has the candour not to treat his ingenious speculations as leading to any certain result, not being founded on experiments worthy of confidence. "The fact of the motion exists," he says—"the progression of glaciers is demonstrated; but the manner of it is *entirely unknown*. Perhaps by long observations and well-made experiments on ice and snow, we may be able to apprehend it, *but these first elements are still wanting*."[2]

I feel bound also to quote the significant expressions of Captain Hall, pointing to the conception of a semi-fluid glacier. "When successive layers of snow," he says, speaking of the Glacier de Miage, "often several hundreds of feet in thickness, come to be melted by the sun and by the innumerable torrents which are poured upon them from every side, to say nothing of the heavy rains of summer, they form a mass, not liquid indeed, but such as has a tendency to move down the highly inclined faces on which they lie, every part of which is not only well lubricated by running streams resulting from the melting snows

[1] See also page 107 of his work [p. 98 of the 1874 reprint] for a comparison between a glacier and a river.

[2] "Le fait du mouvement existe, la progression des Glaciers est démontrée ; mais le mode est entièrement inconnu. Peut-être avec de longues observations, des expériences bien faites sur la glace et la neige, viendra-t-on à bout de le saisir ; mais ces premiers éléments nous manquent encore."—*Théorie des Glaciers*, p. 90 [p. 78 of the 1874 reprint].

on every side, but has been well polished by the friction of ages of antecedent glaciers. Every summer a certain but very slow advance is made by these huge, sluggish, slushy, half-snowy, half-icy accumulations."[1] It is plain, I think, that the author had an idea that liquid pressure might drag a mass over its rocky bed, which would not move upon it as a solid.

But such speculations could not pass into a theory until supported by the definite facts of which M. Rendu deplores the want. I too, like my predecessors, though independently of them, had compared the movement of glaciers to that of a ductile plastic mass, in 1841, when I spoke of the Glacier of the Rhone as "spreading itself out much as a pailful of thickish mortar would do in like circumstances,"[2] and again, when I likened the motion of glaciers to that of a great river, or of a lava stream.[3] But I knew very well that such analogies had no claim to found a *theory*. I knew that the *onus* of the proof lay with the theorist—(1) To show that (contrary to the then received opinion) the centre of a glacier moves fastest; and (2) to prove from direct experiment that the matter of a glacier is plastic on a great scale, a fact which seems so repugnant to first impressions as lately to have been urged in a most respectable quarter,[4] as rendering the doctrine of semi-fluid motion untenable. No one had a right to maintain the theory of fluid motion as more than a conjecture, until at least these preliminary obstacles were removed by direct observations.

These observations have been made, and the result is the viscous or plastic theory of glaciers, as depending essentially on the three following classes of facts, all of which were ascertained for the first time by observations in 1842, of which the proofs are contained in this work.

1. That the different portions of any transverse section of a glacier move with varying velocities, and fastest in the centre.

2. That those circumstances which increase the *fluidity*

[1] *Patchwork*, vol. i. p. 104 *et seq.* The whole passage, which is too long to quote, gives an admirable picture of the glacier world.

[2] *Ed. Phil. Journal*, January, 1842. [*Occasional Papers*, p. 7.]

[3] *Edinburgh Review*, April, 1842, p. 54. Both these articles were written in 1841.

[4] *Bibliothèque Universelle*, January, 1843. See also *Occasional Papers*, pp. 61-67 (1845).

of a glacier,—namely, heat and wet—invariably accelerate its motion.

3. That the structural surfaces occasioned by fissures which have traversed the interior of the ice are also the surfaces of *maximum tension* in a semi-solid or plastic mass, lying in an inclined channel.

There is only one other point to which I would invite attention, and it is this. We have noticed, pp. 146-149, the enormous depression which the surface of the ice undergoes during the warmer months of the year. We may be sure that, in some manner or other, this is made up for during winter and spring. I already suggested, in my fourth letter to Professor Jameson (in *Occasional Papers*, p. 34), that this may be partly owing to the dilatation of the ice during winter by the congelation of the water in its fissures, producing, at the same time, "the veined structure." The glacier is very far indeed from being frozen to the bottom in winter, for we have seen that physical principles are opposed to this, as well as the fact that the motion continues during all that period, showing that a great portion of the icy mass is still plastic. It is, however, extremely probable that the congelation extends to a considerable depth, and produces the usual effects of expansion. I think, however, that the explanation, though correct as far as it goes, is inadequate, and that the main cause of the restoration of the surface is the diminished fluidity of the glacier in cold weather, which retards (as we know) the motion of all its parts, but especially of those parts which move most rapidly in summer. The disproportion of velocity throughout the length and breadth of the glacier is therefore less, the ice more pressed together and less drawn asunder; the crevasses are consolidated, while the increased friction and viscosity causes the whole to swell, and especially the inferior parts, which are the most wasted. Such a hydrostatic pressure, likewise, tending to press the lower layers of ice upwards to the surface, may not be without its influence upon the (so-called) rejection of blocks and sand by the ice, and may even have some connection with the recurrence of the "dirt bands" upon the surface of the glacier. But I forbear to enlarge upon what is only as yet to myself conjectural.

I have no doubt, however, that the convex surface of the glacier (which resembles that of mercury in a barometer tube) is due to this hydrostatic pressure acting upwards with most energy near the centre. It is the "renflement" of Rendu,[1] the "surface bombée" of Agassiz. Exactly the contrary is the case in a river, where the centre is generally lowest; but that is on account of the extreme fluidity, so that the matter runs off faster than it can be supplied; but in my plaster models this convexity, with its wrinkles and waves, was perfectly imitated.

In its bearing on the theory of the former extension of the Swiss glaciers (Chap. III.) we find that the doctrine of semi-fluid motion leads us to this important conclusion,—that as large and deep rivers flow along a far smaller inclination than small and shallow ones (a circumstance depending mainly upon the weight increasing with the *section*, and the friction, in this particular case, with the *line of contact* with the channel), the most certain analogy leads us to the same conclusion in the case of glaciers. We cannot, therefore, admit it to be any sufficient argument[2] against the extension of ancient glaciers to the Jura, for example, that they must have moved with a superficial slope of one degree, or, in some parts, even of a half or a quarter of that amount, whilst in existing glaciers the slope is seldom or never under 3°. The declivity requisite to insure a given velocity bears a simple proportion to the *dimensions* of a stream. A stream of twice the length, breadth, and depth of another will flow on a declivity half as great, and one of ten times the dimensions upon 1-10th of the slope.[3]

Poets and philosophers have delighted to compare the course of human life to that of a river; perhaps a still apter simile might be found in the history of a glacier. Heaven-descended in its origin, it yet takes its mould and conformation from the hidden womb of the mountains which brought it forth. At first soft and ductile, it acquires a character and firmness of its own, as an inevitable destiny urges it on its onward career. Jostled and constrained by the crosses and inequalities of its prescribed path, hedged in by impassable barriers which fix limits to its movements, it yields groaning to its fate, and still

[1] [Page 99 of the 1874 reprint.]

[2] Élie de Beaumont, *Annales des Sciences Géologiques* par *Rivière*, 1842.

[3] This results approximately from the formulæ of Dubuat and Eytelwein,—the velocity varies as the square root of the slope, and as the square root of the mean hydraulic depth.

travels forward seamed with the scars of many a conflict with opposing obstacles. All this while, although wasting, it is renewed by an unseen power,—it evaporates, but is not consumed. On its surface it bears the spoils which, during the progress of existence, it has made its own—often weighty burdens devoid of beauty or value, at times precious masses, sparkling with gems or with ore. Having at length attained its greatest width and extension, commanding admiration by its beauty and power, waste predominates over supply, the vital springs begin to fail; it stoops into an attitude of decrepitude;—it drops the burdens, one by one, which it had borne so proudly aloft,—its dissolution is inevitable. But as it is resolved into its elements, it takes all at once, a new, and livelier, and disembarrassed form;—from the wreck of its members it arises, "another, yet the same,"—a noble, full-bodied, arrowy stream, which leaps rejoicing over the obstacles which before had stayed its progress, and hastens through fertile valleys towards a freer existence, and a final union in the ocean with the boundless and the infinite.

SOURCE OF THE ARVEYRON.

PART II

JOURNALS OF EXCURSIONS

IN THE

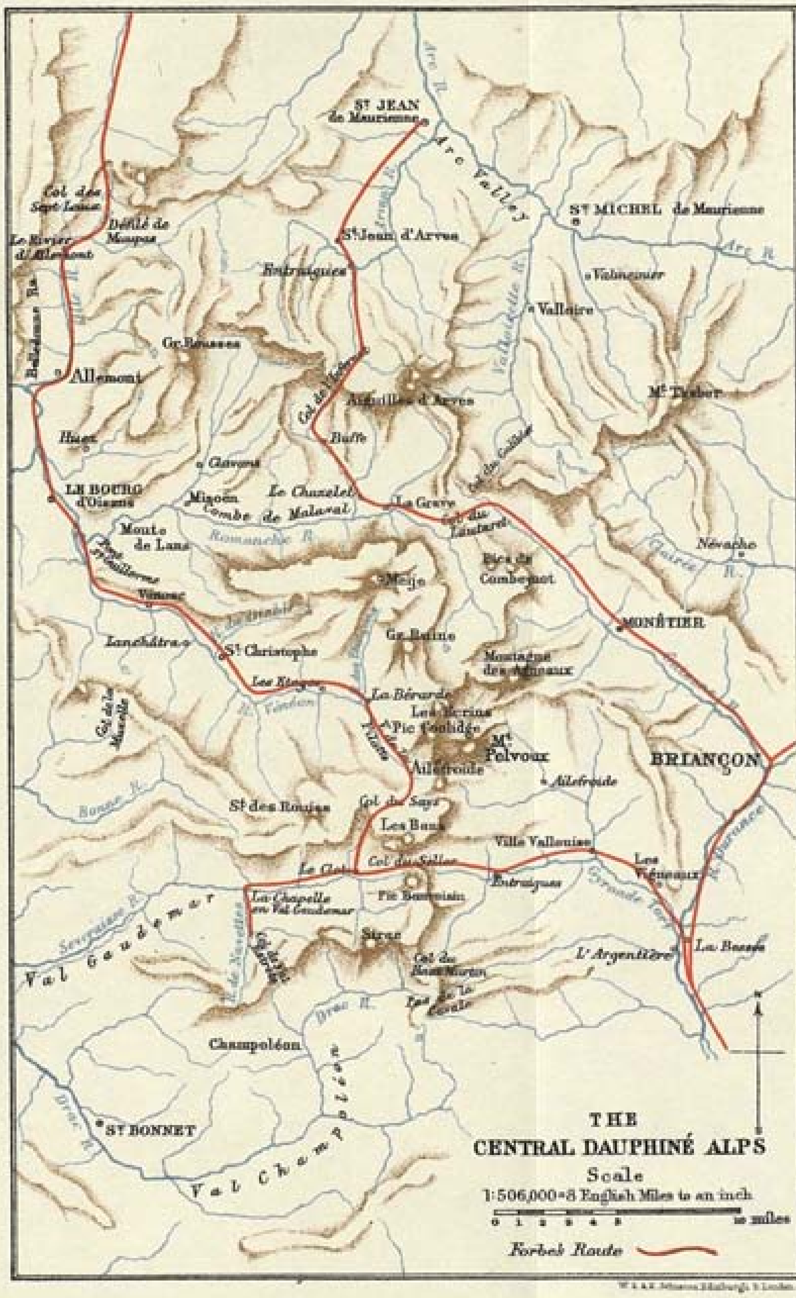
HIGH ALPS OF DAUPHINÉ, BERNE, AND SAVOY

(Reprinted from "Norway and its Glaciers visited in 1851")

Extract from the Preface to "Norway and its Glaciers visited in 1851"

"As a principal object of these pages has been to connect my observations on the glaciers of Switzerland and Savoy with those which I have made in the North of Europe, I have thought it a suitable addition to the volume to incorporate three narratives of alpine journeys of older date, which all refer to the wildest and most ice-bound regions of that noble chain. These were written at the time the journeys were made, or soon after, in the same detail, and nearly in the same words as they are now presented to the reader. They seemed to me worthy of preservation, and I am not likely to find a more natural occasion for publishing them. The first excursion—that in the Alps of Dauphiné—refers to a region as little known as the remoter parts of Norway itself. The Mont Pelvoux [*i.e.* the Ecrins], the highest between Mont Blanc and the Mediterranean, of which I made the circuit nearly twelve years ago [in 1841], is indeed as little frequented now as it was then. The narrative of the ascent of the Jungfrau, performed the same year [1841] in company with M. Agassiz, is now for the first time printed nearly *verbatim* from my journals. The account of the crossing of the chain of Mont Blanc by an undescribed pass higher than the Col du Géant may be considered as a supplement to my former researches in Savoy. This journey was of much later date [1850] than the two former ones; and, indeed, was the last which I made in the Alps." J. D. Forbes.

May, 1853.


THE
CENTRAL DAUPHINÉ ALPS
Scale
1:506,000 = 8 English Miles to an inch
Forbes Route
St. JEAN de Maurienne
Arc Valley
Arc R.
St. MICHEL de Maurienne
St. Jean d'Arves
Entraigues
Valloire
Allemont
Gr. Rousses
Aiguilles d'Arves
Mt. Tabor
Huez
Clavans
LE BOURG d'Oisans
Mizoën
Le Chazelet
Combe de Malaval
La Grave
Romanche R.
Mont de Lans
Névache
Meije
Venosc
MONÊTIER
St. Christophe
Gr. Ruine
Les Etages
La Bérarde
Les Ecrins
Pic Coolidge
Mt. Pelvoux
Ailefroide
BRIANÇON
St. des Roujas
Col du Says
Les Bans
Ville Vallouise
Les Vigneaux
Le Clot
Col du Sellar
Entraigues
La Chapelle en Val Gaudemar
Pic Bonvoisin
Sirac
Val Gaudemar
L'Argentière
La Bessée
Champoléon
St. BONNET
Val Champoléon
Drac R.
Bonne R.
Col de la Muzelle

SCENE AT LA BÉRARDE.[1]

CHAPTER I

NARRATIVE OF EXCURSIONS IN THE ALPS OF DAUPHINÉ IN 1839 AND 1841

Boundaries of the district described—Mountains of the Oisans—Their geological peculiarities—Hot springs—Allevard—Les Sept Laux—Allemont—Bourg d'Oisans—Valley of the Romanche—Valley of St. Christophe—Vénosc—Fall of a mountain—Village of St. Christophe—Scene from Les Etages—Les Ecrins—Hamlet of La Bérarde.

TRAVELLERS have often bent their steps to the remoter regions of the globe to the neglect of objects worthy of attention which might be found almost within their daily range. The soil of

[1] [This shows the entrance to La Bérarde, with the *old* bridge (now replaced by a far more substantial one) over the Etançons torrent.]

Palestine and Egypt is more trodden, and has been more minutely described than many parts of Europe, heedlessly passed over in the anxious haste to remove ourselves as far and as fast as possible from home associations. It may be doubted, however, whether those who pass the great highways of the Alps at a gallop, or are urged with almost railway speed at once by current and by steam down the course of the Rhine and Rhone, are always directing their steps to objects more worthy of attention (for the most part, certainly, to objects more frequently described), than those which exist but a few miles to the right hand or to the left of those beaten tracks, along which tourists follow one another, like a flock of sheep, in interminable succession.

Amongst these almost unvisited, yet far from inaccessible districts, the Alpine country of Dauphiné, including part of the modern departments of the *Isère* and *Hautes Alpes*, is one of the most interesting, whether we regard its geological structure, or the almost fantastical sublimity of its remote and thinly-peopled glens. No great road passes through this country.[1] The pass of the Mont Genèvre, which approaches nearest to it, being very little traversed and now partly out of repair,[2] so that the fortress of Briançon, the frontier town of France on this side, forms nearly the *terminus* of communication on the great line of fine road which stretches along the whole course of the river Durance down to Aix and Avignon.[3] Having been led in the course of an excursion on foot in the year 1839 amongst the Southern Alps to visit a portion of this country, of which the interesting geology, as described by M. Elie de Beaumont, had formerly excited my attention,—and having penetrated a certain way into its remoter valleys, which, from want of time, I left

[1] [Since Forbes's day splendid mountain roads have been constructed over the Col du Lautaret from Bourg d'Oisans to Briançon (38¾ miles), and over the Col du Galibier from the Hospice on the Lautaret past Valloire to St. Michel de Maurienne on the Mont Cenis railway (six hours' drive). Bourg d'Oisans is now connected by a steam tramway with Grenoble (30½ miles), while a magnificent mountain railway leads from Grenoble round to the south of the Pelvoux group by the Col de la Croix Haute and Gap to Briançon (136 miles).]

[2] [There is now an excellent carriage road over the Mont Genèvre from Briançon to Oulx on the Mont Cenis railway (17 miles).]

[3] [The railway from Briançon to Aix en Provence (170 miles), Avignon (198 miles), and Marseilles (189 miles) quits the valley of the Durance at Prunières, branches off from the Grenoble line at Veynes, and re-enters the Durance valley at Sisteron ; at Pertuis it divides, running north-west along the Durance to Avignon, and south across the hills to Aix and Marseilles, which of course are not in the Durance valley.]

with regret,—I took an opportunity in the summer of 1841 of revisiting them, in company with my friend, the Rev. J. M. Heath. We proposed crossing some of those cols or elevated mountain passes which are described as being frequented only by chamois hunters, although they form often the sole communication between valleys, distant horizontally but a few English miles—even this extremely limited communication being practicable during but a very few weeks in the finest part of summer. Accounts to this effect were confirmed by what I had previously seen of the continuous and terrific precipices which bound on both sides the valleys, or rather ravines (called by the natives *combes*), of this granitic nucleus; and with respect to the weather, M. Gueymard, an eminent engineer of Grenoble, has assured me that the statement I have quoted is by no means exaggerated, and that the higher mountains of Dauphiné are rarely accessible for more than the last ten days of July and the first week or two of August.[1]

The country of which I propose to offer some description includes a mountain group of granitic formation, and no very large extent, which is separated from the main chain of Alps stretching from the Mont Cenis to the Monte Viso, by the great valley of the Durance, already mentioned. The form of the group is rudely circular, marked by the outburst of granitic and talcose rocks, through the prevalent strata of lias and chalk which characterise this part of France. It is bounded to the north by the river Isère, where it passes Grenoble, and by the course of the river Arc, which, taking its rise near the Mont Cenis,[2] flows into the Isère above Montmélian. These two rivers form an angle, which is filled by a chain of mountains also granitic, and which at their culmination constitute a desolate and stupendous mass, covered with perpetual snow, and called *Les Grandes Rousses*, whose geological structure has been partly described by M. Dausse in the Transactions of the Geological Society of France.[3]

[1] [This last statement is wholly incorrect. The higher mountains of Dauphiné can be visited at any time between early June and late September, while some bold spirits have explored them even in winter.]

[2] [The Arc really rises in the glaciers of the Levanna, many miles north-east of the Mont Cenis Pass.]

[3] [This essay appeared in vol. ii. (1834) of the *Mémoires* of the Society named. The highest summit of the Grandes Rousses is 11,395 feet. It is odd that Forbes

On the west and south our district is bounded by the river Drac, which unites with the Isère below Grenoble, and which, rising at Orcières, not far from Gap, in the department of the Hautes Alpes, nearly touches the river Durance, which again forms the eastern boundary of the district between Embrun and Briançon.

Within this space, only about forty-five English miles square, rises the highest summit occurring in the mountainous country between Mont Blanc and the Mediterranean. It is called Mont Pelvoux, and its height is 13,468 English feet, as determined by the French Engineers,[1] yet it does not greatly exceed in elevation other summits in its neighbourhood, which are so imperfectly known to topographers, and so variously or inaccurately named on maps (as well as by the natives), that it is difficult to ascertain their identity, on account of the unapproachable positions which many of them occupy, surrounded by precipices, and by glaciers yet more inaccessible.[2] To this general group may be given the name of *Montagnes de l'Oisans,* which has been applied to them by M. E. de Beaumont in a paper published in the fifth vol.[3] of the *Annales des Mines,* in which he has described with much detail and spirit the remarkable geological features which they present. These are of two kinds, the structure of the granitic or gneiss rock itself, and the phenomena which it presents when in contact with the stratified deposits of limestone which surround it. The whole is considered by that most eminent geologist to afford an example of a *Crater of Elevation* in a formation not properly volcanic—the originally

never mentions the still higher chain, a little more to the east, of the Aiguilles d'Arves, three grand pinnacles of rock rising to a height of 11,520 feet; this omission is all the more remarkable, as Forbes crossed in 1841 the Col de l'Infernet very near them, and as they had been described in the *Philosophical Transactions of the Royal Society* as far back as 1791.]

[1] [Really the Pointe des Ecrins, 13,462 feet, the true Mont Pelvoux being 12,973 feet in height. The confusion between the two summits was finally cleared up by the explorations of Mr. F. F. Tuckett in 1862.]

[2] There exists, however, a most admirable and faithful map of Dauphiné by General Bourcet, which may (or might lately) be had at Paris. It is engraved in a quaint, old-fashioned style, but is extremely clear, and its fidelity makes it invaluable to the traveller.[1]

[3] [Of the third series, published in 1834.]

[1] [Bourcet's map (surveyed 1749-1754) has long been superseded. The best general map of the Dauphiné mountains (the outline map given in these pages is based on it) is that (scale 1/250,000) published in vol. i. of the new edition (1898) of Mr. John Ball's *Guide to the Western Alps,* but for minute details as to the glacier region south of the Col du Lautaret, M. H. Duhamel's map (4 sheets, scale 1/100,000, Grenoble, 1889, and in a revised edition, London, 1892) is unsurpassable.]

horizontal structural planes of the gneiss having been elevated on all sides towards a central point or apex, from which, consequently, they appear to dip in every direction. "It presents," he says, "something resembling the form of a half-closed flower, of which the stamina are represented by unstratified masses of granite and dislocated fragments of gneiss, and of which the corolla corresponds to the strata of gneiss, which nearly throughout the circumference of the group rest upon the interior granite, and which sink beneath the secondary deposits raised up around in the form of the calyx." [1]

M. Elie de Beaumont was also one of the first to signalise,[2] in 1829, the existence of that remarkable inversion of geological superposition, in which granitic rocks are found overlying limestones of the age of lias—a circumstance more lately noticed in several parts of the Swiss Alps, but nowhere, if we mistake not, with more perfect evidence than in the mountains of the Oisans.

The most considerable of the fissures of which we have spoken forms the channel of the river Romanche, which intersects in its tortuous course some of the highest ground of the district. Near the village of Bourg d'Oisans, the valley divides itself into two; the stream which retains the name of the Romanche joins the other nearly at a right angle, having flowed in almost a straight course from east to west in the profound gorge called the *Combe de Malaval;* whilst the other branch, taking the name of the Vénéon, runs nearly from south-east to north-west through the valley of St. Christophe, and takes its rise almost at the foot of the Mont Pelvoux, amongst the glaciers which fill the vast rocky basin in which lies the little hamlet of La Bérarde, considered by M. E. de Beaumont as the centre of action of the elevating forces.

The occurrence of mineral and thermal waters near the outskirts, and not at all in the centre of this district, confirms remarkably the views which I have stated in a paper on the mineral waters of the Pyrenees in the *Philosophical Transactions* for 1836. The great convulsions which were productive

[1] *Faits pour servir à l'Histoire des Montagnes de l'Oisans*, p. 30.

[2] *Mémoires de la Société d'Histoire Naturelle de Paris*, tome 5, cited and figured in De la Beche's sections and views, 1830.[1]

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[1] [In a note to his 1834 essay M. de Beaumont informs us that it is an expanded and revised version of that published by him in 1829.]

of fissures, both in the stratified and unstratified rocks, gave vent to these subterranean streams, which issue generally from chasms exactly on the line of demarcation of the primitive and secondary formations. Mineral veins are also not unfrequent accompaniments. The waters of La Motte near La Mure, on the course of the Drac, are exactly in the situation just described, and appear in connection with small outbreaks of granite indicated in the geological map of France. They are described as issuing from a ravine so narrow, confined, and precipitous, that the water (which is stated to have a temperature of 45° Réaum.) has to be carried on the back of mules to some distance before it can be administered medicinally.[1] Two other sources which I have myself examined occur in the valley of the Isère, exactly on the confines of the primitive and secondary rocks. That of Uriage, about six miles from Grenoble,[2] is sulphureous, and rises in a deep valley at the junction of granite and lias, which is, however, concealed for some way by an immense mass of detritus, through which the spring forces itself. It is conveyed in a subterraneous conduit for a space of six or seven hundred yards from its source to the bathing-house, where it issues with a temperature of 70°·5 F. The other spring is that of Allevard, several leagues to the north-east of the former, which rises in a small tributary valley of the Isère, exactly where a stream called the Bréda, descending from the high ground of the chain already mentioned as connected with Les Grandes Rousses, opens into the valley.[3] This little ravine, which is wild and picturesque, appears to have been formed by a rent, and communicates in a manner no less striking in a picturesque than in a geological point of view, between the tame scenery of the fertile lias and the savage grandeur of the snow-clad granite peaks upon which this natural gateway immediately opens. It is exactly at the entrance, then, of this ravine, and within a few hundred yards of the junction of the limestone

[1] [The waters are now conveyed through pipes for about a mile from the springs to the "Etablissement des Bains" of La Motte, 23 miles from Grenoble by a most striking mountain railway. On issuing from the rock the water is said to have a temperature of 60° Centigrade (*i.e.* 48° Réaumur or 140° Fahrenheit).]

[2] [There is now a steam tramway (8 miles) from Grenoble to Uriage. The waters of Uriage issue from the rock at a temperature of about 94° Fahr.]

[3] [Allevard is 9 miles by steam tramway from the Pontcharra station on the railway between Grenoble (26 miles from Pontcharra) and Chambéry (13 miles from Pontcharra).]

with the primitive talc slate, that the sulphureous mineral water, which is extensively employed for medicinal purposes (although not possessing a high temperature), immediately rises. Extensive workings of carbonate of iron are carried on in the same neighbourhood. The sparry iron divides from the walls of the vein innumerable fragments of the matrix, which is a greenish talc slate.[1]

It was on the 21st of July 1841, that Mr. Heath and myself, profiting by the fine weather which, in the midst of a very changeable season, accompanied us in our rambles amongst these mountains, quitted Allevard by the ravine just described, and followed the torrent of the Bréda up towards its source, which has been termed in the patois of the country Les Sept Laux, or the Seven Lakes. Between the villages of Pinsot and La Ferrière we noticed the remarkable occurrence of a polished convex surface of grey slaty rock, very similar to those occurring near the Handeck and on the Grimsel. Unfamiliar though we at that time were with these supposed traces of glacier action, we could not help being struck by the perfect rotundity presented by the exposed surfaces of the rock, exactly at such a contraction of the valley as must have exposed it to the shock of any descending mass. The polish too was extremely perfect when we removed the covering of soil; the hard and the soft parts being equally sawn across at an exact level, and smoothed with wonderful precision. It appears to me, upon recollection, as indubitably marked a specimen of this kind of action as is anywhere to be found in the Alps of Switzerland. It occurs at a very considerable height above the bed of the torrent and close to the path, but we could trace it for a considerable way above and below, although it was only in this part of the valley that it attracted our attention.

After passing an uncomfortable night at La Ferrière, we proceeded to ascend the col of the Seven Lakes. A long and steep ascent, generally, however, practicable for mules, led us to the first of the lakes in question after five hours' walk. This

[1] Allevard is a convenient point from which to commence our narrative, although it is not in this direction that the mountains of the Oisans are most easily approached.[1]

[1] [The easiest approach is from Grenoble, by means of the steam tramway to Bourg d'Oisans (30½ miles), whence a good carriage road leads to La Grave (15½ miles), and a bad one to St. Christophe (12 miles), whence it is 3 hours' walk by mule path up to La Bérarde.]

series of small and beautifully clear tarns lies in a prolonged ravine, which at a great height separates the chain commanding the valley of the Isère from the granitic mountains to the east. By our barometrical observations, the elevation of the col is 7144 feet, yet these lakes are fed by springs, and are not like the usual accumulations of stagnant water derived from the melting snows. The temperature of the first lake was 46°·5, whilst that of the river Bréda, half a league above La Ferrière, at a height of 4000 feet less, was only 46°, arising, no doubt, from the glacier origin of the main branch of that stream, which at Pinsot, below La Ferrière, had a temperature of 52°·5, at Allevard of 54°, and at Pontcharra of 56°. Near the last of the chain of lakes is a small building where travellers might sleep better upon hay than in the wretched beds of La Ferrière.[1] The situation is wild and gloomy, commanding no distant view, the chain of lakes being closed in by bare peaks of no great elevation on all sides.

After a long rest we proceeded to descend the southern side of the pass into the vale of Allemont, which terminates in that of the Romanche below Bourg d'Oisans. This descent is excessively fatiguing, rapid, and even dangerous. In order to avoid the precipices, it is necessary to skirt the mountains at half their height by an intricate sheep track, with which our guide, it appears, was imperfectly acquainted. After scrambling down a space of at least 3000 vertical feet,[2] we reached in 3 hours the hamlet of Rivier d'Allemont.[3] The [Olle] gorge into which we descended was exceedingly striking and wild; cultivation dies away at the foot of the pass. On our left a difficult track called Le Maupas leads amongst lofty granite peaks into the valley of the Maurienne;[4] to the right and before us, the fantastic range of the Montagne de Belledonne[5] throws its jagged peaks to the

[1] [There is now a comfortable little mountain inn near the Lac du Col, the highest of the tarns, which really number eleven in all. Just beyond the inn is the Col des Sept Laux, 7166 feet in height.]

[2] [Really 2940 feet.]

[3] [In the valley of the Olle.]

[4] [More precisely the path runs through the gorge of Maupas to the upper portion of the Olle valley, whence the Col du Glandon leads to La Chambre in the Maurienne or Arc valley, and the Col de la Croix de Fer by St. Jean d'Arves to St. Jean de Maurienne.]

[5] [Belledonne is the mountain that is so conspicuous from Grenoble ; the Croix (ascent very easy) is 9525 feet, while the Grand Pic (ascent difficult) is 9781 feet.]

sky. This summit doubtless receives its name from the obvious resemblance of the outline to the rude representations of the Virgin and Child by the earliest masters of the Italian or the Byzantine school.

Instead of stopping at Rivier, we resolved, in the hope of finding tolerable quarters, to push on to the village of Allemont, a distance of two hours and a half farther.[1] As the evening advanced we were fairly obliged to grope our way amidst intense darkness occasioned by the rich foliage which clothes with extraordinary luxuriance the lower part of this beautiful valley, whose fertility we found next morning to present as striking a contrast as can well be imagined to the rocky scenery of its immediate neighbourhood. Near Allemont, in the mountain of Chalanches, mines of silver and lead have been worked since 1767, but have been more lately abandoned, and were for sale at the period of our journey. Our hopes of tolerable accommodation were again disappointed, and after a walk of more than ten hours we were doomed to pass another sleepless night. We next morning took mules, first to convey us to Bourg d'Oisans[2] through a flat country and along a good highway,[3] from whence we proposed to explore the valley of St. Christophe, which I had visited two years before.

The position of Bourg d'Oisans is sufficiently remarkable; it lies in a swampy flat of a mile or more in width, out of which rise, especially on the west side, perpendicular walls of rock of immense elevation. On the face of these precipices the famous gold mines of La Gardette have been worked from an early period. It is impossible to doubt that this part of the valley of the Romanche (in which the village of Bourg d'Oisans is situated) was once an enormous cleft, of a depth which it seems now almost impossible to estimate, of which we see the original walls still standing; but the lower part has been filled up by the copious depositions of mountain torrents and the degradation of mountains themselves, which have formed the enormous platform of detritus amongst which the river finds its way, leaving

[1] [There is now a char road from Rivier d'Allemont to Allemont.]

[2] Bourg d'Oisans, a country town $30\frac{1}{2}$ miles from Grenoble, by which the country to be described is most easily approached.

[3] [There is now a char road from Allemont to Les Sables at the junction of the Olle with the Romanche, from which point the high road has been superseded by the steam tramway ($4\frac{1}{2}$ miles from the Rochetaillée Allemont Station to Bourg d'Oisans) coming from Grenoble.]

unhealthy swamps at every stage of its passage. Such artificial obstructions have even occurred during historic times. In the lower part of the course of the Romanche, which bends suddenly at less than a right angle after being joined by the river of Allemont, it enters a profound defile called the *Combe de Gavet*, which I had visited on a former occasion, and in which a great lake was formed by the fall of a neighbouring mountain in the eleventh century, which, after existing two hundred years, burst its barrier, and carried desolation into the valley of the Drac, and even to the town of Grenoble.[1] These ravines, with perpendicular walls and zigzag courses, recall in a striking manner the scenery of Norway, especially of the Sognefiord, described in a previous part of this volume.[2] Perhaps no other part of Europe presents so close a parallel; and, as the neighbouring gneiss formation is extremely similar, it is not too much to infer that causes not very different have operated in the two cases to produce effects so grand in themselves, and indicating such astonishing energy in their production.

The cliffs immediately behind Bourg d'Oisans are generally of limestone, and rise perpendicularly to a height probably much exceeding a thousand feet. From the base issue numerous fine springs, which appear to vary greatly in their discharge at different times, for some, which issued nearly at the same season in 1839 in so great volume as to be impassable on foot, were now perfectly dry.[3] I observed, too, the great changes which the course of the torrent[4] had made in its passage amongst the débris in which it has formed a thousand channels, and it had completely carried away the slight track which formerly led to the valley of St. Christophe.[5] The height of Bourg d'Oisans is above 2400 feet.[6] A few miles higher up the valley we left behind us the narrow gorge through which the torrent of the

[1] [The lake was really formed in the plain of Bourg d'Oisans by reason of an immense fall from the Vaudaine, a great spur of Belledonne; the barrier gave way on the night of September 14-15, 1219.]

[2] [It will be remembered that this chapter was originally published by Forbes as an Appendix to his work entitled *Norway and its Glaciers visited in* 1851 (1853).]

[3] One of these springs, a little below Bourg d'Oisans, had a temperature of 48°·5 on the 11th of July, 1839, the height being about 2400 feet.

[4] [The Vénéon, flowing from the valley of St. Christophe.]

[5] [There is now a char road to St. Christophe (12 miles from Bourg d'Oisans); it leaves the Lautaret high road just after this crosses to the left bank of the Romanche (3 miles from Bourg d'Oisans), before mounting through the Malaval gorge.]

[6] [It is really 2392 feet.]

Romanche passes to unite its waters with those of the Vénéon.[1] Following the course of the Vénéon on its left bank, we soon quitted the level plain, and began to rise alongside of the torrent which chafes itself amongst numberless scattered blocks to the little hamlet of Pont Escophier, where a magnificent scene presented itself. Behind us we could still see the whole extent of the valley of Oisans confined by its mural precipices, terminated by the distant peaks of the Belledonne, and seeming like a vast crevasse, of which the eye could not fathom the bottom. In front two confined and savage valleys[2] opened right and left—that on the right, of no great extent, was soon closed to the eye by impassable walls of rock; the other, from which the main mass of water descends, rushing at our feet beneath a frail bridge, presented a grand scene of rough mountains on either hand. In the extreme distance a glacier summit[3] raised itself in glorious perspective precisely in the prolongation of the valley, richly coloured by the full beams of the setting sun; whilst in the middle distance there appeared a speck of exquisite verdure, placed as if by enchantment in the midst of a wilderness, marking the position of the little village of Vénosc, where live in independence, and even in wealth, the most considerable proprietors of this secluded and almost unknown valley.

The fertility of the neighbourhood of Vénosc, which produces so striking an effect, admits of a very simple explanation; for here the granite suddenly ceases, and a tongue of limestone is intruded into its interior, connected with the great deposit near Mont de Lans in the valley of the Romanche.[4] The gentler forms of these strata are well marked, and a pass of easy access, and cultivated almost to the summit, forms the only practicable com-

[1] Up that gorge a splendid new road has been carried, which, long ere this time probably, connects Grenoble with Briançon.[1]

[2] [That to the right or south is the valley of Lauvitel, wherein is a considerable lake famous for its fine trout. Over the wall of rock at its head the rough but not difficult pass of the Brèche de Valsenestre (8642 feet) leads to the Valsenestre, a tributary of the Val Jouffrey; while that to the left or south-east is the main Vénéon valley, up which lies our way.]

[3] This summit appears to be "la Pointe Haute du Grand Glacier" in Bourcet's map.[2]

[4] [This tongue is prolonged on the north as far as St. Jean de Maurienne.]

[1] [It was completed in 1861 only, having been begun in 1808.]

[2] [Bourcet's peak is the Râteau, (12,317 feet), which cannot possibly be seen from the point mentioned by Forbes, who probably saw a bit of the great Mont de Lans Glacier or else the Aiguille du Plat, both of which, roughly speaking, are in the direction of the peak named by Bourcet.]

munication between these two valleys, and is composed entirely of lias.[1] On the opposite side of the Vénéon the limestone strata are prolonged still farther into the heart of the granite, and the Col de la Muzelle, which they form, is one of the least difficult in the interior of the group, connecting the valley of St. Christophe with the Val Jouffrey.[2] The structure of the limestone is extremely remarkable, being completely metamorphosed by the neighbourhood of the granite, so as to present the appearance of a very beautiful black roofing slate, of which it possesses all the most valuable characters. This is a striking example of the production of cleavage planes by metamorphic action.

The village of Vénosc is situated on an elevated slope, clothed with rich walnut woods on the right bank of the stream.[3] It is commanded by the church, a building of Romanesque architecture, from which a good view of the valley is obtained. The green pastures which lead to the Col de la Muzelle are exactly opposite, and the contact of the granite with the lias at a great height may be distinctly perceived. The torrent which flows through it descends into the valley of the Vénéon by a striking cascade, presenting a great volume of water at the season of the melting of the glaciers. It may be remarked of almost all the tributary valleys of this neighbourhood, that they do not join the principal valley at a common level, but are considerably higher, so that a waterfall, often of great beauty, almost invariably accompanies the meeting of the streams, thus presenting a fresh analogy with the configuration of Norway. The lateral valleys therefore cannot be properly considered as fissures, since their section is rounded, and a steep water-course has been cut since their formation by the action of water in the lapse of ages. Vénosc is not only the prettiest village in the district of Oisans, but also boasts a very good country inn,[4] which we may be excused from mentioning amongst the peculiarities of the place.

In ascending the valley of St. Christophe, the gorge soon

[1] [This is the Col de l'Alpe (5446 feet), the summit level of which is composed of a great pasture plain, dotted with many corn and hay huts. It is the chief *non-glacier* pass between the Vénéon and Romanche valleys, which are connected by a great number of glacier passes.]

[2] [Strictly speaking it leads into the Valsenestre, a tributary of the Val Jouffrey.]

[3] [The char road passes through the hamlet of Bourg d'Arud, at the foot of the steep mountain slope on which Vénosc is perched at a height of 3442 feet.]

[4] [This is now a thing of the past, but was the only tolerable stopping-place till within a few years.]

becomes narrower, the rounded forms characterising the intruding lias are quickly left, and, the torrent having been passed on a substantial bridge, a very short distance brings us to a scene of sublime desolation. A mountain on the right hand has, at some remote time, crumbled into fragments, and literally filled the valley from side to side with a colossal heap of ruins.[1] Through and amongst these winds a narrow path practicable for mules, whilst the river dashes from rock to rock with excessive commotion, sometimes passing under the fragments which it was unable to displace. One huge slab of granite, wide enough for three carriages to pass abreast, forms a natural and ponderous-bridge,[2] harmonising with the desolation of the scene. The effect of this natural barrier has evidently been, as in the Combe de Gavet, to form a temporary lake, which has since been silted up, leaving a level plain which extends for a mile or two.[3] On the right stands the romantic village of Lanchâtra, a hamlet consisting of a few houses perched on a projecting rock in a tributary valley above one of the beautiful cascades already mentioned.

Not much farther on, the road leaves the stream and leads up the face of a rough hill to the village of St. Christophe,[4] which gives its name to the valley. On this ascent several fine springs[5] issue from the gneiss (which is here in vertical strata directed *due* north and south), at a height of about 250 feet below the village, or 4550 feet above the sea, the temperature of these, July 10th, 1839, was 44°·0, and July 24th, 1841, 43°·8. Just before reaching St. Christophe, a bridge crosses a very wild and narrow cleft, through which foams a wild glacier stream called Torrent du Diable.[6] We addressed ourselves to the *Curé* for information as to guides who could conduct us across some of the passes at the head of the valley. He received us with great cordiality, and gave us references to two, both chamois hunters, living at the village of La Bérarde, the last hamlet of the district, and to which

[1] [The "Clapier" (slope of boulders) of St. Christophe.]

[2] [The "Pont Naturel," well known to former visitors to this valley; it is now superseded by a solid stone bridge, rather higher up and just at the entrance of the "level plain" mentioned below.]

[3] [Forbes clearly did not know the local name of this level plain—the "Plan du Lac"—which completely confirms his theory as to its origin.]

[4] [The village is built at a height of 4823 feet.]

[5] [These are called the "Fontaines Bénites."]

[6] [Through this wild cleft the glacier pass of the Col de la Lauze (11,625 feet) leads over to La Grave.]

distance his wild parish extended. We could, however, obtain but slender information as to the practicability of any of the passes connecting La Bérarde with the adjacent valleys. Encouraged, however, by what we heard, we proceeded to ascend the course of the stream. Only two other villages exist higher up.[1] The first, Les Etages, commands one of the finest Alpine views which the admirers of Swiss scenery can desire, terminated by the Montagne d'Oursine,[2] which stands immediately above the hamlet of La Bérarde. It presents a series of rocky pinnacles in manifold rows, between which the snow can scarcely adhere; and so utterly inaccessible does that chain appear, that any passage in this quarter to the Val Louise seems almost hopeless;[3] in fact it is stated never to have been accomplished, except by a deserter, who having escaped many years ago from the fortress of Briançon, sought shelter in the unapproached fastnesses of the Montagne d'Oursine. Its form, as seen from Les Etages, especially by the morning light, is comparable to the Aiguilles of Mont Blanc, and the valley which stretches beyond it to the foot of Mont Pelvoux[4] may almost rival the scenery of the Allée Blanche.

La Bérarde, which is placed in the midst of this savage landscape, consists of but very few and poor houses, with a small chapel distinguished from the rest by a belfry.[5] Cultivation ceases just at the village; a few stunted pines are found still higher up, but there is no wood worth mentioning in the valley above Vénosc.[6] Timber for building is all brought from Bourg d'Oisans. This excessive sterility peculiarly characterises the valleys of Dauphiné. The village of La Bérarde is at a height of only 5500 feet, that of St. Christophe is 4800, and of Vénosc 3230,[7] but

[1] [There is another—Champhorent—before Les Etages.]

[2] [Really the Pointe des Ecrins—the monarch of the district. The second summit (13,396 feet) only is visible from Les Etages, the highest (13,462 feet) rising behind it.]

[3] [The deep-cut Col des Ecrins (11,205 feet), to the north of the Ecrins, is very conspicuous from Les Etages; a steep ice couloir leads up to it on this side, but the other slope is quite easy. It was first crossed by Mr. Tuckett in 1862.]

[4] [Really the Ailefroide. See p. 410 below.]

[5] [A stately chapel has been recently built here at the expense of the monks of the Grande Chartreuse monastery above Grenoble. The only other conspicuous house in La Bérarde is the excellent mountain inn, or "Chalet Hôtel" (opened in 1887).]

[6] [There are a few birches and aspens at La Bérarde, in the delta formed by the Vénéon and Etançons torrents.]

[7] [The height of La Bérarde is 5702 feet, that of St. Christophe 4823 feet, and that of Vénosc 3442 feet.]

the character of the scenery is like that of Switzerland at a greater elevation. The unbroken rocky surfaces deceive the eye to such an extent that it is difficult to realise the enormous scale of these mountains. "We seek in vain," says M. E. de Beaumont, "those landscapes, at once grand and graceful, which are so attractive at Grindelwald and Chamouni; the bottom of the valleys is too elevated for luxuriant vegetation. The scanty pasturage soon gives place to snow or bare rock, and some poplars and straggling ash trees are alone found in the valley of La Bérarde; the snows and glaciers are their only decoration, and it is even difficult to attain positions at a sufficient distance to enjoy a good view of them. Lower, no doubt, than Mont Blanc and the Jungfrau, the mountains of the Oisans appear less elevated than they are, on account of the absolute height of the valleys and of their confined position, so that the summits can be but rarely seen. To ascertain their height we must attempt to mount them, and even then the eye has some difficulty to submit to the testimony of the limbs."[1]

Scanty as the pasturages appear, they are in great request amongst the shepherds of Provence, who annually drive thousands of sheep from the plains of La Crau and the delta of the Rhone —a long journey of several weeks—to spend a month or two at the base of Mont Pelvoux.[2] In 1839 I saw a herd of young mules gamboling at the foot even of the glaciers. The inhabitants of La Bérarde received me on both my visits with surprise, but with kindness and hospitality. Their dwellings are very low, mean, and dirty. The sight of a stranger is a rare event. In 1839, on the 10th of July, I was the first visitor of the season. On that occasion, hastening late one evening, on foot and quite alone, in search of the village of St. Christophe, where I was to sleep, I met a man of whom I asked the way. He looked at me rather suspiciously, and then with much simplicity expressed a hope that I had not been guilty of any criminal action which had caused me to take refuge in these valleys. Like most unsophisticated mountaineers, the feeling of the picturesque is unknown. A country is a "mauvais pays" in proportion as it is elevated, and the curious traveller runs some risk of being taken for a

[1] [See his previously cited 1834 essay, pp. 27, 28.]

[2] [This is the case with most of the valleys of the Pelvoux group, as the inhabitants are too poor to keep beasts of their own.]

treasure hunter if he carry a hammer, and in any other case a refugee from justice. But notwithstanding this isolation, I was struck with a certain courtesy of manners, and especially a purity of dialect, which seemed surprising. But I afterwards learned that there is scarcely a man in the whole valley who has not been more or less a traveller; and, indeed, that during the seven or eight months of every year, which may truly be said to constitute their winter, the whole male inhabitants, almost to a man, quit their homes, and range over every part of France as hawkers or colporteurs—their usual occupation being vending live plants and flowers. They return in the late spring with commodities necessary for their consumption, and which their valley is incapable of producing; and in this way, as I have already said, a great deal of real comfort and independence is to be found among the inhabitants of Vénosc and St. Christophe,[1] with a hardihood of character which reminds one more of the aristocratic peasantry of the Swiss republics than that of France generally.

We found Joseph Rodier,[2] the guide to whom we had been recommended, busily engaged in securing his hay crop, which he and his son were carrying in heavy bundles on their backs from the field to the hay-loft. Finding that no one in the village had ever crossed to the Val Louise, and that the practicability of such a feat was altogether doubtful,[3] we inquired whether, by leaving Mont Pelvoux on the left, we could pass by the extreme head of the valley to the Val Gaudemar. Rodier had twice performed this, and engaged to conduct us across the glacier which lay in the way next morning. It turned out, however, that the route which we wished to take, and ultimately took, across the Col du Says, had, so far as we could learn, been traversed by no one in

[1] [This estimate of the prosperity of these villages is certainly exaggerated, though no doubt Vénosc is better off than the two higher villages.]

[2] [Joseph Rodier died at a very advanced age a few years ago. He was known to later travellers as the "grand père." His son Pierre, also mentioned by Forbes, is the present "Rodier père." The best guides in the valley now are the members of the Gaspard family, whose home is at St. Christophe, but who are generally at La Bérarde in the summer season, when their services are in great demand, as many travellers visit La Bérarde each year.]

[3] [Either the Col de la Temple (10,771 feet) or the Col de la Coste Rouge (10,342 feet) was certainly known as far back as 1673. But the old pass seems to have been forgotten. The two Rodiers re-discovered the former in 1844, reaching its summit from La Bérarde, and led a French party across it in 1855. The latter is the lowest and most marked depression in the ridge, and is perhaps that alluded to in the old documents.]

the valley.[1] We spent the afternoon in inspecting the neighbourhood, and received the most hospitable kindness from the family of Richard, to whom we had been recommended by the Curé of St. Christophe. To sleep in the house was (fortunately) impossible; a truss of clean straw was prepared in the hay-loft, and some of its numerous apertures were closed for the occasion. We had brought coverlets as well as provisions from Vénosc. All our property was most carefully and considerately put under lock and key; and, though our instruments and equipments furnished food for the curiosity of all the children and many of the grown inhabitants of the village, we experienced not the slightest rudeness or attempt at imposition. We hung our barometer at the door of the very same cottage (Richard's) at which I had done the same two years before; and though the observations, owing to the distance of the station (Marseilles) with which they are compared, do not very closely agree (and even the morning and evening observation give a considerable difference due to temperature), the height of this interesting station may be approximately given at 5550 feet above the Mediterranean.[2]

[1] [Rodier's pass was probably that now known as the Col du Chardon (10,145 feet). But the Col du Says is mentioned as early as 1673, and was visited from La Bérarde by the famous Dauphiné botanist, Dominique de Villars, on Sept. 13, 1786.]

[2] [The official height is 5702 feet.]

MONT PELVOUX FROM THE VAL LOUISE.

CHAPTER II

Cross the Col du Says—Glacier de la Pilatte—Descent to La Chapelle—Passage of the Col du Sellar—Glacier and dangerous precipices—Entraigues—Ville Val Louise—Mont Pelvoux—Monêtier—Col du Lautaret—Superposition of gneiss to lias—La Grave—The scenery—Combe de Malaval—Passage of the Col de l'Infernet—Remarks on the geology of the Montagnes de l'Oisans.

THE weather next morning was very favourable, and, impatient to avail ourselves of it, we were up before four o'clock; but our haste was in vain, for the guide did not make his appearance, nor was it until past six that, by our united exertions, we could accomplish the fulfilment of his many preparations, which his wife (who appeared to have given but a reluctant consent to the journey) by no means accelerated. No one had for years attempted the passage, nor does any stranger appear to have crossed from the valley of St. Christophe to the Val Gaudemar.[1]

[1] [But see above, p. 406.]

Our guide from Vénosc (who was to return with the mule which had brought our provisions and knapsack), a kind-hearted man, who now visited for the first time this part of the valley, declared it was "le bout du monde," and entreated us not to think of going farther. But seeing that we were not to be moved in our resolution, Rodier at last completed his breakfast of boiled chamois—filled his spirit-flask, took leave of his wife and the other villagers who collected to see us off, and we addressed ourselves to our journey.

For two hours above La Bérarde the ascent is not rapid. Opposite the valley of La Pirade,[1] the most considerable ravine which descends from the Montagne d'Oursine on the left, the valley divides into two branches, both extremely grand.[2] By either we understood that the Val Gaudemar might be reached; but we were not then aware that our guide had passed only by the one to the right. We preferred the other, which kept close by the foot of Mont Pelvoux,[3] whence we were to cross by the Glacier de la Condamina[4] and the Col du Says. Rodier, who was an excellent mountaineer and a trusty guide, though he had never passed this way, had satisfied himself on his previous journey, as he afterwards told us, that if the top of the Col du Says could be gained on the side of La Bérarde, the descent would be practicable on the other. Leaving then the valley of Clot Châtel (in Bourcet's map) to the right, we ascended the Vallée de Conte Faviel, and reached the foot of the glacier in two hours from La Bérarde. We passed a stone cabin, in which slept a Provençal shepherd. The glacier at first was not steep; our course lay nearly due south, and when we had passed opposite to the highest summit of Mont Pelvoux, we turned more to the right, where the glacier divides into two branches.[5] The fallen rocks had hitherto been true granites, consistently with the views of De Beaumont, but now they passed into epidote rocks, and others composed of felspar and hornblende, perhaps analogous to the variolites of the Drac. These gave

1 [Now the Pilatte glen.]

2 [The branch (Clot Châtel) to the right (S.W.) leads to the Glacier and Col du Chardon; that to the left (S.E.) to the Pilatte Glacier and the Col du Says.]

3 [*I.e.* the Col du Says, the route of which passes at the foot of the Ailefroide (Forbes's Mont Pelvoux).]

4 [The Glacier de la Pilatte.]

5 [The Says Glacier, up which Forbes went, is the principal tributary of the great Pilatte Glacier.]

place, as we ascended a very steep bank of débris, to more slaty forms; and the Col du Says is composed of an intermixture of the preceding rocks with those in which talc forms a prominent ingredient, a mineral which appears to characterise a district of this group, lying in a north and south direction, passing through La Bérarde, and coming out near the Col du Lautaret. I speak only in a very approximative manner; but the rocks on the north side, between the Lautaret and Monêtier, have the same character.

Having reached a considerable elevation by climbing on the shingle, we dined (without, however, the advantage of water), and descended upon the higher part of the glacier by a moderately inclined snowy slope intersected by occasional crevasses. Our more direct course would have led us to cross this arm of the glacier near its base, and to have ascended the opposite side; but this Rodier justly considered imprudent on account of the recent traces of avalanches. But though we were now nearly on a level, or at least not greatly below the Col du Says, we had still an anxious passage to make across an extensive glacier basin, which was traversed by impassable rents in various directions, nor was it practicable to ascertain from a distance whether these could be got round or not. At length, having descended considerably, all difficulties were overcome, and a gentle snow slope led up to the summit of the pass. The barometer stood at 19 in. 4 lines French, and the thermometer at 34° of Fahrenheit. The height we computed to be 10,224 English feet.[1] This we gained at one o'clock. Notwithstanding the cold and an approaching snow-shower, I made a careful survey from this magnificent station of the country we had just left, and took a sketch of the outline of Mont Pelvoux and the neighbouring chain, in which the Montagne d'Oursine stands out with its double head in great prominence.[2] The view commenced at the

[1] It is called 3358 mètres, or 11,017 English feet, on the authority of De Zach in Brugière's *Orographie de l'Europe*. [Its real height is 10,289 feet. Nowadays it is not considered a difficult pass; but is rarely traversed.]

[2] [The "Mont Pelvoux" is the Ailefroide (12,989 feet), the "Montagne d'Oursine" the Pointe des Ecrins (13,462 feet), the "Aiguille du Midi de la Grave" is now better known as the Meije (13,081 feet), the "path" (there is none, as the col is a glacier pass) to Villard d'Arène and La Grave is the Col du Clot des Cavales (10,263 feet), mentioned already in 1673, while the "Pointe des Verges" has been renamed Pic Coolidge (12,323 feet) in honour of the present Editor.]

Aiguille du Midi de la Grave on the left, to the right of which is a practicable but rarely traversed path from La Bérarde to Villard d'Arène; next the Montagne d'Oursine, with a most precipitous abutment to the south-east. This is followed by the Pointe des Verges—a peculiarly pointed summit marked by M. Elie de Beaumont in his ideal section as the centre towards which all the upraised gneiss strata seem to point. I cannot say that the extensive and commanding view I now enjoyed altogether confirmed this opinion. There are undoubtedly points of view presenting a section of the mountains of Oisans from E. to W. which seem to indicate something like an anticlinal axis running N. and S.; but, from the Col du Says, the mountains within view have a singularly rough and formless appearance. There is a gap between the Pointe des Verges and the Mont Pelvoux, and through this gap it is possible that a passage into the Val Louise might be attempted; beyond and through it appear (as I judge by the direction on the map) the distant peaks of the Montagne des Agneaux. There rose just opposite to us, and to a height of more than 3000 feet above us, the pyramidal summit of the Mont Pelvoux itself, which predominates over the whole.[1]

As we reached the Col du Says a cold sleet shower passed over us, and the sky became overcast. Fortunately it was not violent or continued, for we looked with some anxiety to the descent, which our guide had never traversed. The view to the south-west carried the eye into the Val Gaudemar at a profound depth (nearly 7000 feet) below us.[2] The prospect of the descent was sufficiently fatiguing, if not dangerous, for, as we attained the summit, we looked over what appeared a precipice perhaps 3000 feet high, composed of rock intermixed with snow-beds of extreme steepness. There was, however, no alternative, and we boldly faced the abyss. Our intelligent guide, avoiding the inclines of

[1] [There are two gaps between the Pic Coolidge and the Ailefroide,—both crossed long before Forbes wrote,—that to the N. being the Col de la Temple (10,771 feet), and that to the S. the Col de la Coste Rouge (10,342 feet). Forbes probably alluded to the latter. See above, p. 406. The Montagne des Agneaux (12,008 feet) is a fine summit that rises between the sources of the Romanche and those of the stream flowing through the Vallouise. The "Mont Pelvoux" is really the Ailefroide (12,989 feet), which hides the true Mont Pelvoux; the error arose from Bourcet's map, and was not finally cleared up till Mr. Tuckett's journey in 1862. The Ailefroide rises 2700 feet above the Col du Says, and is described by Professor Bonney (who visited the Col du Says in 1860) as "one of the grandest things I have ever seen in the Alps."]

[2] [The difference in height between the Col du Says and Le Clot, the highest hamlet in the Val Gaudemar, is 5489 feet.]

snow,[1] led us down the least difficult parts of the precipice of rock with skill and address. The rock was still composed of a mixture of steatitic gneiss, with a variolite composed of felspar and augite, which occurs in large grained patches. The footing was often by no means firm, the rock decomposing into angular fragments; but the last part we accomplished easily and agreeably by allowing ourselves to slide down a moderately steep declivity of snow until we reached the pastures, when, looking back to the precipice we had passed, it seemed very nearly inaccessible, in the ordinary sense of the word. Near the bottom we saw a chamois. Our progress was now easy and rapid. Each chose his own path, and we ran gaily over the very steep pastures which form the upper part of the wholly uninhabited Val de Gioberney. At the junction of this valley with the main one of Gaudemar is a fine cascade, buried so deep in a ravine that it can with difficulty be seen; and a little below is the hamlet of Le Clot, where it might be possible to sleep:[2] but we preferred walking two hours farther down the valley to the first *commune*, that of La Chapelle, where we arrived about 7 P.M.

The arrival of strangers at La Chapelle is at all times a subject of surprise, but when they came from the glacier-bound head of the valley, it was a matter of curiosity to the whole inhabitants of the village, a majority of whom appeared to be more or less under the influence of wine (being a *fête* day[3]); and, as we were driven from door to door by the hope of finding a decent lodging, we were followed by crowds of curious speculators. The mayor of the village was seated in the crowded room of the filthy *cabaret*, which formed the only pretence of an inn. A glance at the beds satisfied us that it was impossible to sleep there, and having submitted with calmness to the drunken expostulations of the man of office on the illegality of the spiked alpine poles which we carried, we at last, after much delay, found shelter with the Curé, whose timely hospitality we have good reason to remember. Clean beds and a hospitable meal were offered to us with simplicity and kindness, and we were invited to stay all next day, an offer of importance, for

[1] A narrow one, but of formidable steepness, and softened by the warmth of the day, we were, however, compelled to cross.

[2] [The present Editor has often slept there in a primitive inn, but now a little mountain inn has been opened at Le Clot.]

[3] [St. James's day, July 25.]

we had another long and difficult alpine walk before us, and desired some repose.

A short excursion into the valley of Navettes [1] gave us some further insight into the singular character of this part of Dauphiné. When we had descended to La Chapelle, of which the elevation is 3525 feet,[2] we supposed that the Val Gaudemar was one which offered easy communication with the neighbouring valleys; but this is far from being the case. Its lateral branches, like Navettes, are sealed with glaciers, and it is an arduous day's journey to escape on either hand from the single narrow channel which the stream of the Val Gaudemar (called the Severaisse) flows to join the Drac.[3] By Navettes is a pass leading to Champoléon,[4] a point of geological interest, on account of the displaced and altered limestones, but it is so lofty as to be covered with perpetual snow. My desire to visit Champoléon did not equal that to explore more completely the environs of the Mont Pelvoux, and to intersect again the heart of the chain by passing from La Chapelle to Val Louise, whence we proposed, by the circuitous route of Freissinières, to reach Champoléon, and to return to La Chapelle by the Col de la Méande.

In the neighbourhood of Navettes, in the ravine called the Combe d'Ourcette,[5] the same limestone occurs, which at Champoléon and other places in this neighbourhood breaks into the granitic nucleus. This is very well marked in the geological map of France; but the authors of it do not appear to have been aware that a stripe of limestone, composed of highly inclined strata and of considerable extent, crosses the upper part of the Val Gaudemar in a N.N.W. and S.S.E. direction,[6] and

[1] [This glen opens just to the south of La Chapelle.]

[2] [The French Government maps give no height, but Forbes's estimate seems a trifle too high.]

[3] [The Val Gaudemar is one of the narrowest of Alpine glens, and hence all the passes leading out of it are laborious and steep.]

[4] [The head of the Navettes glen is blocked by the ice and snow-clad range of Chaillol. At its north-east foot is the easy glacier Col de la Méande (c. 9351 feet), mentioned by Forbes; but the usual and more direct route to Champoléon is by the stony Col de Valestrète (or Valestrèche), 8596 feet, also marked on Bourcet's map. The Champoléon glen is traversed by the main stream of the Drac, which some way below the chief village receives the Drac d'Orcières; from Orcières the easy Col d'Orcières (8859 feet) leads through the Freissinières glen to the valley of the Durance.]

[5] [Better known now as the Tempier ravine.]

[6] This is also the direction of the gneiss strata. This band of limestone crosses the Val Gaudemar at the village of Riou or Rif du Sap. The limestone communicates apparently with that of Navettes.

communicates, in all probability, with the valley of Champoléon on the one hand, whilst it stretches away into the Val Jouffrey on the other. Fragments of the epidote rocks are extremely abundant near Navettes, and I observed an amydaloid, which I afterwards noticed at Monêtier, near Briançon, but which I have not found *in situ*.

The following day we prepared to start from La Chapelle to cross into the Val Louise by the southern branch of the chain of Mont Pelvoux. Our intention was nearly frustrated by the suspicious activity of the police. A rumour of the arrival of strangers with iron-shod poles across the glaciers had reached the town of St. Firmin at the foot of the valley;[1] and the gendarmes arrived just in time to intercept our departure, which had been retarded by the morning mists. Seizing upon an irregularity in my friend's passport, they had almost detained us, but the letters with which I had been kindly furnished by M. Arago procured our liberation, and we started to ascend the Col du Sellar at a later hour than we should willingly have done had we been aware of the difficulties which awaited us.

We had to retrace our former steps to the highest hamlet of the Val Gaudemar, named Le Clot,[2] consisting of but a few scattered houses, after which cultivation ceases, and we laboriously ascended the steep but rich pastures which intervene between the valley and the glacier, which as usual descends from the col. After two and a half hours of ascent, and four and a half hours from La Chapelle, the glacier was gained. The latter part of the way was extremely rough over the loose moraine. At this great elevation I gathered a specimen of metamorphic limestone, of which doubtless some imbedded fragments are to be found in this central and very elevated range. The limestone had a bluish colour, and was accompanied by a portion of red schist almost converted into porcelain jasper. It is probable that their position and relations would be very interesting if discovered; for here we are upon the verge of the true granitic nucleus, and we quit for a time the strata of gneiss. The scenery during the ascent is very grand. The

[1] [It is 10 miles by char road below La Chapelle, near the mouth of the Val Gaudemar, and is 4 miles from the great high road that connects La Mure and Gap *viâ* Corps and St. Bonnet.]

[2] [Its height is 4800 feet. There is now a little mountain inn here.]

stupendous mountain, marked Garroux[1] on Bourcet's map, with a *talus* of bare rock as steep as a house roof, broken here and there into pinnacles, and powdered with the fresh snow of the past night, rose majestically on our right.[2] At length we entered upon the snow, and after crossing a considerable tract, came to the first rocky step or stage, over whose centre a glacier pours its torpid mass, taking its origin in the mountain basin above, at the foot of the col. This barrier of rock was gained easily, but the access to the col promised greater impediments. The unusual quantity of snow of last winter had prevented all access to the second tier of rocks, except by crossing its steep inclined surface, which was of great extent, and being at this advanced time of day completely softened, presented a kind of walking which, though not difficult in itself, required the utmost precaution, since an ill-placed step would infallibly have launched the traveller on the soft snowy slide—a circumstance which had occurred but a little before to one of the party, when it was only a matter of amusement, since no greater danger than a fracture of the barometer was to be apprehended, whilst at present, unless by great address in the use of the pole, the victim of a false step must have slid down a snowy bank of some hundred feet, and landed amongst glacier precipices at the bottom. For a whole hour we had to pick our steps along this disagreeable slope, and gently mounting, at last reached the foot of the final precipice which conducted us to the col. It was soon climbed; when a scene not less striking in its way than that from the Col du Says presented itself. The col was a mere ridge of angularly shattered granite, rising on both sides into fantastic forms of singular wildness of outline. Before and behind us were glacier basins, the one of which poured its tribute into the Vallon des Bans (a tributary of the Val Louise), the other into the Val Gaudemar. We stood suspended above both, with the intervention of a rocky precipice, so that our position resembled a gigantic wall of masonry, battered by time and the elements into irregular embrasures, and to which the snow could scarcely cling. The barometer stood at 19 French inches 6 lines $\frac{3}{10}$; the temperature of the air was about 36°.

[1] [Now called "Sirac" (11,280 feet); it was first ascended from the other side by the present Editor in 1877.]
[2] [*I.e.* on the south.]

Consequently, the height was nearly as great as that of the Col du Says, and proved to be 10,073 English feet.[1]

We had ascended about 6500 feet, and had nearly an equal descent before us, which evidently was not unattended with difficulty, for beyond the glacier basin immediately before us the eye in vain sought for a slope to guide it into the seemingly unfathomable depth of the valley beneath; in truth, the glacier is guarded by precipices on every side. A great rent separated the snow from the rock: this was our first difficulty, but soon overcome. We had little time to waste, for we had spent eight hours in climbing the col. The glacier basin was crossed without any of the difficulties we had experienced in ascending; but we soon reached the rocky chasm which separated us from the habitable world beneath. Our guide, who had already passed this way several times,[2] led on with confidence and skill; but it required all our assurance to follow him down the almost perpendicular cliff, exposed and convex, without any of those narrow crevices into which a man can, with a little practice, squeeze his body, and let himself gently down. This was a work of clinging from step to step; and though our guide manifested much patience for our slow movements, he had none of the adroit usefulness of the Swiss guides, whose familiar acquaintance with travellers enables them to assist in a thousand ways, and many of whom have often risked their own lives to save that of their employers. The chamois hunter of Dauphiné feels (not unnaturally) no such bond between him and the traveller whom he conducts, and will often scarcely take the trouble of making a circuit, however trifling, to avoid a pass which would make the hair of a common tourist to stand on end. Here, however, there really was no escape. Precipices surrounded us on all hands, unless where they were masked by vertical walls of ice, or snow beds of impracticable inclination. To turn back was out of the question. Evening approached, and the col was not yet far behind us. Who would stand upon trifles at such a moment?

In the course of this descent, I was not inattentive to the

[1] [The true height is 10,063 feet, or 226 feet less than that of the Col du Says.]

[2] [The Col du Sellar is believed to have been known for several centuries. It is quite possible to descend towards Entraigues *entirely* by the glacier, or to turn its steepest portion by the hollow between the ice and the rocks. But in 1841 as now the Dauphiné guides prefer difficult rocks to what their Swiss colleagues would consider an easy glacier.]

nature of the rocks by which we were compelled continually to cling, and was particularly struck by the occurrence of thin green veins or dykes cutting the granite dykes, which at the time I took for serpentine, but a more careful inspection shows to be green felspar. These are doubtless of the same nature with the dykes of felspar described by M. Elie de Beaumont on the Col de la Haute Pisse, between St. Christophe and the Val Jouffrey. One of the dykes on the Col du Sellar exhibited a shift or dislocation. Having reached in safety the foot of a precipice several hundred feet high, we found ourselves on the level of the glacier, and thought that our descent would now be accomplished on its surface; but from this the guide entirely dissuaded us. Fresh traces of avalanches were everywhere strewed on the steep surface over which we must have passed. Before us rose a buttress of rock, by the foot of which the glacier swept, and which, therefore, it was impossible to turn. There was no alternative but to climb over it. A new cliff was to be scaled, then a longer precipice was to be descended by ledges of scarce a hand's-breadth; but this being accomplished, we found ourselves on a moderately inclined slope of snow, which, owing to the very unusual extent which it had this season attained, stretched into the valley for a distance of nearly two miles, along which we slid and ran at ease; and, as we approached the first habitations of the Val Louise—the wretched hovels of Entraigues—the evening had already fallen, and we looked back almost with awe to the rugged heights from which we had just descended, flanked by glaciers and rocks which appeared equally inaccessible.

Entraigues (as its name imports) is placed at the union of two streams, of which that on the right descends from the Vallon de Beauvoisin, which offers a circuitous but less difficult communication with the Val Gaudemar which we had just quitted.[1] To remain at Entraigues was out of the question, so we pushed on in the dark for fully two hours farther, to gain the *chef lieu* of the valley, the poor village which goes by the

[1] [The Beauvoisin glen is now known as the Selle glen. Through it the glacier Col du Loup du Val Gaudemar (10,210 feet) leads to Le Clot, an easier though longer and more circuitous route than the Col du Sellar. But Forbes was probably thinking of the twin passes of the Col du Haut Martin and the Pas de la Cavale (8990 feet),—a military road now traverses them,—which afford an easy route from the Vallouise to the sources of the Drac and the Champoléon glen.]

imposing name of the *Ville* de Val Louise. We soon found ourselves amongst wood; and, even in the twilight, we could see that the stern features of the granitic mountains had yielded to the gentler character of the limestone hills, which commence an hour above *La Ville*. These hills are studded with villages and church spires, their tops clothed by the warm green pine woods, their flanks covered with fresh pasturage, and the well-watered valleys rearing stately walnut and other trees, present a scene more verdant and engaging than our eyes had rested upon since quitting Allemont; for even Vénosc, beautiful as it is, and owing its beauty to the same cause—the limestone formation—is but a gem set in a massive framework of granite peaks on every hand.

Little of this, however, we saw till next morning. All was dark long before we arrived at Ville Val Louise; and we wandered disconsolately about its deserted streets, composed of great barns more than of houses, with those vast projecting roofs and verandahs which characterise this part of the French Alps, under which in unfavourable seasons the poor inhabitants strive to preserve from total destruction the crops which have not had time to ripen on the stalk ere the autumnal frosts have seized upon them. At length we got a direction to the house of the Curé, the traveller's best resort in Dauphiné, where we were hospitably received, and lodged better than we had any reason to expect.

The position of this village is remarkable.[1] It lies near the union of the valley of Entraigues, which we had descended, with the principal branch of the Val Louise itself, called Ailefroide, which stretches up quite to the foot of the monarch of the group, the Mont Pelvoux itself,[2] which, though at no great distance, cannot be seen from the "Ville" on account of the hill which rises immediately behind. It is from this side that the ascent of the Mont Pelvoux has been attempted; and it appears that the French engineers succeeded in attaining a summit but little inferior to the very highest point which has acquired the peculiar name of *Pointe des Arcines* or *des Ecrins*. It is, as we

[1] [Its height is 3773 feet.]

[2] [The Mont Pelvoux is really surpassed by the three summits of the Ecrins, by two of the Meije, and by one of the Ailefroide. See also the next bracketed note.]

have said, estimated by the French engineers to be 4105 mètres or 13,468 English feet above the sea, by Carlini and Plana 4100 mètres,[1] and by Von Welden and the Austrian engineers[2] 12,612 French or 13,442 English feet. It is, therefore, the highest mountain between Mont Blanc and the Mediterranean, Mont Iseran being 4045 mètres (Corabœuf), and Monte Viso being only 3836 mètres—a height surpassed by several of the mountains of Dauphiné.[3]

The Val Louise is, as I have observed, very fertile in its lower part; and, when we descend a few miles below the town, the Mont Pelvoux is seen to rise with almost architectural solidity and boldness, the prominences of the granitic tables giving an effect, now of buttresses and now of pinnacles, which is exceedingly grand.[4] Below the pretty village of Les Vigneaux, the valley contracts by the approach of the limestone rocks, and then opens rather abruptly on the valley of the Durance. We shall not detail the features of the country farther in this direction, because we soon quit the prescribed limit of the district we have to consider, but shall conclude with a short description of the north-western boundary of these mountains.

The proper group of the Oisans is bounded in this direction by the valley of Monêtier, by which the Guisane flows to join the Durance a little way below Briançon. It takes its rise at the Col du Lautaret, the mere watershed of the two extremities of one and the same valley, which terminates in a westerly

[1] De Beaumont, *Mémoire*, p. 19.

[2] *Der Monte Rosa*, p. 30.

[3] [The lower summit (la Pyramide)—12,921 feet—of the true Mont Pelvoux was attained by Capt. Durand with two hunters in 1830; but, though the party spent several days there making observations, they do not seem to have crossed the easy snow slopes that lead in a few minutes to the highest summit (12,973 feet), which does not appear to have been visited till 1848 by M. Puiseux.

E. de Beaumont wrongly gave it the name of "Pointe de Ecrins," while the other writers named wrongly give the Pelvoux the height of the Ecrins. The two peaks are divided by the deep basin of the Glacier Noir, and their separate and distinct existence was finally proved by Mr. Tuckett in 1862. The Ecrins (4103 mètres, or 13,462 feet) *is* the highest summit between the Mediterranean and Mont Blanc.

The height of 4045 mètres assigned to Mont Iseran by Corabœuf rests on a confusion of that peak with the Grand Paradis, for the true height of Mont Iseran is 10,634 feet, while Monte Viso rises to a height of 3843 mètres, or 12,609 feet.]

[4] See the vignette at the head of this chapter.

direction in the deep gorge of the Combe de Malaval formerly alluded to. This great valley, in its whole extent, occupies nearly the boundary of the granite and lias, the limestone of the upper part of the Val Louise being, according to M. Elie de Beaumont, "nummulite" limestone or chalk. At Monêtier, about six miles above the valley of the Durance,[1] the glaciers appear on the left descending from the group of the Montagne des Agneaux, which, according to the same author, are composed of gneiss strata so regularly disposed as to be easily mistaken for limestone at a distance, dipping to the N.E. The strata of this part of the range appear to be very close in their nature, and resemble those of the Col du Says. A gentle ascent leads to the summit of the Col du Lautaret, which is covered with verdure to the very top; and even the neighbouring mountains are clothed to a great height with pasturages of the utmost luxuriance, filled with a greater and more gorgeous variety of flowers than I recollect to have seen in any other part of the Alps. The height of the col is 6740 feet,[2] and from it a view of wonderful grandeur is obtained down the gorge of Malaval,[3] and especially towards the Aiguille du Midi de la Grave, rising to a height of above 13,000 feet,[4] fancifully compared by M. Elie de Beaumont to a gigantic nut-cracker menacing heaven with its open jaws. Immediately to the south of the Col du Lautaret is a very remarkable mountain which presents a section of granite and limestone which has not been, I believe, described, and which does not yield in interest, or in evidence of inverted superposition, to that at Villard d'Arène, so ably described in the memoir just cited.

Immediately above the village called Le Pied du Col two streams unite,[5] whose courses are separated by a hill not named in Bourcet's map, but descending from the Pointe de Combeynot, whose sides, parallel to each ravine, form a horizontal angle vary-

[1] [Monêtier is 9½ miles from Briançon. There is now a splendid carriage road over the Col du Lautaret from Briançon to Bourg d'Oisans (38½ miles).]

[2] [The true height is 6808 feet, and there is now a good inn on the summit. The pastures of the Lautaret are familiar to botanists, as the flora is very rich.]

[3] [Strictly speaking this name belongs only to that portion of the Romanche valley *below* La Grave.]

[4] [Now better known as the Meije (13,081 feet).]

[5] [The Lautaret stream, flowing from the Col du Lautaret, there joins the Romanche. The hill alluded to by Forbes is now called the "Pyramide du Laurichard."]

ing from 60° to 90°. When this promontory is viewed in front it is evident that the superior part is composed of granite or gneiss, and that the base of the whole hill is limestone. This I had noticed in a general way in 1839, but in 1841 I quitted the road at the Col du Lautaret, and after ascending above a thousand feet, I reached the junction of the two rocks, where the limestone dips under the gneiss at an angle of from 65° to 70°. Both rocks were very materially altered at contact, but within a few feet of each other were perfectly well characterised. A similar section was obtained at *each side of the hill;* the limestone dipping under the gneiss both ways, so as to leave not a moment's doubt that we have here a cap of primitive rock overlying the secondary rocks, just as we so often see in the case of basaltic summits resting upon stratified bases. The view of the junction from Villard d'Arène (a village below Pied du Col) leaves nothing to be desired, after the nature of the rocks has been ascertained by actual inspection.

A great road, leading from Grenoble to Briançon, was being conducted, at the time of our visit, across the Col du Lautaret. Already great difficulties had been overcome. When completed,[1] it will vie in the wildness of the scenery through which it leads with almost any of the Alpine passes. The descent from Villard d'Arène to La Grave is steep, and the nature of the rock (a crumbling black calcareous slate) opposes peculiar difficulties to the engineer. A striking cascade is passed, the whole grandeur of the glaciers of La Grave is spread out before the traveller as the path winds through the narrow street of La Grave, and then plunges steeply into the ravine of Malaval. This remarkable chasm, the result of some awful convulsion, runs nearly east and west, and is bounded on either hand by a wall of rock so steep as effectually to conceal the vast ice-fields by which (on the south side) it is surmounted.[2] The fallen masses of rock which strew the valley equal in magnitude those between Vénosc and St. Christophe, whilst the almost monotonous straightness and uniformity in breadth of the defile, and the towering walls which shelter it even from the mid-day sun, give the ravine a

[1] [This took place in 1861 only.]

[2] [These are grouped under the general name of the Glacier du Mont de Lans; the easy glacier pass of the Col de la Lauze (11,625 feet) leads over it to St. Christophe by way of the Vallon du Diable.]

character of sombre wildness, which the almost total absence not only of wood, but of verdure for many miles, serves to increase. The great public work, the formation of the new road, has taken something from the solitude of the scene, and yet the scale is so great that the eye may almost overlook the tunnels and embankments which have cost years of labour.

At La Grave we enter again upon the granitic formation, which here, near its junction with the sedimentary rocks, is, as usual, metalliferous. The galleries from which the copper ore is extracted open in the face of naked cliffs in spots apparently inaccessible to all but birds; yet up these cliffs are carried wooden tubes through which the broken ore is allowed to slide down to be smelted at the works beneath.[1] It is in these mines that these crystals, for which Dauphné is so celebrated amongst mineralogists, are commonly found.

This defile, with slight variation of direction, extends as far as the valley of the Vénéon, which, as already mentioned, it joins at a short distance from Bourg d'Oisans, which is about [15½] English miles from La Grave, or [29] from Monêtier.

The valley of the Romanche just described is separated from the valley of the Arc and the district of the Maurienne by the lofty range of mountains of which the culminating mass is that of the Grandes Rousses, already adverted to. This savage mountain rises to a height of 11,900 feet above the sea.[2] It is consequently covered by perpetual snow, and the distance of every part of it from inhabited valleys must have rendered its geological description by M. Dausse a task of no small labour. The most prolonged chain connected with it stretches in an easterly direction towards Briançon, and presents numerous passes, all of considerable elevation, by some of which the valley of the Arc may be reached from those of Dauphiné in the course of a long day's walk.[3] The excursion from La Grave to St. Jean

[1] [The *lead* mines are now no longer worked.]

[2] [The Grandes Rousses attain a height of 11,395 feet, but rise much nearer Bourg d'Oisans than La Grave. Due north of La Grave are the three fine rock pinnacles of the Aiguilles d'Arves (the highest is 11,520 feet), which (as noted above, p. 394) are strangely omitted by Forbes, though when crossing the Col de l'Infernet he was close to them.]

[3] [The easiest and most frequented of these passes is the Col du Galibier (8721 feet), over which a carriage road (the highest in the Alps save that of the Stelvio) now runs from the summit of the Col du Lautaret direct to St. Michel de Maurienne.]

Maurienne presents some subjects for geological remark with which I shall conclude these observations.

The ascent of the hill, immediately behind the village of La Grave to the northward, soon commands fine views of the ravine of Malaval and the mountains which rise to the south. The church, a picturesque structure of the Romanesque style, stands on a green eminence, right in front of the great glacier which streams from the Aiguille du Midi or Meije; and immediately to the left of it is admirably seen the section of granite and lias, which are there in contact for above half a mile, and after rain the colour of the rocks distinguishes them perfectly at any distance. The first heights gained, we overlook a small tributary ravine [1] which pours its torrent over a precipice of granite into the valley below to swell the volume of the Romanche. A beautiful cascade, just above the hamlet of Les Fréaux, is the result, and this little stream intersects the junction of the granite and limestone, the whole cliffs of the Combe de Malaval being, however, composed of the former, and the limestone overlying it, and dipping to the W.N.W.[2] The mountains to the northward, notwithstanding their elevation and bareness, being composed of limestone, afford good pasture; and in the small tributary ravine just mentioned, not far above the cascade of Les Fréaux, lies the secluded village of Le Chazelet, a frontier station of the French Custom-house officers, whose duty requires them to watch this dreary frontier of Savoy.[3] My letters procured me a good reception from them, and likewise a guide for the pass to St. Jean de Maurienne—that which we selected as the most direct is called the Col de l'Infernet. As we mounted, our attention was continually attracted by the increasing magnificence of the southern range opposite to us. The higher we ascended the more lofty did it appear—the more we receded the

[1] [That of Buffe.]

[2] Elie de Beaumont, p. 44. A little below Les Fréaux, in the valley of the Romanche, and on the right bank of the river, I found, where the rubbish had been cleared away in the recent excavations, a mass of limestone. I am unable to say whether it was there *in situ*, or was only a portion of an enormous mass which had fallen from the rocks above. As the cliff *there* contains, so far as I know, no limestone, the latter supposition is in some degree improbable, though it might have descended from between Les Fréaux and La Grave; but were the limestone really beneath the cliffs of gneiss, the fact would be a very interesting one, as representing a wedge or stratum of gneiss contained between two of lias.

[3] [It must be recollected that Savoy formed part of the Sardinian kingdom till 1860-61.]

more did it enlarge. So completely is it true that the grandeur of these mountains is lost sight of, in consequence of the profundity of the ravines. Like a great city seen from a distance, its spires and turrets come first into view, when we emerge from the confinement of its streets. What seemed but a naked wall of black rock from the depths of the vale of the Romanche, now stood forth as but the colossal base of trackless snow-fields of many leagues in extent. Above and through these rise fantastic summits, which perpetual winter clothes almost every week of the year with a slight covering of snow, again to be tossed towards heaven by the stormy blasts which echo from rock to rock, whose sounds, though mingled with the thunder of the avalanche, are all unheard by ear of man or beast.

The height of the Col de l'Infernet is not known, and our barometer was now broken; but, by the time required for the ascent, I estimated it at fully 5000 feet above the village of La Grave, which I had previously determined to be 4971 feet above the sea, giving, therefore, a height of 10,000 feet.[1] It was the *third* pass of this elevation (besides several lower ones) which we crossed in little more than a week. On the second of August it was covered with fresh fallen snow to a great depth, though in the latitude of only 45°; but it offered no farther difficulty than steep and dirty paths. So piercing, however, was the cold even at this season, that, though we walked as fast as we could, we had not descended very far into Savoy before my companion had nearly fainted from the effects of the alternations of temperature to which we had been exposed. The descent to St. Jean de Maurienne[2] from so great an elevation was of course extremely long, and being in great part over arid limestone rocks, which for many miles afforded not a drop of good water, and cut the feet by their angular fragments, we were sufficiently fatigued ere we reached the fertile valley of the Arc, smiling with verdure, the hills clothed with rich woods, and the valleys with fruit trees, vineyards, and maize—in strange contrast with the Arctic scenes we had left but a few hours before. But how various are the causes

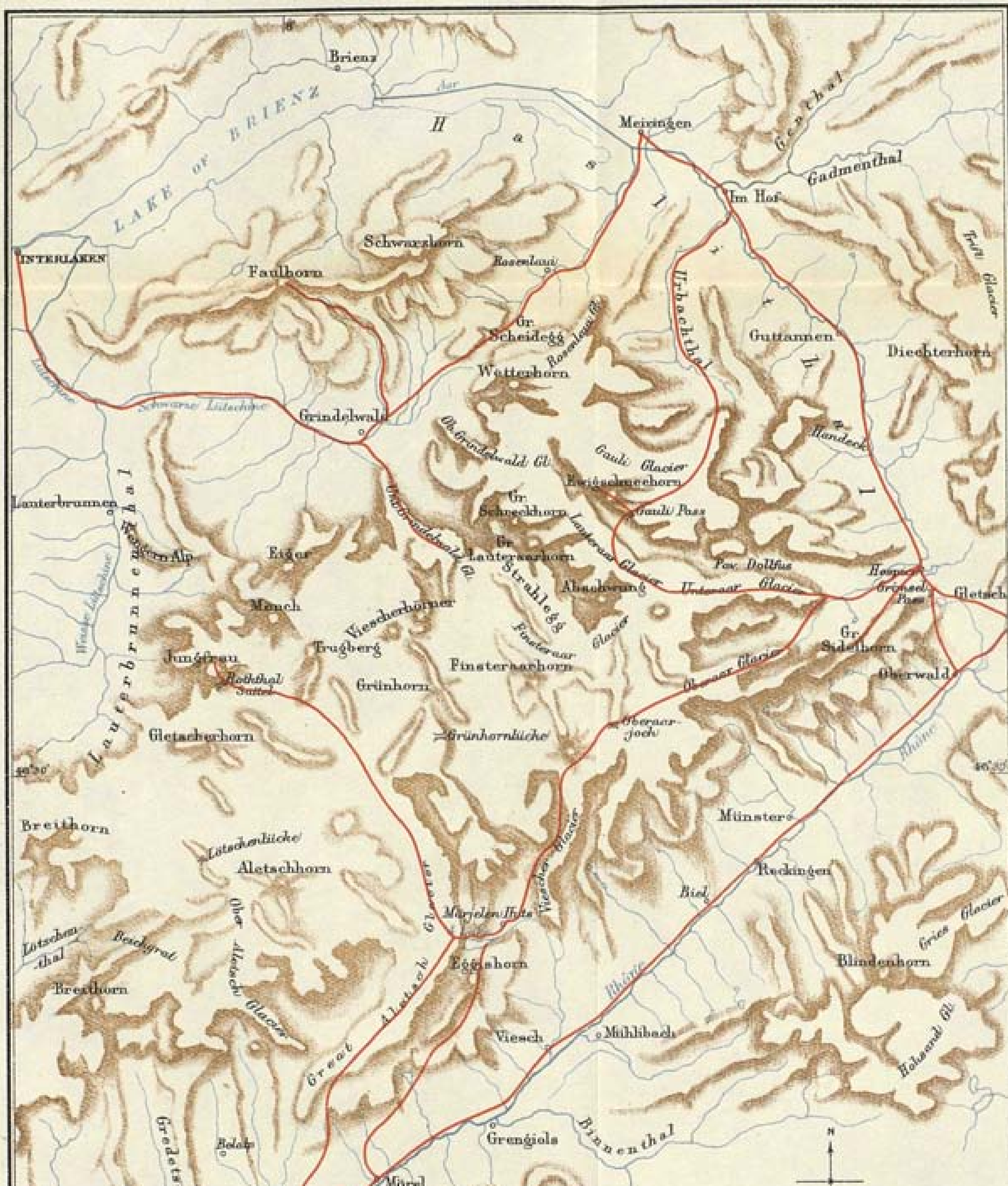
[1] [The height of the Col is but 8826 feet, and no portion of the route is permanently covered with snow, a mule path traversing all but the uppermost slopes on either side. The height of La Grave is 5007 feet.]

[2] [It does not appear whether Forbes took the route past the beautifully situated village of St. Jean d'Arves, or the more direct way through the entire length of the striking gorge of the Arvan.]

of human happiness or misery! At La Grave not a stick can be had for firewood. Cow dung is the chief combustible in a climate which may truly be said to consist of nine months of winter and three of bad weather. Poverty, and cold, and filth offend the senses; and yet who would exchange the robust and healthy constitution of the mountaineer of Dauphiné for poverty amidst luxuriance, filth amidst natural beauty, with the superadded curse of crétinism and goitre in the sunny valleys of the Maurienne?

The view from the Col de l'Infernet presents a noble profile of the Dauphiné Alps, viewed from the N.W. Though the question of the manner and form of elevation of the gneissic formation, with its superincumbent limestone, is rather to be determined, in my opinion, by a careful comparison of the dip and direction of strata at various points, than by the outline of the mountains seen at a distance, yet the latter is also well worthy of notice. The conclusion to which I on the whole incline is this, that the elevation has not been so much circular and directed towards the valley of La Bérarde as a centre, but rather towards an axis of elevation running N.N.W. and S.S.E., and passing through that locality. This supposition will correspond to the really well-marked features of the profile when viewed in either continuation of that line, as, for instance, from mountains beyond Bourg d'Oisans, or from the main chain of Alps in the direction of Barcelonnette; whereas in the contrary direction, as from the Col du Says and the Col de l'Infernet, the mountain profile being parallel to the axis of elevation, no trace of grouping round a centre is perceptible. But the best confirmation of this view will be found in the following observations of the direction and dip of the strata (most of which have been collected from incidental notices in M. Elie de Beaumont's excellent memoir), which, though occurring in all parts of the group, indicate a very general tendency to parallelism in the direction which I have indicated, excepting the neighbourhood of a single locality, La Grave:—

Locality.	Formation.	Direction of Strata.	Dip.
St. Christophe	Gneiss	N.N.W.	Vertical.
Montagne des Agneaux above Col d'Arsine	Gneiss	N.W.	30° to N.E.
Pointe de Combeynot . . .	Gneiss	N.W.	30° to N.E.
Montagne d'Oursine [Ecrins]	Granite	N.W. ?	To N.E.
Aig. du Midi de la Grave [Meije]	Granite	N.W. ?	To N.E.
Mont Pelvoux	Gneiss	N.W.	To S.W.
Entraigues, Val Louise . .	Gneiss, sandst. and limest. of age of chalk	N.W.	45° or 50° to S.W.
Les Fréaux, La Grave . . .	Gneiss	N. 20° E.	70° to W.N.W.
Villard d'Arène	Contact gneiss and lias	N.N.E.	65° to E.S.E.
Do.	Lias	N. 60° E.	50° or 55° to S.E.
Val Gaudemar	Gneiss	N N.W.	Nearly vertical.



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CHAPTER III

EXCURSION ON THE GLACIERS OF THE BERNESE ALPS, PRECEDING THE ASCENT OF THE JUNGFRAU

Engagement with M. Agassiz—Residence on the Unteraar Glacier—Topography of the Bernese Oberland and the glaciers originating near the Finsteraarhorn—Two panoramas—Excursion from the Grimsel to the Glacier of Aletsch in Vallais—Departure—The Glacier and Col of the Oberaar—Descent on the Glacier of Viesch—Caverns in the névé—Enormous block of stone on the moraine—Arrival at the chalets of Märjelen—Preparation for the ascent of the Jungfrau.

THE summer of 1841 I spent in a series of journeys requiring almost constant exertion. The month of June and part of July was devoted to explore part of the volcanic countries of central France, in company with my lamented friend Mr. John Mackintosh.[1] The remainder of the month was devoted, in company with Mr. Heath, to the excursions in Dauphiné, which have been partly recorded in the preceding pages; and from thence we proceeded by the shortest practicable route to reach the Grimsel hospice in the canton of Berne, where I was under an engagement to meet M. Agassiz[2] of Neuchâtel on a certain day [July 8]. This cost us seven days of continuous exertion, during which we twice crossed the main chain of the Alps, and also several other passes of considerable elevation.[3]

Arrived at the Grimsel, and having met M. Agassiz, we pro-

[1] An account of the results is contained in a paper in the 20th volume of the *Edinburgh Transactions*. [As to Mr. Mackintosh see *Life and Letters*, pp. 153, 154.]

[2] [Louis Agassiz, born 1807, died 1873. A portrait of him is given on page 221 of vol. ii. of *Die Schweiz im 19ten Jahrhundert*, 1899.]

[3] [It would appear that Forbes went from the Maurienne to the Grimsel hospice by the Little St. Bernard, the Col Ferret, the Rhone valley, and the Grimsel Pass. The hospice was reached on the evening of August 8, 1841. It was in September, 1840, during the meeting of the British Association at Glasgow, that Forbes agreed to visit the Bernese glaciers with Agassiz. The "huge stone" on the Unteraar Glacier is well known in Alpine history as the "Hôtel des Neuchâtelois."]

ceeded, by his kind invitation, to pass some time on the Unteraar glacier. During several weeks, when not compelled by stress of weather to seek a more hospitable shelter, we remained in a sort of bivouac under a huge stone on the moraine of that noble glacier, and acquired an intimate acquaintance with the varying features of that astonishing ice-world which few persons have an opportunity of visiting, except for some hours at a time, generally urged by haste or overcome by fatigue. I here willingly record that I shall never forget the charm of those savage scenes; the varying effects of sunshine, cloud, and storm upon the sky, the mountains, and the glacier; the rosy tints of sunset, the cold hues of moonlight, on a scene which included no trace of animation, and of which our party were the sole spectators. M. Agassiz had lately published his interesting work on the glaciers, in which he embodied the bold reasonings of Venetz and De Charpentier with the results of his own observation. Guided by this, and the ready illustrations by means of examples on the spot, which M. Agassiz was as willing to afford as I was desirous to learn from, I soon found that a multitude of interesting facts had hitherto been overlooked by me, although I was already tolerably familiar with alpine scenes, and with glaciers in particular. Animated and always friendly discussions were the result; and, without admitting in every case the deductions of my zealous and energetic instructor, I readily allowed their ingenuity. Thus the latter weeks of August passed; and the separation of the party was approaching. Mr. Heath and myself intended to close the campaign in the environs of Monte Rosa, and to cross the pass of Monte Cervin.[1] In order to arrive there, we wished to avoid the long return down the valley of the Rhone from the Grimsel to Brieg, and I inquired as to the possibility of finishing our survey of the snowy territory commanded by the giant peak of the Finsteraarhorn by traversing the glaciers near its southern base, leaving the Rhone valley considerably farther to the south. I learned that this was practicable, and M. Agassiz kindly promised us the use of his best guide. Eventually, however, he and his other friends determined to be of the party, and further proposed, if circumstances turned out favourably, to attempt the ascent of the Jungfrau, which it was well known could only be attained from the southern side.

[1] [Better known as the St. Théodule Pass.]

The arrangements, so far as this part of the excursion was concerned, were undertaken and carried out entirely by M. Agassiz, and with him rests the credit of our success. I was not at all aware of the nature of the ground, the obstacles to be overcome, or the chances of doing so. Perhaps I did not attach so much consequence to the result as did some of my companions, with whom it had been a subject of meditation and discussion in a previous year, and I desired to be considered as a supernumerary. One reason was, that I had, a week previously, severely sprained my back and leg by half falling into a concealed crevasse on the glacier of Gauli, an accident which made me lame for some days,[1] and from which I had not by any means recovered when this expedition was decided on, of which the *preliminary* journey only was to be a formidable day's work of twelve hours, nearly all over snow and ice. I will only here add that the ascent of the Jungfrau proved a sovereign remedy for the sprain.

It may be convenient, for the better understanding of the journal which follows, to sketch briefly the disposition of the mountains and glaciers through which our journey lay.

The principal group of the Bernese mountains, which runs parallel to the great chain of the Alps in nearly a N.E. and S.W. direction, has the Finsteraarhorn for its culminating point. It is principally bounded on the north by the valleys of Lauterbrunnen and Grindelwald, and on the south by the valley of the Rhone. The northern side is by much the steepest, has the smallest valleys, and the least considerable glaciers, but the aspect of the mountains is on that account more imposing. On the south, and also on the east, on the other hand, lateral valleys of great extent are found, the slope is most gradual, and the glaciers are the largest in Europe.

On the north side, the Jungfrau, with its companions called Mönch and Eiger are the most conspicuous,[2] because they overhang the valleys, and the elegance of the form of the former has

[1] [This was on August 19. Forbes, Heath, and Agassiz, with the guide J. Leuthold, on the recommendation of Desor, mounted from their bivouac on the Unteraar Glacier to the summit of the Ewigschneehorn (10,929 feet), were tempted to descend on to the Gauli Glacier, and finally traversed the whole of the Urbachthal (see Desor, vol. i. p. 336).]

[2] [It seems strange to omit the Wetterhorn, perhaps the most graceful of all the great Oberland peaks.]

given it a deserved reputation second to none other in Switzerland. It is from this side absolutely inaccessible.[1] The Finsteraarhorn is situated nearly due east from the Jungfrau, and belongs to the same range, but it is near the centre of the mountain mass, and from it the glaciers may be said to radiate. The chief ones we shall now recount: (1) The only glacier of considerable size on northern declivity is the Lower Grindelwald Glacier. Its reservoir, or snow basin, is extensive, and takes its rise close under the northern foot of the Finsteraarhorn. (2) The principal branch of the Unteraar (Lower Aar) Glacier also rises immediately at the foot of the highest precipices of the same mountain. It is separated from the glacier last mentioned by the col of the Strahleck, a passage of considerable interest and some danger, from Grindelwald to the Grimsel. This glacier has two branches or affluents.[2] That farthest from the Finsteraarhorn rises between the Schreckhorn and the Ewigschneehorn. The Unteraar Glacier has a nearly due E. course, and the hospice of the Grimsel lies in its prolongation. It is remarkable for its vast extent and level surface, and here the annual progress of a glacier was first measured by the energetic Hugi.[3] (3) The Oberaar (Upper Aar) Glacier is parallel to No. 2. It does not spring immediately from under the Finsteraarhorn, but from the south-eastern spurs of it at no great distance. This glacier is separated from the last by an excessively rugged and probably impassable ridge.[4] (4) The Glacier of Viesch, which runs almost perpendicularly to the last,[5] and is separated from it at one place by a col or pass of no great difficulty,[6] though very

[1] [The Jungfrau was first climbed from the Wengern Alp in 1865, and from Lauterbrunnen direct, by what is called the "new route" through the Roththal and up the south-west ridge in 1885. In 1864 the Roththal Sattel was first gained by a difficult and dangerous climb direct from the Roththal, and thence the ordinary route up the Jungfrau followed to the summit of the peak.]

[2] [It would be clearer to say that the Unteraar glacier is formed by the junction of the Finsteraar and the Lauteraar Glaciers; the Finsteraarjoch and the Strahleck lead from the two branches of the former to the Lower Grindelwald Glacier, while the Lauteraarjoch connects the Lauteraar Glacier with the Upper Grindelwald glacier]

[3] [In 1827, 1829-30, 1832, and 1836-37.]

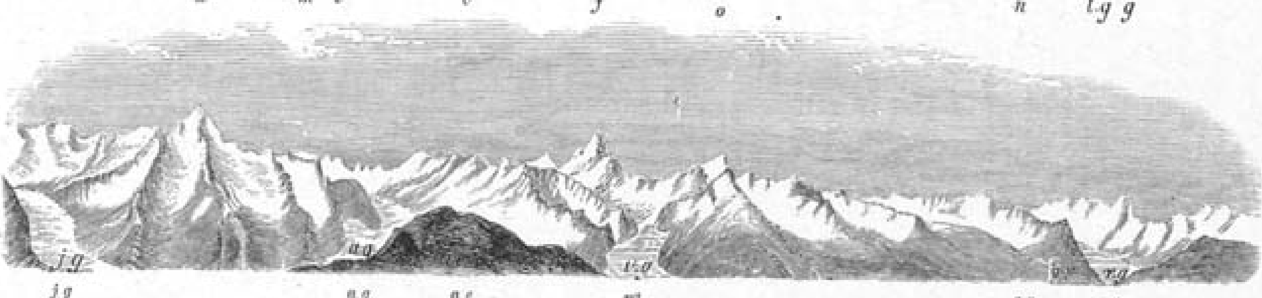
[4] [Several passes have of late years been effected across it. In 1842 Desor ascended the Thierberg (10,506 feet), one of the summits of this chain.]

[5] [The main stream of the Viescher Glacier flows along the west base of the Finsteraarhorn, and at the foot of the south-east ridge of that peak is joined by the Oberaar branch, flowing from the peak and pass of that name.]

[6] [The Oberaarjoch, described below.]

w, Wetterhorn. *s*, Schreckhorn. *f*, Finsternarhorn. *e*, Eiger. *m*, Mönch. *j*, Jungfrau.

THE BERNESE ALPS FROM THE NORTH.



j g Jägi Glacier. *a g* Aletsch Gl. *a e* Æggischhorn. *v g* Viesch Glacier. *g r* Grimsel Pass. *r g* Rhone Gl.

a, Aletschhorn (concealing the Jungfrau). *m*, Mönch. *t*, Trugberg. *v*, Viescherhörner. *f*, Finsteraarhorn. *o*, Oberaarhorn. *n*, Nägeli's Grätli. *t g*, Trift Glacier. *g*, Galenstock.

THE BERNESE ALPS FROM THE SOUTH.

elevated, takes its rise at the south [eastern] foot of the Finsteraarhorn, which, in the only two ascents which have been made of it,[1] is approached on this side. The snow basin or névé is wide and magnificent, and the glacier is proportionably long, and descends to a comparatively low level, so as to reach within no great distance of the valley of the Rhone above Brieg, where the village of Viesch (from which no doubt it takes it name) is situated. (5) The glacier of Aletsch, the largest in Switzerland or the Alps,[2] runs nearly parallel to that of Viesch, but a little farther west, being separated from it by a range of rugged hills. A passage[3] from one to the other may, however, be effected in the higher part near the great chain, and also not far above the lower termination of the glacier of Viesch, where are situated the chalets of Mörill or Märjelen, referred to in the following pages. The glacier of Aletsch has three main feeders—one which comes from near the ridge to the west of the Finsteraarhorn; the central one from the south-east foot of the Jungfrau and the back of the Mönch; a third from the direction of the Lötschenthal to the westward.[4] The western boundary of the Aletsch glacier is the magnificent mountain of the Aletschhorn, which has numerous though smaller glaciers of its own, and with which our survey may for the present terminate.

These details will, I hope, be made more clear by the two annexed panoramic views taken from my own sketches, one of which represents the Bernese Alps from the north, or as seen from the town of Berne, the other from the south, as seen from the commanding summit of the Wasenhorn, near the pass of the Simplon. The former presents in grand succession the noble forms of the chain. It commences with the Wetterhorn on the

[1] [These took place in 1812 (Arnold von Abbühl, Alöis Volker, and Joseph Bortis, three of R. Meyer's guides) and 1842 (Herr Sulger); the next (by an English party) was not made till 1857. The 1812 ascent was made by the south-east ridge (gained from the east), but the descent made on the west side of the peak.]

[2] [It is 15 miles in length, with an average breadth of 1 mile, while its area (including its feeders) is no less than 65½ sq. miles.]

[3] [This is the Grünhornlücke (10,844 feet.]

[4] [It would be more accurate to say that the Great Aletsch Glacier has six main feeders. Four of these—that flowing from the Lötschenlücke on the west, the Jungfrau Glacier from the Jungfrau, the Ewigschneefeld from the Mönch and the Viescherhörner, and the Grünhorn Glacier (all four being rather névés than true glaciers), unite at the spot which has been called the "Place de la Concorde" of Nature. Much lower down its course the Great Aletsch Glacier receives the Mittel Aletsch Glacier and the Ober Aletsch (formerly Jägi) Glacier, both descending from the Aletschhorn, the second in height of the Oberland peaks (13,721 feet).]

left; next the Schreckhorn, boldly stands out—the upper glacier of Grindelwald being intermediate, though unseen. Next comes the slender and distant but imposing pyramid of the Finsteraarhorn, between which and the spectator (also too low to be seen) is the lower glacier of Grindelwald. Then follow in a culminating series the Eiger, the Mönch, and the Jungfrau, the last being seen in its most familiar aspect. It is followed by the Gletscherhorn and Ebnefluh.

The second view is a portion only of an extensive panorama, taken under very favourable circumstances in 1844, from the Wasenhorn, at a height of at least 9000 feet, which may be attained without much difficulty from the Simplon hospice, and which commands unquestionably one of the grandest views in the Alps, extending from the Dent du Midi to the mountains of the Valtelline.[1] The portion connected with the Bernese Alps is here engraved, and, though on a small scale, gives a sufficient idea of the scenes described in the following pages.[2] The Grimsel hospice, from which our tour commences, is situated in the valley immediately beyond the col of the same name, which, owing to the great elevation of the spectator, appears in a depressed position towards the right of the figure, but a little to the left of the glacier of the Rhone. The hospice from which we started is in fact just under the rocky ridge marked Nägeli's Grätli. The Oberaar glacier, first traversed in the following tour, lies behind the horizon of the view to the right of the Oberaarhorn. The *col* or *joch* of the Oberaar, by which we descended on the glacier of Viesch, lies between the Oberaarhorn and the mountain between it and the spectator, which is the Kastenhorn.[3] The descent of the glacier of Viesch is well seen, and the passage in a depression of the mountains between Viesch and Aletsch is immediately behind the summit of the Æggischhorn, which is comparatively in the foreground of the panorama. Concealed, therefore, by the Æggischhorn are the chalets of Märjelen, where we passed the night, and also the lake of Aletsch; but the extent of the glacier of Aletsch, in the direction in which we traversed it, to its head beneath the Mönch, is well seen, only the Jungfrau

[1] [This peak (10,680 feet) was ascended by Forbes on July 22, 1844. Forbes exaggerates the extent of the view, which is, however, very fine.]

[2] I regret to state that the wood-engraver has failed in giving the desired effect to this view.

[3] [The Oberaar Rothhorn of modern maps.]

is unfortunately concealed by the majestic form of the Aletschhorn, which rises above the west bank of the glacier. This summit is believed to equal, if not exceed in height, the Jungfrau itself, and is perhaps not inaccessible, but it has not, so far as I am aware, been measured.[1] It is clothed with numerous short glaciers, and in a valley to the westward lies the considerable Ober Aletsch or Jägi glacier, which dies away before attaining the main stream of ice. The great glacier of Aletsch terminates in the profound Massa ravine close to the left-hand corner of the drawing.

With the aid of this description and a tolerable map of Switzerland, it will be easily understood that the expedition which I originally contemplated was confined to passing from the Grimsel hospice to Brieg in the Vallais, by passing over the Oberaar, Viesch, and Aletsch glaciers in succession. The additional excursion to the Jungfrau was to be accomplished by passing from Viesch to Aletsch, either by the upper or lower pass which I have mentioned, tracing the central stream of the Aletsch glacier to its origin at the base of the Jungfrau, and scaling that mountain as might be found most practicable, then returning to the lower part of Aletsch.

I shall now give the narrative nearly as recorded in my notes at the time.[2]

August 27, 1841.—We started from the Grimsel, with fine weather, at 5 A.M., a formidable company of six travellers and six guides,[3] who carried provisions, two or three small knapsacks of clothes, two or three very small casks of wine, one of brandy, a hatchet and cord for the glaciers. Jacob Leuthold, our confidential guide, led the way, and another, by name Johannes Währen, who had been under medical treatment for a diseased knee, knowing that the Jungfrau was in prospect, had stolen on before, to join us about a mile from the hospice, lest

[1] [The Aletschhorn is 13,721 feet, and ranks as the second highest of the Oberlands peaks; it was first ascended in 1859 by Mr. F. F. Tuckett.]

[2] [See also the detailed account of the whole expedition given by M. Edouard Desor in the first series of his *Excursions et Séjours sur les Glaciers* (1844), pp. 356-417. It was the fourth ascent of the Jungfrau, but the first in which a native of Great Britain took any part.]

[3] [The six travellers were Forbes, Heath, Agassiz, Desor (born 1811, died 1882—a portrait will be found in the *Neue Alpenpost* (Zürich) vol. xv. p. 76),—Duchâtelier et de Pury. The six guides were the two men mentioned in the text, J. Abplanalp, M. Bannholzer, J. Jaun of Meiringen, and J. Jaun of Im Grund—all Hasli men and servants of the landlord of the Grimsel hospice.]

he should have been prevented from accompanying us. These two excellent guides were deserved favourites. Währen, a powerful, large, good-humoured, intrepid man. Leuthold, a spare, sinewy, also very strong man, with a small twinkling grey eye, intelligent expression, and a mild thoughtful face, which was very engaging, and at the same time showed a degree of resolution which inspires confidence. As we walked down the slope from the hospice the less bright stars were vanishing before the dawn, and we thought that the situation had never before appeared half so romantic. Scarce a word passed in our numerous company for two hours, except a faint exclamation on meeting Währen. Each was occupied with his own thoughts of how the expedition might end—which of the objects proposed he should attain—and probably all felt that they were engaging in an enterprise of some danger as well as labour, voluntarily, and on their individual responsibility—a thought which affects for a moment the most volatile. We thus traversed in silence the well-known path leading to the Unteraar glacier, but soon left it to the right, when we took the opposite bank of the river, and proceeded by the faint track through loose masses of stones, which we had one day followed before, leading up the right bank of the Aar towards the Oberaar glacier. Long before the sun had risen upon our valley, Leuthold and Währen lingered behind the other guides (who preceded us) to point out to M. Agassiz a distant peak just touched with sunlight. It was the Jungfrau![1] Little was said, some perhaps doubted the assertion,[2] but all probably welcomed it as a good omen touching the projected end of our excursion. The Schreckhorn, Ewigschneehorn, and other mountains rising above the Unteraar glacier, had a grand appearance as we ascended the rugged and now pathless slope which leads to the upper glacier of the Aar. In

[1] The Jungfrau first has caught the rosy hue,
The Blümlis Alp and Glärnisch glitter now,
And starting into life and light, we view
Lake, wood, and river from the mountain's brow.
Promethean-like the vital spark seems given,
Even at the instant, to all under heaven.
Poetische Reise (by a Lady), p. 57.[1]

[2] [It is certainly most astonishing and unfounded. Desor states (p. 361, note) that he later ascertained that it was probably one of the Grindelwald Viescherhörner, but even this seems unlikely.]

[1] [The *Poetische Reise* (privately printed c. 1838) is a poem in English (title only in German) by Miss Drinkwater, describing a journey through Switzerland in August, 1837.]

two hours, that is at 7 A.M., we were already at the wretched shepherds' huts, which lie below the foot of the glacier, at a height already of 7000 French feet (according to Hugi) above the sea.[1] Instruments, I should have said, we had none, excepting only hammers and thermometers, a hair hygrometer, a chronometer, polariscope, and compass. Three barometers had been broken during the summer's campaign, and one put out of order; there was none remaining to accompany us.

The Oberaar Glacier lies in a wide, rather open valley; it has a regular, well-defined form, with *longitudinal* crevasses near its lower extremity, and generally a well-marked vertical striated structure, parallel to its length, as in the Unteraar, although this has no medial moraine. The end front of the glacier exhibits the usual false appearance of horizontal stratification, curved upwards at the sides, as in the Rhone Glacier.

The lateral moraine is well developed; the glacier is increasing, and the blocks it disengages push and furrow up the soil in wrinkles in a singular manner. We followed its left bank for about half-an-hour, then made a halt, when we observed a shepherd descending a tributary glacier on the other side at this early hour. We now got upon the ice, which presents this year a very even surface; the transverse section of the glacier below is convex—of the upper part, where it passes into *Firn*,[2] as usual, concave. We entered the Firn, or granular snow, the higher parts of which were horizontally stratified. Walking became less secure, crevasses were to be avoided. We followed Jacob Leuthold in a line. A chamois was seen on our right. These animals are now scarcest, I was informed, in the higher Alps of the Oberland, and most frequent near Interlaken, etc., where they are protected, for the chase is illegal. Jacob has killed seventy-two, chiefly in spring and autumn.

By and by the ascent became steeper, and the snow more yielding as we approached the col, precisely at the head of the glacier, between the Oberaarhorn and Kastenhorn. On the border of the Firn we stopped for the important operation of

[1] [Their height is 7405 feet.]

[2] *Firn*, German for névé, the part of a glacier from which the snow does not altogether melt. It in fact becomes incorporated with the ice during the summer months, whilst part of it thaws.[1]

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[1] [Firn or névé is rather the hard snow on the upper slopes, which in its descent becomes compressed into ice—it is, in short, the raw material of a glacier.]

putting on gaiters before entering on the snow. This our guides always did with great solemnity. The view looking back from this point was striking; the rounding and polishing of the rocks on the left side of the glacier, and to a great height, was very evident. The weather now looked no longer favourable; clouds crowned the Oberaarhorn, and even descended near the col; we pushed on, and soon reached some dangerous crevasses, which it required considerable precaution to pass. The great quantity of snow facilitated this, and at half-past ten we arrived safely at the col which divides the glacier of Oberaar from that of Viesch. The height of the col of Oberaar is, according to Hugi, by different measures, from 10,000 to 10,400 French feet, say 11,000 English.[1] It is a depression in the principal chain of the Bernese Alps at this point, being connected on the right with the mass belonging to the Finsteraarhorn, and on the left with the less important range which extends to the Sidelhorn and the col of the Grimsel. The rocks on the right-hand side were schistose, intermediate between gneiss and mica slate, containing a good deal of limestone in a friable form, perhaps like that which Saussure described as calc tuff on the St. Théodule. Some enormous crevasses prevented our descent by the right hand on the glacier of Viesch; by the left we clambered down, partly on loose rocks, partly by the snow, and soon reached the comparatively level surface of the Viescherfirn. Keller's map of these glaciers is bad; Wörl's and Hugi's detailed ones are perhaps worse; and the Munich map of 1830 worst of all. It is hardly possible to recognise the position of even the chief points.[2]

When we descended from the col of the Oberaar we had before us, and rather to the right, a col[3] which would have conducted us to the glacier of Aletsch, where it divides in three below the foot of the Jungfrau. The question was, whether we were to cross this col or go down the glacier of Viesch. As we walked across the even flat my left foot sunk in a crevasse, as my other one had done in the glacier of Gauli a short time before, an accident by which I was rather seriously lamed. It

[1] [The height of the Oberaarjoch is 10,607 feet. A few minutes to its south-west, on the Viesch side, is now a conveniently-placed club hut, belonging to the Bienne section of the Swiss Alpine Club.]

[2] [Nowadays, of course, there is the wonderfully exact Swiss Government map ("Siegfried Atlas"), on a scale of 1/50,000 for the mountain districts.]

[3] [The Grünhornlücke (10,844 feet).]

sufficed to show on what a treacherous surface we were walking, as we soon after learned more fully. Red snow was here very abundant; its colour comes out by trampling; our course was marked as by footsteps of blood. Soon after Jacob (who had now carried for a long way the heaviest package of all the six guides) suddenly stopped, deposed his burden, sat down, and said we should dine. The suddenness of the procedure and the arbitrariness of the command rather amused us. But we were in no humour to dispute it, and accommodated ourselves as well as we could. A table was made of one of the porters' frames stuck in the snow, and to work we went with cold meat, bread, and wine. After dinner the sky was anxiously consulted. No one, perhaps, except Jacob Leuthold, understood very well what were the alternatives to be pursued in good or bad weather. He decided that the col which separated us from the Aletsch glacier should not be crossed, but that the glacier of Viesch should be descended to the Möriller See, a lake of Aletsch,[1] where we should sleep in the chalets. Notwitstanding some grumbling from the other guides, and pointing to a clearing sky, this was put in practice.

I was glad that it was so determined. Viesch is a magnificent specimen of a glacier. The crevasses in the Firn became wider as the slope was greater, and we saw some yawning chasms with greenish-white walls (the colour of the Firn), forty, sixty, or eighty feet wide. But the grandest of all were some just under our feet. A casual opening in the snow but a few inches wide disclosed to us several times some of the most exquisite sights in nature. The crevasses of the Firn or névé are not like those of the glacier—mere wedge-like splits with icy walls—but roomy expanded chambers of irregular forms, partly snow and partly ice; partly roofed over with tufted bridges of snow; partly open to the air, with vast dislocated masses tossing about. Stalactites of ice, possibly forty or fifty feet long,[2] hanging from the walls and sides exactly like those in the finest calcareous grotto, but infinitely superior in so far as the light which shows them is not the smoky glare of a few tallow candles, but a mellow radiance streaming from the sides of the caverns themselves, and which, by the faintness or intensity of its delicate hue, assists the eye in seizing the relations of many parts.

[1] [Now well known as the Märjelen lake.]

[2] So in my notes.

I do not recollect to have imagined anything of the kind so exquisitely beautiful as one in particular of these chasms, over which by chance we found ourselves walking, when a gap not a foot wide in its snowy roof admitted us to the somewhat awful acquaintance of the concealed abysses over which we trod.[1]

The horizontal stratification of the Firn was here still distinct. Soon after it became confused in the general rupture of the mass by the declivity over which it was forced to incline. The ice now became too crevassed to be passed in the centre, and an extensive tributary glacier (according to some, the main feeder of the Viescher Gletscher)[2] falling in from the right, we were unable to follow the side, and were obliged to pass over the latter, which was fearfully crevassed, and appeared all but impracticable. Nevertheless the skill of our guides accomplished this with very few bad steps; and we resumed the right moraine of the united glacier. After a pause we proceeded, not without difficulty, being forced in one place to leave the glacier entirely, and to climb the rocks and re-descend a considerable precipice again to its level. The moraine continued very uneven, and, now upon it, now on the bank, and now on the solid ice, we had a rough walk until we came to some small chalets, not a great way above the lower termination of the glacier of Viesch. Less than an hour above these chalets, we observed very admirable polished surfaces in contact with ice, whose very recent character, and the height to which they were rubbed, left hardly a doubt as to their origin. Near this we observed an enormous transported block on the ice, probably 100 feet long, and 40 or 50 high. It had been detached from the rocks of the higher glacier, and in the course of a few years more will be deposited on the terminal moraine. The glacier has also medial moraines, which may be traced amongst all the fissures and aiguilles into which it is broken. From the chalets above mentioned (marked *auf Tiler* on Wörl's map, more correctly *auf dem Titer*[3]) we had a steep hill to ascend on the right (which, at the end of such a day's journey, was fatiguing) to reach the chalets of Märjelen. They are situated at a height, it is stated, of not less than 7600 English

[1] "Ringsum in dämmerenden Abgründen die Welt in grauser Gestaltenfülle sich vergletschert."—Hugi [*Naturhistorische Alpenreise*, p. 277.]

[2] [This is certainly the case. See above, p. 430.]

[3] [Really the Stock huts (6273 feet.) The Titer chalets are at the very extremity of the Viescher Glacier.]

feet,[1] near the Möriller or Aletscher See,[2] on the Glacier of Aletsch, which lies at so great a height here above that of Viesch, that this long and steep ascent brings us only to its level. The lake has been artificially drained in this direction to avoid the floods occasioned by an accumulation of water behind the ice of the Aletsch Glacier. This condition of things is interesting, because a small increase of ice would give a second outlet to the Glacier of Aletsch through that of Viesch, and the polished rocks between the Möriller See and the Viesch Glacier are similar to those on the col of the Grimsel.

We arrived, some of us at least heartily tired, at half-past five at the chalets, one of which afforded much more tolerable accommodation than could have been looked for. We found plenty of milk and butter, a good fire, with sufficient hay (rather damp indeed) to lie on, made more agreeable by great civility and a cordial welcome from the owners. The weather seemed more promising. If fine, to-morrow was to be devoted to the Jungfrau, and a man was despatched down to the village of Viesch for a ladder[3] to cross the crevasses. I lay down, but could not sleep. Past eleven, the man returned from a fruitless errand, and another messenger was sent off to obtain the indispensable article at all hazards. I got up and went out; the evening was splendid, with a bright moon. I afterwards fell asleep, and slept soundly till five, when the man returned with the ladder.

1 [Really 7756 feet.]

2 [The Märjelen See.]

3 [Desor (p. 377, 78) tells us that Leuthold, on occasion of his attempt to ascend the Jungfrau in 1832 with Hugi, had left a ladder near the great crevasse at the foot of the Roththalsattel. A Viesch man, however, later brought it down, and having repaired it claimed it as his own property. Hence a second message had to be sent down to this man, declaring that if the ladder was not restored at once the whole party would come down and take it by force. This threat proved successful, but the start for the ascent was much delayed.]

CHAPTER IV

THE ASCENT OF THE JUNGFRAU

History of attempts to ascend the Jungfrau—Departure from the chalets of Märjelen—Lake and Glacier of Aletsch—Prospect of the range of the Jungfrau—The Firn or névé—The Ascent commences—Passage of the great crevasse—Col of the Roththal reached—Final ascent of 1000 feet on a slope of ice—The summit described—The view, and stupendous cloud—Return to the chalets by moonlight—The lower portion of the Glacier of Aletsch described—Its termination in the Massa ravine—Arrival at Brieg.

THE ascent of the Jungfrau was claimed to have been first made in 1811 by the brothers Meyer of Aarau, who published an account of it.[1] Their flag was not, however, seen from the valleys, and probably the inhabitants of Grindelwald were not prepared to watch for it, the ascent being made from the southern side, in which direction the Jungfrau is not visible from any inhabited spot whatever. This, the only independent evidence of their success, being wanting, doubt was thrown upon the reality of the expedition, and another of the same family,

[1] [There is *no doubt whatever* that the Jungfrau had been successfully ascended thrice before Forbes's expedition. The first ascent was made on August 3, 1811, by Herren J. R. and Hieronymus Meyer (two brothers, of Aarau) with two Vallais hunters. They approached the peak from the Lötschenthal, crossing the Lötschenlücke, and then attaining the Roththalsattel from the *south* by traversing round or over the Roththalhorn. The second ascent was effected on Sept. 3, 1812, by Herr Gottlieb Meyer (son of J. R. Meyer) with the same two hunters, Alöis Volker and Joseph Bortis. They bivouacked on the Grüneck rocks (opposite the present Concordia Inn), having mounted the Aletsch Glacier from the Märjelen huts, and reached the Roththalsattel from the *east*—their route being precisely that of Forbes's party. The third ascent took place on Sept. 10, 1828, and was made by six Grindelwald men (headed by Peter Baumann). They crossed the two Mönchjochs from Grindelwald (as is done nowadays by Jungfrau parties starting from Grindelwald), and then joined the 1812 route at the foot of the ascent to the Roththalsattel.

Forbes's ascent was the fourth, but the first in which a native of Great Britain took part.]

the Meyers, repeated it next year, when he asserts having again gained the summit from the eastern side. The flag, I suppose, remained still unseen, for, unreasonable as it may appear, a general scepticism continued to prevail as to their having really attained the peak of the Jungfrau. At this distance of time it is impossible to unravel these doubts, which are not perhaps deserving of much weight,[1] unless in so far as they are confirmed by the unquestionable ambiguity of the narratives themselves,[2] which is indeed such as to be scarcely accountable, except on the supposition that they had been written some time after the events—although the details of such an expedition can hardly be erased from any memory by the lapse even of years. The description by the Meyers of the very peculiar form of the summit is, however, sufficiently precise to make it very probable that it was written from observation. At the same time, it appears to me (as to others) little short of impossible, that the Jungfrau can be gained on the side of the Mönch, as described in the second of these journeys.[3]

A long interval succeeded the journey of the Meyers; but in 1828 Baumann and some other peasants of Grindelwald unquestionably attained the summit, and by the same route as we afterwards took. The enterprising Swiss naturalist and traveller Hugi, soon after made some attempts, but from the side of Lauterbrunnen, which presents probably insuperable obstacles.[4] He was afterwards foiled by bad weather on the opposite side, when our present guide Jacob Leuthold accompanied him. This was in 1832, the date, I believe, of the last attempt of

[1] I observe, however, that it is mentioned by M. G. Studer, in the account (p. 131) of his subsequent ascent, that a respectable person assured him that he had seen the Meyers' flag from Unterseen. The Vallaisan guides, on the other hand, maintained that *they alone*, and not the Meyers, reached the top. As an instance of the disposition to suggest and propagate doubts on such matters, I may mention that two years after our successful ascent, being at the inn on the Faulhorn, near Grindelwald, the ascent of the Jungfrau in 1841 having been incidentally mentioned, I heard the fact stoutly denied; and yet our flag was seen, I believe, as far as Thun.

[2] [The narratives are clearer than the map which accompanies the latter. It should not be forgotten that these expeditions were the *first* exploration of a hitherto completely unknown world of ice and snow.]

[3] [Forbes makes a slip here, for the 1812 route was precisely that taken by his party in 1841.]

[4] [Hugi's attempts from the Roththal were made in 1828-29. On August 21, 1828, two English travellers, Mr. Yeats Brown and Mr. Frederick Slade, with a number of Lauterbrunnen guides, made an attempt from the same direction.]

the kind. I now resume my narrative, commenced in the last chapter.

August 28, 1841.—The expedition for the ladder prevented our leaving the huts of Märjelen (7180 French feet, Hugi)[1] till 6 A.M. when we set forward, the travellers first, the guides behind. Three quarters of an hour brought us to the end of the lake next the glacier. It is, I believe, the only one in the Alps in such a position, being enclosed, as I have endeavoured to explain, in an elbow of the valley in which the Glacier of Aletsch rests by the ice of the glacier itself. The usual efflux of the lake is towards Viesch by the artificial canal already mentioned, but occasionally its waters drain off almost entirely beneath the ice of the glacier in the opposite direction. There are floating masses on its surface, and a precipitous wall of ice next the glacier. The artificial outlet is at the farther end next the huts. Fortunately, walking is comparatively easy on the upper part of the Aletsch Glacier, for its extent is very great. We had not much trouble in traversing the crevasses, and each advanced in his own path without much communication. M. Agassiz had previously announced Leuthold's declaration, that, owing to the lateness of the hour of departure, all must be prepared to follow at a tolerably quick pace, or else give up the attempt.

At first we had the Mönch right in front, the great Eiger a little behind it, and to the right. Soon after reaching the glacier the Jungfrau itself appeared. Plate X.[2] is from a sketch drawn on a subsequent occasion, and gives an idea of the disposition of the mountains near the head of Aletsch.

I immediately perceived that the ascent must be up the steep snowy slope, immediately to the left of the summit, and that this would be the chief danger, if the ascent was otherwise practicable. The rocks just appeared to the left of this slope, but not so as to give much hope of a guard or safe footing; they are in fact the prominences of the tremendous precipices of the Roththal, into which a false step would hurry the climber. Looking back we had a superb view of the chain of Monte Rosa, though not of the Monte Rosa itself. The Matterhorn (Mont

[1] [Really 7756 feet.]

[2] [This plate is omitted in the present edition, as it is far below the standard now required.]

Cervin) rose in superior grandeur between the Weisshorn and Strahlhorn, which are generally seen from the Vallais.

After nearly two hours' walk on the glacier, the crevasses became concealed with snow, and dangerous, then the whole passes into the state of Firn and is nearly safe; whilst a great arm of the glacier (*c*) separates to the left, towards the glaciers of the Lötschthal. On the right (at *d*) we left the col leading across the range of the Viescherhörner to the top of the glacier of Viesch.[1]

After 4½ hours' *hard* walking we made a halt, where the snow thickened near the foot of the hill marked Trugberg in the sketch.[2] This name (the *deceptive hill*) was given to it by some of our party in consequence of the man whom we brought with the ladder from the chalet insisting that it was the Jungfrau—an assertion scorned by our leader, Leuthold, who knew very well what he was about, from the experience of his former reconnaissance with Hugi, when he approached the Jungfrau from a direction in which it could not be mistaken. All persons, however, who have ascended the Aletsch Glacier admit that the familiar forms seen from Interlaken are no longer recognisable. The place of our halt was at the entrance of the deep bay or recess at the head of the Aletsch Glacier, the Mönch before us, to the left the Jungfrau, rising from the snowy plain almost precipitously. Still farther to the left, the projecting ridge of the Kranzberg, on the right the ridge of the Trugberg. We were somewhat exhausted by the rapidity of our march from the chalets, and partook of bread and wine. Then the serious task of putting on gaiters, which Jacob performed with more than common solemnity and deliberation. After half an hour we started forward up the narrowing and steepening névé, always with splendid weather. The walking became more laborious from the depth of the snow, but we followed all in one another's steps. Crevasses in the higher Firn commenced, and the rope was produced. Jacob went first, having tied it round his waist. Johann Jaun held the rope fast, which was then passed round the left arm of every one behind in succession. Here the real

[1] [Forbes is here describing the view from the "Place de la Concorde": (*c*) leads west towards the Lötschenlücke, and (*d*) east towards the Grünhornlücke.]

[2] [It is the snow ridge rising between the Jungfrau glacier (or rather Firn) and Ewigschneefeld, and attains a height of 12,904 feet, or only 765 feet less than the Jungfrau itself.]

ascent began. Melchior Bannholzer, a young man we brought from the Grimsel, carried the ladder, which was 22 or 24 feet long, with great dexterity—going everywhere indifferently, making a path for himself, and advancing with his load whilst others rested. Several crevasses and some loose ground being passed, we were again on deep snow of considerable depth and softness. It became also very steep, and about this time we turned round the foot of the hill marked b[1] in Plate X., when we found ourselves in a narrow valley terminating in precipices at the proper base of the Jungfrau. The precipices on the right were of rock, those on the left of ice and hardened snow. We pushed nearly straight forward, and attained a considerable height by climbing up the steep soft snow. At a height which I estimated at not above 12,000 English feet I felt my breathing sensibly affected—but I was much fatigued this morning on starting; after a few steps at a time, I felt some exhaustion, which passed off after a moment's repose. Some others of the party felt the same thing about the same level.

Having passed some trifling crevasses, and rested twice, we were forced to come to a decision as to the exact course to be chosen for the ascent. The snowy precipice before us presented an enormous fissure near its base, the usual separation of the icy part of the snow on the higher mountains, and the névé or Firn beneath. It was doubtful whether, on account of the limited length of the ladder, we could both cross the crevasse and ascend the steep face beyond. The section was this.

The ladder was planted at b, and steps made in the very steep face above, which had a good consistence, allowing the feet to be well dug in, and sustaining them. Jaun went up and held one end of the cord as a sort of rail, another holding it

[1] [*I.e.* the Kranzberg.]

below, and so we proceeded one by one.[1] I suppose that the lower part of the ascent was at an angle of above 60°, though only for a short way. Above, the snow being soft, it was easy to keep our footing, and we ascended to a sort of hollow where we could rest a moment. The snow here lay at an angle of 50°.

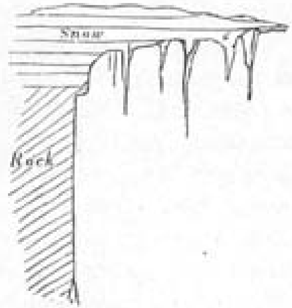
Jacob Leuthold and some of the party had now advanced to a second crevasse more to the right, which threatened to become a gulf of separation between the fixed and the detached ice, so that the mass we had mounted since quitting the ladder might be considered as but half supported. Jacob and three others had crossed this crevasse, and I stood a little below it, when a distinct noise was heard beneath the ice. Jacob felt a *sensible subsidence.* It gave us an unpleasant sensation. We got all safely, however, across the crevasse, and mounting obliquely a soft steep snowy surface, which had been first carefully sounded with a staff, we arrived at two o'clock upon the col at the head of the Roththal, a precipitous ravine on the northern face of the Jungfrau, communicating with the valley of Lauterbrunnen, and by which Hugi had vainly attempted to ascend. This col is marked *a* in the view, Plate X.; we ascended by the hollow immediately to the right of it. Clouds had now collected from the west, and attached themselves to the mountain, so that we could not see at all into the Roththal; but the eastern view and the top of the mountain remained clear. Our height might be 12,800 or 12,900 English feet.[2] There remained the final slope between *a* and the summit. Poor Währen with his bad knee was already quite exhausted, and attained this col with difficulty—but no higher.

We drank some wine and advanced to the arduous ascent, keeping to the right hand as near the precipice overhanging the

[1] In the narrative of the subsequent ascent of the Jungfrau by M. G. Studer [*Topographische Mittheilungen aus dem Alpengebirge* (Bern and St. Gallen, 1844), pp. 126-128], we find a striking account of a descent into this terrific crevasse of one of the guides, Bannholzer by name, above referred to. M. Studer in descending had allowed his cap to drop into the abyss—nothing would hinder young Bannholzer from trying to recover it. Tied by a rope, 95 feet in length, he descended amidst ice walls, and overhanging masses, and gigantic icicles everywhere menacing detachment, and when he could get no lower by aid of the rope, he detached himself, and perceiving the object of his search still below him, he quitted the rope and clambered alone out of sight and hearing of his fellows into the dim and awful gulf. He descended in all some 120 feet, then coolly returned with his prize! The crevasse, however, there seemed as unfathomable as ever.

[2] [The Roththalsattel is 12,655 feet.]

Aletsch Glacier as we could do without the risk of falling through the treacherous bank of snow, which often overhangs precipices, apparently sound and level above, but projecting like the eave of a roof without any support below, as in the figure. Whilst we were marching patiently at what seemed a safe distance from the edge, Jacob made us almost tremble by piercing, with a few blows of his alpenstock, the frail covering within two or three feet of us, revealing through the gap the vacuity through which we might have dropped a stone upon the glacier beneath. The snow helped us but a few paces. It was plain that the ascent was to be made over ice, and that our steps must be cut. Leuthold went first with a small axe, and with a rope round his waist, and was followed by Jaun, who improved the steps with the aid of his iron-shod staff, and held the rope attached to Jacob. Next to him the travellers, then three other guides—all of us with the rope twisted round our left arms. Since we ascended nearly straight up, as on a stair, this rope was a real security, which it could not have been to the same extent had we ascended obliquely, when the fall of one must, in all probability, have dragged the others after him. Here, if one made a false step, he would be supported by those behind, and at the same time, an alarm being given, the rope would have been tightened by all those in front. At different parts of the ascent I took the angle carefully, which in several places amounted to 43° and 45° on the real ice. The steps were more than a foot high, and we reckoned that in the course of our two hours' ascent about 700 steps were made. We estimated the height of this part of the mountain at 800 or 900 feet.[1] Before we had advanced far, one of our guides turned back, not liking the ascent. Next to Leuthold and Johann Jaun, Bannholzer, the young man who carried the ladder, was the most successful, spirited, and attentive, and by and by assisted Jacob in cutting the steps, having at his immediate risk jumped up the snowy ledge on the right, in order to change his place in the



[1] [It is really 1014 feet.]

row. The work proceeded but slowly, when we were enveloped in clouds, which had all the time filled the Roththal in such a way that we scarcely saw into it—but at intervals we saw the top. Our position seemed rather frightful, hanging thus on a slope of unbroken slippery ice, steep as a cathedral roof, or those of the high pitched Dutch houses; with precipices at the bottom of the slope, of an unknown and dizzy depth. We were surrounded with mist, so that we occasionally only saw our immediate position, suspended thus in the midst of the frozen mountain, from which it really appeared as if a gust of wind might have detached our whole party. Fortunately it was calm, otherwise we must have suffered greatly from the cold, long before we reached the top, owing to our slow progress, and our feet being perpetually forced into the steps. I felt my toes benumbed, and had some trouble to restore animation by shaking and striking them. This slow progress, on the other hand, took away any suffering from difficult breathing. After we had gone on in the same way for nearly two hours, straight up the right-hand edge of the slope, we made to the left, gained a few rocks which lay loosely there, on a less slope than the rest, and saw the top immediately before us, covered with soft snow.

The top remained separated from us by a ridge of snow about 30 feet long, resembling an excessively steep house roof, an expansion of which, at the farther end, formed the snowy pinnacle on which we successively arrived, but could only remain one at a time.[1] The annexed figures[2] (sketched soon after the ascent from recollection) will give an idea of the very peculiar form of this singular mountain top. The whole is an exceedingly narrow ridge directed nearly north and south, flanked on each side by terrific precipices. The summit B, which is snow covered, is the one first reached. The part A is but a few feet higher, in form almost like a bee-hive, of snow piled up, and so

[1] The party on the top consisted of MM. Agassiz, Desor, Duchâtelier, myself, and four guides.[1]

[2] [They will show the practical difficulties of erecting a permanent platform on the summit, to which access is to be gained by a "lift" from the terminus of the projected Jungfrau railway. The highest point of the Jungfrau is 13,669 feet in height.]

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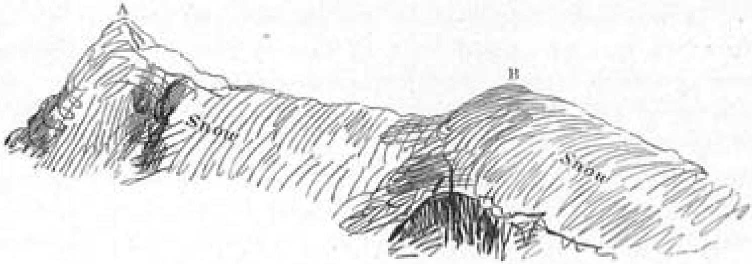
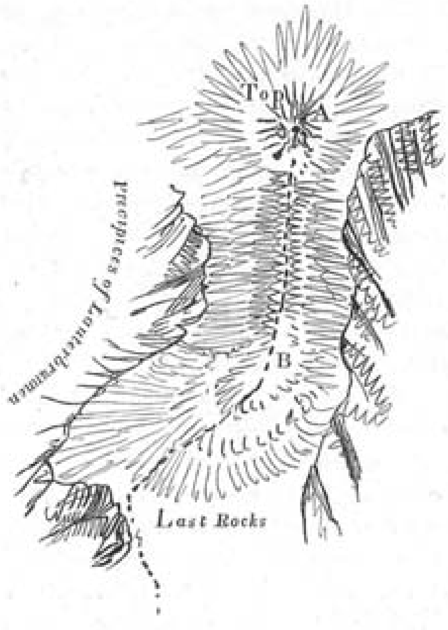
[1] [The guides were Leuthold, Bannholzer, Abplanalp, and Jaun of Meiringen. Währen and M. de Pury were left on the Roththalsattel, and the other Jaun turned back between that point and the summit, while it does not appear what height Mr. Heath and the Vallais man, who carried the ladder, attained.]

small that even when smoothed over and trodden down, scarcely



SKETCH OF THE TOP OF THE JUNGFRAU

afforded footing for more than one person at a time. The access to it is along the ridge above mentioned, apparently of heaped snow lying at the natural angle of repose, terminating in precipices on each side. The snow was fresh but binding, and the guides made a series of footsteps with the toes inwards, on one slope of the ridge, by means of which we advanced sideways, securing ourselves by the alpenstock planted on the opposite slope, until we reached the apex. In this proceeding, however, though awkward, there was no real danger, the footing being good.



PLAN OF TOP.

> Here on snows, where never human foot
> Of common mortal trod, we . . . tread ;
>
> . . . .
>
> And this most steep fantastic pinnacle,

> The fretwork of some earthquake—where the clouds
> Pause to repose themselves in passing by.[1]

It was four o'clock when we reached the summit of the Jungfrau, and we stayed half an hour. The view to the east was generally clear—the Finsteraarhorn and Schreckhorn, the Glacier of Aletsch, the Mönch and Eiger—and we got a glimpse of the bottom of the valley of Grindelwald. The view to the west was in one respect scarcely less remarkable, for there a magnificent cumulus-headed cloud stood in wonderful majesty, reaching apparently from the valley to at least 2000 feet above us. It was a glorious sight, a single cloud at least 10,000 feet high!

> The mists boil up amongst the glaciers; clouds
> Rise curling fast beneath me, white and sulphury,
> Like foam from the roused ocean of deep hell.

The thermometer at the top was 25°·5. When the mist approached, the icy spiculæ in it were distinctly visible. The sky to the east was clear and fine, but not of so intense a blue as we had observed it lower down, before the fog came on. On the top the polarisation by Savart's polariscope seemed quite normal and distinct, the tints brighter than I have often seen them from the Unteraar glacier. Its intensity diminishes as the sky is of a darker hue. I took specimens of the rock, which is a sort of gneiss by no means crystalline, and we began to think of descending. I felt no discomfort or uneasiness of any kind on the top, nor did any one else. We drank some wine which we had brought with us.

The descent promised to be much more alarming than the ascent, but by the excellent management of the guides, it was little worse. We were carefully connected by the rope; the guides were distributed amongst us, and Bannholzer was very useful in assisting me in placing my feet in the steps made during the ascent. We walked with our faces to the wall of ice, as in descending a ladder. During our descent I experienced a singular and painful deception. Looking accidentally into the abyss between my feet, I saw the basket and clothes we had left on the little snow plain above the ladder at the crevasse. Some of the party, who had not joined in the last ascent, had been there shortly before. I perceived something black begin to

[1] *Manfred*, Act ii. Scene 3.

move near the spot, and descend with an accelerated pace, not unlike a man hurried along a snow incline with tremendous velocity. It was an eagle which had been examining the contents of our basket!

In one hour we reached the bottom of the slope of ice at the col of the Roththal. From thence we descended the steep snow, much in the same manner, as far as the crevasse across which the ladder stood, which, when we had passed with light and thankful hearts, we ran down the snow with little further anxiety, for the track we had before taken guided us in safety across the crevasses. The snow had been softened since morning, so that in many places we sunk to the knee, which made the descent rather laborious. At length we reached the foot of the steep snow at 6 h. 45 m. P.M., or two and a quarter hours from the top. During the latter part of this descent our footsteps left distinct flesh-coloured marks by exposing the red snow beneath that freshly fallen.

We walked gaily along the snow in the twilight for an hour or so, till the crevasses commenced, when the moon shone out, and all clouds cleared away. We connected ourselves by a cord, to avoid all danger, and proceeded by her light at a rapid pace down the glacier, with the occasional interruption of the immersion of one or both legs of a companion, through the treacherous fresh snow which covered the crevasses or pools of ice-cold water.

We heard calls or cries of a man to the left, and thought him in difficulty, and charitably (at Jacob's suggestion) crossed half the glacier to join him. It was a messenger from the chalets, who brought warm milk and other provisions. We then pursued our way unbound down the glacier with great elasticity, by a splendid moonlight brilliancy, reflected by the crystallised surface of the ice, and still more beautiful was its effect on the ice-cliffs and islands of the Lake of Aletsch when we arrived there. We took a short rest, and then had a disagreeable stumbling walk across the blocks between the glacier and the chalets of Märjelen, where we arrived at half-past eleven, by no means over-fatigued, having been seventeen and a half hours on foot. None of our party complained of thirst, though we took no water for twelve hours at least, and part of the time the reflected heat was intense. We ate snow, however, pretty freely.

The difficulties and dangers of the ascent of the Jungfrau may be fairly judged of by the preceding, certainly not exaggerated, account. It must be remembered, however, that the forms of ice are at all times liable to alteration, and that the description of one season by no means invariably applies to another. Travellers have thus been very unwarrantably blamed for either over-, or under-stating the obstacles which they may have met with in particular positions. The only ascent which, so far as I know, has since taken place, was effected by Messrs. Gottlieb Studer and Bürki in 1842,[1] and even then, only one year after us, they found the second glacier crevasse, on the ascent to the col of the Roththal, far more formidable than we had done. Another reflection suggests itself—that it was an uncalled-for exertion to cross the glaciers of Oberaar and Viesch one day, and to ascend the Jungfrau the next. The great uncertainty of the weather could alone have excused such a proceeding, especially taken in conjunction with the formidable disadvantage of making a start from the chalets so late as 6 A.M., and performing a forced march in consequence throughout the day. We ought unquestionably to have spent the day at Märjelen, and have started the following morning before dawn. M. Studer, indeed, passed the night on a rock half-way up the glacier, from which his party (after a miserable night) started at 4 A.M.; having thus, on the whole, an advantage of four and a half hours over us, yet they returned to the chalets at night very little earlier than we had done, and remained but little longer on the top.

The day following our ascent some of the party, including myself, proceeded from Märjelen to Brieg in the Vallais by the steep and tedious, though not difficult path, by the extensive Möril Alp,[2] where are fed in summer large numbers of the cattle which form the wealth of the Vallaisan. But I shall take the opportunity of describing the more interesting and less easy

[1] [See Herr Studer's *Topographische Mittheilungen* (cited above), pp. 99-144. The date of the ascent was August 14. Two of Forbes's guides—Bannholzer and Abplanalp—were of the party, which included two others, J. von Weissenfluh and Kaspar Abplanalp. The next *successful* ascent did not take place till July 26, 1856. It was made by Mr. Robert Chapman with Christian Almer and Peter Bohren. On August 8 of that year the future Bishop Lightfoot and Professor Hort achieved the ascent, which was made four times within a fortnight.]

[2] [Apparently the Bettmeralp and the Riederalp of to-day. See the map at the end of Hugi's book.]

route which I traversed three years later (1844), when I revisited Aletsch for the purpose of examining the glacier more thoroughly. Having spent two nights at Märjelen, I returned to the Aletsch See, then nearly empty, its waters having passed out a fortnight before under the ice of the glacier, and occasioned an overflow of the torrent at its extremity, and proceeded to descend the glacier, sometimes on the ice, sometimes on the left bank. The structure of the ice, so far as I could observe it during various different excursions, possesses less of the well-marked *ribboned* character which is usual in glaciers of the first order, than I have anywhere else observed. Its appearance is more completely crystalline than perhaps that of any of the ice in Switzerland, presenting great plates at various angles, which reflect light in the beautiful manner above mentioned, as we saw it by moonshine.[1]

The blue bands, such as they are, generally tend from the side obliquely towards the centre; but they are much contorted and confused. This may be explained on the principles which in my former work on the Alps I have applied to other glaciers, by observing the immense breadth of the glacier, and the remarkable uniformity of that breadth, the absence of great rocky promontories, and also of important tributary glaciers, all of which circumstances tend to produce (just as in the corresponding case of a river) a comparative uniformity of the motion from centre to side of the glacier, at least until within a short distance of either shore, and consequently an absence of that differential motion producing internal friction, by which the production of these blue bands has been explained. To this may be added the small inclination of the glacier of Aletsch, which in the part I principally examined does not exceed 4°, thus diminishing the effect of gravity on the plastic mass, and giving less decision to its movements. It is thus that great rivers, moving on extremely small declivities, have no absolutely regular gradation of velocity from side to centre; but the current is diverted into numerous eddies, which are not *worked out*, as in a narrow stream, by the regular drag towards the faster moving mass of water in the middle.

[1] The analogous structure of the Norwegian glacier of Nygaard has been described in a previous part of this volume.[1]

[1] [These chapters were originally published in Forbes's book entitled *Norway and its Glaciers visited in* 1851 (1853).]

I finally quitted the ice nearly two hours' walk below the Lake of Aletsch, and crossing over a projection of the hill, close to the chalets of Möril,[1] descended by a very insignificant path into the deep valley, in the bottom of which the lower extremity of the glacier buries itself, having wound round the projection just mentioned. My wish was to follow the glacier as closely as possible to the termination of its vast career, but from the point where I quitted it, the declivity increases so rapidly that the ice is impassable, and the banks become sheer precipices. The descent by which my guide (a peasant I had brought from Möril) led me was nearly pathless, but extremely romantic, the green slopes being often intermixed with cliffs, and the whole partially clothed with pines. We sometimes lost our way amongst the broken ground, but at length I was gratified by a very fine view over the excessively narrow ravine into which the glacier is finally squeezed. It contracts suddenly, and the surface is dirty, crevassed, and steep. The greater part of this singular valley is inaccessible by the side of the stream, and can only be reached by long circuits over the adjoining mountains, some of which are of considerable height, for example the Bel Alp, a summer pasturage on the west side of Aletsch. I was unable to gain a sight of the *very lowest* point of the glacier, which seems impenetrably concealed in a ravine, probably unapproachable by man. The rapidity of its fall, and its rapid attenuation to perhaps one-sixth or one-eighth of its breadth above, are very striking. It does not extend far below the point of confluence with the valley of the Ober Aletsch or Jägi glacier, the ice of which does not extend so far as the main glacier. The Ober Aletsch glacier appears accessible, and the pass from it into the valley of Lötsch is said not to be difficult. I was even assured by my guide that a man of Möril had walked by the Bel Alp, Jägi glacier, and Lötsch to Lauterbrunnen in one day![2]

[1] [Probably the Riederalp chalets, which belong to the village of Möril in the Rhone valley. Forbes then describes the well-known gorge of Massa, through which the Massa flows from the Aletsch Glacier to join the Rhone a little above Brieg.]

[2] [A long day indeed! But some travellers in recent years have gone in one day from the Hôtel Bel Alp to the Steinberg inn above Lauterbrunnen, or to Mürren. The first pass is the *Beichgrat* (10,289 feet), an easy glacier pass (crossed by the 1811 Jungfrau party), which leads from the Ober Aletsch Glacier to the Lötschenthal, whence the equally easy glacier pass of the *Petersgrat* (10,516 feet), (crossed by Hugi in 1829 and long before by natives), leads to the Lauterbrunnen valley.]

The final descent into the bottom of the valley of Naters, traversed by the tremendous torrent of Massa, to which the drainage of Aletsch gives rise, is magnificent though laborious. The splendid range of the Mischabelhörner, between Saas and Zermatt, the Matterhorn and Weisshorn, all mountains of the first class, and which in scarcely any other point of view, can be distinctly seen at once and together, filled the background of the picture. Its nearer features were not less characteristically alpine, being a deep and richly wooded valley, in which the pines are interspersed with singular dome-shaped rocks, rising from the bottom near a spot called Auf der Platte [Platten]. In the more immediate foreground was a solitary green meadow, quite uninhabited, but containing two or three barns, reached by a lofty and picturesque wooden bridge across the Massa, which foams and roars beneath in a terrific manner. A little lower, the torrent is crossed by a water conduit, which conveys a stream from the Bel Alp all the way to the meadows of Ried, near the chalets of Möril (which are destitute of water), the distance being several leagues. The conduit is said to be carried along the face of the precipices through the gorge of the Massa, with great boldness, at a dizzy elevation, and the peasants are accustomed to pass from one place to the other by means of the precarious footing which it affords. The way to Brieg from the meadow just mentioned offers no difficulty, but many picturesque sites, and everywhere may be seen the astonishing forms of the roches moutonnées, which have evidently been abraded under the anciently extended ice of Aletsch.

THE GLACIER DU TOUR FROM THE AIGUILLE DE LA GLIÈRE[1]—CHAMOUNI

CHAPTER V

NARRATIVE OF THE PASSAGE OF THE FENÊTRE DE SALEINAZ FROM THE VALLEY OF CHAMOUNI TO THAT OF FERRET IN 1850

Peculiarities of the chain of Mont Blanc—Glacier of Le Tour little visited—Leave the Col de Balme—Ascend the glacier—Its features—Attain the Ridge—Its unexpected elevation—Exceeds the Col du Géant—Proposed as an experimental station—Descent on the glacier of Saleinaz—Fine Protogine—Topography—Difficult route—Sudden fog—Extrication—Reach Orsières in the Val Ferret.

IN a former work[2] I have described the greater part of the chain or mountain group of Mont Blanc, particularly with reference to its glaciers.

It is remarkable not less on account of its isolation, both geologically and topographically, from the rest of the Alps, than for its great elevation and inaccessibility. It is in fact merely linked on to the Alps of the Tarentaise on the one hand, and those of Mont Vélan on the other, by the secondary passes of the Cols

[1] [The Aiguille de la Glière is a point in the range north of Chamonix. *a* is the Pointe des Ecandies; *b*, the double-peaked Aiguille du Tour; *c*, the Tête Blanche; *d*, the Petite Fourche; *e*, the Grande Fourche; between *e* and *f* is the Fenêtre du Tour (the direct and easy way, probably that aimed at by Forbes) between the Tour and Saleinaz Glaciers; *f*, the Aiguille Forbes (11,418 feet), so named in 1895 in honour of Forbes; *g* the ridge of the Aig. du Chardonnet.]

[2] [*Travels through the Alps of Savoy* (1843, 2nd edit. 1845), see above, pp. 1-388.]

de la Seigne and Ferret, which form, neither geologically nor otherwise, a prolongation of the group. The axis of the range of Mont Blanc runs nearly S.W. and N.E.; it may be said to terminate with the Col du Bonhomme on the one hand, and the mountains about Trient on the other.[1] In this extent of twenty-five or thirty English miles, only a single pass has ever been described, that of the Col du Géant, which is above 11,000 feet high.[2] Besides this, are, of course, the terminal passes of the Col du Bonhomme and the Forclaz, and the Col de Balme, and the connecting attachments of the Col de la Seigne and Col Ferret, already mentioned. All of these have been described in my former work.

Having learnt some years previously to 1846 the existence of a pass quite undescribed, and known to only one or two natives of the valley of Chamouni, communicating by the Glacier of Le Tour with the Swiss Val Ferret, I attempted it in that year, but was foiled by bad weather. During a very hasty journey in 1850, I was more fortunate; and as the information I then obtained throws some new light upon the topography of this part of the chain of Mont Blanc, and as the excursion itself offers some interest, I now publish an account of it from notes made at the time.

The Glacier of Le Tour is the only one of those descending into the valley of Chamouni which I had not previously carefully examined. It descends in a wide, though not very imposing mass, immediately above the village of the same name, and occupies, for a long way, the right of the spectator who ascends from Chamouni towards the Col de Balme. It is lodged in a spacious valley, parallel to that of the Glacier of Argentière, and to the eastward of it; it is commanded by the summit called the Aiguille du Tour to the east, and by the stately Aiguille du Chardonnet to the south. Its general position amongst the mountains may be best judged of from the vignette at the head of this chapter, which was drawn from a point pretty nearly due west of the glacier, being the summit of one of the aiguilles belonging to the range of the Brévent, and behind the Col de la Flégère, the height of the spectator being more than 9500 feet

[1] See the map of the Pennine Alps [in the pocket] and the glacier map in Johnston's Physical Atlas. The position of the glacier of Saleinaz is there, however, incorrect.

[2] [It is 11,060 feet.]

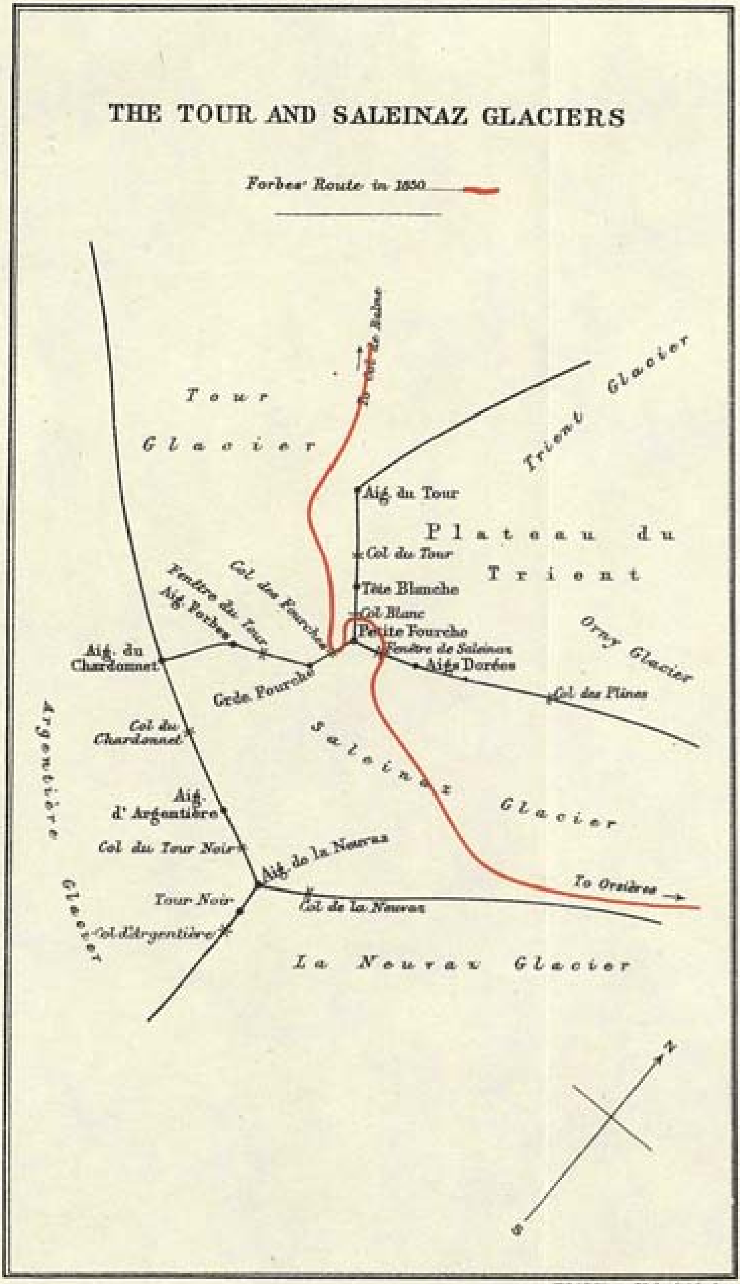
above the sea.[1] The extreme left of the figure shows the slopes between the Glacier of Le Tour and the Col de Balme; and the rugged mountains immediately above form that part of the ridge which separates Savoy from Switzerland, and the basin of the Arve from that of the Trient, as well as the glacier of that name from the Glacier du Tour. As this last presents few noticeable features beyond its extent, having neither icy pinnacles, narrow gorges, nor a cavern comparable to the source of the Arveyron, it is little noticed by passing tourists, and is probably quite unvisited by them.

Having determined, however, to trace the glacier to its source, and, if circumstances allowed, to descend into Switzerland by the Glacier of Saleinaz, with which I understood that it communicated, I slept at the Col de Balme on the 19th of July, 1850, in company, as usual, with my tried guide, Auguste Balmat. The weather proved so stormy that I expected nothing but a repetition of the disappointment of my former attempt. But as it appeared to improve the following morning we started, taking Michel Charlet, the tenant of the chalet on the Col de Balme, as a guide (the route being as new to Balmat as myself), though it was already half-past eight o'clock, with the intention of at least exploring the Glacier of Le Tour.

By sleeping at the Col de Balme, we have the immense advantage of starting from a level of nearly 7300 English feet above the sea.[2] Walking first nearly on a level through the pastures towards the glacier, we soon began to ascend grassy steeps, in order to avoid the precipices which face the northern side of the Glacier of Le Tour. Having reached a certain height we were compelled to descend a little, before gaining (at ten o'clock) the snow slopes, which still occupied the space between the moraine and hill side. These were next to be ascended, which, in consequence of the extreme softness of the snow, was fatiguing. At length we got fairly upon the glacier, which (after attaining a certain elevation) continues to rise with much steadiness and uniformity, but which was everywhere covered with tolerably soft snow. From the considerable elevation at which we first joined the glacier, we soon reached the level of the névé, and, keeping too near the centre, became involved for

[1] 3140 above the Col de la Flégère, by a good barometrical observation, 17th July, 1850.

[2] [The Col de Balme is 7221 feet.]


THE TOUR AND SALEINAZ GLACIERS
Forbes' Route in 1850
Tour Glacier
To Col de Balme
Trient Glacier
Aig. du Tour
Plateau du Trient
Col du Tour
Tête Blanche
Col Blanc
Petite Fourche
Fenêtre de Saleinaz
Aigs. Dorées
Orny Glacier
Col des Plines
Col des Fourches
Fenêtre du Tour
Aig. Forbes
Aig. du Chardonnet
Grde. Fourche
Saleinaz Glacier
Argentière Glacier
Col du Chardonnet
Aig. d' Argentière
Col du Tour Noir
Aig. de la Neuvaz
Tour Noir
Col d'Argentière
Col de la Neuvaz
To Orsières
La Neuvaz Glacier
N
S

a time amongst its enormous chasms. From these we withdrew to the left without serious difficulty, and continued to traverse the snowy basin, which here attains its widest expansion, until we passed close to the small bare rock (called by the mountaineers *rognon*) marked c' in the sketch, page 456, at 12 h. 50 m. The chief part of the ascent was now accomplished, and we stood face to face with the Aiguille du Chardonnet, which had a splendid appearance, being curtained with steep glaciers on its eastern side. We continued to advance steadily, but with labour, over the snow-fields, which still separated us from the rocky ridge of the Alps. Fresh snow lay to a considerable depth, and the hot sun rendered the effort of wading through it more fatiguing. But this was soon forgotten in the pleasure of watching the summits, which gradually displayed themselves. Referring to the same sketch as before, b is the Aiguille du Tour; c is a snowy summit, overlooking the upper basin of the Glacier du Trient, and is steep on the east side; d and e are pyramids of rock, forming the ridge of the Alps. That to the right (e) is a very beautiful aiguille, and is conspicuous from a distance. It is without a name. [See note on p. 456.]

The ascent continued, though more gently, from the *rognon* to the col[1] between d and e, where we arrived at half-past one, five hours from the Col de Balme. The weather had still an unsettled appearance. Mists concealed many of the summits behind us, and also the more distant chain of the Great St. Bernard before us. The nearer peaks and glaciers were quite clear. The snow had drifted with violence into this ravine, and we took shelter from the force of the wind on a platform of rock a few feet below the level of the drifted snow. The scene towards the Val Ferret was extremely grand. Immediately beneath us, a *very* precipitous slope of frozen snow covered the rocks on which we stood, overhanging the glacier of Saleinaz, which lay some hundred feet below. This glacier fills a fine circus of wild rocks, of which the part A B e d E[2] (see the

[1] [This col is now known as the *Col des Fourches* (11,267 feet), as it is the depression between the Grande and the Petite Fourche. It would lead to the bit of the Saleinaz Glacier actually traversed by Forbes on his descent from the Fenêtre de Saleinaz, but the descent from the Col des Fourches has never yet been effected.]

[2] The position where we stood was between the summits d and e, which are denoted by the same letters both on the plan (page 460) and on the sketch (page 456).

Plan below) corresponds to the main chain, separating the

PLAN OF THE GLACIER OF SALEINAZ.[1]

glaciers of Argentière, Tour, and Trient from those of the Val

[1] [This plan is erroneous in the angle A B F. A is meant for the Aiguille d'Argentière, which is really on the ridge between B and F. B is the Aiguille du Chardonnet. D is the Col Blanc. E the Aiguilles Dorées. F the Col de la Grande Luis (leading to the La Neuvaz Glacier). G is the Evole Glacier. H the site of the present Saleinaz club hut of the Neuchâtel section of the Swiss Alpine Club. I P O N the *old* track followed before this club hut was built. K L M N indicate the Plines range, *d* is the Petite Fourche, and *e* the Grande Fourche, while "snow cliffs" represent the ridge of the Tête Blanche and the Col Blanc, and "Port" the Fenêtre de Saleinaz. Forbes did not cross the true Col du Tour. He *reached* the *Col des Fourches* (between the two peaks of the name), then circled round the Petite Fourche to the *Col Blanc* (between that summit and the Tête Blanche, the true Col du Tour lying on the other side of the latter), crossed this

Ferret. The chain F of wild glacier-clad rocks separates this glacier from others, also descending into Val Ferret, whilst the chain M stretches towards the glacier and chapel of Orny. The Glacier of Saleinaz is forced through the narrow gorge bounded by the precipitous rocks H and L. A glance sufficed to show the great difficulties to be experienced in descending the Swiss side.

Having reconnoitred our position, I proceeded to observe the barometer (a syphon, by Bunten) which stood at—

1 h. 30 m.—505·2 millim.—Attached Ther. + 4° 0 Cent.—Detached, 30° Fah.

After a pause, I read again—

504·3 millim. 0·5 Cent. ... 29° Fah.

I immediately perceived that we were at a height equal, if not superior, to that of the Col du Géant. Subsequent calculation indicated 4044 feet above the chalet of the Col de Balme, which, from five comparisons made with the observatory of Geneva, is 7291 English feet, or 2220 mètres above the sea, a result agreeing closely with the recent measurement by M. Favre, which is 2222 mètres. Adding this result to the former, we obtain 11,335 English feet for the height of the granitic axis at the lowest point between the Glaciers of La Tour and Saleinaz on the side of the Swiss Val Ferret.[1] By a single direct barometrical comparison with Geneva,[2] I obtained 11,284 English feet above the sea, or 140 feet higher than the Col du Géant, and nearly 1200 feet higher than the Buet, which lies towards the north-west, exactly in the prolongation of the axis of the Glacier of Le Tour.

This unexpected result suggests some interesting considerations. There are few spots of the same elevation so easily accessible, and it is unquestionable that some of the numerous peaks which rise from this lofty platform could be ascended

to the Plateau du Trient, and thence gained the Saleinaz Glacier by the *Fenêtre de Saleinaz*.]

1 [The Col de Balme is 7221 feet and the Col de Géant 11,060 feet. As the Col des Fourches is 11,267 feet, it is 4046 feet higher than the former and 207 feet higher than the latter. The Buet is 10,201 feet, so that the Col des Fourches is 1066 feet higher.]

2 The barometers were carefully compared by Professor Plantamour, at Geneva, a few days later.

without risk, to a height of some hundred feet more. The rocks hemming in the Glacier du Tour present shelter against the severity of the terrific gales which blow at these altitudes. An observer might be stationed here for meteorological observations, with a degree of security and ease which Saussure never enjoyed in his perilous encampment on the Col du Géant. Provisions could be regularly obtained from the elevated station of the Col de Balme, which is within a walk of which a mountaineer thinks little, and devoid of danger. Even the extent of surface which the mountains here present at so great a height, is itself very favourable to several kinds of observation.

I have called the fact of the great elevation of this part of the chain of Mont Blanc unexpected, both because it was entirely so to myself, and because the existing maps and models gave an entirely different idea. Even the admirable model of M. Séné,[1] which I inspected soon afterwards at Geneva, shows a rapid depression in this part of the ridge, which indeed might have been imagined from the rapidity with which it dies out altogether in the space of a few miles in the direction of Martigny.

The temperature of the air, as we have seen, was three degrees (Fahrenheit) below freezing. As we turned round and, facing the north wind, clambered from under the sheltering snow drift, we first perceived its biting coldness, and at the same moment the strong draught of air setting through the gorge nearly detached all our hats in a moment, and actually carried Balmat's over the precipice down to the Glacier of Saleinaz. We were then struck, whilst looking in each other's faces, at the pinched and ghastly appearance which all presented. Both the guides looked nearly bloodless; but none of us felt unwell. We took some brandy as a precaution (probably a needless one) against the cold, and tied our handkerchiefs over our ears. Charlet now told us that when here twelve years before he had succeeded in descending on the glacier of Saleinaz by turning round the north side of the peak *d* (which is partly of rock, partly of snow, and appears to be accessible),[2] in the direction of the Glacier of Trient. In following this course, we passed between the summits *c* and *d*, and gained a

[1] [See pages 536, 537 in Part IV. of this volume.]
[2] [It was not, however, climbed till 1876.]

point somewhat higher than the barometrical station.[1] From D we had a view of a new glacier, or névé, which Charlet told us (and it is no doubt so) communicates with the Glacier of Trient. It was by descending upon this first that he had gained the level of the Glacier of Saleinaz afterwards.

The question now was, should we retrace our steps to Chamouni, or push on to Orsières? Charlet feared that our non-appearance at Col de Balme or Le Tour might create uneasiness; but after some discussion it was agreed that the opportunity of proceeding was too tempting to be lost, especially as the weather appeared fine towards Val Ferret. After scarcely a minute's delay, then, we resolved to seek a safe place of descent to the level of the névé connected with the Glacier of Trient, which we had to effect over an almost precipitous surface of hardened snow (which in some places presented an *overhanging* edge of alarming appearance), but which admitted of a passage at one point with little difficulty or danger. This snow cliff scarcely existed when Charlet formerly passed—an instance of the great changes undergone by the glacier regions. Being now on the level of the névé, we turned towards the right hand, and found a wall of rock cut through by a magnificent gateway,[2] flanked by two pinnacles of highly crystalline protogine not many yards asunder, between which we passed with the greatest ease, and, descending a snow slope of no great height, we found ourselves on the névé of the Glacier of Saleinaz. The abruptness of the change and the beauty of the portal (like the *ports* of the Pyrenees, but still narrower) rendered this a very striking and peculiar pass. The basin in which we now found ourselves is remarkably enclosed by precipitous rocks, everywhere interspersed with glaciers and prepetual snow. Our station between the peaks *d* and *e* now appeared at a great height above a most precipitous snow slope, towards which Auguste long and wistfully looked for his lost hat. Behind the peak *e*, to the westward, it appeared as if a passage might lead from the Glacier of Le Tour to that of Saleinaz,[3] but Charlet

[1] [This is the Col Blanc (11,162 feet), which connects the Tour Glacier with the Plateau du Trient, whence flow the Trient and Orny Glaciers. It is really 105 feet *lower* than the Col des Fourches.]

[2] [This is the Fenêtre de Saleinaz, 10,709 feet.]

[3] [This is the Fenêtre du Tour (11,008 feet), an easy glacier pass.]

assured us that he had formerly explored the Glacier of Le Tour and found no exit in that direction. It appeared to us not impossible that a pass might exist from the head of the Glacier d'Argentière directly to the Glacier of Saleinaz, between *e* and the very white summit marked Aiguille Blanche;[1] but my recollection of the Glacier d'Argentière is not favourable to this idea. Charlet strongly insisted that the Glacier d'Argentière does not terminate behind the Aiguille Blanche, as I thought, but, bending, stretches to the S.W. behind the summit A, which I rather conjectured to be the summit seen to the S.E. of the Jardin, and marked in my map of the Mer de Glace.[2]

The névé of the Glacier of Saleinaz, seen from the point, or rather the snowy basin at which we are now arrived, might well appear to have no issue. The formidable barriers of rock, between which the glacier descends almost precipitously, might seem to bar a passage in the direction of the valley. From Munier's account (the guide of Chamouni, whom I engaged in 1846 for this excursion), it appears certain that he did not attempt to descend (his words to me, I recollect, were, "Nous n'avons pas osé descendre"), but he had preferred crossing the lofty range somewhere about F, by which means he arrived at the Glacier of La Neuvaz,[3] by which he descended near the Col Ferret. Trusting, however, to Charlet's report of what he had actually done (for the advancing afternoon left us no time for abortive attempts), we resolved to descend as much as possible by the Glacier de Saleinaz. We accordingly secured ourselves once more together by ropes, and soon came amongst newly opening crevasses as we approached the gorge which offered the great obstacle to our passage. We resolved to retreat to the left bank of the glacier, and to dine on the rock at K, near abundant streams of snow-water descending from a glacier[4] connected with the heights above us on the left, amidst a perfect chaos of stupendous blocks of the finest granite, or rather protogine, anywhere to be seen in the Alps. This was at 3 h.

[1] [This is the Col du Chardonnet (10,909 feet), the "Aiguille Blanche" being really the Aiguille du Chardonnet.]

[2] [Charlet was quite right. Forbes wrongly identifies "A" of the above sketch—really the Tour Noir—with "A" on his map of the Mer de Glace, which is the Aiguille de Triolet.]

[3] [This is the Col de la Grande Luis (11,086 feet).]

[4] [The Glacier des Plines.]

10 m.; at 3 h. 45 m. we were ready to start, and again used the ropes for a short space, but, soon clearing the snow, we abandoned them, and following for a little way the left bank of the glacier, as it got steeper and steeper, and began to break into wider crevasses, Auguste volunteered to go on and see whether it might be possible to effect the descent over the broken ice. As we more than anticipated, however, he returned to say that it was quite impracticable, and that, therefore, we must submit to clamber over rocks to a great height above the right bank, and to pass beneath the small glaciers G G,[1] which was not unattended with danger, in event of stones rolling from them. We first crossed the main glacier without much difficulty, and could now inspect those small glaciers of the second order, which seemed almost to overhang the path we must follow, so steep was the mound of débris which stretched from their foot. We could distinctly see stones on their upper fronts, but the guides pronounced them apparently safe, and recommended the precaution merely of mounting the slope of débris, and slanting over to the shoulder of rock H[2] as rapidly as possible. It was a fatiguing but a short effort, and the risk I should say was inconsiderable, at least in the then condition of these glaciers. The summit of the rocky shoulder H was strewed with enormous blocks, tossed in confusion, shattered and bruised by the mutual shocks which they had evidently undergone no farther back than last spring, when they had thundered down with the early thaw, from the upper level of the little glaciers. At present, however, there was no danger, and we paused a while for breath.

We were now at a great height above the Glacier of Saleinaz, not only on account of the ascent which we had made, but also from the steep fall of the glacier in a contrary direction. Having passed the summit of the knoll which had formed the great obstacle, we were now to seek a safe descent to the main glacier once more. This would have been, in all probability, a matter of small difficulty, had not the fogs which all day had been hovering on the summits, suddenly descended at 5 P.M., and enveloped us almost without warning. Our position was

[1] [Different arms of the Evole Glacier.]

[2] [The site of the present Saleinaz club hut (8829 feet), belonging to the Neuchâtel section of the Swiss Alpine Club. Hence to the Val Ferret there is now a good marked track.]

not free from anxiety, for it was impossible to see more than 30 or 40 yards in any direction. Charlet continued to advance until we found a small steep glacier in front of us, descending from the heights above, and completely barring passage in a forward direction—(it is shown at I in the plan, p. 460). We then attempted to ascend the rocky ridge upon which we found ourselves, which fell steeply toward the main glacier, but a moderate distance brought us to impracticable precipices. In these circumstances, only two courses remained open, either to wait for the rising of the fog, or to descend from the rock upon the moraine and rubbish which bordered the small glacier, and then attempt to scramble down it. We followed the latter course, and our descent was facilitated by long snow inclines, over which we slid rapidly; whilst so engaged the fog happily cleared for a few minutes, revealing our entire position, and giving us an opportunity of resolving on our ultimate route, for we knew that sooner or later we must cross the main glacier. Fortunately we had selected what appeared to be the *only practicable descent*. On the one side of us was an impassable glacier, on the other impassable cliffs. Having made very rapidly a great descent, we diverged to the right, passing (at a safe distance) under the termination of the small glacier, and soon after reached the level of the Glacier of Saleinaz without difficulty, which we also crossed with no great delay. We had then a tedious descent over rough moraines, here and there diversified by patches of the most superb vegetation, till we came to a torrent which we understood to descend from the glacier of Orny,[1] where we halted for a short time at 6 h. 45 m. This stream we also crossed without difficulty, and had now reached the limit of trees; we had a stony and laborious descent through woods nearly pathless before we came to a certain track. By this time we had passed the termination of the Glacier of Saleinaz, which we saw distinctly below us. Amidst the woods were vast blocks of the granite of Orny, and, looking back, fine views of the glacier we had left; but the mists were *again fallen below the level of the place of our perplexity*, so that, but for the momentary rise, we must have remained in much anxiety. At 7 h. 55 m. we reached the village of Praz de Fort, in Val Ferret, close to the remarkable moraine which protrudes into the valley, and which

[1] [This is so.]

attracts the attention of all travellers. An hour's sharp walking brought us to Orsières, which we entered at 9 P.M., 12½ hours from the Col de Balme.

The junction of protogine and gneiss, on the north side of the glacier, appeared to be not very far above our ingress on the Glacier of Le Tour. On the south side, the gneiss formation is comparatively narrow; I did not notice the junction accurately, being too happy at our escape from the fog to think of anything else; but I believe that it was near the point where we crossed the Glacier of Saleinaz after our rapid descent. The calcareous schists appeared in the wood on our left, some time before reaching Praz de Fort.

PART III

PEDESTRIANISM IN SWITZERLAND

Reprinted from the "Quarterly Review," No. 202, April, 1857, pp. 285-323

Art.

1. "Murray's Handbook for Travellers in Switzerland and the Alps of Savoy and Piedmont." Seventh edition. 1856.
2. "The Story of Mont Blanc." By Albert Smith. Second edition. 1854.
3. "Wanderings among the High Alps." By Alfred Wills, Barrister-at-Law. London, 1856.
4. "Where there's a Will there's a Way: An Ascent of Mont Blanc by a New Route and without Guides." By the Rev. Charles Hudson and Edward Shirley Kennedy, B.A. London, 1856.
5. "Voyages dans les Alpes." Partie Pittoresque des Ouvrages de H. B. de Saussure. Troisième édition. 12mo. Paris, 1855.
6. "Untersuchungen über die physicalische Geographie der Alpen." Von Hermann und Adolph Schlagintweit. Leipzig, 1850.
7. "Neue Untersuchungen." By the same, with Atlas. Leipzig, 1854.
8. "Topographische Mittheilungen aus dem Alpengebirge." Von Gottlieb Studer. Bern, 1843.
9. "Die Seitenthäler des Wallis und der Monterosa." Von Melchior Ulrich. Zürich, 1850.
10. "Die Bergkrankheit, oder der Einfluss des Ersteigens grösser Höhen auf den thierischen Organismus." Von Dr. Conrad Meyer-Ahrens. Leipzig, 1854.
11. "On Mountain Beauty" (being vol. iv. of Modern Painters). By John Ruskin, M.A. 1856.

PART III

PEDESTRIANISM IN SWITZERLAND

A PERIODICAL writer said lately of a deceased poet that "he wanted an out-of-door mind." The deficiency is not an uncommon one. It occurs both in the old and the young, in large classes of all civilised peoples, and in persons of otherwise the most opposite tendencies and tastes. If it is lamentable to see young persons engrossed by the frivolities of metropolitan life, it is hardly less sad to find others, of the fairest promise and even commanding ability, spending their manhood in studies of a merely speculative or imaginative cast, remote from the interests of humanity and the glorious realities of the natural world. They have limbs endowed with elastic muscles, fresh and healthy blood circulates in their young veins; their eye is clear, their step is firm, yet the former is cramped in its range to the pages of a book—the latter is doomed to expend its spring against the resisting pavement of the streets. Let such persons cultivate the "out-of-door mind"; and for doing so, we cannot recommend a better school than Switzerland, or a better grammar than Mr. Murray's Handbook—dear to pedestrians.

It is true that there are fair outlets for the lovers of scenery in our own island; and many of our intensest admirers of Nature have passed their apprenticeship in Wales, the English lakes, or the Highlands; but it is equally certain that the alpenstock and the knapsack are thoroughly naturalised in no country except Switzerland, and that its glorious scenery has awakened in the breasts of many, who never felt such impressions before, a love of Nature and a spirit of independence in thought and action, which the tamer character of our own mountains and the more familiar occurrences of a traveller's daily life in these islands have often failed to impart. This nomade life becomes, during summer, epidemic in Switzerland. Men—aye, and women too—of all civilised nations communicate the infection;—Chamouni and Grindelwald allure even the indifferent and the timid; but though their rocks and ice be annually trodden by thousands of irreclaimable Cockneys and Parisians devoted to Tortoni's and the Champs Elysées, they are yet touchstones by which the qualities of the aspirant may be tried; and he who does not feel his step lighter and his breath freer on the Montanvert and the Wengern Alp, may be classed among the incapables,[1] and be permitted to return in peace to paddle in a skiff on the lake of Geneva, or to loiter in the salons of Baden Baden.

Strange, on the other hand, is the metamorphosis which even a very ordinary Alpine walk produces in the youth nurtured perhaps in the self-indulgent habits of a tranquil home, or whose tastes have been conformed to the gentlemanly routine of an Oxford college. His ideas of sustained exertion do not go beyond a cricket or a rowing-match; his school for scenery may not extend beyond a few miles of a trouting-stream near his country home, and his stiffest climb is perhaps a hill in the Peak, or a *tor* on Exmoor. Of personal privations he has experienced absolutely none. He cannot have felt that his chance for a meal or shelter depends upon his walking for six, or eight, or ten hours over a rugged mountain where unknown, and what may appear to him insurmountable, difficulties may intervene; nay, that at times even his life may, as it were, be placed in his hands. A false step, a passing giddiness, an instant's hesitation in avoiding a detached rock rolling with the momentum of a cannon-ball, may hurry him to destruction. These are thoughts that make the most mercurial grave, that give a decision and force to a naturally capable, but timid and hesitating disposition, of which it is hard to overrate the value. We have all lately heard much

[1] We have much sympathy with Mr. Ruskin's remark, that "it is a great weakness, not to say worse than weakness, on the part of travellers, to extol chiefly what they think fewest people have seen or can see. I have climbed much, and wandered much, in the heart of the High Alps; but I have never yet seen anything which equalled the view from the cabin of the Montanvert."—*On Mountain Beauty*, p. 181.

of the influence of even remote chances of danger on the minds of our gallant officers and soldiers; we have heard much of the transition from the indolence of barrack life to the privation and risk of the battle-field, and the sobering, humanising effect which it produced on minds possessing any tinge of nobleness of character. An Alpine journey is perhaps the nearest approach to a campaign with which the ordinary civilian has a chance of meeting. He has some of the excitements, and many of the difficulties and privations of warfare, without any of its disgusting and dreadful features. He combats only the elements, storms only the fortresses of nature, yet he has continually in his mind the consciousness of the power by which he is surrounded, and at times overawed. He cannot be insensible to the possibility of occurrences placed wholly beyond his control—a whirlwind or a fog, a new fissure in the ice or a critical thaw—which, if they do not arouse his fears, may frustrate in an hour, nay, a moment, the best-laid plans. Then in such crises his trust—after God—must be in the humble, hardy fellow, whom in other circumstances he might treat as an inferior, but whom now a community of interests and perils renders a friend indeed; whose counsels are to be regarded, whose experience is to be valued, whose steps are to be followed; nay, with whom he may be willing and thankful to lie down as familiarly as with a brother in the exposed cleft on the hill-side, where necessity may compel him to pass the night, and by the communication of natural warmth hinder both from freezing.

But apart from such serious risks and unusual exertions the mountaineering life has in it elements of manly regimen which can come amiss to few, and which we have known to change totally, and in one short summer, the character of delicately brought-up and unadventurous youths, so that they became self-reliant, enduring, and full of resource, presence of mind, and enthusiastic love of Nature. In point of corporal development also, having well-knit limbs, powerful lungs, erect gait, and fearless weather-beaten countenance, in exchange for physical timidity, dyspepsy, and a student's dreamy bashfulness, and pallor.

Habitually to exercise the muscular powers even to fatigue is part of a masculine education. He to whom physical endurance and the toil of the limbs are unknown is deficient in a knowledge of what belongs to him as a man. We have never sympathised much with those philanthropists who regard mechanical toil as in any sense degrading. The "sweat of the brow," though part of the primæval curse, is not, in relation to our fallen nature, in itself an evil. The necessity of toil is rather a blessing, though it may be a badge of the level to which our physical state has descended. A certain amount of daily labour is a condition of well-being, bodily and mental, and even a full and compulsory measure of it is far preferable to the lot of indolence and supineness which many fancy to be delightful. The beneficial influence of ordinary exercise in removing the pressure of care, and the ill effects of anxiety and of intellectual application, are so familiar as to be proverbial. A greater amount of muscular toil, such as day by day may be repeated without excessive fatigue, is a tonic to the system, of which few who have tried it will deny the efficacy. The charms of repose cannot be known without the excitement of exertion. That man, we repeat, has not done justice to the capacities of his nature, both for action and for enjoyment, who has not exercised his limbs as well as his head; who, besides recognising the pleasure of intellectual conquest, has not felt the physical exultation consequent on the triumph over mechanical difficulties.

Take, for example, even the most ordinary style of a pedestrian tour in an Alpine country. The day begins with him at least two or three hours sooner than at home. He rises with the consciousness of having a well-filled day before him, certain that before evening closes he will have laid up memories of what is charming and sublime. Accoutred and on foot while the horizontal morning rays touch the mountain tops still far above him with a milder radiance than the glowing tints of sunset, he proceeds, knapsack on his back and the trusty Alpine pole in his hand, through the comparative obscurity of the lower valleys, where the sun will not penetrate for hours, and brushes from the grass the plentiful dew which heralds calm and bright days, especially in autumn. He has indeed many a league before him, but of that he recks not. His sinews are braced by the refreshment of perfect repose, and the keen, yet not too penetrating mountain air, which, blowing at this time of the morning from the heads of the valleys, meets him in the face, and gives such elasticity to his whole frame, that he with difficulty restrains his march within the sober limit which experience and the consideration of the prospective heats of noon, and the length of his journey impose. If he has a guide, the dogged pace of that unimpassioned monitor will soon bring this to his remembrance; if not, he quotes for himself the Shakspearean adage:—

> To climb steep hills
> Requires slow pace at first: anger is like
> A full-hot horse, who, being allow'd his way,
> Self-mettle tires him.
> [*Henry VIII.*, Act i. Scene 1, lines 131-134.]

From paths through fields, where in passing he receives from the early peasant the customary greeting, he advances probably into the forest region where the pine and the larch, alternating with the more formal spruce, tower towards the sky, disclosing at intervals summits of snow or bare rock on either hand, between which our traveller is passing, bound we may suppose for a pass or *col* at the head of the valley, and tolerably regardless of lesser mountains thus left behind. Yet, at intervals, the roar of a cataract on the right or left attracts his attention to an opening in the massive wall, and permits him a peep into the depths of that wilderness of hills, where snowy basins feed the ever-moving glacier, which in its turn sends forth the discoloured torrent, whose noise first called his attention to the scene, and which thunders on increasingly as the more vertical noontide sun dissolves the icy fountains whence it flows.

But now the trees are rarer. Glades of shorter turf, bedizened with more purely Alpine flowers, offer to the pedestrian the very ideal of pastoral scenery. And now the scanty trees wear a ruggeder aspect, the upper limit of forests is gained, though a hardier trunk here and there throws its gnarled arms outwards, its roots fast clenching the rocks which alone enable it to resist the tempest, or a whole tree of statelier growth than its neighbours—a relic of a former age—stands leafless and barkless, bleached to a spectral whiteness by the tempests of many a year.

And here the main toil of the day commences; the ascent becomes steep if not precipitous; the shade of the forest is left behind, the hill-breeze of the morning is gone, and the sun's rays shoot more vertically on the head of the traveller now fully exposed to their force. At length, tired but not beaten, and seeing the limit of his present toil but a short way before him, he stops to refresh himself with the fare he has brought with him, and rests by the side of some bubbling spring on the green mountain slope till he has acquired new vigour for the remainder of his march. Dear are the recollections of those noonday halts to every wanderer in Switzerland. The perfect solemn stillness of mountain solitudes—broken only by the distant tinkle of the cattle-bells left far below—soothes his spirit and encourages the dreamy feeling of repose which succeeds to active exertion. The exhilarating combination of solar warmth with cool bracing mountain air, so dry as to remove all perception of chill or relaxation, soon repairs his forces. Then, turning in the direction of his morning's walk, he traces, as in bird's-eye view, its course; he looks down on the summit of the hill from under whose foot he had started; he traces the opening of each valley and the course of every stream which he has crossed, while in the farther distance rises a panorama of hills which separate him from the sunny plains and the calm waters of one of the greater Swiss lakes, whilst an undistinguishable haze seems to prolong the horizon to infinity.

When fully refreshed, our wayfarer once more faces the acclivity, and in an hour or so steps upon the ridge which has been his goal since morning. Here one of the chief joys of the pedestrian awaits him. He has been for some time intent on the single object of making his way over the bare and gloomy rocks or the mountainous snow patches which he has to climb with as little effort as he may. He is conscious of fatigue chiefly by the concentration of his thoughts on the objects immediately under his feet, till at length, on clambering over a mound of slaty débris, or extricating himself from a jagged and tortuous goat-track in the rock, or more rarely by marching almost on a level through a colossal portal by which nature points the way from one kingdom to another,—a fresh hemisphere of Alpine glory displays itself in a moment, all fresh and resplendent, as if apparelled in majesty for his sole delight. Alps rise on Alps through the dark azure of a more than Italian sky. The unflecked snow of these untrodden, perhaps nameless, pyramids glitters with almost unsupportable brightness. Where several summits unite to form a theatre, the ice-stream at their base rolls its ponderous wave, whose motion, like the great planetary inequalities, may be traced from age to age and from century to century. There it is, spreading out its marble flood in a magnificent glacier some thousand feet below the spectator. Far lower still the valleys deepen into defiles crowned with impending forests, while the mountain-sides of that middle region are seamed by white lines of foaming cataracts, of whose noise no single vibration reaches the elevated platform where we stand. All there is silent, sparkling, and unchangeable; far, far beneath all, are the first traces of life—of human interests and necessities. Here above dwells an eternal composure from which we part with a pang, to jostle perforce once more with the busy world, to feel its wants, and to share its struggles and its sympathies.

We will not follow our traveller along the steps of his descent. His toil and its chief reward are past. He reaches at length the humble inn or the less inviting chalet where he is to pass the night. He may have more or less of a welcome, a good bed or a truss of hay, company more or less good, or, what he often prefers, none at all; and after striving to note for future memories some of the features of his happy day—with a mind thoroughly at ease, and a body stiffened a little with exercise, yet not unstrung, he sleeps the sleep of forgetfulness until another morning's sun calls him to enjoyments alike in kind, yet infinitely various and incapable of producing satiety.

Now a country which, day after day and week after week, is capable of producing, in inexhaustible succession, scenes such as we have just attempted to trace, and that in a variety and profusion which no pen or pencil can portray, must needs exercise a powerful and lasting impression on the mind of one who surrenders himself for a time to the full enjoyment of its beauties, whose soul can bow itself in enthusiastic admiration in the presence of its sublimer scenes. He leaves them, in a sense, a new man. His current of ideas has been diverted from its ordinary course; new energies have been called into action, and others long and exhaustingly exercised before have been charmed to rest. The young, unspoilt and generous nature feels the metamorphosis most completely: but strong men of middle age have, to our knowledge, found a distraction in such scenes from the severest anxieties of life; and even those whose grey hairs are not few have occasionally borne testimony to their power of restoring, at least for a while, the happiest impressions of their departed prime.

If these descriptions and statements be not unfounded, there must be something pre-eminent in the physical characters of a region which can contribute so greatly to human enjoyment. Though every mountainous country partakes in some degree of these qualities, it would really appear that the Alps of Central Europe possess them in a singular, perhaps unequalled, measure. The Pyrenees, with some isolated scenes of almost Alpine grandeur, are wanting in variety, and especially in concentration of interest around a few predominating mountain-centres. Perennial snow has not there the same overpowering sublimity as in Switzerland, and the northern valleys, although exquisitely luxuriant, do not in this respect exceed those of the Italian slope of the Alps, while the unmitigated solar heat of the Spanish frontier deprives the southern side of this charm. The Carpathians, so far as we are informed, do not boast of the variety and grandeur which even the Pyrenees possess, and their higher summits reach little above the snow-line, while the more elevated of the Apennines do not attain it. In the north of Europe, the great chain of Scandinavia, though possessing a peculiar grandeur of its own, especially in the scarped precipices which face the Atlantic, is destitute of the accessibility,[1] the concentration of interest, and the positive sublimity of any of the greater Alpine centres. The comparatively small scale of the mountains of North and West Britain, and the important modifications which the scenery receives from its maritime character, prevent any strict rivalry with Switzerland.

It is more obviously questionable how far the Alps of South America and India will bear away the palm of grandeur and interest from those of Europe. The colossal dimensions of the two former would, at first sight, appear to leave no doubt of their superiority. Yet the testimony of ex-qualified travellers makes us hesitate on this point. Chimborazo, in Ecuador, long supposed to be the highest mountain in the world, rises only 5600 feet above the limits of perpetual snow, while Mont Blanc in Europe, of which the absolute height is 6000 feet less, is snow-clad

[1] [It must be remembered that Forbes is writing in 1857, since which date Norway has become very accessible. It is curious that he mentions neither the Abruzzi, nor the Caucasus, nor the Alps of Japan and New Zealand.]

throughout the upper 7000 feet. The Himalaya are not only far higher than any of the Andes, but by their forms and arrangements, and by the multitude of magnificent snowy basins and gigantic glaciers with which they are diversified, challenge a closer comparison with Switzerland. It is now known that several of their peaks exceed 28,000 feet—one, recently discovered, attains 29,000—that there are vast table-lands, and lakes of an elevation not inferior to that of Mont Blanc, or even exceeding it, and yet the most trustworthy travellers hesitate to pronounce upon the superiority even of single views of these giants of the earth over our own familiar and easily attainable Alpine scenes. Dr. [now Sir Joseph] Hooker, whose opinion is the more impartial because his *first* impression of the effects of grand mountain scenery was derived from the Himalaya, describes the effect of the Swiss Alps as "far more beautiful." Without entering into particulars, this may be accounted for on the following principles: (1) The average slope of the ground from the mountains to the plains is not very different in India and in Switzerland. The apparent angular elevation of the chain to the eye of the spectator is therefore not very different in the two cases, and the notorious incapacity of the eye to judge of the true distance and height of such objects prevents a detection of the difference of the scale. (2) In the next place, the commencement of perpetual snow, which is by far the most conspicuous mode of estimating elevation, is 7000, 8000, even 10,000 feet higher in different parts of the Himalaya than in Switzerland. This is so much to be deducted from the really enormous preponderance of the scale of the Asiatic peaks. (3) As regards these colossal mountains, it is impossible to get an effective close view of them without climbing Alps already as high as Mont Blanc, or nearly so, in order to command a clear perspective of their awful slopes, such as that which we obtain of Mont Blanc itself from the Brévent. This leaves the proportions of the scenery not very different from that of Switzerland, while from the larger scale the effect is more monotonous, since we cannot embrace at a glance the splendid contrast of snow-covered pyramids with luxuriant forests and even cultivated fields and human habitations at their base. (4) Lastly, stupendous distant panoramas, in which alone the Himalaya bear away the palm, are excessively rarely seen to advantage. Rare they are indeed even in Switzerland. Thousands of its visitors have never witnessed the impressive morning view of the Bernese Alps from Neuchâtel, or of Mont Blanc from the descent of the Jura. All meteorological conditions are still more unfavourable in India. The distances are twice or three times as great, and though the higher summits dwell in an atmosphere usually of cloudless serenity, the sub-alpine regions are commonly overshadowed with a damp and misty veil.

For these and other reasons we are entitled to say that, practically, the Alps afford the enjoyment of picturesque and sublime scenery in greater perfection than any other known region of the globe; for if any region could challenge comparison it is unquestionably the Himalayan chain. If any doubt remained on this point, the balance would be turned in favour of Europe by the facility with which its mountain recesses may be explored. There is no *transverse* valley in the Alps which may not be traversed by the pedestrian throughout its entire length in about two days, and usually less. A larger scale of geographical configuration increases the labour without increasing the effect on the eye. Monotony is almost unknown in Switzerland. The reaches of the valleys are short enough to afford a continual succession of prospects. The successive vegetative regions afford an almost hourly variety; the minor summits are attainable by the expenditure of a few hours of active exertion, whilst in the Himalaya, to use the words of Dr. [now Sir Joseph] Hooker, similar prospects "will always remain inaccessible to any but the most hardy seekers of the picturesque, for they can only be viewed under circumstances of extreme physical discomfort."

Baron Humboldt records in his *Kosmos*, that "no descriptions of the eternal snows of the Alps when tinged in the morning or evening with a rosy hue, or of the beauty of the blue glacier ice, or of any part of the grandeur of the scenery of Switzerland, have reached us from the ancients, although statesmen and generals, with men of letters in their train, were constantly passing through Helvetia into Gaul." "All these travellers," he adds, "think only of complaining of the difficulties of the way; the romantic scenery never seems to have engaged their attention."[1]

Wordsworth, in an expostulatory letter to the *Morning Post* on the subject of the Windermere railway, shows that the picturesque appreciation of mountains is of entirely modern date,

[1] A similar remark occurs somewhere in Francis Horner's *Memoirs*.

even in England, where it is perhaps more general than in any other country. With the exception of a single passage in the writings of Bishop Burnet, Wordsworth finds British travellers and naturalists alike silent upon the sublimity and beauty of the Alps down to the time of Gray. Even Windham's narrative of his visit [1741] to Chamouni is scarcely an exception to this remark, since, while he dwells much on the curiosity and strangeness of what he saw, he hardly alludes to the sublimity of the views either at Chamouni itself or from the Montanvert.[1]

The first approaches to a closer acquaintance with the ice-clad summits of the Alps were made in somewhat the same spirit. Exaggerated fears of the dangers which beset the adventurer within the limits of perpetual snow preoccupied the earliest Swiss adventurers to such a degree, that they were only too happy to find themselves once more upon *terra firma* to have time to recollect minutely their picturesque impressions (if they had any), except perhaps the wonder of an extensive panorama from some commanding summit. We can now smile at many of these needless terrors much as we do at Windham and Pococke's precaution of going to Chamouni[2] armed to the teeth; and what is more, after being there, recommending it as "an easy precaution, and, on certain occasions, very useful." It is principally to the great Swiss naturalist, De Saussure,[3] that we owe the rectification of these mistakes, as well as a lively appreciation of the aspects of nature in the Alps. Independently of the great scientific value of his labours—immense at the time, great even now—his writings give expression to the feeling of the sublime and beautiful, which few perhaps have felt more deeply than he. General readers will be glad to find in the little work mentioned at the head of this article the more popular and descriptive parts of De Saussure's writings, published in the form of a pocket volume.

[1] [The rise and development of the taste for mountain scenery is described in detail in two German pamphlets—J. Frey, *Die Alpen im Lichte verschiedener Zeitalter* (Berlin, 1877), and L. Friedländer, *Ueber die Entstehung und Entwickelung des Gefühls für das Romantische in der Natur* (Leipzig, 1873: reprinted with additions in the same writer's *Darstellungen aus der Sittengeschichte Roms*, vol. ii. pp. 206-259). English readers may also consult the rather sketchy outline history given by Mr. Leslie Stephen in his two chapters on the "Love of Mountain Scenery—The Old School and the New School," in his *Playground of Europe* (1st edition, 1871; 2nd edition, 1894). As to Bishop Burnet, see p. 525 below.]

[2] [In 1741. See p. 528 of the present volume.]

[3] [Born 1740, died 1799. See above, p. 4.]

Since the time of De Saussure Switzerland has not wanted explorers, even to its most remote recesses.[1] Expeditions once considered the most hazardous which a man could undertake, such as the ascent of Mont Blanc, are nowadays performed several times a year, and even by ladies. Guide-books immeasurably superior to that of Ebel,[2] which for a long time monopolised the field, have been published in English, French, and German. Of these, Mr. Murray's[3] is decidedly the best as well as the most original. It contains all the information required by any ordinary traveller. It has wonderfully facilitated the methodical examination of the Alps, to which his *Handbook for France*, and more particularly that for South Germany, have also materially contributed.[4]

Unscientific travellers may be divided into two classes: those who are contented with pursuing the ordinary routes, which conduct them amongst the finest scenery of the Alps, their most celebrated passes, and some of their most accessible heights; and those who, besides this, aim at gaining the most difficult and commanding summits, and at crossing the more dangerous and glacier-clad *cols*. We assume both one and the other class to be pedestrians. Nineteen-twentieths, perhaps ninety-nine hundredths, of tourists of all nations belonged not many years ago to the former class, and the same proportion of all nations, except English, belong to it still. But in the last few years a powerful interest has been excited towards the more difficult feats of climbing. At first, as was natural, the desire to explore the scientific wonders of the High Alps, their geology, their climate, and their glaciers, induced men to incur these risks; but mere tourists began to discover that other attractions besides those of physics and natural history powerfully contributed to this pursuit. Accordingly, year by year, for rather more than a dozen summers past,[5] the thirst for distinction in overcoming the difficulties and

[1] [Written in 1857; this statement is much exaggerated.]

[2] [*Anleitung auf die nützlichste und genussvollste Art die Schweiz zu bereisen*, 1st edition, 1793; 8th and last edition, 1843. The French translation (1795) is entitled the *Manuel du Voyageur en Suisse*.]

[3] [The 1st edition was published in 1838.]

[4] [The 1st edition of the French volume was published in 1843, and that of the South German volume in 1837.]

[5] [*I.e.* from 1843, the date of the publication of Forbes's *Savoy*, the historical importance of which has been brought out in the Introduction to the present volume. The more minute study, since Forbes wrote in 1857, of the early history

dangers of the High Alps has been on the increase.[1] The successive editions of Mr. Murray's *Handbook* bear witness to the fact. If we compare the first two editions [1838 and 1842] with the seventh, which is now before us, we find that a multitude of serious undertakings, which formerly were never thought of by any mere tourist, are now methodically described, so that it is possible to anticipate to a great extent the time, the fatigue, the comparative danger, and the expense of almost every ascent which has ever been made, at least in the more frequented parts of Switzerland.

When we attempt to analyse the causes of this immense popularity of what might be called break-neck trips, we find them as usual to be of a very mixed character. Probably one of the commonest but lowest motives is that of notoriety, such as tempted for a series of years to the ascent of Mont Blanc, while other mountains hardly less interesting and even more difficult were left unassailed.[2] The aspirants got their glory, and paid £25 to £40 for it. They have "done" Mont Blanc, which, being the highest of the Alps, they probably possibly imagine they have "done" the Alps generally, and so their Swiss tour ends.[3] Not unfrequently, however, we find that our tourist returns from a "grande course" a wiser and a better man. He went vaingloriously or in the mere gaiety of his animal spirits, and he comes back thoughtful, impressed, conscious of a new feeling, it might be called passion, in his soul. He has been initiated into the awfullest of the temples of Nature, and he longs to return once and again to pay his orisons there. He is touched with a sense of the greatness of the Almighty through the works of His creation, and of the littleness of self. He longs with the longing of the heart for the recurrence of summer,

of climbing has shown that the higher Alpine summits and passes were explored for the first time by far more "tourists," as distinguished from "scientific men," than Forbes imagined. But he was under the glamour of the career and writings of his master, Saussure.]

[1] [The English Alpine Club, the first society of the kind, was not founded till nine months after Forbes's article was published.]

[2] [Forbes here assumes that "tourists" always, but "scientific men" never, climb mountains for the sake of "notoriety." This seems to the present editor quite wrong, though the "notoriety" in each case is not the same. Professional guides first arose at Chamonix, and even in 1857 it was hard to find good mountain guides elsewhere in the Alps.]

[3] [Forbes here, as often, uses "Swiss" as equivalent to "Alpine." In 1857 Mont Blanc was, of course, Sardinian.]

and his hard-won holiday, again to taste the air of the mountain, and with the genial Talfourd [1] to exclaim once more—"A *char-à-banc* for Chamouni!"

A majority of the tourists are young Englishmen, of whom a great many are very properly contented with the publication of their experiences in difficult passes in Mr. Murray's *Handbooks*, which are enriched with a great deal of valuable matter thus unostentatiously offered for the use of future travellers. A few, and only a few, have given us the benefit of their information in a separate form. Of these we may specify the *Wanderings among the High Alps*, by Alfred Wills,[2] which is the result of several years' experience in the Alps, and by its genial, unaffected style, the modesty displayed by the author throughout, and the real interest of many parts of it, is calculated to please almost every class of readers. It were to be wished that the majority of tourists took a little more pains to ascertain how their recreations may be turned to some account, and would educate themselves to the kind of observations—many of which are by no means difficult—which would stamp a permanent interest upon their holiday rambles.[3] Many, *we know*, have such a desire, but the education which even our universities bestow has little or no tendency to impart the habit of observation, and the commonest mechanical facility in the use of instruments.[4] Add to this, that these tours are usually unpremeditated and casual pastimes. It is only by gathering up the experience of successive years that a man becomes fitted for exercising systematically his powers of observation.

In estimating the effects of the material hindrances to which travellers in high mountains are exposed, we ought to remember how much danger is increased by inexperience, and how—really as well as apparently—obstacles are more formidable in proportion as they are unknown. The man who first ascended in

[1] [T. N. Talfourd, author of *Vacation Rambles*, 1841-43, 2 vols. 1845. Nowadays most of the great Alpine centres are accessible by rail.]

[2] [Since 1884 the Hon. Mr. Justice Wills.]

[3] [On this suggestion the present editor permits himself to remark, first, that many summer travellers travel solely for rest and change after a hard winter's work, and, next, that many take but the feeblest interest in so-called "scientific observations." The aims of ordinary travellers and of "scientific men" are quite different, and it is not right to force "natural science" on unwilling minds.]

[4] [Really the English universities teach better and higher things than the manipulation of instruments. Forbes's scientific ardour has here led him astray.]

a balloon into regions of air previously unbreathed by human lungs,—he who first tempted the depths of the sea in a diving-bell,—the navigator who first passed a winter amidst Arctic ice, —all these men required far other heroism than is necessary for such as follow in their adventurous tracks. They braved dangers unknown, and, because unknown, alarming. But the dangers were also the more real and greater, because the experience necessary to avert them was wanting. So the first man who voluntarily slept above the limits of perpetual snow in spite of the unascertained cold at those elevations,—he who first ascended to regions abounding in perils peculiar to the permanent ice of which he had little or no previous acquaintance,—and he who sought to attain heights where it was only known that the primary function of life—that of breathing—is performed with difficulty,—these men had far other trials than belong to the most adventurous climbers of the nineteenth century, to whom the *general* course of events in all these predicaments is well known, and who only run the same sort of risks which others have surmounted.

A more vivid idea of the reality of these obstacles to the early Alpine adventurers will be derived from a single passage of De Saussure's writings than from elaborate description. That admirable traveller had for many years been urging the experienced mountaineers of Chamouni to attempt to scale Mont Blanc, and the second serious attempt of the kind was made by three hardy peasants, bearing the well-known local surnames of Couttet, Meunier, and Carrier. They appear to have attained a considerable though an unknown elevation.[1] They suffered so much from the direct and the reflected heat of the sun, and from the loss of appetite, and tendency to faintness now known to be common at such heights, that one of them [Meunier, *dit le Grand Jorasse*], in reporting his journey to De Saussure, seriously informed him that it was unnecessary to carry any provisions on that journey, and that, were he to return thither, he should provide himself merely with *a parasol and a scent-bottle.* "When,"

[1] [The first attempt was made by Pierre Simond in 1762, and the second in 1775 by F. and M. Paccard, Victor Tissai, and Couteran. Forbes alludes to the *third* attempt made in 1783 by J. M. Couttet, Lombard Meunier, and Joseph Carrier, which is described by Saussure in § 1104 of his great work: the party perhaps reached the Grand Plateau. See M. Durier's *Mont Blanc*, 4th edition (1897), pp. 75-81.]

adds De Saussure, "I pictured to myself this tall, robust mountaineer climbing these snows, holding in one hand a lady's parasol, and in the other a bottle of *Eau sans Pareille*, the idea seemed so strange and ridiculous, that nothing could have better proved his opinion of the difficulty of the undertaking, and consequently its impossibility for those who have neither the strong head nor the walking powers of a good guide of Chamouni" (§ 1104). Obstacles, then, so great as to unman a hardy peasant could not fail to affect doubly persons of slighter physical constitution and more lively imagination. Poor M. Bourrit, the contemporary of De Saussure, and at times his companion, could not even ascend the Buet, a mountain little exceeding 10,000 feet [really 10,201 feet], without numberless overpowering sensations. Yet he had pluck enough to attempt the ascent of Mont Blanc oftener perhaps than any other man.[1] But the narrative of his sufferings under what would now be called ordinary circumstances reminds us of the anecdote of the philosopher who first by accident passed the contents of a small Leyden jar through his body, an experiment which he declared he would not repeat for a free gift of the whole kingdom of France.

The different impressibility of different persons by the same dangers renders a strict estimate of the risks of Alpine adventure all but impossible. Unless we have the measure of each man's endurance and coolness, we cannot compare accurately, say, the ascent of the Finsteraarhorn with that of Monte Rosa. Add to this that the nerve of the same individual varies in an important degree with the state of his health and training, and, what is still more significant, that where the risks are those of ice and snow, they vary so materially from one year to another, and even from month to month, that a feat which is at one time comparatively easy may be physically impossible at another. This well-known fact should make travellers very careful in charging their predecessors with exaggerating the difficulties of their conquests. Now and then it may be the lot of the critic to find the tables turned upon him.[2]

[1] [See Bourrit's *Description des Glacières*, 1785 edition, pp. 197 sqq. (Buet in 1775); and pp. 167, 295 (attempts on Mont Blanc in 1783-84-85-87-88): for the latter see also Durier, pp. 82-90, 148-150.]

[2] The passage of rocks is not liable to the same fluctuation, and affords a tolerable measure of the nerve of the pedestrian. Thus, when Mr. Albert Smith enlarges, in terms which provoke a smile (*Story of Mont Blanc*, 2nd edition, p. 197),

We shall now endeavour to give a fair estimate of the chief difficulties attending Alpine climbing:—

Bad Weather.—This we believe to be by far the most serious danger of pedestrian enterprise. The power of violent wind, when accompanied by rain, not to say snow and piercing cold, in exhausting the physical powers is little appreciated, and would hardly be believed if certain evidence of it did not exist. The chilling effect of a current of air is familiarly known. Arctic travellers have no difficulty in bearing a cold of 30° or 40° below zero if the atmosphere be perfectly still, but the smallest wind, with a temperature even of zero, is almost insupportable. Even in the temperate climate of Great Britain, and at very moderate elevations, not unfrequent cases of death by exposure have come to our knowledge which took place in the summer months. One remarkable instance occurred in August, 1847. Two Englishmen travelling on foot by a well-marked road from King's House to Fort-William in Scotland during a storm of wind and rain—violent, yet not excessively cold, and without a flake of snow — lay down and died on the path. Similar instances have happened of late years in Westmoreland. When there is any snow hardy natives sometime perish. Even in Devonshire this occurred not long since. If such be the case on hills under 2000 feet high, and even in summer, what must be the trial to the human frame of the war of elements above, or even near, the snow-line? There snow may fall any month of the year—there the winds rage with an uncontrolled power, seeming to blow from all points of the compass at once, and, tearing the fallen snow from the ground, mix up its sharp spiculæ in a turbulent compound, dazzling, blinding, wounding, and finally stiffening the traveller until, goaded by despair, he loses all idea of direction, and finally relinquishes the unequal contest, and sinks into a painless and perpetual sleep.[1] These

upon the horrors of the passage of the rocks called "les Ponts," near Montanvert, we have a scale by which we may estimate the probable amount of the innocent exaggeration of the difficulties of Mont Blanc.

[1] "From hill to dale still more and more astray
Impatient—through the drifted heaps
Stung with the thoughts of home, the thoughts of home
Burst on his nerves and call their vigour forth
In many vain attempts—till down he sinks
Beneath the shelter of the shapeless waste,
Thinking o'er all the bitterness of death."

THOMSON'S *Winter*.

dreadful assaults of the elements, called *Tourmentes* in the French Alps [*i.e.* in the Alps where French is spoken], and *Guxen* in those of German[-speaking] Switzerland, are fortunately rare in summer, and may usually be avoided by common prudence, and attention to the opinion of the guides.[1] From a neglect of this precaution two Englishmen perished on the Col du Bonhomme in 1830;[2] and it is perhaps surprising that such accidents are not more frequent. They are, however, more often probably even than avalanches the cause of the loss of life still common at unfavourable seasons amongst the poorer class of travellers when crossing such passes as the Grimsel, the [Great] St. Bernard, and others still less formidable. At such awful moments the instincts of self-preservation are wrought up to the highest pitch. When the *tourmente* prevails each man is in a little snow world of his own—he can scarcely see his nearest neighbour, and the struggle for dear life too often severs the tie of the nearest kindred. To pause is to die, and he who stops to render assistance, or to give encouragement, to one sinking under the fatal lethargy of cold, is liable in an instant later himself to succumb to the same fate.[3]

On great ascents the occurrence of such storms at a critical moment would be almost certain death to a whole party.[4] Consequently, when the traveller is to penetrate for many hours beyond the snow-line, a reasonable prospect of fine weather must be the primary condition of the journey, and decided symptoms of a change must be the signal of instant return.[5] If a storm of wind and sleet were to occur on such a perilous passage as the Mur de la Côte on Mont Blanc, where it is impossible to move, except at a creeping pace, and with the toes dug into the ice-steps, congelation or "frost-bite" would be the consequence; and even on the levellest snow it would be impossible to trace

[1] [They can be *avoided* by not starting, but they also often come on unawares in summer, and then cannot be avoided.]

[2] [See above, p. 180.]

[3] See an instance in Forbes's *Travels through the Alps of Savoy*, pp. 281-283 [above, pp. 278-280; this accident took place in 1841 on the Col de Collon. The statements as to *tourmentes* in the text above are *much* exaggerated. The present editor has often been in such blizzards at very great heights in the Alps, but no member of the party ever thought of abandoning his comrades.]

[4] [Perhaps, but by no means always, if the party is a strong one.]

[5] [Retreat is not *always* possible in such a case, for it may be easier to cross a pass or a peak than in such a storm to retrace the route taken on the ascent.]

any path, to recognise any landmarks, or to preserve any constant direction.[1]

A far less alarming, yet not insignificant, danger arises from fogs. Few pedestrians have not met with a fog in some critical position, and felt its bewildering influence on unfrequented ground. None but steady and experienced guides deserve much confidence on such occasions. The difficulty is greatest where wide and flat-topped mountain ranges have to be crossed. These occur but rarely in the Alps, occasionally in the Eastern Pyrenees, but perpetually in Norway. The chance of being lost is there most imminent if the guide be not perfectly at home on the track. Again, in difficult and untracked passes in the Alps, a deviation of a few yards to the right or the left in a fog may lead the traveller into inextricable difficulties.

Difficulty of Breathing—Hill Sickness.—A more direct obstacle, however, to very lofty ascents is difficulty of breathing, when it occurs, and the giddiness, exhaustion, or sickness which are yet more common. Because it not unfrequently happens that parties arrive on the highest Alpine summits without experiencing all or any of these sensations, it has sometimes been absurdly supposed by travellers that they have been the result of the imaginative fears of their more timid predecessors. The fact is, that this singular, yet very real, affection, varies as much in different persons as sea-sickness does—a malady with which it seems to have a strong analogy. It happens, indeed, that the extreme elevation of the Alps reaches a point where these physiological effects only begin to be developed in many individuals, yet observations in tropical countries, and at still greater heights, show that they are amongst the most certain penalties of venturing into imperfectly ærated regions, and that there is, no doubt, a limit even on the earth's surface unattainable by man, unless he be passively moved as in a balloon. As early as the sixteenth century the learned Jesuit Acosta described correctly the effects of rarefied air which he witnessed in Peru: and he accounted for them on true grounds. Bouguer, a century and a half later, experienced them in his own person, but errone-

[1] [Forbes here almost prophesied the fate of the eleven men (three travellers and eight Chamonix men) who perished in September, 1870, in such a storm just above the Mur de la Côte. Forbes did not know the Mur de la Côte by his own experience.]

ously attributed them rather to excessive fatigue than to the rarity of the air, an opinion which De Saussure [§ 2021] justly controverts, by remarking—(1) That as the ascent of the Andes is mainly accomplished on horseback, the mere fatigue of mounting a few thousand feet could not be so extreme as to occasion such effects. (2) That he, himself, has, like most pedestrians, been fatigued to the limits of his muscular power without feeling the smallest nausea or shortness of breath. This accurate traveller has recorded nearly all the facts yet known regarding this singular malady. On the occasion of his ascent of Mont Blanc some of the most robust peasants of Chamouni were the first to leave the summit in order to recover themselves in a denser air [§ 2021]. Besides insupportable lassitude, which renders the smallest effort a severe toil, palpitation of the heart, vomiting, faintness, and febrile pulse are four of the commonest results of excessive elevation. De Saussure marks [§ 2021] 1900 toises (about 12,000 English feet) as his own healthy limit, and that of most of the natives of the Alps; some persons, however, begin to suffer much lower. Whilst he remained perfectly still, he suffered nothing on the top of Mont Blanc, but the effort of even reading off thermometers and other instruments, and of recording his observations, was such that he barely accomplished in four and a half hours what three hours sufficed for at the level of the sea [§ 2021].[1] He very justly adds that the fatigue of such sedentary occupations arises in part from the involuntary holding of the breath when the attention is deeply engaged.

It is not unlikely that the reason why we hear less nowadays of these inconveniences is because both travellers and guides have usually been for a considerable time "in training" before the ascent of a high mountain. In De Saussure's time few persons[2] had any occasion to ascend to the heights of even the Montanvert and the Col de Balme. The regular guides are now doing so every summer, and many travellers are but little less seasoned.[3] Still it must be owned that there are great

[1] [Most, probably all, of these inconveniences felt by Saussure and his party were simply due to not being accustomed to mount to such heights.]

[2] [We must always except the shepherds and herdsmen, who are often overlooked by scientific inquirers.]

[3] [As the Montenvers is but 6267 feet, and that of the Col de Balme is but 7221 feet, and there are now inns on both, this remark of Forbes in 1857 raises a smile in 1900.]

anomalies. One of a party, equally robust and equally well trained, falls suddenly sick, and becomes decidedly pale at an elevation of only 10,000 or 11,000 feet, while all the rest are buoyant and healthy. M. Hugi relates [p. 218] that his guide Währen, "certainly the most powerful man in the whole Oberland," was taken unwell on the formidable summit of the Finsteraarhorn [in 1829]. We have seen a hardy peasant seized with sickness at a height inferior to that of the Col du Géant, where no one else of the party suffered in the smallest degree. It is said that at some periods the effects are earlier fallen in with than at others even on the same mountain. It is also believed that some districts are more liable to produce the effect than others. Mr. Wills considers [p. 172] that the rarefaction of the air is less felt about Monte Rosa than near Mont Blanc. But this seems doubtful, for, though he himself did not suffer on the occasion referred to, he records [p. 147] having "felt the rarity of the air sensibly," and being a good deal exhausted the year previously.[1] The experienced Professor Ulrich [pp. 68 and 75 of his book] suffered considerably on Monte Rosa at about the same elevation, although not at all at the same spot the following year.[2] In South America some localities are supposed to be more favourable than others to attacks of "the Puna," as this malady is locally called, from one of the districts in which it prevails.[3]

It has been believed that difficult breathing is sooner felt upon snow than upon rock, and M. Boussingault, in his account of the ascent of Chimborazo,[4] attributes this to the sensible deficiency of oxygen contained in the pores of the snow, which is exhaled when it melts. The fact that the air absorbed by snow is impure was ascertained by De Saussure [§ 578], and has been confirmed by Boussingault's experiments.

The inconvenience is common to the various races of men and to the lower animals. Baron Humboldt was deserted by all

[1] [The former occasion was the passage of the Adler Pass, 12,461 feet, and the latter that of the Allalin Pass, 11,713 feet.]

[2] [The "spot" was somewhat below the Silbersattel, between the Nord End and the Höchste Spitze of Monte Rosa, and the dates 1848-49.]

[3] See the curious essay on "Hill Sickness" by Dr. Meyer-Ahrens, cited at the head of this article.

[4] [He did not, however, reach the summit, which was first attained by Mr. Whymper in 1880.]

his Indians at an elevation about 1000 feet greater than that of Mont Blanc. Mules begin to suffer at 11,000 feet, and it is said, on the authority of Tschudi, that cats cannot live above 13,000 feet, a height at which villages occur in the Andes and Himalaya.[1] In the latter range Dr. [now Sir Joseph] Hooker states that horses may be ridden to a height of over 19,000 feet. Habit appears to be the only remedy. The upper part of the town of Potosi is stated by Humboldt to be only 2000 feet below the summit of Mont Blanc, and in India those who live habitually at great elevations experience no inconvenience from the rarity of the air. Dr. Hooker recommends a stay for two or three days at a height of 16,000 feet as preparatory to ascending to 20,000. Yet Thibetans, who live at 15,000 feet, always have headaches on walking over passes of 18,000, which they attribute to a poisonous vapour issuing from the mountains. Dr. Hooker asserts that "bleeding at the nose and ears has never been experienced by any practised traveller in health, and is unknown among the natives." We believe alarming hæmorrhage to be really unheard of on such occasions; but unquestionably slight bleedings from the nose, gums, and lips are not unfrequent. Such are recorded by De Saussure, Humboldt, and Boussingault. The latter hints at more serious results in the case of an Indian who had used his voice too strongly in these elevated regions, and recommends, with good reason, that conversation be carried on in an under-tone in order to avoid exhaustion.

The physiology of these various effects is as yet imperfectly understood.[2] The preternatural lassitude which is more commonly

[1] [F. von Tschudi, *Das Thierleben der Alpenwelt*, 2nd edition, 1854, p. 498; the statement is limited to the high towns in the Andes, and dogs are said to live there comfortably, though cats cannot do so.]

[2] [This is still true, and many different opinions have been expressed on the subject. See a good essay on "Mountain Sickness," by Dr. Egli-Sinclair, in vol. xxvii. of the *Jahrbuch* of the Swiss Alpine Club.

As facts are worth more in this matter than theories, I venture to give my own experience in the High Alps. During thirty-three seasons spent in climbing the highest summits of the Alps, and having been nearly one thousand times above a height of 10,000 feet, I have *never* experienced any of the symptoms of mountain sickness, save on one occasion. That was near the summit of the Ober Gabelhorn (13,364 feet), near Zermatt, in 1878. I had then been climbing high peaks for six weeks continuously. On the descent from the summit both I and my leading guide, old Christian Almer (not the younger second man), were taken with slight feeling of nausea. This disappeared as soon as we ate a biscuit and drank a mouthful of wine, and was, I feel sure, due to the intense cold, and to the fact that, for that reason, experienced near the top of Mont Blanc than any other symptom —a lassitude which, in many cases, takes away every sense of pleasure from success—has been ingeniously attributed by the brothers Weber to the deficiency of atmospheric pressure loosening the compactness of articulation at the knee and hip-joints, thus preventing the limbs from working steadily in their sockets. But this is at least a partial view of the subject.

Slopes of Turf.—Turning now to the more external obstacles to success in the ascent of mountains, we shall first mention one which would scarcely seem alarming at first sight to most pedestrians; this is the slopes of short dry turf which so frequently occur on the calcareous mountains of the secondary chains of the Alps, and which, frequently ending in tremendous precipices, constitute a danger, all the more real because it is unimposing. A pedestrian once losing footing on such a slope is almost certain to be carried helplessly to the bottom of it, however it may terminate. No break or irregularity gives him a chance of holding on. The spike of his *alpenstock* is not long enough to take hold on its velvet-like surface. The nails in his shoes are equally inefficacious. In this respect the slope of turf is more dangerous than that of frozen snow, unless it be of the hardest kind. The following example, from Mr. Wills,[1] is applicable to those numerous

we had not been able to halt to eat or drink for many hours. Neither of us had ever before experienced any similar inconvenience. Yet in 1869 we had, owing to very soft snow, taken $12\frac{3}{4}$ hours from the Grands Mulets to the summit of Mont Blanc by the Bosses ridge; but though it was our very first ascent of the season, we felt nothing on the top but sheer fatigue, and slept there comfortably for some time, as also in 1870, when we again reached the same summit from the Brenva Glacier, after a tremendous struggle of nearly 15 hours from our bivouac. I am therefore strongly of the belief that (given fine weather) all the painful symptoms mentioned by Forbes are, as a rule, due to want of training, or to sheer physical weakness, and not to the rarefaction of the air. There are exceptions, however. I knew one person who could not get up the last rocks of Monte Rosa, despite several attempts, by reason of mountain sickness; and yet we had been on Mont Blanc together, in a most violent wind, and the individual in question had not suffered in the least.

For many years I travelled with a dog, named Tschingel, in the high mountains. The dog made a great number of high ascents, including Mont Blanc, Monte Rosa, the Finsteraarhorn, the Aletschhorn, the Jungfrau, etc., yet it never suffered any inconvenience from the high air. Indeed, on Mont Blanc it ran ahead of us to the summit, barking loudly, and then came running back to us; yet it was then ten years old, but had been born and bred in the mountains.

I think it all depends on the strength of the individual, and on the fact whether or no he is accustomed to mount to great heights.]

[1] [Mr. Wills alludes to the Harder (5801 feet). Many fatal accidents have since then taken place there and on other similar slopes, especially to ladies without nails in their shoes. There is a mule-path to the summit of the Harder; but many tourists leave it to pick flowers on the dangerously steep grass slopes on either side.]

English men and women who frequent the familiar environs of Interlaken, little recking of danger:—

Soon afterwards one of the party slipped, and was unable to stop himself. With great presence of mind, he threw himself over by a sudden effort on to his face, and spreading out his arms and legs, and digging his fingers into the ground, succeeded in checking his descent. Nobody could have helped him, and had he not stopped himself, he would, in all probability, have slipped with increasing velocity for some hundreds of feet, and shot over a precipice which happened to be below, between us and the belt of wood. His finger-nails were all broken in the effort to save himself. . . . Seen from below, the slope appears so gentle that this description would scarcely be credited, but it is strictly accurate. A melancholy accident which occurred in 1850, on the other side, where the descent is of the same character, but more rapid still, attests its truth. An English lady staying at Interlaken, one day took the path, and wandered on till she came to the summit. She never returned, and next day her mangled remains were found, some thousands of feet below, on the other side of the mountain. Her foot had slipped, and she had begun to roll: she had seized a young sapling, hoping to arrest her progress, but the impetus was too great; it snapped, and was found in her grasp when the body was discovered. . . . I have twice ascended, and once descended these grassy steeps, and have seldom performed a more dangerous task—easy as it looks. The peasants who mow the grass on the sides of the mountain wear crampons, otherwise even they would hardly get up and down with safety.—*Wanderings*, etc., pp. 242-244.

It was among such treacherous slopes near the Col de Balme that at least one tourist perished in attempting to reach a point called the "Croix de Fer." It is also probable that poor Jacques Balmat, the conqueror of Mont Blanc, ignobly fell a victim in the same way amongst the calcareous mountains intermediate between the Col de Balme and the Dent du Midi.[1]

Rocks and Precipices.—Above the limits of vegetation the surface of a mountain is, of course, either rock or ice and snow. In some districts the former abounds more than the latter, or the reverse, and the skill of the natives in overcoming the difficulties of either depends on their greater experience and opportunities. The peasants of Chamouni are more at home on the glaciers, those of Monte Rosa on rocks. The best guides of the Oberland are,

[1] [The Croix de Fer is 2691 feet, and is a peak of crumbling rock, a slip on which cost the life of Herr Escher of Zürich in 1791. Jacques Balmat made the first ascent of Mont Blanc, with Dr. Paccard, in 1786, and disappeared in 1834 in the limestone precipices of the Sixt valley, at the foot of the Mont Ruan. In neither case apparently did the accident occur on grass slopes, like that on the Harder in 1850. Jacques Balmat was the great-uncle of Auguste Balmat, the guide of Forbes and of Wills, and Mr. Wills dedicates his book to Auguste, "my tried and faithful companion in many difficulties and some dangers."]

perhaps, pretty equally confident in either exercise. More skill is requisite for eluding the difficulties of the ice, more nerve in overcoming those of cliffs; consequently we find that amateurs, after a certain amount of experience, are more at ease among snow than among really dangerous precipices. It is indeed only on the latter that experienced and zealous amateurs have suffered themselves to be left behind by their guides. It requires education of the eye and foot from childhood, unless in special cases, to venture with confidence to scale cliffs nearly perpendicular, and still more to descend them.[1]

Almost every kind of rock is subject to form precipices. None, for instance, are more tremendous than those formed of granite in the Combe de Malaval among the Alps of Dauphiné. The slaty rocks, however, do not stand second in this respect, though they oftener leave distinct footholds. The schistose cliffs of the Jungfrau, as seen from Lauterbrunnen, are familiarly known to all tourists in Switzerland, and the ascent of a portion of them by Hugi, in the Roththal, on the western side of the mountain, forms one of his most ticklish adventures. The comparatively modern slaty rocks of the Mont Cervin exhibit in that astonishing pinnacle the most inaccessible of all European mountains.[2] Towards the north it forms an almost continuous precipice between 7000 and 8000 feet in height.[3] Calcareous rocks are celebrated for their vertical cliffs.

[1] [Forbes's remarks as to the superiority of amateurs over guides on snow are no longer true, if they ever were. It is on rocks that amateur guideless climbers have most distinguished themselves. One of the best of modern rock climbers, the late Mr. Norman Neruda, writes thus: "To the leader of a guideless party the technical difficulties of a snow mountain are most evident, and he will require the greatest skill and experience ere he can aspire to cope with them. . . . In short, he will need an amount of skill and experience which cannot be learned in one or two seasons' climbing, as is the case of rock-climbing." "The highest branch of mountaineering is beyond all doubt snowcraft, and it requires a longer training for the mountaineer to become proficient as an ice-man than as a rock-climber."—*The Climbs of Norman Neruda*, pp. 329-331.]

[2] [The Matterhorn was not conquered, indeed, till 1865; but far lower points have offered much greater difficulties to mountain climbers.]

[3] We preserve this passage as we wrote it, not having then seen Mr. Ruskin's elaborate chapter on "Precipices," in his beautifully illustrated and often able volume *On Mountain Beauty*, which contains many true and original things drawn from a long and ardent study of the Alps. There is an apparent discrepancy between the statement in the text and Mr. Ruskin's assertion that the steepest part of the Matterhorn or Mont Cervin, over which a plumb-line might be hung without striking, is only about from 600 to 800 feet (Ruskin, p. 242), and he appears to consider that as nearly unexampled in Switzerland. Of this we have doubts, but so technical a definition of a precipice is neither usual nor appropriate. All the majesty of truly

The chasms of the Dent du Midi and Dent de Morcles can be forgotten by no traveller who has passed between Bex and Martigny; and such rocks have this additional danger, that limestone is the most slippery and treacherous of any, since strongly-nailed shoes, which in other situations are a defence, become here accomplices to destruction. The rocks of Gosau, in the Eastern Alps, celebrated by Professor Sedgwick and Sir Roderick Murchison, which rise towards heaven in apparently inaccessible spires, are the geological equivalents of the tame scenery of our English greensand.[1]

A "good head" is as much a natural endowment as any other. It may, however, be greatly improved by practice; and the tonic effect of mountain air, as well as the comparative insensibility which experience induces to the really stupendous scale of Alpine scenery, render feats of climbing easier than would be the case under other circumstances. Many men who would hesitate to cross a well-fastened plank of a mason's scaffolding at home will pass *erect* across the "Ponts" at Montanvert, or traverse the Mer de Glace without a moment's misgiving.

Except in the effort to attain a given summit, the climber is not very commonly driven to straits upon rocks, for nature commonly provides a considerable choice of ways in traversing a country.[2] It is rarely that we are shut up to a single prescribed course. But where a direct ascent is our aim, we are never certain till the last moment of attaining our object. Far more

precipitous scenery is sufficiently given by rocks cloven at an angle *approaching* the vertical, even if they do not overhang, which is almost a *tour-de-force* of nature, being in standing contradiction to the ordinary effects of gravity. Still less does a series of narrow *steps*, uniting vertical precipices, interfere essentially with their majesty—nay, such breaks may even add to it as viewed in dizzy perspective from above, and (as in the case of the Brévent as described, we have no doubt most accurately, by Mr. Ruskin) yet may effectually prevent the full descent of the plumb-line. Mr. Ruskin himself virtually admits as much a few pages farther on in his work (p. 248), where, speaking of the limestone cliffs of the Rochers des Fys, not far from Chamouni, he says, "the wall is not less than 2500 feet high—not vertical, but steep enough to seem so to the imagination."

[Those who have been on the north-east face of the Matterhorn, over which the ordinary route from Zermatt more or less passes, will agree with Mr. Ruskin rather than with Forbes. There are, too, many more overhanging precipices in the Alps than Forbes dreamed of.]

[1] [Hence nowadays climbers among the Dolomites wear rope-soled climbing shoes instead of nailed shoes. The Gosau precipices and pinnacles have long ago been scaled.]

[2] [This is not always true of the Dolomites, which Forbes had seen in 1837, though no doubt he considered them quite impossible.]

than in the case of snow and ice we are subject to be "brought up" by an impassable obstacle. This occurs even in mountains of second and third-rate size. The Riffelhorn, near Zermatt, which is now so well known, was deemed inaccessible until within a few years, although nothing was easier than to approach within a few fathoms of the summit. At length some boys tending goats found a passage by first descending upon a rather sloping ledge of rocks.[1] A similar difficulty attends the access to the highest of the Cuchullin hills in Skye, which was first overcome not many years since by a gentleman of Edinburgh, attended by a native guide. These hills, though only about 3000 feet high, may be reckoned as amongst the most difficult of their class, and decidedly the least accessible in Great Britain. Yet the excellent footing of the rugged hypersthene rock of which they are composed prevents any real danger. On the other hand, few rocks, not consisting of sheer precipices, can be pronounced inaccessible until after trial. A mountain face down which we have just descended will often appear, on looking back, absolutely impracticable to human foot. The pass of the Gemmi, which may be traversed on a mule, is a familiar instance of this.[2] The northern face of the Cramont, on the Italian side of Mont Blanc, is another.

The combination of rock precipices with snow or ice is probably the most baffling combination of any. The summit of the Finsteraarhorn in the Bernese Oberland, and that of Monte Rosa, are striking examples. In the former instance the intrepid Hugi [see pp. 207-209 of his work] left it to his robust guides, Leuthold and Währen, to ascend alone the last precipice, the base of which he had more than once attained with extreme toil.[3] A similar result attended the ascent of the experienced Professor Ulrich to the highest of the summits of Monte Rosa, in 1848, from the side of Zermatt.[4] Whilst only snow and ice opposed

[1] [In his *Savoy* (p. 314 above) Forbes attributes the conquest of the Riffelhorn (vainly tried by him in 1841) to some students from Hofwyl in 1842.]

[2] [Few persons would care to mount on mule-back from Leukerbad to the summit of the Gemmi, while since a French lady was thrown off her mule and killed in 1861 the *descent* of the wall on mule-back is forbidden by law.]

[3] [Hugi's guides went up in 1829, their route being the now usual one by the north-west arête, which offers no difficulties to a climber of any experience.]

[4] [See pp. 69-71 of Ulrich's pamphlet. His guides, so far from reaching the summit of Monte Rosa, only attained the Grenzgipfel, the point at which the spur on which rises the highest summit of Monte Rosa joins the frontier ridge. See

his advance all went well, but the precipitous rocky cap, about 300 feet high, was attempted by his guides alone—Madutz and zum Taugwald—who found not only precipices which offered little hold for the feet, but the crevices in the rock were filled and glazed over with slippery ice. The re-descent was so terrific, that one of the guides [z. Taugwald] owed his safety to the nerve of the other, who held him on by a rope. The Messrs. Schlagintweit, who with their guides made the ascent of this precipice in 1851, were also incommoded by the ice, and they had recourse to driving chisels into the rock where they could not by other means obtain a footing.[1]

Many of our readers will recollect the ability with which Sir Walter Scott has given in the second chapter of *Anne of Geierstein* a thrilling account of the younger Philipson's adventure among the precipices of Mont Pilate.[2] This account is the more remarkable because the writer had but a slight personal acquaintance with Swiss scenery, and it may be reasonably doubted whether he ever found himself in such a predicament as that which he so graphically describes. A real adventure of a similar kind was depicted in 1829 in glowing colours by a writer in *Blackwood's Magazine*. The article is now in all probability remembered by few, but the style and the initials (E. S.) point it out as the production of the late Bishop Stanley, to whom it was ascribed at the time. It is entitled "The Mauvais Pas," and describes the ascent of the valley of Bagnes by the author, soon after the catastrophe of 1818, by which all the ordinary means of communication were swept away. We can only select some isolated passages, but the whole paper is worth perusing as a vivid and powerful piece of description:—

the *Alpine Journal*, vol. xv. pp. 493-495. From the Grenzgipfel to the true summit there is no real difficulty according to modern standards, and the expedition has been made several times of late.]

[1] [See pp. 77, 78 of their 1854 book: the 1851 party reached the same point as the guides in 1848. In 1887 the present editor went in $1\frac{1}{4}$ hour from the Silbersattel (where Ulrich halted in 1848) up to the gap a very few feet below the Grenzgipfel, though there was so much snow on the rocks that we floundered rather than climbed, hardly ever seeing the rock, yet encountering no difficulty. From the gap we went in forty minutes more by an easy climb across the Ostspitze to the highest summit of Monte Rosa. We were not the first party which had taken this route, but I mention my own experience to show the difference in standards between the older climbers and their successors.]

[2] [Pilatus, near Lucerne, is 6998 feet in height. In 1887-88 a cog-wheel railway was constructed nearly to the top.]

For a foreground (if that could be called a foreground, separated as it was by a gulf of some fathoms wide) an unsightly facing of unbroken precipitous rock bearded me on the spot from whence I was to make my departure, jutting out sufficiently to conceal whatever might be the state of affairs on the other side, round which it was necessary to pass by a narrow ledge like a mantelpiece, on which the first guide had now placed his foot. The distance, however, was inconsiderable, at most a few yards; after which I fondly conjectured we might rejoin a pathway similar to that we were now quitting, and that, in fact, this short but fearful *trajet* constituted the substance and sum-total of what so richly deserved the title of the *Mauvais Pas*. "Be firm; hold fast, and keep your eyes on the rock," said the guide, as I, with my heart in my mouth, stepped out. "Is my foot steadily fixed?" "It is," was the answer; and with my eyes fixed on the rock, as if it would have opened under my gaze, and my hands hooked like claws on the slight protuberances within reach, I stole silently and slowly towards the projection, almost without drawing a breath. Having turned this point, I still found myself proceeding, but to what degree, and whether for better or worse, I could not exactly ascertain, as I most pertinaciously continued to look upon the rock, mechanically moving foot after foot with a sort of dogged perseverance, leaving to the leading guide the pleasing task, which I most anxiously expected every moment, of assuring me that the deed was done, and congratulating me on having passed the *Mauvais Pas*. But he was silent as the grave—not a word escaped his lips; and on, and on, and on did we tread, slowly, cautiously, and hesitatingly for about ten minutes, when I became impatient to learn the extent of our progress, and inquired whether we had nearly reached the other end. "Pas encore." "Are we half way?" "A peu près," were the replies. Gathering up my whole stock of presence of mind, I requested that we might pause awhile; and then, as I deliberately turned my head, the whole of this extraordinary and frightful scenery revealed itself at a glance. Conceive an amphitheatre of rock forming throughout a bare, barren, perpendicular precipice, of I know not how many hundred feet in height, the two extremities diminishing in altitude as they approached the Drance, which formed the chord of this arc; that on our left constituting the barrier which had impeded our progress, and which we had just ascended. From the point where we had stepped upon the ledge, quitting the forest and underwood, this circular face of precipice commenced, continuing without intermission till it united itself with its corresponding headland on the right, the only communication between the two being along a ledge in the face of the precipice, varying in width from about a foot to a few inches; the surface of the said ledge, moreover, assuming the form of an inclined plane, owing to an accumulation of small particles of rock, which had, from time immemorial, scaled from the heights above and lodged on this slightly-projecting shelf. The distance, from the time taken to pass it, I guessed to be not far short of a quarter of a mile. At my foot, literally speaking (for it required but a semiquaver of the body, or the loosening of my hold, to throw the centre of gravitation over the abyss), was spread the valley of the Drance, through which I could perceive the river meandering like a silver thread; but from the height at which I looked down its rapidity was invisible, and its hoarse brawling unheard. The silence was absolute and solemn; for, fortunately, not a zephyr fanned the air to interfere with my precarious equilibrium. . . . Every sense seemed absorbed in getting to the end, and yet in the midst of this unenviable position a trifling incident occurred which actually, for the time, gave rise to something of a pleasurable sensation. About midway I espied, in a chink of the ledge, the beautiful and dazzling little blossom of the *Gentiana nivalis*, and stopping the guides whilst I gathered it, I expressed great satisfaction in meeting with this lovely little flower in such a lonely spot. And I could scarcely help smiling at the simplicity of these honest people, who from that moment, whenever the difficulties increased, endeavoured to divert my attention by pointing out or looking for another specimen. We had proceeded good part of the way, when to my dismay the ledge, narrow as it was, became perceptibly narrower, and, at the distance of a yard or two in advance, I observed a point where it seemed to run to nothing, interrupted by a protuberant rock. I said nothing, waiting the result in silence. The guide before me, when he reached the point, threw one foot round the projection till it was firmly placed, and, holding on to the rock, then brought up the other. What was I to do? Like Arthur Philipson's guide, Antonio, I could only say, "I was no chamois hunter, and had no wings to transport me from cliff to cliff like a raven." "I cannot perform that feat," said I to the guide; "I shall miss the invisible footing on the other side, and—then!" They were prepared for the case; one of them happened to have a short staff; this was handed forward, and formed a slight rail, while the other, stooping down, seized my foot, and placing it in his hand, answered, "Tread without apprehension; it will support you firmly as the rock itself. Be steady—go on." I did so, and regained the ledge once more in safety. . . . By keeping my head obliquely turned inwards I had in great measure avoided more visual communication than I wished with the bird's-eye prospect below, but there was no possibility of excluding the smooth, bare frontage of rock right ahead. There it reared itself from the clouds beneath to the clouds above, without outward or visible sign of fret or fissure, as far as I could judge, on which even a chamois could rest his tiny hoof; for the width of whatever ledge it might have was diminished by the perspective view we had of it to Euclid's true definition of a mathematical line—namely, length without breadth. At this distance of time I have no very clear recollection of the mode of our exit, and cannot speak positively as to whether we skirted any part of this perilous wall of the Titans, or crept up through the corner of the curve by some fissure leading to the summit. I have, however, a very clear and agreeable recollection of the moment when I came into contact with a tough bough, which I welcomed and grasped as I would have welcomed and grasped the dearest friend I had upon earth, and by the help of which I, in a very few more seconds, scrambled upwards, and set my feet once more, without fear of slips or sliding, on a rough heathery surface forming the bed of a ravine which soon led us to an upland plateau, on which I stood as in the garden of paradise.[1]

Descriptions like these afford, of course, but a *relative* measure of the difficulty and risk of any such task, which ceases to be

[1] [This glowing description seems to relate to the side of a mountain valley, and not to any real mountain ascent.]

agreeable when it passes the limits of what Dr. Johnson happily characterises as "a kind of turbulent pleasure between fright and admiration."

Slopes of Snow and Ice.—We now turn to the peculiar difficulties and risks connected with the passage of slopes of snow and ice. Formidable as these often are they offer more resource to skill and perseverance than precipices of rock, where art can assist little and where everything depends on nerve. Snow of course never exists in absolute precipices, and even those of ice are more limited in extent than may be generally supposed,—always excepting the walls of crevasses underneath the level of a glacier, and with such the less a traveller has to do the better. Extensive steep inclines of snow and ice are among the most serious obstacles which the pilgrim of the higher Alps can encounter,[1] and there are few considerable ascents in the course of which they are not met with. A slope of imperfectly frozen snow, the result of spring avalanches, and lying in highly inclined ravines called *couloirs,* are often more difficult to cross than if they were of the hardest and most slippery ice. Snow has sometimes that treacherous degree of consistence which allows a partial consolidation by the foot-tread, but which suffers the ball or clot thus formed under the sole of the foot to slide like an unctuous substance over the less perfectly compressed snow beneath. In this way the footstep of a traveller may give way after two or three persons have already planted their feet in safety on the same spot. To cross a snow *couloir* of great height and inclination under such circumstances appears to us to be one of the most real dangers of the Alps. But such places can always be crossed safely in the morning when the snow is hard. A surface of ice, covered by some inches of snow, is formidable for the same reason.

A slope of pure ice, at an inclination exceeding 40 or even 30 degrees, has a sufficiently terrific appearance, especially if it terminate below in a precipice of rock or a crevasse of a glacier. Yet the traveller has here in some degree his safety in his own hands. Footsteps may be made so as to give a firm hold to the pedestrian's nailed shoes, if sufficient time be allowed for that purpose. In some rare cases hand-holds as well as foot-holds

[1] [Modern pilgrims to the Alps make a pilgrimage in *search* of such "obstacles," now become rather the "chief objects" of an Alpine journey.]

must be made in the ice face; but only small spaces are ever crossed in this way. Mr. Auldjo has represented an instance of this kind in the tenth illustration of his ascent of Mont Blanc,[1] and M. Hugi has described [p. 207] a similar case in the last ascent of the Finsteraarhorn [in 1829] by his guides, in which he alleges, with what accuracy we know not, that at each step the men had to pause and let their shoes be *slightly frozen to the surface to which they clung.* In ascending steep slopes of ice it is often advisable to take them *right in front* instead of going in zig-zag, as one is naturally inclined to do; for though more laborious, travellers and guides may thus effectually assist one another, and in case of a rope being used to tie them together, or for all to hold by, the risk of accident to the whole party is materially diminished.[2] For it is evident that if a file of men ascend a ladder and one of them slips, he is sustained by those immediately beneath him, and his weight is partly thrown by means of the rope on those directly in advance; but if one of a file in an oblique ascent lose his footing, he comes into contact with no man, and the strain falls, by means of the rope, on the two persons alone between whom he is placed. By the obliquity of the strain it is also, by a well-known principle in mechanics, rendered more intense, and if either of his immediate supporters lose their footing the whole party must inevitably go down. The *Mur de la Côte*, on the final ascent of Mont Blanc, is one of

[1] The pleasing illustrations of Mr. Auldjo's work unquestionably present exaggerated views of several scenes. This is probably one. The breakfast party on the snow bridge certainly is. If such a mass of snow could hang for a moment in the circumstances there represented, no sane man would stand upon it for a moment longer than necessary. We may remark that such scenes are rarely carefully drawn at the moment, but are usually executed afterwards under a vivid recollection of the dangers run. Nor are authors always to blame for pictorial exaggeration. It is one of the vices of the day that artists of all kinds find it their interest to astonish, by "cooking" the sketches placed in their hands up to the stimulant tone required by the appetite of book-buyers. Mr. Browne's sketches of the ascent of Mont Blanc, though evidently done for the most part from recollection, are probably the best that have been published of this kind of scenery.

[Forbes's severe remarks as to the accuracy of Mr. Auldjo's illustrations are fully warranted. But it need hardly be said that none of these sketches of terrible bits were done *on the spot*. Nowadays such bits can be taken at once by photography. The title of Mr. J. Auldjo's book is *Narrative of an Ascent to the Summit of Mont Blanc on the 8th and 9th of August, 1827*. London, 1827. Forbes refers to the 1830 8vo edition, which alone has the two illustrations mentioned, Nos. 10 and 12. The title of Mr. J. D. H. Browne's work is *Ten Scenes in the Last Ascent of Mont Blanc*. London, 1853.]

[2] [It is right enough to cut straight up a steep ice-slope, but the party must *always* be *tied* together by the rope on such occasions.]

the best known and most frequently described ice-slopes of the kind. But even the Mur de la Côte is a much less serious obstacle of its kind than many other ice-slopes which occur in the Alps. One certain proof of this is, that hardly any climber of Mont Blanc, not even Mr. Albert Smith, dwells on the difficulty of the descent, which is really by far the most formidable affair when the incline is severe. On such occasions it is necessary to descend as on a ladder with the face towards the hill, in order to insert the toes in the steps previously made. It is extremely difficult to hew out ice-steps in descending; hence in crossing elevated *cols* the frozen side should be preferred for the ascent.[1] Messrs. Schlagintweit, in their ascent of Monte Rosa in 1851, returning by a different way, fell in with difficulties so serious, that even with their experience they were almost overtaken by evening on the heights of the mountain before they had a prospect of extrication; and at last were compelled to *descend* a couloir of hard ice, having an inclination of from 60° to 62° (which viewed from above appears almost vertical), perhaps the steepest which has ever been approached in that manner.[2]

Occasionally the ice of mountain-tops presents a *double* incline, like the ridge of a house-roof, only usually far steeper, so that a man may easily sit astride of it. This is, of course, a formidable trial to the nerves, especially if it be of hard ice in which steps must be cut. It is to be traversed lengthways by making good footsteps on one side of the incline parallel to the ridge, and planting the ice-pole firmly into the opposite slope. The extreme summit of the Jungfrau is of this description.[3] The approach from the south to the highest part of Monte Rosa is similar to it.

There is one peculiarity of the higher regions of snow and ice which deserves a passing notice, on account of its singularity and of the caution which it suggests. There is no elevation in the Alps at which fusion of the snow does not occasionally take place by the force of the sun's rays; but as it rapidly freezes,

[1] [But what if, as often happens, *both* sides are frozen?]

[2] [See the 1854 book of the Schlagintweits, pp. 78, 79. As pointed out above, this party reached the Grenzgipfel only, and not the summit of Monte Rosa. The couloir is stated to have been of snow, which was only here and there turned into ice.]

[3] [See Forbes's sketch in *Norway*, p. 321: it is given above, p. 449.]

the tendency is to form a hard crust of ice upon the softer snow beneath. In consequence of this and of the drifting of the snow in the eddies which always occur at the top of a precipice on the lee-side of an exposed slope, a hardened crust of projecting ice [or snow] is apt to be formed in such situations, which may be compared to the eave of a roof. Now a traveller groping his way on the difficult slopes of the higher ice, while he leaves, as he thinks, from two to three feet of solid ground between him and the abyss, may in fact be resting his weight on the treacherous and baseless projection of ice [or snow] which we have described.[1] In his account of the ascent of the Jungfrau with M. Agassiz, Professor Forbes gives in a few words an idea of this serious danger:—

> Whilst we were marching patiently at what seemed a safe distance from the edge, Jacob [the guide] made us almost tremble by piercing, with a few blows of his alpenstock, the frail covering, within two or three feet of us, revealing through the gap the vacuity through which we might have dropped a stone upon the glacier beneath.[2]

Professor Hugi of Soleure was nearly the victim of a similar incident in one of his attempts to reach the summit of the Finsteraarhorn, which he has described in graphic terms [pp. 193, 194]. The scene of the adventure was laid 13,000 feet above the sea, on the sharp [N.W.] ridge of that savage mountain, which terminated on one side in a precipice of terrific height, on the other in a steep incline of ice hardly less formidable. One of the guides, Dändler [Tännler] by name, was in front of the Professor, holding in his hands a long pole, perhaps intended as for a flagstaff to commemorate their exploit. Suddenly the guide slipped on the face of ice, and would have glided instantaneously to the bottom had not M. Hugi leaping forward seized the other end of the spar. The instant he did so the ice[3] gave way beneath his feet: he had unawares thrown his weight on the treacherous crust of frozen snow of which we have spoken, which in this instance projected five or six feet over the edge of the rock on the precipitous side of the ridge. There he hung quite loosely

[1] [This projection, generally of snow, rarely of ice, is technically called a "corniche," or an "Ueberhang."]

[2] [See Forbes's *Norway*, p. 319. The passage is reprinted above at p. 447. The spot was some way above the Roththalsattel, the corniche overhanging the névé of the Great Aletsch Glacier. A diagram is given in both cases.]

[3] [The original text says Firn, *i.e.* névé, or hard snow, *not* ice.]

in the hole which he had made, and through which he could deliberately view beneath his feet the surface of the Finsteraar Glacier 4000 feet vertically beneath him. His sole security was the counterpoise of the guide who had lost his footing on the opposite incline of ice, but who fortunately retained his hold upon the spar. From this unpleasant game of *see-saw* both parties were with some difficulty rescued by the assistance of their companions.

The Glaciers—Crevasses.—Trifling, indeed, compared to the dangers of such ascents as the preceding, yet not unworthy of notice, are those of the lower and more accessible glaciers, which, as every one knows, are traversed by fissures which constitute one of the great objects of interest to the curious traveller. These fissures or *crevasses* (for the English word *crevice* is wholly inapplicable to their usually stupendous dimensions) may be found of all degrees of magnitude, and they present to the traveller obstacles more or less formidable. Many glaciers whose slope is inconsiderable exhibit for a great space fissures so trifling in extent compared to the solid parts of the icy river as to offer no difficulty whatever in their passage; and to walk over such level ice is less fatiguing than over rock or even over turf, the feet being kept pleasantly cool and the nerves reinforced by the perpetually fresh atmosphere which prevails over the glacier even in the warmest weather. The glacier on the Col of Mont Cervin,[1] although 11,000 feet above the sea, is frequently crossed by loaded mules; as is, we believe, the glacier of the Gries between the upper valley of the Rhone and Domo d'Ossola.[2] The Unteraar Glacier might probably be traversed without difficulty on horseback for several miles.[3] But the contrary case is the more common, and perhaps no glacier is devoid of difficult chasms in some part of its extent. At their lower extremities in particular they are often altogether impracticable. The steepness of the slope on which they sometimes terminate breaks up the texture of the semi-solid ice by crossing fissures or hatching, while the great summer heat of the valleys into which they thrust their icy snouts acuminates the parallelograms into which they are

[1] [The St. Théodule Pass, 10,899 feet.]

[2] [The Gries Pass, 8098 feet, from Ulrichen in the Upper Rhone valley to the Val Formazza and so to Domo.]

[3] [The chief difficulty nowadays would be to surmount the vast moraines at the snout of this glacier.]

thus broken up, and occasions those exquisite pyramidal structures of pellucid ice [1] which all travellers admire in the Glaciers of Bossons and Rosenlaui.

In their higher portions again, near the limits of perpetual snow, where the ice-river becomes indistinguishable from the vast reservoirs whence it takes its origin and its supply, the fissures have a somewhat different character. The ice in motion is imperfectly consolidated, and has less resistance to fracture than elsewhere. It is consequently broken short across, as it is forced by gravity over even slight inequalities; but where the descent is rapid, fissures of the most enormous size occur, seaming the glacier entirely from side to side,[2] and hindering a passage save by some snow bridge which has survived the thaws of spring and summer. The upper part of the Glacier des Bossons presents such obstacles to the ascender of Mont Blanc from Chamouni as that of the Géant opposes, by a perhaps more serious barrier, the passage of the col of the same name. Such difficulties, common to most extensive glaciers, are the more perplexing that they usually occur in defiles or ravines through which the icy masses uneasily struggle, and which very commonly, in proportion that their channels (Germ. *Thalweg*) are more inclined, have their walls also more precipitous, so that footing is alike denied on ice or rock to the explorer of the upper Alpine world. To pass among such crevasses requires, as has been already said, a *rational* acquaintance with the principles according to which the accidents of the ice are affected by the fixed obstacles opposed to its motion. In some cases we may take a glacier right in front, in others we must first gain its surface at 1000 feet or more of elevation; in some instances we must eschew the centre, in others the sides. Every promontory has its influence on the state of the ice above and below it, which may be shrewdly guessed at by a skilled person traversing the glacier even for the first time.[3] Most tourists know nowadays something of the complex path which leads across the Mer de Glace of Chamouni to the Tacul and the Jardin, of which

[1] [These are called "séracs," from a stage in the process of making whey.]

[2] [These are called "ice falls."]

[3] Mr. Wills repeatedly mentions the advantage which his Chamouni guide, Auguste Balmat, had even over natives in finding the best route across glaciers quite unknown to him, in consequence of his accurate knowledge with the circumstances which regulate the state of the ice.

[Such skill is only possessed by a few first-class guides.]

the curiously monotonous irregularities are faithfully reiterated year by year, notwithstanding the perpetual flow of the ice. This traverse is indeed the *pons asinorum* of amateurs, the Scylla and Charybdis of "aspirant" guides. Take a single wrong turn to the left (we speak of *descending* the glacier) and you are thrown upon knife edges of ice, with vertical sides thinning out as you approach the *moraine;* escaping that, and turning to the right, you are gradually but inevitably drawn into the vortex of confusion which exists towards the centre of the glacier, whence escape is physically impossible, except by retracing every step to the point where the error was made.[1]

The respectable Bourrit's remark[2] on this singular passage (opposite the point called *l'Angle*) is as true now as ever: "I never once succeeded," he says, "in finding an exit by the same block of ice on which I had entered; but, on the contrary, often wandered about for three quarters of an hour, the guides meanwhile having recourse to witchcraft to explain this effect of the multiplicity of similar objects which long habit does not enable us to distinguish." Of course the lesson is *at last* learnt—the practised guide threads his way like an Indian on his trail; the less experienced are content to place little piles of stones to guide themselves day by day.

The dangers of the lower and middle glaciers are at least open and undisguised. No one ought on any consideration to traverse them to any extent without a companion, though not necessarily a guide in all cases. The consequences of an irretrievable slip beyond the reach of help are too awful to be lightly risked. But it is only in solitude that there is any real danger. The cases of men lost or nearly lost in glacier crevasses have, in every instance that we can recollect, been of those who were unaccompanied.[3] A clergyman named Mouron[4] is probably the only amateur who has died in consequence. Bohren, a peasant of Grindelwald, slipped once alone into the upper glacier of that valley, and after three hours of sufferings, such as we may imagine in that horrible

[1] [The difficulties of the Mer de Glace and the degree of skill required to overcome them are far less according to modern standards than in the days of Forbes.]

[2] [*Description des Glacières*, etc., 1785 edition, vol. iii. pp. 106, 107.]

[3] [This statement was not exact even in Forbes's day; since then many persons, even accompanied, have been so lost, as they were not tied together by a rope.]

[4] [A young Swiss pasteur, who fell into a crevasse in 1821 on the Eismeer, or upper part of the Lower Grindelwald Glacier.]

dungeon, regained the upper world.[1] Michel Dévouassoud, of Chamouni, fell into a crevasse on the Glacier of Talèfre, a feeder of the Mer de Glace, on the 29th of July, 1836, and after a severe struggle extricated himself, leaving his knapsack below. This identical knapsack reappeared in July, 1846, at a spot on the glacier surface *4300 feet* from the place where it was lost, as ascertained by Professor Forbes, who himself collected the fragments, thus indicating the rate of the flow of the icy river in the intervening ten years.[2]

The more plastic forms of the snowy matter of the highest glaciers and its greater fragility produce, as has been observed, more stupendous, if less profound and definitely bounded chasms. These terrific rents sometimes stretch almost from side to side of the glacier, and require much address in evading them. Sometimes the traveller must perform a succession of ascents and descents on nearly vertical walls of ice, and at others must pass under menacing pinnacles which a few instants may detach and cover his difficult pathway with their ruins. Still higher up the rents frequently become grottos covered with snowy roofs, beautiful but treacherous, which, yielding beneath the foot of the unwary pedestrian, would in all probability introduce him to a nearer acquaintance than he desires with the palaces of enchantment beneath, were he not brought up by a sudden tug at the good rope well fastened to his waist, and that of his firmly footed companions in the rear, who are ever on the watch for the disappearance of a friend through pitfalls as invisible as those on the frail bridge of Mirza's vision. Yet it is usually a sign of inaccurate pilotage if such an incident occurs. The "sounding" of superficial snows by the pike or alpenstock of the foremost guide is as necessary as the heaving of the lead in a fog in Yarmouth Roads; and rarely does that good implement belie the trust reposed in it. His

[1] [Christian Bohren's adventure took place in 1787 on the Upper Grindelwald Glacier.]

[2] [For details see the *Life and Letters* of Forbes, pp. 318, 319. Perhaps the most remarkable finds of this kind are those made of recent years, near the snout of the Bossons Glacier, of relics of Dr. Hamel's and Captain Arkwright's parties, who perished respectively in 1820 and 1866 on the highest slopes of Mont Blanc in the "Ancien Passage," in both cases by reason of an avalanche. In 1886 the present editor discovered on a glacier at the head of the Val de Rhèmes (a tributary of the valley of Aosta) the bones, fragments of clothing, etc., of a man. He was told at the village below that similar discoveries had been made previously, in one case a coin of the seventeenth century having been found with the remains of some poor shepherd or chamois hunter, who had met his death alone by falling into a crevasse.]

alpenstock is the first security of the traveller over snow and ice, a rope the second, and a hatchet the third. The loss of any one of these implements may endanger a man or a party. A geological hammer, with an axe-like termination, habitually worn by means of a strap round the waist, is a sure help in many unforeseen accidents.[1]

Avalanches.—This is the greatest and the most resistless catastrophe which can overtake the Alpine pedestrian. Very few indeed are the casualties which it has occasioned amongst amateur frequenters of the mountains,[2] because they go thither at a season when the "dread lauine" is comparatively rare; but of all the thousand crosses which mark the slopes of those Alpine thoroughfares which the humble traveller is driven to pass at untimely seasons, or by which the hardy peasant seeks his home in the upper valleys, the vast majority are memorials of this unforeseen and most appalling messenger. The very commotion in the air occasioned by the impetuous rush of millions of cubic feet of consolidated snow have been sufficient in some instances to uproot trees, and to unroof cottages, or even to remove them bodily to a distance.[3] The avalanches of summer and autumn are, of course, far more local and far less tremendous.[4] But they do occur, and tact in discriminating localities affected by passing avalanches (not only of snow, but of stones from the surface of lofty glaciers[5] niched in the recesses of the higher mountains), and in estimating the general condition with reference to consolidation of the snow which may recently have fallen, are important articles of mountain craft. Almost the only instance[6] of a climbing party being overtaken by an avalanche in summer is the well-known one of Dr. Hamel and his companions in their attempt to ascend Mont Blanc

[1] [Alpenstocks, hatchets, and axe-like geological hammers are now quite superseded in the High Alps by the ice-axe, an instrument scarcely known in 1857.]

[2] [Unfortunately many amateurs have perished since 1857 by reason of avalanches. The spring avalanches, to which Forbes alludes, are but one of the many varieties of avalanches; and the most dangerous falls take place in summer, as those in the spring are mainly of "dust snow," but in summer of ice.]

[3] [Forbes thinks only of large snow avalanches in winter or spring, but many smaller ones occur at all seasons.]

[4] [The present editor resides all the year round in the High Alps, so that he permits himself to express his entire disagreement with this dictum of Forbes. At the two seasons named the size of the avalanches may be less than in winter or spring, but they are even more dangerous.]

[5] [Every climber now knows that stones come down from rocks as well as from glaciers and from ice or snow slopes, above the traveller.]

[6] [Alas! the list has been much enlarged since 1857.]

in 1820. An interesting narrative of the accident, by which three guides perished,[1] was printed by one of the party, Mr. Durnford [really Dornford], in the *New Monthly Magazine* [for 1821], and has since been transferred to the pages of Mr. Albert Smith's little work [pp. 110-127]. It does not appear that by any amount of foresight the catastrophe could have been certainly foreseen, although the immediately preceding bad weather, which detained the travellers for a whole day at the Grands Mulets, most probably helped to occasion the treacherous state of the snow.

Having thus drawn some outlines of the difficulties of the higher Alps, we may add that, with few exceptions, they are real dangers chiefly to the timid or the foolhardy. The former want the determination to conquer, which is often the talisman of success; the latter, seeking dangers unprepared, may really fall a sacrifice to them when they least expect it; and, looking to the tone of some of our recent young English tourists, we cannot but fear that some grave accident may ere long occur as a warning to the rash and inexperienced. Alpine adventure has a great analogy to that of our Arctic expeditions. In both the average freedom from casualty has been surprising. This is to be attributed to the caution inspired by an adequate conviction of the risks to be encountered. We all know that in daily life accidents usually occur when we least think of them. People seem to take a pleasure in breaking their legs when they are doing nothing heroic. Circumnavigators are drowned in pleasure boats, and Crimean heroes come home safe and sound to blow off a hand in following grouse or red deer. In the case of Arctic adventure, the public feels that one great calamity obliterates the lustre of many partial yet fruitless successes, and we rather think that our roaming countrymen in Switzerland will do well not to intermit the precautions which hitherto have been so successful in averting accidents, even though Mont Blanc should be scaled one time the less, or the subjects of the King of Sardinia at its foot should pocket a few more needless English sovereigns.

And now let us be excused for saying a few words on the subject of *guides*, prominently brought before us by the narrative of Messrs. Hudson and Kennedy. It appears that though these

[1] [This accident occurred in the "Ancien Passage," a route rarely taken since. The three guides lost were Pierre Carrier, Pierre Balmat, and Auguste Tairraz. As to the recent discovery of relics of this party, see above, p. 508.]

gentlemen and their companions claim to have ascended Mont Blanc "without guides," they took the chasseurs of St. Gervais over all the ground which was, properly speaking, new, and availed themselves of their directions in recovering and following the beaten track from Chamouni, with every incident and particular of which they had made themselves familiar by previous inspection of the mountain and of models, and by obtaining, as far as it could be had *gratis*, the local information possessed by the guides of Chamouni. In executing the ascent they had indeed to rely on their own courage and presence of mind, and in this they ably succeeded. But their circumstances were peculiar. The powers of endurance of every one of the party were thoroughly known, and had been tried by previous experience, accompanied by guides, in equally or more dangerous places. Fortunately all went well with them. They did not meet a single obstacle or inconvenience on which they had not counted. Had any one been taken ill, or had bad weather even to a moderate extent supervened, the conclusion might have been less happy. As it was, on their return they had the difficulty in crossing the Glacier of Bossons [1] by daylight, and they admit that it might have happened to them to "pass the night on the ice without any shelter," and to "keep themselves warm by exercise until the sun rose" [p. 77]. When we recollect that the whole of the provisions and the wine had been disposed of the previous forenoon, save an "atom of mutton and an equally insignificant piece of bread" [p. 67],[2] the chances are that that night would have been the last for one or two of the party; and had it begun to blow or snow, the whole of them must have perished. Fortune indeed favours the brave, as these our young countrymen undoubtedly are, but it is possible that they have not yet known what it is to be put to shifts by bad weather.[3] In such cases a tried mountaineer, one who passes his *winters* [4] as well as his summers among the High Alps, has an unquestion-

[1] [Properly speaking, the "junction" of the Bossons and Taconnaz Glaciers.]

[2] [Forbes did not think that in later years many parties would be benighted on the ice, without much food or drink, and yet would suffer only temporary inconvenience.]

[3] [But a few days previous to their success the same party had been defeated, very high up, by bad weather, in an attempt on Mont Blanc from the Col du Géant. See p. 16 of their book.]

[4] [Forbes did not imagine that in later years amateurs, as well as guides, would pass their *winters* among the High Alps, as has been the case in several instances.]

able advantage over less experienced, however zealous, and courageous climbers.

As to the rates charged for the ascent of Mont Blanc, and the rules which prevent the selection of guides at Chamouni, we think them provoking enough. But it is fair to recollect that they are the result of that elaborate bureaucratic system which prevails in most continental states, and which the mere actors in it are utterly incompetent to redress. The code of laws of the Society of Guides, far from being the result of local association, is concocted and enforced at Bonneville and Chambéry, and the smallest change in them [1] requires as many protocols as to alter the frontier of the Danubian Principalities. Consequently the harshness of the step announced in the following passage is only equalled by its absurdity: "There has been lately," say the Mont Blanc tourists,[2] "a destructive fire at Chamouni. A member of our party left a cheque for the sufferers, on condition that it should remain untouched until an English traveller should be at liberty to choose his own guide, and to determine for himself the number he required."

In truth we fear that neither the conduct of our self-guided friends, nor that of a majority of candidates for the reputation of having ascended Mont Blanc, will tend to raise the character of our countrymen with the keen-witted peasants of Chamouni. These last unite a discrimination of character such as we do not recollect to have met with in any other persons of their rank of life with truly diplomatic power of turning it to account, and of accommodating their behaviour to the temper of the persons with whom they have to deal. Hence they cannot but feel the thoughtless *brusquerie* and affectation of superiority with which it is to be feared they are too often treated. It is easy to scoff at the guides of Chamouni as in "great part competent only to escort the *dilettante* tourist to the giddy heights of the Montanvert, or to carry a lady's shawl to the dangerous pinnacle of the Flégère."[3] But in this, as in other callings, life is not all spent in heroic actions. The less excited observer will rather find reasons for high commendation in observing how the bravest and

[1] [At the end of 1892 the Society of Guides at Chamouni was dissolved as an official corporation, and the rules (more or less amended since 1857) abolished; but the new *voluntary* Society of Guides since formed has adopted pretty nearly all the worst features of the old rules.]

[2] [Hudson and Kennedy, p. 4.]

[3] [*Ibid.* p. 3.]

most intelligent natives of Chamouni fulfil, not only with faithfulness but with alacrity, the daily routine of their business,[1] and adapt themselves with a skill and good humour which has often excited our admiration to answer the silly questions with which they are pestered, and to keep on good terms with the young hot-bloods, who are apt enough to fancy that they can give them a lesson in their own calling.[2]

Indeed, to appreciate the advantages (without calling in question the disadvantages, which are not denied) of the Chamouni system, one ought to be acquainted with the intolerable inconveniences to which the traveller is perpetually subjected in nearly every other part of the Alps.[3] The guides of Courmayeur are, as described in the work before us,[4] ignorant and impracticable; those of Martigny, in general, stupid and sulky. The Oberland guides are, many of them, excellent; but the German constitution, though enduring in a high degree, is often unimpressible and disagreeably phlegmatic, not rarely obstinate and imperious.[5] Beyond the places which we have named, the traveller is often at his wit's end to find competent guides. He may induce a chamois-hunter now and then to give him a day's service, which stands him in good stead; but to engage such guides for prolonged journeys is usually impossible, the safety of their precarious harvest far outweighing such remuneration as a tourist can offer.[6] In the Eastern Alps and in part of Piedmont drunkenness is the rule and sobriety the exception.[7] The guides of Chamouni are, in short, nearly the only men who can be counted on at all

[1] [Forbes here allows himself to be carried away by his natural partiality for the Chamouniards, unless these have greatly altered since 1857.]

[2] [Forbes evidently here is thinking of his own favourite guide, Auguste Balmat, an exceptional man in many ways.]

[3] [In reading the following remarks of Forbes, one should bear two points in mind:—

(*a*) That the Chamouni guides were the first to be organised, and so long enjoyed a monopoly, which has now passed away, in great part owing to the annoying rules already mentioned.

(*b*) That since 1855 the guides of other districts have been organised, and avoiding the errors of the Chamouni system, have completely beaten the Chamouni men out of the field, the Oberland guides being now at the top of the tree.]

[4] [Hudson and Kennedy, pp. 4, 5.]

[5] [The present editor has had Grindelwald guides *continuously* for thirty-one summers and winters, so that he cannot resist repelling with indignation these unfounded accusations of Forbes.]

[6] [Naturally men only take up the *profession* of guiding when there is a considerable and constant demand in their district for guides.]

[7] [Things are now greatly improved in both districts.]

seasons for engagements of any kind and of any length, whose sobriety, honesty, and courage are even still almost without a blot.[1] Something must be paid for these advantages, and though the dangers of Mont Blanc may not be very great, a series of successive ascents of such a mountain undoubtedly take a great deal out of a man even when he is in the highest prime of life, and on that account require higher compensation. It is all very well to ascend Mont Blanc for once—nay, even once a year;[2] but if it becomes regular taskwork it deserves to be well paid for.[3] It is indeed strange that a feat to which so little that is heroic can now be attached should still excite such earnest longing on the part of Englishmen.[4] There are other fields of adventure not hemmed in by the rules of the Guides' Society [of Chamouni]. Why do our aspirants for mountain honours not attempt the almost untrodden snows of Monte Viso, and Mont Pelvoux, of the Aletschhorn and Fletschhorn, of the Tödi and the Bernina?[5] Even at Chamouni, if they want a difficult feat, not on the tariff of the guides, did they ever try the highest part of the Aiguilles Rouges? Who has mounted the Aiguille du Midi since Mr. Romilly nearly forty years ago?[6] And is it

[1] [Things are greatly altered for the worse at Chamouni, and local men are rarely taken now to other districts, as in the olden days.]

[2] The only tourist who has been more than once on the summit of Mont Blanc is M. Ordinaire, a medical man, we believe, of Besançon, who ascended twice *within a week* in the summer of 1843; and in the interval, if we recollect rightly, performed several other fatiguing excursions. His object was merely amusement or "distraction." [Of course many other travellers have since Forbes wrote climbed Mont Blanc several times, Mr. C. E. Mathews (one of the founders of the Alpine Club) having performed this feat twelve times, and M. Vallot (director of the Mont Blanc Observatory) no fewer than twenty-five times. M. Ordinaire is remembered in Alpine history as having, with his brother professor at Besançon, M. Puiseux—in 1848 the first to reach the highest summit of the Pelvoux, in the Dauphiné Alps—been the first to attempt, in 1847, Monte Rosa from the Zermatt side, though his party did not get beyond the Silbersattel, less than 500 feet below the highest summit.]

[3] [On the contrary, thinks the present editor. Experience has shown that the ascent of Mont Blanc by the ordinary route (and Chamouni guides nowadays do little else in the matter of high ascents) is very easy in every respect, while it has also been shown that the least capable guides in any district are those who go on climbing their own mountains, and the best those who also travel to other regions of the Alps.]

[4] [Why not? It is the highest summit in the Alps.]

[5] [Of the six peaks named but two were still virgin in 1857, when Forbes wrote—the Aletschhorn (first climbed in 1859) and Monte Viso (conquered in 1861). The Tödi was attained in 1824, the two summits of the Pelvoux in 1830 and 1848, the Piz Bernina in 1850, and the two summits of the Fletschhorn in 1854 and 1856.]

[6] [As to this alleged ascent, see above, p. 232.]

on record that the summit of the Aiguille Verte—next but one in height to Mont Blanc in that group—has even been attempted?[1]

The ascent of Mont Blanc has been degraded into an affair of waste and absurdity; of excess in eating and drinking; of salvos of artillery and syndic's extortions.[2] The Chamouni guides, seeing that no honour nor much credit is now to be got out of it, make it an affair partly of lucre and partly of jollity;[3] and it is to the credit of the peasantry that worse scenes than have taken place cannot be quoted, and that the voice of detraction has never been able to record of them a momentary dereliction of responsibility or even a brutal word.[4]

The question cannot fail to be asked and answered, how far these pedestrian feats have fulfilled expectation, and are worthy of being encouraged and repeated? It has been customary to consider them as perilous adventures, to be justified only by their contributing important information in physical science to the common stock. This is the tone taken by the author[5] of that part of Murray's Handbook relating to Savoy, in which much is said of the cruelty of risking the lives of the guides for the gratification of mere curiosity. Serjeant Talfourd, in his pleasant *Rambles*, criticises this statement as not justified by the risk incurred, which he holds to be trifling, and also as placing a mere acquisition of scientific *facts* so immeasurably beyond the influence of such unparalleled scenery in enlarging our ideas and fascinating the human mind. In this we think that Talfourd is perfectly correct.[6] Even were the experiments which can be made upon mountain tops of very material importance, they could not confer alone the privilege of embarking on such expeditions. But this becomes a more irresistible conclusion by

1 [The Verte is surpassed in height by the Grandes Jorasses, and several of the satellites of Mont Blanc itself, see above, pp. 90, 115. It was not climbed till 1865 by Mr. Whymper.]

2 [Even in 1857 this was only true of ascents from Chamouni by the ordinary route, and since that date many new routes up have been discovered.]

3 [Naturally, in order to beguile the almost intolerable tedium of always making the same ascent.]

4 [Things have since 1857 changed much for the worse at Chamouni.]

5 [Probably Mr. W. Brockedon.]

6 [Forbes here rises above his usual level, and goes against several of his own statements in the earlier part of this article. Climbing is an amusement as much as hunting or yachting, and scientific observations are not required from votaries of these two "sports," which are, too, far more dangerous than climbing.]

far when it is clearly perceived, what we unhesitatingly affirm to be the fact, that in scarcely one instance have the results of such hasty ascents to Alpine pinnacles been of real service to any of the physical sciences. Some of the observations made by De Saussure on the top of Mont Blanc were of interest at the time [1787], when the condition of the atmosphere at such heights could only be inductively guessed at. But one or two repetitions were more than sufficient to register these broad and incontrovertible facts. The *laws* deducible from them, and which alone are important, cannot be obtained from a few hours of difficult and embarrassed observation. De Saussure did more —infinitely more—for science by residing for seventeen days [July 3-19, 1788] at the more moderate elevation [11,060 feet] of the Col du Géant, than he did by his ascent of Mont Blanc, or than has been done by all the ascents [of Mont Blanc] which have occurred since his time. M. Agassiz in like manner benefited science materially by his prolonged sojourn [in 1840-44] on the accessible Unteraar Glacier, but he added nothing to it by his adventurous ascent of the Jungfrau.[1] Baron Humboldt complained that he was wearied with questions about the ascent of Chimborazo[2] by persons who imagined that he was to reap there in a few hours a harvest of information about physical geography which was in reality due to his long and patient study of more accessible regions. In truth so inconsiderable was the result that the account of the expedition is to be sought among the fugitive pieces of the great naturalist.[3] So it is with every other ascent to a mountain top which could be named. As we get beyond in succession the woods, the pastures, the animal and vegetable life of medium elevations, the scope of observation is restricted; we leave the very glaciers below us, the rocks are fewer and less varied, and all organic and inorganic nature, so far as it can be studied with minute attention, is commonly reduced to a small foothold of unblemished snow. Thus, then, the scientific argument is reduced to a very narrow compass. The lessons are to be gathered on the road, and not at the goal.

The lover of scenery and the more general student may be

[1] [With Forbes in 1841. See pages 443-451 above.]
[2] [Of course he did not *ascend* Chimborazo, but only tried the ascent.]
[3] *Kleinere Schriften.* Erster Band.

allowed a wider range of motives; and to such the attainment of an exalted elevation is a pleasure, peculiar, exquisite, and impossible accurately to define. The completeness of the conquest over obstacles, the perfect comprehension of all the parts of a mighty whole, the immeasurable grandeur of a wide horizon suddenly presented to the eye, are sources of pleasure which must have been experienced to be understood. Of these we believe that the entire apprehension of the topographical and other details of an extensive hilly country, previously estimated only by a partial insight into its component elements, is to an intelligent mind the most pleasing and permanent.[1] The thorough comprehension of every detail of a majestic Alpine group, ramified into mutually dependent chains and pinnacles, diversified by valleys and ravines, broken up by glaciers, snow-beds, and precipices, the whole arising out of undulating lines of wood and cultivation, and of which the mutual relations are comprised in a single glance; such a revelation may be compared to that which the mathematician enjoys when he arrives at a knowledge of a widely general theorem which embraces in one compact expression a volume of previously scattered knowledge, or to that which a naturalist may feel when he masters some comprehensive principle in the structure of the animal or vegetable world, and sees how it accounts for and co-ordinates a thousand minute particulars before scarcely understood.

Another, and perhaps a still more universal source of pleasure in a mountain view arises from the novelty as well as the completeness of the point of view. A bird's-view, if not, properly speaking, picturesque, and the impossibility of rendering it pictorially pleasing is a proof that it is not so, presents familiar objects in new and surprising combinations and aspects. To see under our feet pinnacles on which we have always hitherto gazed upwards with admiration and awe; to trace the ice-stream from its very birthplace in the mountain-cleft to its point of dissolution among the warm verdure of the valleys; to have eternally sterile rocks and unchanging snows for our foreground, while shelter and cultivation and all the works of man are removed to a distance which *feels* unapproachable though clearly discerned; to see at a glance, *all round* the most stupendous

[1] [The present editor ventures to applaud this opinion, on the ground of his extended experience of such scenes.]

barriers of nature, and be present, as it were, at the same moment in two different valleys, leagues apart, which belong to different kingdoms, where different languages are spoken, and whose waters flow into different seas, such novelty of combination among familiar elements excites the imagination, and gives rise to that feeling of admiring surprise which persons possessing the smallest share of the poetic temperament have usually felt in such situations.

To these pleasurable and ennobling sensations we must add the physical exhilaration which commonly attends all ascents not pushed to the extreme limit which occurs in the mountains of Europe. At all elevations of from 6000 to 11,000 feet, and not unfrequently for even 2000 feet more, the pedestrian enjoys a pleasurable sensation imparted by the consciousness of existence, similar to that which is described as so fascinating by those who have become familiar with the desert life of the East. The body seems lighter, the nervous power greater, the appetite is increased, and fatigue, though felt for a time, is removed by the shortest repose. Some travellers have described the sensation by the impression that they do not actually press the ground, but that the blade of a knife could be inserted between the sole of the feet and the mountain top.

Such, then, appear to us to be the elements of the enjoyment attending the ascent of mountains made under propitious circumstances. There is, first, the thorough comprehension of a complex idea previously partially received; then there is the charm of novelty in the unwonted combination of objects more or less familiar; and lastly, there is consciousness of physical exhilaration. As one or other of these elements predominates, the resulting emotion will affect the analytical, the poetical, or the sensuous faculties; and we cease to feel surprise that persons of the most varied temperament discover alike in such scenes a peculiar charm, described by some one as "beyond and without a name," and which is more or less intensely felt as one or more of these sensibilities are called forth.

Fortunately these rewards of toil and perseverance are not peculiar to the accomplishment of the highest and the most admired feats of pedestrian achievement. We imagine that even the most successful Alpine travellers will, if disposed to be candid, admit that the happiest, if not the proudest, moments of their experience have been spent on some of the more majestic *passes* of the Alps, or on some summits not of the highest class.[1] In such situations a favourable concurrence of circumstances is less improbable; there has been no exhaustion from previous preparation and anxiety, the atmosphere is often serene and delightful, the earlier hour at which the station may be attained[2] increases the chance of a noble prospect, and even the prospect is itself more noble if every snowy peak has not been already sunk beneath the feet of the spectator; if the view, in short, combine the range and precision of the eagle's outlook with the contemplation of the still higher summits, which preserve the grandeur of an ascending perspective with the detail of rough-hewn masses of granite and sparkling diadems of snow brought into illusory proximity by the transparency of the upper air.[3]

On the whole, without dissuading our energetic travellers from attempting even the most difficult feats of pedestrian attainment if occasion invites, and a natural taste deliberately prompts to them, we advise that they be made rare, not essential parts of Alpine journeys; especially they ought not to be the employment of a first or second tour. Habits of observation should be formed in the more accessible parts of Switzerland, for it is only after a time that the majesty of the upper world can be fully understood. The most trodden passes of the Alps, and their most frequented stations are, in their way, as admirable as any other. He who is insensible to the greatness of the scenery of the Montanvert, the Wengern Alp, and the Cramont, need scarcely go in quest of the sublime to the Jardin, the Col du Géant, or the Stelvio; still less need he brave the difficulties of Mont Blanc or Monte Rosa. A tour composed of great ascents would be like a dinner consisting entirely of stimulants.[4] The well known but never obsolete tours, of which Mr. Murray's

[1] [By all means, says the present editor, for the finest views are generally to be gained from the *moderately* high snow peaks or passes.]

[2] [Not always, as for very high peaks the start is usually made from a lofty bivouac or club hut, while for a moderately high peak the starting-point is often a village.]

[3] [A view which fully answers all these requirements is that from the Mont Vélan (12,353 feet), as compared with that from its lofty neighbour, the Grand Combin (14,164 feet), though the latter is the highest peak in the Alps outside the immediate neighbourhood of Mont Blanc and Monte Rosa.]

[4] [What would Forbes have said to the summer journeys of modern climbers, made up wholly of the highest and most difficult ascents, and the Matterhorn taken in the first season?]

work contains a judicious selection, must be the solid fare upon which the aspirant should be content to satisfy the ordinary demands of a healthful appetite for scenery. A common fault with our young tourists is to attempt too much in one season. A limited district well explored yields pleasanter recollections afterwards than a surfeit of marvels crammed into the compass of a summer excursion.[1] And it would add much to the enjoyment and utility of such tours if a somewhat greater acquaintance were attained in the rudiments of physical geography than is usually to be found even among our more highly educated classes.

[1] [By all means, but what if the unlucky tourist never expects to have the chance of making more than one visit to the Alps?]

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PART IV

TOPOGRAPHY OF THE CHAIN OF MONT BLANC

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Art. V.

1. "A Map of the Chain of Mont Blanc: from a Survey." By A. Adams Reilly, Esq. Privately Photographed, 1864.
2. "The Alpine Journal." Vol. i. 1864. 8vo. Longman and Co.
3. "Scenes from the Snow Fields" [; being Illustrations from the Upper Ice-World] "of Mont Blanc." By Edmund T. Coleman, Esq. With Coloured Lithographs by Vincent Brooks. Folio. 1859. Longman and Co.

PART IV

TOPOGRAPHY OF THE CHAIN OF MONT BLANC

Could Windham and Pococke revisit Chamouni in the year of grace 1865, after their sleep of a century [and a quarter], no doubt they would be somewhat astonished. Instead of the poor cabaret, with its bush hanging out as a sign,[1] they would find luxurious hotels, thronged by wealthy and fashionable parties, and placarded with advertisements in English of the "Chamouni Hôtels Company (Limited); capital £100,000." Not less would the pious Saint François de Sales[2] be scandalised to find his priory defunct, and a place of English Protestant worship built not far from the massive Catholic Church erected during his episcopacy. But it may be doubted whether the consternation of these worthies would not be exceeded by that of the great De Saussure (though he lived far later than either),[3] to find that parties of active young Englishmen, fresh from barristers' chambers and mercantile counting-houses, stroll unconcernedly amongst the "séracs" of the Glaciers of Géant and Bossons, start one morning *à l'improviste* for the summit of Mont Blanc, and

[1] [For this tradition, see below, p. 529.]

[2] [The famous bishop of Geneva (but resident at Annecy), 1602-21. He came to Chamouni, which was in his diocese, in 1606, and officiated in the newly constructed church, built in 1602. The Benedictine Priory existed from the early thirteenth century till 1519, when it was annexed to the collegiate church of Sallanches; the Priory buildings were destroyed by fire in 1758. In 1786 the men of Chamouni bought their freedom from all feudal dues, and in 1793 the lands of the Chapter in Chamouni became the property of the inhabitants of the valley.]

[3] [Born 1740, and died 1799.]

cross as many dangerous cols and ascend as many *aiguilles* in one week as the sedate Genevese (more frugal in his excitement) thought of undertaking in a twelvemonth.[1] We say nothing of the spirit of feminine adventure, of bivouacs at the Tacul, and of picnics at the Jardin; these are every-day matters.

It is refreshing to think that while fashion and civilisation have altered so much, Nature in her stupendous constancy remains unchanged. A new road or bridge[2] may make a scar here or there, but the trace is lost amidst the gigantic scenery around; cultivation may be pressed a little higher than formerly, but the eternal hills and the inexhaustible ice-floods keep their own without challenge. The voice of gay or of discordant music, the rattle of equipages, and the many-tongued voice of the crowd, assembled out of every nation under heaven, are altogether but as an inaudible whisper in the boundlessness of that mountain space, whose echoes can resound only to the crash of thunder, the ill-boding fitful noise of distant cataracts, and the roar of the icy avalanche. Happily, we say, there are some things which human art cannot utterly spoil. Of these Chamouni (by which we mean the Alpine district of which it is the capital) is one.

To return for a few moments to Windham and Pococke. Their visit to Chamouni and Montanvert took place in June, 1741. It was related with much simplicity and absence of exaggeration in a letter[3] from Mr. Windham to his friend, M. Arlaud, a landscape-painter[4] at Geneva, which was published later (1743), [really 1744] as a small quarto pamphlet, in English, which appears to be rare, as but a single copy has ever fallen under the notice of the present writer.

It is quite true, in a general sense, that Windham and

[1] [As a matter of fact, Saussure never ascended any of the Chamouni aiguilles, not even the Aiguille du Goûter.]

[2] [Now the new railway from Geneva, to be opened soon right up to Chamouni.]

[3] [This letter (as well as that of Martel, describing his own visit in 1742) was originally written in French and circulated in MS. in Geneva, etc. The French text of both letters was first printed, with notes by M. Théophile Dufour in the *Echo des Alpes* (Geneva) for 1879, pp. 85-99 (Windham) and 180-196, 247-263 (Martel). The English translation, 1744, of both letters has recently been reproduced in facsimile by Mr. C. E. Mathews at the end of his *Annals of Mont Blanc* (1898), and it is to this reproduction that the references are given below. The two versions present differences, especially in the case of the second letter.]

[4] [J. A. Arlaud, born 1668, died 1743, a celebrated Genevese *portrait*-painter.]

Pococke were the *discoverers* of Chamouni.[1] Unquestionably a Priory had existed there for several centuries previously. It had been visited by bishops and other dignified clergy in the course of their ecclesiastical journeys; the valley was inhabited and cultivated, had an annual fair, and traded with the neighbouring town of Sallanches in agricultural produce.[2] But all this did not bring it within the ken of the general outer world, or even of some of the more curious prying travellers and naturalists,[3] the Simlers, the Merians, the Fatios, the Wagners, and the Scheuchzers, not to mention foreigners, such as Burnet and Addison.[4]

[1] [But Windham himself says (p. 4), that other travellers had been to Chamouni—though not to the Montenvers and the Mer de Glace—before his party. Indeed there is still extant a letter, written at Chamouni in 1669, from a high financial official, named Le Pays, which describes the horrors of the journey to Chamouni. See the *Echo des Alpes*, 1879, pp. 19, 20. But Windham's is the earliest *published* notice of a visit to the Montenvers and Mer de Glace.]

[2] [Forbes is here relying on Captain Markham Sherwill's *Historical Sketch of the Valley of Chamouni.* Paris, 1832. But in 1879 and 1883 a great collection, entitled *Le Prieuré de Chamonix: documents relatifs au Prieuré et à la Vallée de Chamonix*, 2 vols., of mediæval documents relating to the valley was published by MM. Bonnefoy and A. Perrin at Chambéry, while in 1887 M. A. Perrin put forth, also at Chambery, a history of the valley and Priory,—*Histoire de la Vallée et du Prieuré de Chamonix du 10ème au 18ème siècle.* These volumes throw a flood of new light on the early history of Chamouni, of which a brief summary will be found in the new edition (1898), prepared by the present editor, of Mr. John Ball's *Western Alps*, pp. 337-339. The valley is first heard of in 1091, when it was granted by the Count of the Genevois to the Benedictine Abbey of S. Michel de la Cluse, near Turin. It seems to have been colonised in the course of the twelfth century, and in the early thirteenth century the Priory (a daughter of that of S. Michel de la Cluse) came into existence, and gradually absorbed all rights in the valley. In 1519 the Priory was annexed to the collegiate church of Sallanches, the buildings burnt in 1758, the feudal rights sold in 1786, and also the landed property of the Priory in 1793, in both cases to the inhabitants of the valley. In 1399 some Priory men went from Chamouni to Geneva and back, as shown by the Priory accounts, though no doubt this was not uncommon: in 1411, 1443, 1471, 1481, 1517, and 1606 the valley was visited by its diocesan, the Bishop of Geneva: in 1530 the Count of the Genevois granted the inhabitants the privilege of holding two fairs a year, and in 1533 of having a weekly market. Civil officials came also (as in 1700) to the valley to collect taxes.]

[3] [Simler (Josias)—*Vallesiae Descriptio et de Alpibus Commentarius:* Zürich, 1574. Merian (M.) and Zeiller (M.)—*Topographia Helvetiae, Rhaetiae, et Valesiae:* Frankfort, 1642. Wagner (J. J.)—*Historia Naturalis Helvetiae Curiosa:* Zürich, 1680. Scheuchzer (J. J.)—*Itinera per Helvetiae Alpinas Regiones facta annis 1702-11*; collected edition, Leyden, 1723. Burnet (Gilbert)—*Some Letters containing an account of what seemed most remarkable in Switzerland, Italy,* etc.: London, 1686. Addison (J.)—*Remarks on several parts of Italy and Switzerland:* London, 1705. Fatio de Duillier (J. C.)—*Remarques faites sur l'Histoire Naturelle des Environs du Lac de Genève*, published in vol. ii. pp. 449-470 of Spon's *Histoire de Genève*, 1730 edition.]

[4] Chamouni knew more of the outer world than the outer world knew of Chamouni. The natives, with what appears to be the instinct of the Savoyard

It appears to be unquestionable, however surprising, that the cultivated men of Geneva had never yet thought of penetrating to the foot of that noble snowy range, which forms one of the chief glories of their landscape;[1] nay, they believed that the mass of the glaciers lay to the *north*, instead of to the south of Chamouni; that is to say, between Chamouni and Sixt. J. C. Fatio de Duillier,[2] a Genevese of some reputation, and a member of the Royal Society of London (where, however, his brother Nicolas was better known), although he estimated with considerable accuracy the height of Mont Blanc from trigonometrical measures taken at a distance, propagated these errors, and manifested the same incredible absence of curiosity. This was in the first quarter of the eighteenth century. Chamouni and the district of Mont Blanc were to all intents and purposes (save ecclesiastical) unknown to the outer world until Windham's journey; and its subsequent notoriety is directly traceable to that alone. So that our modern Guide-books (such as Mr. Murray's and Mr. Ball's) have gone somewhat towards the opposite extreme from the older ones of Ebel and Richard, when they represent Chamouni to have been well known to strangers at the period to which we refer.[3]

Windham and Pococke were both remarkable men; and we

and the dwellers in the Piedmontese valleys, even at that early period, went abroad in the prime of life to learn trades and make money in foreign countries, but generally returned to settle and to die in their native glens. Let us here say, once for all, that we adhere to the good old-fashioned spelling of Chamouni, sanctioned by De Saussure, in preference to the modern official corruption of Chamonix. The derivation of the name is ascribed by Captain Sherwill, with great probability, to the Latin words *campus munitus*, by which it is designated in an early monastic charter [that of 1091—the name probably refers to the position of the valley fenced in and fortified by a great mountain barrier]. And it is interesting to find in Scheuchzer's map of Switzerland [1723], antecedent to Windham, that the spelling is given "Chammuny," approaching still nearer to the Latin. [The first appearance of the name on a map seems to be "Chamonis" on Hondt's map of Savoy in Mercator's Atlas, 1595.]

[1] [But it was so dreaded at Geneva that it was there called the "Montagne Maudite."]

[2] [He lived from 1656 to 1720. The name of his work is given above. He fortified Geneva in 1692. M. Durier (*Mont Blanc*, p. 23) says—the statement is also found in the English version only of Martel's letter, p. 28—that Fatio estimated the height of Mont Blanc as at least 2000 toises (3218 mètres) above the level of the Lake of Geneva; as this level is about 372 mètres, the height of Mont Blanc is thus made 3590 m. as against the true height of 4810 m., so that Forbes's description of "considerable accuracy" is itself inaccurate.]

[3] [But Murray (10th edition, 1863, pp. 385, 386) and Ball's *Western Alps* (1863, p. 185) simply give the facts as to the Priory, etc., mentioned in a previous note. Ebel's book—see above p. 482—is the *Manuel du*

think it not without interest for our readers to note a few particulars respecting the society of Englishmen who thus invaded the peaceful valley which has since become so celebrated. Pococke,[1] the best known of the group, had just returned from his travels in the East, which had lasted from 1737 to 1741, when, happening to pass through Geneva, he became associated with a party of his countrymen, who for several winters had made that city their home. This intelligent and cultivated society consisted of William Windham of Felbrigg in Norfolk, father of the statesman who was the contemporary and colleague of Pitt; his tutor, Benjamin Stillingfleet, the naturalist; Lord Haddington and his brother Mr. Baillie, with their tutor, Mr. Williamson, an eminent but somewhat eccentric scholar; Mr. Aldborough [Aldworth] Neville, an ancestor of the present Lord Braybrooke;[2] Robert Price, a man of great worth and accomplishment, father of Uvedale Price; Mr. Chetwynd; and last of all Pococke, as already mentioned, who joined but did not originate the expedition. All these above named, except Mr. Williamson (whose health did not allow it), took part in the expedition to Chamouni. But Windham was the leader, for which post his alert, muscular, and ardent temperament well fitted him. Hs is described as having been tall, thin, and narrow-chested, yet eminently handsome, and so fond of athletic sport as to have been known in London as "boxing Windham." He rather affected the air of a gay man of fashion, impatient of restraint, yet he was an excellent linguist, and was acquainted besides with the sciences and fine arts to an extent of which few believed him capable. Had he lived a hundred years later, he must inevitably have been first President of the Alpine Club.[3] He was exemplary in private life, and several of his friends have recorded the affection which he inspired; especially his tutor Stillingfleet, both in prose and verse. Windham and Price both

Voyageur en Suisse (Forbes generally quotes the 1810-11, second French, edition), and Richard's the *Guide du Voyageur en Suisse* (many editions from 1824 onwards).]

[1] [Richard Pococke, born 1704, died Sept., 1765; was Bishop of Ossory in 1756, and Bishop of Meath in July, 1765.]

[2] [The gentleman in question was Mr. Richard Aldworth, born 1717, and died in 1793. In 1762 only he took the additional surname of "Neville," and it was *his* son, another Richard (who took yet a third surname, that of "Griffin"), who succeeded his third cousin in 1798 as second Lord Braybrooke, and was the ancestor of the present bearer of that title.]

[3] [But fortunately that office has always been filled by men quite different from Windham as above described.]

died in 1761; Pococke in 1765, having become previously an Irish bishop [of Meath].[1]

Next to Windham, Price and Stillingfleet[2] seem to have taken most interest in the expedition to Chamouni; the former acted as draughtsman, the latter as naturalist. It is stated in a Swiss publication [the *Journal Helvétique*, May, 1743, in an article by Leonard Boulacre] that Pococke amazed the population of Sallanches by appearing in the dress of an Arabian emir, an account which seems scarcely probable.[3] The journey was undertaken in June, 1741, and occupied seven days.[4] The first they slept at Bonneville; the second at Servoz; the third they proceeded to Chamouni, visited Montanvert, descended on the glacier, and returned to Chamouni to sleep. The fourth day they slept at Sallanches, and the fifth at Bonneville.[5] There is no exaggeration to be found in the narrative.[6] Considering the unfrequented[7] nature of the country, and the size and character of the party, it was natural for them to take their own servants, horses, provisions, and a tent. That they carried firearms was conformable to the habits of travellers of the period even in Britain. Windham's party was too short a time (half an hour) on the glacier to make more than passing observations. That it resembled the seas of Greenland, or a lake[8] put in agitation by a strong wind and frozen all at once, were the apt comparisons by which they described it. The magnificent slab on the moraine near Montanvert, which has

[1] See *Literary Life of Benjamin Stillingfleet*, 3 vols., 1811. From this interesting work we have extracted these particulars of Windham. Had it not appeared too great a digression, some account of the other members of this remarkable group of men might have been added.

[2] [According to W. Coxe, the biographer of Stillingfleet, the account of the trip was mainly written by Windham and Price, assisted by Stillingfleet.]

[3] [This incident is, however, narrated at length in the original French version of the journey, *Echo des Alpes*, 1879, p. 89.]

[4] [They left Geneva on June 19 and returned on June 24, stopping a day to ascend the Môle, and sleeping at Annecy.]

[5] [Something is wrong here in the original, for both versions of the narrative state that the visit to the Montenvers was made on June 22, the day of their arrival at Chamouni, while they state that next day they slept at Sallanches, yet on the 23rd reached Bonneville. Perhaps "June 22" is a slip for "June 21," which agrees better with the text, as they only slept two nights between Geneva and Chamouni and but one night at Chamouni.]

[6] [Oh, oh, oh!]

[7] [Only by travellers; for there are numerous villages on the way.]

[8] [The English text has "your lake," so that the Lake of Geneva is clearly meant.]

the names of Windham and Pococke painted on it, still traditionally commemorates the spot where they took refreshment. It has been immemorially called "la Pierre aux Anglais," but was unfortunately broken in half some years ago by some foolish persons lighting a fire upon it.[1] Another possibly less certain tradition exists that one Tairraz, an ancestor of the present or recent proprietor of the Hôtel de Londres, had the honour of lodging the English party in his humble inn, and that Windham himself suggested the name for the hôtel.[2]

Windham, by his letter to Arlaud the Genevese, had made known the wonders of Chamouni to the curious of that capital, who for ages had lingered listlessly under the shadow of Mont Blanc. In 1742, accordingly, a party from Geneva,[3] better provided than the English had been with the means of observation, made a more detailed survey of the Valley of Chamouni and the Mer de Glace. They made a sort of rude survey of the ground, measured the heights of some mountains,[4] and recorded many useful and correct observations on the phenomena of glaciers, as well as on the mineralogy of the district. Pierre Martel [born in 1701 or 1702, died in 1761], an engineer and teacher of mathematics, seems to have taken the lead in the matter, and published an English account of it in a letter to Windham, along with which we find, for the first time, Windham's own letter to Arlaud.[5] The plates are grotesque, and that of the village of Chamouni and the aiguilles so extravagantly inaccurate, that we

[1] [The names of Windham and Pococke have now been cut on a large flat rock between the moraine and the mountain side. The only refreshment mentioned in the narrative is drinking the health of Admiral Vernon. But local legend, in defiance of the formal statements in the narratives, has it that the party *slept* under the stone.]

[2] [This tradition is mentioned by Albert Smith, p. 72. But *both* narratives state that the party camped in their tents, as does Bourrit (*Description des Glacières*, 1773 edition, p. 5), and Saussure (§ 732). Very probably there was a cabaret in the village in 1741 (though none is actually mentioned till 1760), and local legend gradually attached to it the sojourn of the "discoverers" of Chamouni.]

[3] [The party consisted of P. Martel; of Etienne Martin, called an artist but apparently a cutler; Etienne Chevalier, a goldsmith; P. Girod (or Giraud-Duval), a grocer; and M. Roze, a stranger and botanist. They left Geneva on August 20, slept at Bonneville, reached Chamouni on the afternoon of the 21st, spent the 22nd there, and climbing the Môle on their return, regained Geneva on the 25th, *not* the 26th, as stated in the English narrative. It does not appear whether they camped in a tent or went to a cabaret.]

[4] [Among others, that of Mont Blanc, pp. 19 and 28, the observation agreeing nearly with that of Fatio.]

[5] [The full title of the book or pamphlet is, "*An Account of the Glacières or Ice Alps in Savoy*, in Two Letters, one from an English Gentleman to his friend at

must suppose it done, for the most part, from memory.[1] Of the small attempt at a map we shall speak by and by.

De Saussure was born [at Geneva] in 1740, whilst Windham and his friends were residing at Geneva. His biographer, Senebier,[2] expressly refers his first journey of 1760 to the interest excited by the Englishmen's visit to Chamouni. In the interval we know of no allusion to Chamouni, except the narrative of Martel.[3] After the date of De Saussure's visit it became notorious enough. Deluc, Pictet, Bordier, Bourrit,[4] and many others made the mountains of Savoy the objects of their summer excursions, but De Saussure excelled them all in the ability and perseverance of his researches, and in the ability of his descriptions. These are too well known to require notice here. Our chief object in this article is a limited one. It is to give an outline of the geography and physical peculiarities of the chain of Mont Blanc, and to make the reader acquainted with some recent and partly unpublished investigations of that wonderful mountain group.

An outline map, on a small scale, of Mont Blanc and its dependent chain, is given in connection with this article, because it would be otherwise impossible to convey an intelligible account of their structure and conformation.[5] We shall first give a brief

Geneva; the other from Peter Martel, Engineer, to the said English Gentleman. Illustrated with a Map and two Views of the place, etc. As laid before the Royal Society, London. Printed for Peter Martel, 1744." (As to the French originals, see above, p. 524).]

[1] [The first of the two plates given in this pamphlet is signed "R. Price," one of the travellers of 1741, as the artist, and contains a view from the Montenvers; the other is by Martel himself, and contains a map, a view of the valley from above the church (done by Martel himself on the spot, see Mr. Mathews' reprint, p. 17), and figures of a bouquetin, a chamois, and a marmot. Martel (p. 17) speaks of a view he took himself of the Mer de Glace from the Montenvers, which, however, is not reproduced in the pamphlet. Mr. Mathews gives a facsimile of the map, but not of the rest of the views.]

[2] [J. Senebier, *Mémoire Historique sur la vie et les écrits de H. B. de Saussure.* Geneva, 1801.]

[3] [That is, no account of the visit of a traveller, though the Genevese philosopher Abauzit—died 1767—on whom Pococke called, seems to have visited Chamouni *before* Saussure (see Bourrit, vol. iii. p. 4, and *Echo des Alpes*, 1879, p. 86, note 5), for we know the local history of Chamouni during the interval.]

[4] [Deluc (J. A.)—*Relation de Différents Voyages dans les Alpes du Faucigny.* Maestricht, 1776. Pictet (J. L.) visited Chamouni in 1760 with Saussure, and in 1808 published at Geneva a *Nouvel Itinéraire des vallées autour du Mont Blanc.* Bordier (A. C.)—*Voyage Pittoresque aux Glacières de Savoye. Fait en 1772.* Geneva, 1773. Bourrit (M. T.)—*Description des Glacières, Glaciers, et Amas de Glace du Duche de Savoye.* Geneva, 1773. Bourrit had first visited Chamouni by 1769 at latest.]

[5] [In the present edition this sketch map has been replaced by a far more

outline of the topography of Mont Blanc; next trace the steps by which our present knowledge of it has been obtained; and then illustrate some of its more striking features in a little more detail.

Mont Blanc, as every one knows, is the highest mountain in Europe,[1] and, indeed, in the old world, with the exception of the Himalayas. It lies in the chain of the Alps, yet peculiarly situated with regard to these, being on a sort of angle or elbow where the Alps[2] turn from a south and north direction (starting from the Mediterranean) to a direction more nearly, though not accurately, west and east, which they may be said to follow throughout the remainder of their course till they terminate in Styria. But the chain is not continuous, like the vertebræ of a serpent, as it used to be represented in the older maps. On the contrary, it is being much broken up into groups having more or less definite boundaries. One of the most distinct of such groups or mountainous centres is that of Mont Blanc. It may be described as a rude parallelogram, whose longer diagonal extends from south-west to north-east, and which is enclosed by four valleys. These are:—

1. On the N.W., the [upper] valley of the Arve; chief place, Chamouni.

2. On the S.E., the valley of the Doire [Dora Baltea]; chief place, Courmayeur.

3. On the W., the valley of Montjoie; chief place, Les Contamines.

4. On the E., the [Swiss] valley of Ferret;[3] chief place, Orsières.

accurate one. Hence the following paragraph, "A glance . . . copy from nature," of Forbes relating to his map is now omitted. Forbes's map is really an early and not quite perfect copy of Mr. Reilly's.]

[1] [Always excepting the Caucasian peaks, the highest of which, Elbruz, 18,470 feet, rises on a spur on the north or European side of the main chain, and so is completely in Europe.]

[2] [In this sentence Forbes uses "Alps" as equivalent to "the main chain of the Alps.]

[3] [Forbes omits altogether the Italian Val Ferret, or perhaps counts it (as it is properly) as a part of the Dora valley.]

Of these valleys, the two first are by much the longest; and the parallelogram has its two acute extremities at the Col du Bonhomme on the south-west, and the Catogne on the north-east, the distance of these two points being twenty-nine English miles. Mont Blanc is situated, *not* in the centre of the parallelogram, but much nearer to its western end. Throughout its extent, the mountain ridge of which Mont Blanc is the culmination is single and continuous,[1] so far resembling the serpentine vertebræ to which, as we said, the Alps cannot as a whole be likened.

The southern slopes in general are much steeper than the northern slopes. The summit of Mont Blanc is considerably nearer to the valley of Courmayeur than to the valley of Chamouni; in consequence, it is utterly inaccessible from that side.[2] But it is also the more imposing object as seen from thence. The stupendous walls of the range rising from the valley of Courmayeur form a spectacle perhaps unequalled in the Alps,[3] especially when enhanced by the exquisite scenery and Italian vegetation of the valley of the Doire. Courmayeur is only 4200 English feet [really 4016 feet] above the sea; and as Mont Blanc has a height of 15,780 feet [really 15,782 feet], the relative elevation is in the highest degree impressive. The relative elevation is 11,580 feet [really 11,766 feet], an amount barely exceeded in the case of even the highest mountains of the globe, which rise from valleys or from table-lands already of great height. The valley of Chamouni is 3425 feet [really 3416 feet] above the sea at the *Prieuré* or village.

As it is well known that the magnitude of glaciers depends principally on the area of the mountain-basins in which they take their origin, and by whose snows their waste is continually

[1] [Mr. Ball, p. 328 of the new edition, 1898, of his *Western Alps*, writes however: "It is questionable whether the Mont Blanc range may most properly be described as a single ridge, throwing out on the north side massive buttresses, which are crowned by towers and pinnacles that rival in height those of the central ridge, or as two parallel ridges, linked together by connecting walls of rock, and with this peculiarity, that the north ridge is broken through by numerous gaps, through which the vast accumulations of ice formed in the central basins are drained by the glaciers descending into the valley of Chamonix."]

[2] [True in 1857, but no longer so, as at least five routes have been forced up Mont Blanc direct from Courmayeur, besides the route from the Col du Géant by the Mont Blanc du Tacul.]

[3] [No one can really appreciate Mont Blanc who has not seen it from the south or south-west, say from one of the peaks in the Graian or the Dauphiné Alps. Then only can its supremacy in the Alps be fully grasped and recognised.]

supplied, it follows that the glaciers are least important when the slopes are most precipitous. With one notable exception [S. Miage Glacier] the glaciers of the Chamouni side of Mont Blanc are by far the most important of the chain, as well as the best known.[1]

As the glaciers form the key to the topography of the district, we will here enumerate the larger ones according to their position on the four sides of the chain, commencing from the north-east angle, distinguishing by small capitals those most remarkable by their size :—

N.W. Slope. (Chamouni).	W. Slope. (Val Montjoie).	N.E. Slope. (Courmayeur).	E. Slope. (Swiss Val Ferret).
Trient. Tour. ARGENTIÈRE. BOIS (Mer de Glace). Bossons. Taconnaz.	Bionnassay. Miage (N.). TRÉLATÊTE.	Gl. des Glaciers. Allée Blanche. MIAGE (S.). Brenva. Jorasses.[2] Triolet. Mondolent.[3]	La Neuvaz. Saleinaz. Arpette.[4]

The position of these glaciers (which are all shown upon the map) is important, as indicating the natural drainage of the district; and we shall find that an extraordinary diversity of opinion has obtained at different periods as to their distribution and arrangement.

Early in the last century, as we have seen, the chief glaciers were supposed to lie to the *north*, instead of to the south of Chamouni.

This, of course, was rectified by the visit of Windham and Pococke; but their idea of the extent and course of the ice-streams of Mont Blanc was extremely limited and inaccurate.[5] Windham

[1] [In 1857, and to a certain extent even in 1900.]

[2] [Formed by the Planpansière and Pra Sec glaciers.]

[3] [Now called Pré de Bar.]

[4] [Forbes has confounded the Arpette glen (no glacier) with that of Orny (where there is a glacier). In general Forbes's distinction between greater and smaller glaciers need revision in the light of our present knowledge, *e.g.*, the Brenva is immense and the Saleinaz is very great. Several smaller glaciers are omitted, *e.g.*, Frasse, Frébouzie, Montdolent (that now so called), and Grands.

[5] [Would modern tourists who, like Windham, spend half a day at Chamouni have any clearer ideas than he had?]

says [p. 8 of Mr. Mathews' reprint]: "The *Glacières* consist of three large valleys, that form a kind of Y; the tail reaches into the *Val d'Aoste*, and the two horns into the valley of *Chamoigny*."[1] We might at first sight imagine that the Y represents the Mer de Glace and its branches—the Glaciers of Géant and Léchaud. There is no doubt, however, that this is not the case, and that the branches he refers to are the Glaciers of Bois and Bossons, the only two of those in the valley of Chamouni which he distinctly saw, and that the "tail" reaching into the Val d'Aoste was symbolical of the Glacier of Brenva, or possibly of the Col du Géant, which he mentions [p. 10] as traditionally spoken of as a pass or col in the chain. This interpretation of Windham's meaning is rendered more clear by the words which follow [p. 8]: "the place where we ascended was between them (*i.e.* the horns), from whence we saw plainly the valley, which forms one of these horns." As the "place" he speaks of was the Montanvert, the "horns" could only be, as already said, the glaciers of Bois and Bossons, the only ones which actually obtrude themselves on the notice of the visitor to Chamouni by the route of Servoz.

Pierre Martel in his expedition of 1743 [really 1742] made a considerable step [forward]. For in the quaint map which accompanies his pamphlet, we find all the chief icy outlets of the N.E. slope indicated after a fashion, beginning with Trient, and ending with Bossons and Taconnaz considered as one. This map, of which we here introduce a lithographic facsimile,[2] represents very curiously the idea which seems strongly to possess the minds of the dwellers near great glacier-bearing chains, that the glaciers are but the overflows of *one* great central reservoir or accumulation of snow and ice. In some parts of the Alps singular traditions prevail of such unvisited central valleys,[3] imagined to

[1] [In the original French MS. of Windham's account—not an autograph one—printed by M. Dufour, there is the following note on the margin opposite this passage: "Ceci n'est pas exact: la grande branche de cet Y doit être celle qui va au Mont Blanc, et la branche qui descend dans la vallée de Chamoigny doit être plus courte que celle qui va à la Val d'Aost." But this correction does not seem to help us much.]

[2] [Omitted in the present edition: a reproduction is given in Mr. Mathews' reprint of the 1744 pamphlet.]

[3] [This probably alludes to the story told by Saussure (§ 2156), how in 1778 seven young men of Gressoney made an exploration of the glaciers at the head of the Val de Lys, and having reached the "Rock of Discovery" (Entdeckungsfels)—

be habitable, and peopled by a race who hold no communication with the lower world. The natural tendency is to exaggerate the extent and importance of what is unknown. All untraversed mountain chains are assumed to be greater in area than they prove to be when surveyed, and the popular estimate of the length of glaciers is at least double or three times the reality. The persistence of the notion of a common reservoir or Mer de Glace, with numerous outflows reaching to the valleys, by means of which its accumulations are discharged,[1] together with the acknowledged fact of the motion of the ice of glaciers (referred to in Windham's letter) [p. 10], proves that the "viscous" or "plastic" theory of glaciers has been the creed of the peasantry from early times.[2] Martel conciliates easily and ingeniously what he could see with what he imagined. An ice-stream or ocean is represented as taking its rise near Mont Blanc, and flowing parallel to the whole chain, in a N.E. direction, terminating in the glacier of Trient. From it descend, as separate overflows, the Glaciers of Bossons, Bois, Argentière, and Tour. A "tail" extends towards Courmayeur, symbolising probably the Glacier of Brenva. It is sufficient here to note, that in every case the ridges separating the Glaciers of Chamouni, indicated here as mere islets in the icy flood, are stupendous ranges, nearly or altogether impassable,[3] and linked on to the backbone of the chain.

It is astonishing how slight was the improvement of the map of Mont Blanc during the remainder of the last century. In 1779 De Saussure put forth, in the first and second volumes of his immortal work, two maps,[4] based on the map of Savoy by

just west of the present Lysjoch—looked down on the "Vallée Perdue," filled in its higher part by the ice-stream of the Gorner Glacier, and girdled by a long line of savage rocky and snowy peaks from the Mischabelhörner to the Dent Blanche. This valley was simply the valley of Zermatt, though Saussure thought it was that of Petriolo, near Macugnaga, which never belonged to the Vallais, as was said to be the case with the "Lost Valley." See p. 336 above.]

[1] [This point of view is still represented in Altmann's *Versuch einer historischen u. physischen Beschreibung der helvetischen Eisbergen* (1751), but is combated by Gruner's work in 1760.]

[2] [See pp. 43, 44 above.]

[3] [All these cross or dividing ridges have now been traversed.]

[4] [The smaller map appeared in vol. i. and the larger in vol. ii. See the *Discours Préliminaire* to vol. i. p. xix. Borgonio's *Carta Corographica degli Stati di S.M. il Re di Sardegna* appeared originally in 1680: no doubt it was the revised edition of 1772 that Saussure used. Much interesting information as to early maps of the Mont Blanc region before that of Martel may be found in vol. iii.

Borgonio, with emendations by Pictet of Geneva, of which [maps] it is hardly possible to speak too disparagingly. They are in one sense worse than the map of Martel, because they are filled up with material absolutely fictitious. The great ice-sweep is now interrupted by the range at the back of the Glacier of Talèfre; but the Glaciers of Argentière, Tour, and Trient are thrown into one, as are those of Bionnassay, Trélatête, and Miage. De Saussure's sense of truth could never, one would suppose, have been satisfied with these wretched productions,[1] yet they reappeared in 1803 (after his death, indeed), in the second edition of his *Travels*.

Very superior, undoubtedly, to these must be considered the special map of Mont Blanc by Raymond, published early in the present century, when Savoy was under the régime of Imperial France.[2] The valleys are tolerably well laid down, and some of the features of the best-known parts of the chain have a certain truth; but a hazy feebleness predominates over the whole; the boundaries of the glaciers are very inaccurate, and the interior of the group is hopelessly conjectural.

In 1842, the writer of the present article made a special survey[3] of the Mer de Glace of Chamouni and its tributaries, which, in some following years, he extended by further observations so as to include the Glacier of Bossons. The area of this survey extended parallel to the chain from the summit of Mont Blanc to the borders of the Glacier of Argentière, and in a perpendicular direction from the Grandes Jorasses to the chain of the Brévent.

About the same time M. Séné of Geneva was engaged on his remarkable model, on a considerable scale, of the chain of Mont

pp. 532-546 of Professor Alphonse Favre's *Recherches Géologiques dans les parties de la Savoie voisines du Mont Blanc* (Geneva, 1867).]

1 [But Saussure himself was much pleased with Pictet's larger map (that in vol. ii.), which alone figures the snowy regions; indeed, in his *Discours Préliminaire* (vol. i. pp. xix., xx.) he speaks highly of its accuracy, and calls upon his readers to mark what a vast improvement it was on Borgonio's. Forbes credits Saussure with far too much detailed topographical knowledge. He was but a pioneer, and topographical science is always moving on.]

2 [Forbes is probably thinking of J. B. Raymond's *Carte physique et minéralogique du Mont Blanc*, published at Geneva in 1797-99. Perhaps he knew of a later edition, as he writes below—p. 546—of the map as 60 years old in 1865.]

3 [This map was issued with Forbes's *Savoy* in 1843, and in a revised shape with the 2nd edition, 1845, of the same book. It is given also with the present volume, but has not been retouched.]

Blanc. It was acquired by and is still exhibited[1] in his native town. Though immense patience was bestowed on this interesting work, the author of it had two defects which seriously marred its accuracy. In the first place, he was no surveyor, and used no divided instruments; and secondly, he eschewed glaciers and mountain peaks, and contented himself with peering into the recesses of the chain from the most commanding points which he could find on its outskirts. Hence, wherever the chain becomes intricate, or its central parts are removed from ordinary observation, this otherwise fine model is valueless.

The only parts of the range of Mont Blanc, which, down to 1850, could be said to be well understood, were those which were opened up by three well-known expeditions—the route to the Jardin, the passage of the Col du Géant, and the ascent of Mont Blanc. The extreme eastern and western parts of the chain were as yet untraversed.[2] In 1850 the present writer succeeded in traversing the main chain[3] from the Col de Balme, but the time was too short to unravel the intricate mountain group which intervened between this route and the Jardin. The fact was, however, established of the undiminished height of the main chain, even so near its eastern extremity. At the head of the Glacier du Tour it was found to be 11,300 English feet [really 11,267 feet], or somewhat higher [207 feet] than the Col du Géant in the immediate vicinity of Mont Blanc. All the existing maps—mainly feeble copies from one another—throw very little light on this part; and M. Séné's model was especially in fault. Not less ambiguous was the course of the chain between Mont Blanc and the Col du Bonhomme to the westward, which includes three or four magnificent summits, such as the Aiguilles of Bionnassay, Miage, and Trélatête, and several noble glaciers.

In 1858,[4] if we recollect rightly, the Alpine Club was founded

[1] [It is now in the "Jardin Anglais."]

[2] [That is by travellers, for both the Col de Miage and Forbes's route of 1850 had been made previously by natives. See pp. 213, 457, 462, 464 above.]

[3] [By the Col Blanc, 11,162 feet, and the Fenêtre de Saleinaz, 10,709 feet. See chap. v. of Part II. above, pp. 462, 463.]

[4] [The preliminary meeting was held on December 22, 1857, the draft rules approved on January 19, 1858, the first dinner held on February 2, 1858, and Mr. John Ball elected the first president on March 31, 1858. For the early history of the club see Mr. W. Longman's paper (chap. iv. of *Modern Mountaineering*, printed as an appendix to vol. viii. of the *Alpine Journal*).]

in London,[1] and those who felt an interest in the improvement of our knowledge of mountains were sanguine as to what might be done by its members. In the first volume of its transactions (*Peaks, Passes, and Glaciers*, 1859) we find an account of the passage of the Fenêtre de Saleinaz by Mr [now Mr. Justice] Wills, and an exploration of the Col de Miage on the north side by Mr. Vaughan Hawkins. The last-named col, and the summit of the Aiguille [now Dôme] de Miage had, however, been already attained by Mr. Coleman,[2] whose magnificent work (*Scenes from the Snow-Fields of Mont Blanc*), published in 1859, contains the most vivid pictures of glacier landscape which have yet appeared. But neither Mr. Coleman nor his companions possessed the enviable gift of topographical sketching—at least they did not exercise it on this occasion; and such geographical knowledge as they may have personally acquired could not be communicated or rendered definite by the use of words alone. At this time an unfortunate prejudice [3] against the use of a theodolite was present to the minds of most members of the Alpine Club, whose leading passion—that of boundless muscular exertion and unfettered freedom of range—would certainly have been controlled by the companionship of that estimable instrument, which is somewhat heavy to carry, as well as liable to damage, and which demands for its use leisure, patience, and unlimited power of resisting cold on isolated summits and glacial wastes. No, the theodolite was not popular amongst the Alpine Clubbists!

Mr. Tuckett, of Bristol, however, one of their number, possessing a correct eye and good fingers, as well as legs, contributed some able sketches of country in 1860 and 1861. In the former year he followed the Glacier of Argentière for the first time to its origin behind the curtain of rocks which separates it from the Glacier of Talèfre,[4] and ascending [with Mr. Wigram] the main ridge of the Alps, he attained (the Col d'Argentière) a

[1] The more immediate antecedents to the formation of the club were the appearance in 1856 of Mr. Wills' *Wanderings among the High Alps*, and Messrs. Hudson and Kennedy's *Where there's a Will there's a Way; An Ascent of Mont Blanc by a New Route and Without Guides.*

[2] [But the col had been already crossed by natives. See p. 213.]

[3] [In his 1857 article Forbes has himself pointed out the absurdity of such an attack. See p. 515.]

[4] [Written from the point of view of one who, like Forbes, had often been on the Talèfre Glacier, and had wondered what was behind that ridge. But, properly speaking, the Argentière Glacier does not flow from behind that ridge, but direct from the main ridge of the Alps.]

col of the immense height of 12,500 feet [really but 11,536 feet], without, however, descending on the opposite side—a passage first effected in 1861 by Mr. [Stephen] Winkworth, who reached the [Swiss] Val Ferret by the Glacier de la Neuvaz.[1] Mr. Tuckett, however, made a sketch of this knot of mountains—not unworthily called the Gordian knot—for its extrication was not reached without further time and labour. In 1861 he contributed a careful eye-sketch of the country between the summit of Mont Blanc and the Col du Bonhomme, which was a great advance upon anything which had then appeared; but the meagre engraving from it in [vol. i. p. 189 of] the second series (1862) of *Peaks, Passes, and Glaciers* was very far from doing it justice. In Mr. Tuckett's drawing something like the mutual relations of the Glaciers of Trélatête, Miage [both glaciers], and Bionnassay appears for the first time, although the proportions of the ground plan were far from exact—the S.W. extremity of the chain being carried out to an angle far too acute.

It was in 1861 that the much desired Sheet XXII. [scale 1/100,000] of the Swiss Federal Map was issued by General Dufour. It contained so much of the chain of Mont Blanc as is included within Swiss territory, that is the eastern slope between the Col de Balme and the Col Ferret. Unfortunately this was not a very important part of the chain, but at least it furnished one boundary of the "Gordian knot" already referred to, which lay between the Glacier of Talèfre, already surveyed [by Forbes], and the Glacier of Saleinaz, which is wholly Swiss. The chain of Mont Blanc was, however, laid down in outline throughout a considerable part of its extent, but the Swiss surveyors were only responsible for its accuracy up to their own boundary. The remaining features were taken, it is believed, from Piedmontese documents; but it required only a slight inspection to show that the data on the two sides of the frontier were not reconcilable, and the result proved the truth of the proverb, that old work patched with new makes the rent worse. The relative position of the Glaciers of Argentière, Tour, and Saleinaz was, if possible, more unintelligible than it had ever been.

In 1862, Mr. A. Adams-Reilly, a gentleman of liberal education and an accurate draughtsman, directed his attention to

[1] [*Peaks, Passes, and Glaciers*, 2nd series, vol. i. pp. 231-240.]

the "Gordian knot" in question. He crossed the Col d'Argentière, discovered by Mr. Tuckett, and made panoramic drawings of the chain in various directions.[1] But it was found impossible to reconcile these with the position of the summits and glaciers as indicated on the Swiss map, and Mr. Reilly decided[2] on directing his journey of 1863 expressly to clear up such ambiguities. For this purpose he provided himself with an excellent theodolite, and arranged to extend the triangulation [by Forbes] which formed the basis of the survey of the Mer de Glace of 1842 up the valley of the Arve to the Col de Balme, and thence again to the very origin of the Glacier of Tour. The present writer was fortunately able to place at Mr. Reilly's disposal[3] the unpublished additions which he had made in 1846 and 1850 to his original survey, extending it from the south to the north bank of the Arve near Chamouni. In particular, he had determined with considerable accuracy the interval in English feet between the Pavillon de la Flégère and the summit of the Brévent. The distance between these is nearly three English miles, and it forms an admirable base for extending the triangulation in any direction. Mr. Reilly dexterously availed himself of it, and after a survey of much labour, owing to the exceeding roughness of the country, finally connected the survey of the Mer de Glace and Chamouni district (including Mont Blanc) with the Swiss survey, which terminated at the Col de Balme and the east boundary of the Glacier du Tour. The annexed wood-cut shows on a larger scale than our sketch-map of the chain the relations of the three glaciers of Saleinaz, Tour, and Argentière, at their contact, as determined, *it may be said entirely*, by the labours of Mr. Reilly.[4]

It would require the reader to have before him the Swiss map of 1861, or some equivalent authority, to understand the

[1] [Much, though not all, of the following notice of Mr. Reilly's survey is taken from his article, "A Rough Survey of the Chain of Mont Blanc," published in the *Alpine Journal* for March, 1864 (vol. i. pp. 257-274).]

[2] [Mr. Reilly has gratefully recorded the kindness and help received from Forbes in drawing up his plan of operations. *Alpine Journal*, vol. i. p. 258.]

[3] [Mr. Reilly and Forbes were close personal friends, and the former wrote the account of Forbes's Alpine career in the *Life and Letters* published in 1873. Mr. Reilly died in 1885; see the obituary notice in the *Alpine Journal*, vol. xii. pp. 256-259.]

[4] [This wood-cut is taken from the *Alpine Journal*, vol. i. p. 274, so that it is not given here. But the exact topography of these three glaciers is shown in outline in the diagram facing p. 459 of Part II. chap. v. of the present volume.]

geographical emendation thus effected. To state its chief result in a single sentence, two mountains, each 13,000 feet high, and *standing on the map a mile and a half apart*, were pulled together and made one; while a snow-field of some four square miles in extent was annihilated. It will be seen in the diagram that the Glacier of Tour takes its origin from a mountain spur leading north-eastwards from the Aiguille du Chardonnet. Behind that spur the Glacier of Saleinaz extends itself southwards up to the foot of the Tour Noir,[1] and is separated from the Glacier of Argentière solely by the ridge extending from that summit to the Aiguille du Chardonnet. Now previously things had been very differently represented. The Glacier of Tour was imagined to extend southwards far beyond the Aiguille du Chardonnet, and far beyond even that of Argentière, and to be bounded on the south-east by the Glacier of la Neuvaz, which in reality it does not approach within two miles, which are occupied by the upper basin of the Glacier of Saleinaz. If this description be followed, it will be understood that the Swiss surveyors, when mapping the upper basin of the Glacier of Saleinaz, had right in front of them the great rocky boundary of the Glacier of Argentière, including the two vast peaks of Argentière and Chardonnet. But, misled by the Piedmontese survey, they believed that they were still divided from it by a parallel ridge, to the culminating point of (a magnificent frosted cone as seen from the east) they gave the name of *Pointe des Plines*,[2] a peak which proved the very bugbear of geographers; and no wonder, for the Pointe des Plines, *as such*, had no existence—it was and is neither more nor less than the long familiarly known Aiguille d'Argentière.[3]

[1] [Strictly speaking to the foot of the Aiguille de la Neuvaz.]

[2] [This name is now given to a summit, 10,017 feet north-east of the Aiguille d'Argentière, and on the opposite side of the Saleinaz glacier.]

[3] [Without wishing to take away from the merits of Mr. Reilly's discovery, and while most fully recognising his very great services to the cause of Alpine cartography, the present editor feels it but right to make two remarks :—

(*a*) Mr. Reilly made his discovery quite independently and in consequence of his own prolonged and patient observations. But the identity of the Argentière with the Pointe des Plines had been already proved (though not published) by the French map surveyors in their preliminary survey, some years before. Mr. Reilly himself frankly tells the story (*Alpine Journal*, vol. i. p. 266).

(*b*) Similar discoveries are made in every mountain district, when it is being explored and mapped accurately, and made, as in the above case, by private individuals. So in 1859-60 two members of the Alpine Club, Messrs. W. Mathews and J. J. Cowell, disproved the very *existence* of the lofty Mont Iseran, 13,271 feet, in the Western Graians, though it was figured on the Piedmontese

The results of his painstaking survey of the Glacier of Tour Mr. Reilly laid down on a map to the scale of 1/40,000, or about an inch and half to the mile, and nothing can be more satisfactory than the clear and beautiful draught which now lies before us, in which even the secondary clusters of peaks are defined with admirable exactness by readings of the theodolite. It is a work which leaves nothing to be desired, and would do credit to the most expert professional surveyor.

But Mr. Reilly, having theoretically disentangled the Gordian knot, confirmed his extrication of it by actually *walking through it*. Ascending the Glacier of Argentière to the gap [now called the Col du Chardonnet] separating the Aiguille du Chardonnet from that of Argentière, he ascended [to] that gap. A glance from the summit, of course, showed how the land lay. When he descended upon the eastern side of the ridge he found himself on the Glacier of Saleinaz, *not* on the Glacier of Tour. Had the Federal map been correct, he would have been still in Savoy; as it was he found himself in Switzerland. This col he distinguished by the name of the Col du Chardonnet. Not long before,[1] two members of the Alpine Club, Messrs. George and Macdonald, having been led astray in seeking for the Col d'Argentière of Mr. Tuckett (which lies to the south of the Tour Noir) had already effected a passage from [the Glacier of] Argentière to the Glacier of Saleinaz across the ridge intermediate between these two passes. But it is so highly dangerous and impracticable that it will probably be never tried again.[2] The

Government map, and described in detail in Joanne's *Savoie*: the hill which now bears the name is but 10,634 feet, and the pass near it 9085 feet (see the whole story told in vol. i. pp. 229-231 of the new edition, 1898, of Mr. Ball's *Western Alps*). Another case is the neighbourhood of the Meije and Grande Ruine in the Dauphiné Alps. The French Government map (surveyed about 1853, and published in 1866) was shown to contain the most serious errors by a young Frenchman, M. Duhamel, who published the first accurate map of this part of the Alpine chain—based on his own observations—in 1879 in vol. ix. of the *Alpine Journal* (revised edition in 1881 in vol. x. of the same periodical), while further accuracy is attained in the same observer's beautiful maps of the snowy region of the Dauphiné Alps originally issued in 1889, and in a revised edition in 1892. These are but two of the many instances that might be cited to show that Mr. Reilly's discovery does not stand *alone*.]

[1] [Reilly crossed the Col du Chardonnet on August 24, 1863, and the other party the Col du Tour Noir on July 22 of the same year.]

[2] [It was crossed a second time and in the reverse direction in 1890 by MM. Fordham and Jaccottet (*Echo des Alpes*, 1891, pp. 1-16). There is no doubt whatever that this was the pass of 1864, so that the note in *Alpine Journal*, vol. xv. pp. 497,498 is based on a mistake.]

relative position of the three routes across the chain are shown [on the diagram opposite p. 459].

Most amateurs would have considered it a fair summer's work to explore and map an intricate and desolate country, which had for years been the despair of topographers. But Mr. Reilly was of a different opinion, and having surveyed the chain upwards from Chamouni as far as its eastern declivities, he proceeded with his theodolite in a westerly direction, and proceeded to make a *reconnaissance* of the far larger remaining portion of the chain of Mont Blanc. Taking suitable and prominent stations, especially the Mont Joly and [Mont] Rosaletta (in the Val Montjoie), he turned the Col du Bonhomme, and continuing his observations on the Col de la Seigne, managed to connect his observations on the north side with those on the south side of Mont Blanc, and to complete a topographical draught of the entire group by means of a chain of twenty stations, extending to the Col Ferret, where, entering Switzerland, the Federal map supplied all needful information.

This *reconnaissance*, as we have called it, was performed, though with the utmost care, yet in a far less elaborate style than that which we have described as belonging to his survey eastward. Considering the short time in which it was done,[1] and absence of extraneous materials, it is one of the most admirable instances which have come across our notice of what is commonly called a "tour de force." Aided no doubt he was by two or three fundamental positions which he obtained[2] from an engineer to whom they had been communicated by the Dépôt de la Guerre. But with this trifling exception, and the base line from which he first started, all was his own. The map of the chain of Mont Blanc, founded on these observations, and displayed at a meeting of the Alpine Club in London on the 3rd May, 1864,[3] is in all respects a triumph of sagacity and of art. Mr. Reilly in a short paper explanatory of that map has stated the principles on which it was constructed:—

"All the points I have determined," he says, "about 200 in number, lie

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1 [Six or seven weeks in the summer of 1863.]

2 [Mr. Reilly himself allows that he obtained more information than Forbes stated from the "engineer," who was Captain Mieulet, then engaged in surveying the chain for the French Government, his map being published in the same year as Reilly's, 1865 (*Alpine Journal*, vol. i. pp. 269, 270).]

3 [When Mr. Reilly read the paper already referred to several times.]

where my observations placed them, and I have not changed the position of one of them in deference to any map, however much I might differ from it. I was careful to do this, for I thought that a series of original observations would be far more useful—useful in its very errors—than any compilation of existing ones, for in dealing with these it is impossible to say whether any change one makes increases or diminishes the error. . . . This departure from the system usually employed I found to be of inestimable value, and had it been more generally pursued, nearly all the mistakes with which mountain maps abound would have been avoided.—*Alpine Journal*, June, 1864, vol. i. pp. 269, 270."

After this very clear statement, no one can doubt that Mr. Reilly's results, whatever they may be, are original to him; and we cannot but admire the union of boldness and sagacity, amounting to genius, with which our amateur, undertaking work of the kind for the *first* time, proceeded to execute a plan, so self-denying, yet so wise. We are prepared to allow that the structure of Mr. Reilly's chain of triangles was not what an officer of the Ordnance Survey would have chosen. We may perhaps admit with him that "the hair of an engineer would rise up on his head at the unprofessional way in which [in some certain cases] my results were arrived at" [p. 269 of his article]; but we also know how much may be done by a thorough insight into the matter in hand, even with irregular materials. Had Mr. Reilly been able to spend twice as long as he did in fixing his stations and connecting them, he would no doubt have saved himself a world of anxious labour in the protraction of his results, and in the final draught of his map. We are satisfied, however, that the result would have been little different from what it proved to be; in fact, that as far as the map is to be useful to the tourist or to the geologist, the deviations in it from the proportions of nature are inappreciable and of no positive importance. The result, however, is owing to the admirable manner in which, on his return home, Mr. Reilly made use of the observations which he had accumulated. The rapidity of the survey was to be compensated for by the patience of the reductions. And one is at a loss whether most to admire the truly masculine vigour with which observations of a very fatiguing and elaborate kind, extending over a crooked line of fifty miles in the most rugged country in Europe, were obtained and recorded in the course of a very few weeks, or the indomitable perseverance with which he spent the whole succeeding winter and spring at his desk, evolving point by point the exquisite convolutions of that chain, and the details of its wonderful structure. With certain trifling exceptions, Mr. Reilly states that he "has not indicated the smallest feature for which he had not the authority of a photograph, or of a series of rough sketches which he had taken from nearly all his stations, and on which his theodolite observations are noted" [p. 270 of his article]. The remarkable panoramas,[1] which he thus slightly mentions, form no insignificant part of Mr. Reilly's contributions to the topography of the district. They extended, we believe, to the length of some 160 feet, and embraced views of the chain in almost every conceivable direction. They have been largely increased in number by his excursions during the past summer (1864),[2] and experience has enabled the author to combine in making them a rapidity of execution with an accuracy of proportion and detail which might well seem to be irreconcilable.[3]

We have already said that 200 points of the chain were fixed by the actual intersection of theodolite angles. This is sufficient to trace out the main skeleton of the whole range. The intervals were filled up by the aid of eye-sketches, and of the panoramas just mentioned.

The map, on a scale of 1/40,000, beautifully shaded and coloured, having been presented by the author to the Alpine Club, the first consideration, of course, was how it might be most fitly rendered available to travellers and men of science. In deference to the author's wishes, its publication was delayed until he should have revisited the ground in the course of the succeeding summer (1864), and thus again tested the general accuracy of the whole. In the meantime, a reduced photographic copy was made at the expense of some members of the Alpine Club. The small sketch-map[4] accompanying the present article shows in an unpretending style the broad topographical features of the chain of Mont Blanc, as they have become known to us mainly

[1] [Unfortunately not one of them has been published, we believe.]

[2] [These excursions are described in a paper in the *Alpine Journal*, vol. ii. pp. 97-114.]

[3] [One is reminded of the 710 panoramas, etc., drawn between 1823 and 1881 by Gottlieb Studer during his long Alpine career (*Jahrbuch* of the Swiss Alpine Club, vol. xxvi. p. 318).]

[4] [This map—a copy of Mr. Reilly's first draft—is in the present edition replaced by one based on later authorities, with which it is instructive to compare the 1859 and Raymond's maps.]

through Mr. Reilly's labours. The value and extent of these may be, to a slight degree, judged of by comparing the sketch-map in question with that compiled in 1859 under the eye of the Alpine Club, and published in the first series of *Peaks, Passes, and Glaciers* [p. 1]. With the exception of the district adjoining the Mer de Glace and its tributaries, taken from a previous survey, we find the mountains and valleys of the eastern and western regions of the chain weakly and conventionally indicated rather than expressed.[1] Just as in the sixty-year-old map of Raymond, the guiding ridge of the mountain range is ambiguous, and destitute of the sinuosities which give it all its character, the glaciers taper at both extremities like leeches crawling down the valleys, instead of being each connected with a suitable mountain reservoir, such as is essential to its formation and maintenance.[2] All this can, no doubt, be but feebly traced in the index map[3] which alone we can pretend to furnish to the readers of this article. We would not for the world—even if we could—anticipate the pleasure which all who love the Alps will enjoy when Mr. Reilly's map, on a moderately large scale, and executed in artistic style (as we hope and trust it will be), shall be given to the public. Yet even our little index map shows how artfully (if we may use the phrase) the *packing* of these glaciers is accomplished, and how the irregularities of the ridges, and the sinuous course of the main chain, combine to subdivide the whole of this rugged district into a number of cavities and valleys, unequalled perhaps in the variety of their contours and the steepness of their walls.[4]

[1] [The editor of the 1859 volume (Mr. Ball) makes in the preface (pp. xiv.-xv.) the following statements as to the Mont Blanc map: "The map of the Mont Blanc range may be considered altogether new, as large portions, quite incorrectly laid down in all preceding maps, have been drawn afresh, with the great advantage of the accurate local knowledge of the well-known and respected Auguste Balmat, of Chamouni, now on a visit to this country. Though slight errors may still be detected, the present map is confidently offered as very superior to any hitherto given to the public."]

[2] [It should be remembered as regards this 1859 map that the exploration of the chain of Mont Blanc had then scarcely begun (apart from the highest peak and the Mer de Glace), while it was far more advanced in 1863; and next that the 1859 map is on a very small scale (it barely fills an 8vo page), while Mr. Reilly's draft is on a scale of 1/40,000.]

[3] [Omitted in the present edition.]

[4] [The peaks, glaciers, and ridges in the Dauphiné Alps are far more closely "packed" together than those of the chain of Mont Blanc, while the walls enclosing the valleys and glens in that region are far steeper than in the Mont Blanc range.]

The routes indicated in red[1] show the principal traverses of the chain of Mont Blanc, which, chiefly of late years, have been effected. They have, we believe, been all crossed by Mr. Reilly himself in one or other of the last few summers, and it is evident to simple inspection how full an insight these expeditions must give into the deepest recesses of the chain, and that to one so eminently qualified to use the advantages of his position, no considerable peculiarity of structure or arrangement could have remained undetected by his eye or unrecorded by his unwearied pencil. But, in point of fact, the routes in question by no means exhaust our topographer's explorations. The ordinary pathways round about the entire chain, which are printed in black, have of course been all, once or oftener, trod by him; but further, to avoid confusion, we have, with the exception of the tracks to and from Mont Blanc, indicated in red only "through routes" leading from one face of the chain to the other. Numberless ascents and deviations in different directions have been made by him besides. During last summer, 1864, besides the now usual feat of mounting Mont Blanc—the ordinary summer recreation[2] of an Alpine Club man—Mr. Reilly had the good fortune to ascend [in company of Mr. Whymper], for the first time, three virgin peaks of the chain all among the highest of the second order of summits.[3] There was first the Aiguille d'Argentière (12,800 feet) [really 12,819 feet], whence he could survey at a glance the "Gordian knot," and testify to the non-existence of a distinct[4] "Pointe des Plines." Then there was the Mont Dolent (12,566 feet) [really 12,543 feet], which he reached from the Col Ferret, and which, though lying on the very outskirts of the chain in a south-easterly direction, commands, as Mr. Reilly records in his notes, "*the very perfection of a view.*"[5] Mont Blanc is thence seen from an uncommon direction, supported on the left by the vast summits of the towering [Grandes] Jorasses seen in profile, and on the right by the aspiring, and till lately all but unknown, Aiguille de Triolet. The views towards the Combin

[1] [These red markings are not given on the map in this edition; but the list of passes appears below in the text.]

[2] [Now so no longer.]

[3] [See Mr. Reilly's second paper in the *Alpine Journal*, vol. ii. pp. 97-114.]

[4] [Forbes means, of course, as a rival of the Argentière, making no allusion to the very real peak now bearing the name of Pointe des Plines.]

[5] [Neither Forbes nor Mr. Reilly seemed to be aware that the Mont Dolent is the meeting point of the French, Italian, and Swiss political frontiers.]

and the Alps of Cogne are unsurpassed. The third and loftiest summit of the three new ascents was the Aiguille de Trélatête (12,851 feet) [really 12,832 feet], in a very different (the south-western) quarter of the chain, commanding the whole of that region,—so lately almost a *terra incognita*,—and an unparalleled panorama of the western and steepest slopes of Mont Blanc.

To return, however, for a few moments—for we must draw to a conclusion—to the "through routes" of the chain indicated in red, we must recall the fact that until little more than a dozen years since (*i.e.* c. 1850), only a single pass[1] was recognised in the whole extent of twenty-eight miles intervening between the Col du Bonhomme and the col or valley of Champex, where our sketch-map terminates on the north-east. This was the Col du Géant,[2] celebrated—in the days when Alpine Clubs were unknown—for its height and difficulty; more justly celebrated, however, for the truly remarkable sojourn there in 1788, for seventeen days, of the great De Saussure, for the purpose of scientific experiment. But now our map shows by its red lines eight other passes (or nine in all) by which the chain has been crossed. Beginning at the south-west end, we find two of no special difficulty, the Col du Mont Tondu [9498 feet], and the Col d'Enclave[3] [8813 feet] (numbered with the figures 2 and 3), which must afford a grateful variety to the traveller bound from the Val Montjoie to the Allée Blanche, who has already crossed the somewhat wearisome pass of the Bonhomme. Next we have the Col de Miage (numbered 6),[4] connecting the northern and southern glaciers of that name, which probably yields in interest to no other in the chain. Its height is 11,100 feet [really 11,077 feet], and it is one of the steepest and narrowest of the practicable barriers of the Alps. It was first traversed in 1858 by Mr. Coleman,[5] thus abridging immensely in point of distance,

[1] [Forbes forgets that the Col de Miage was crossed in the eighteenth century, that in 1838 his guide of 1850, Michel Charlet, had passed from the Tour to the Saleinaz Glaciers by the Col Blanc and the Fenêtre de Saleinaz, and that before 1846 Jean Munier had crossed the Col de la Grande Luis. See above, pp. 213, 457, 462, 464. Nowadays there are about thirty snow passes known across the chain.]

[2] See p. 212.

[3] [The Enclave is not a snow pass. The Col des Fours (like the Enclave, a short-cut on the Bonhomme) is Forbes's No. 1.]

[4] [Forbes's No. 4 is the Pavillon de Trélatête, and his No. 5 the Aiguille de Béranger. As to the Col de Miage, see above, p. 213.]

[5] [He was only the first *traveller* over this pass. Since March, 1865, much steeper and narrower passes than the Miage have been effected in the Alps.]

though not so much in time, the long circuit from Chamouni to Courmayeur; while the perfect insight which it gives into the unsurpassed magnificence of the great glacier of the South Miage, with its views of the western precipices of Mont Blanc, place it in the very first rank in point of scenery.[1] The Col de Miage will long be remembered for a singular accident which happened there in 1861 to a young Englishman, who slipped down a face of snow and ice through a *vertical* height of more than 1700 feet, and barely escaped with his life.[2]

Intimately connected with this col is the fifth in order (numbered 8 on the map)[3] which we have called the Col de Bionnassay. It was traversed last summer (1864) for the first time by Mr. Reilly, who calls it the Col du Dôme du Goûter.[4] It undoubtedly forms a most remarkable pass, as by it Courmayeur may be reached from Chamouni by the route of the Grands Mulets and the Dôme du Goûter. Mr. Reilly's point of departure was the Col de Miage, from whence he reached diagonally the ridge which extends from the Aiguille de Bionnassay eastwards to the "Dôme"; and it is still uncertain whether this ridge can in all circumstances be reached directly from the level of the S. Glacier de Miage.[5] Having attained the summit of the Dôme du Goûter by this novel route, Mr. Reilly, with his accustomed intrepidity, proceeded to cut down the N.E. face of the Dôme right upon the Grands Mulets, instead of going round by the Grand Plateau.[6] It is interesting to know that he was accompanied on this occasion by Mr. Birkbeck, the victim

[1] [Certainly, says the present editor, who crossed it in 1870.]

[2] A detailed account of the accident will be found in *Peaks, Passes, and Glaciers*, second series, vol. i. pp. 208-224. [The diagram at p. 211 shows that Mr. Birkbeck slipped down nearly the entire final wall on the north side of the pass.]

[3] [Forbes's No. 7 is the Mont Vorassay.]

[4] [The name "Col de Bionnassay" is now given to the lowest point in the ridge between the Dôme du Goûter and the Aiguille de Bionnassay. The name "Col du Dôme du Goûter" is not now recognised, as the expedition in question was the traverse of a *peak* and not of a pass. See Mr. Reilly's narrative, published, six months after Forbes's article, in the *Alpine Journal*, vol. ii. pp. 110-113.]

[5] [There is no great difficulty in doing so, and this route is now a favourite one from Courmayeur. It was not till 1898 that a party (Mr. J. P. Farrar's) went *in the day* from the Col de Miage over the Aiguille de Bionnassay and the Dôme du Goûter to the summit of Mont Blanc, always keeping to the ridge, which sometimes was very sharp.]

[6] [Mr. Reilly made a virtue of necessity, for he only reached the Dôme at 4.35 or 5 P.M. (he gives both times, *Alpine Journal*, vol. i. p. 375 and vol. ii. p. 113), and wished to take the shortest route to the Grands Mulets, which he reached with "no difficulty" at 6.45 P.M.]

of the accident of 1861 above referred to, whose Alpine ardour appears to have suffered no diminution in consequence of that tremendous somersault. The expedition which it had interrupted was directed towards the very passage thus effected three years later.

It will be seen by the map that the neighbourhood of the Dôme du Goûter is intersected by several routes. Two of these lead to the summit of Mont Blanc. One is the usual route by the Grands Mulets and the Rochers Rouges.[1] Another is that originally tried by De Saussure, and repeatedly attempted since by the [French] Glacier de Bionnassay and the Aiguille du Goûter. This last route offered no advantages while it was necessary to *redescend* from the level of the Dôme to the Grand Plateau and take the old course to the top;[2] but in 1859 the Rev. C. Hudson[3] [with Messrs. Joad and Hodgkinson] effected the direct passage from the Dôme to Mont Blanc by the N.W. ridge of the latter, which overhangs the awful precipices of the S. Miage, traversing the intermediate knoll, known from an early period under the name of the Bosse du Dromadaire. It does not appear that any special difficulty occurs on this, the most natural mode of access of any to the highest mountain of Europe [really of the Alps only]; and it is inexplicable why, though repeatedly "prospected," it has for generations been regarded as impracticable.[4]

Mont Blanc was ascended in 1863 from one other direction

[1] [But this route has nothing to do with the Dôme, at the foot of which it passes, while even in 1865 the "Corridor," and not the "Rochers Rouges," was the usual route up from the Grand Plateau. The Dôme can be reached from below from three directions, the Grands Mulets, the Aiguille du Goûter, and the Aiguille de Bionnassay, whilst thence the Bosses ridges mounts towards the summit of Mont Blanc.]

[2] [This was the route made for the first time by the guideless party of Messrs. Hudson and Kennedy in 1855.]

[3] So stated in Mr. Ball's *Western Alps* [p. 212 of the 1863 edition]. We cannot recollect to have met with the original account. [Unluckily no detailed account has ever been published.]

[4] [To sum up the history of the St. Gervais route. Two hunters of St. Gervais about 1784 attained from that side both the Aiguille and the Dôme du Goûter, but returned by the same route. In 1855 Mr. Hudson's party followed this way to the Dôme, descended to the Grand Plateau, and attained Mont Blanc by the Corridor. In 1859 Mr. Hudson's party mounted from the Grand Mulets to the Dôme, and then for the first time traversed the whole ridge of the Bosses to Mont Blanc. Finally in 1861 Messrs. Leslie Stephen and Tuckett went in one day from St. Gervais to the shelter hut on the Aiguille du Goûter, and next day followed the ridge over the Dôme and the Bosses to the summit of Mont Blanc, thus completing the route first tried in 1784. There is no real difficulty in it. The present editor in 1876 went from the Pavillon Bellevue, above the Col de Voza, in eight hours over the Aiguille du Goûter and Dôme du Goûter to near

by Messrs. Maquelin and Briquet [of Geneva]. By crossing the Col du Géant from Courmayeur, and bivouacking at the south foot of the Aiguille du Midi, they gained the summit by [the Mont Blanc du Tacul] the Mont Maudit and the Corridor. This route presents some points of interest, but it is absurd[1] and illogical to consider it as a route from Courmayeur to the summit of Mont Blanc. It is essentially a route by Montanvert and the Glacier du Géant, entirely situated on the northern slopes.[2] Of the next pass in order, the Col du Géant (11,200 feet) [really 11,060 feet), numbered 27[3] on the map, we need say no more here. The following one, the Col de Triolet, achieved by Mr. Reilly [with Mr. Whymper] in 1864, has a newer interest, and is likely, we should think, to become popular amongst members of the Alpine Club.[4] This is the only outlet yet discovered from the Glacier of Talèfre,[5] and it leads into the Italian Val Ferret near the col of that name, by the Glacier de Triolet. It is close to [the south-west foot of] the Aiguille de Triolet. Mr. Reilly, starting from the Montanvert, slept under a shelter-stone on the Couvercle. From the notes[6] which he has kindly furnished us, we find that, leaving his bivouac at 4.30 A.M., passing

the Bosses, whence a very high wind compelled a hasty descent to the Grands Mulets.

Nowadays the Bosses ridge from the Grands Mulets is the usual one from Chamouni ; there is a hut near the Bosses (of which there are two), and an observatory close to the summit of Mont Blanc. The Bosses ridge was formerly much dreaded by reason of wind. Hence it was first *ascended* only in 1859 by Mr. Hudson's party, while it was not first *descended* till 1869 by the present editor.]

1 [Quite true. Neither the Tacul nor the Mont Maudit are actually climbed.]

2 [For the routes from Courmayeur direct, effected since Forbes's article was published in March, 1865, see the new edition of Mr. Ball's *Western Alps*, pp. 357, 358. They are five in number—by the Brenva Glacier (1865), by the Dôme Glacier (1868), by the Mont Blanc Glacier (1872), by the Fresnay Glacier and the ridge leading up to Mont Blanc de Courmayeur (1877), and by the Italian Bionnassay Glacier to the ridge between the Aiguille de Bionnassay and the Dôme du Goûter, and thence over the Dôme and the Bosses (1889). As yet all attempts to scale the precipices above the Brouillard Glacier have failed.]

3 [Forbes's numbering passes along the north side of the chain to the Pointe d'Orny, and then returns along the south side. This explains the leap from No. 8 to No. 27.]

4 [This has not, however, been the case. The pass offers no considerable difficulties, but lands the traveller in the upper bit of the Italian Val Ferret, a long way from either Courmayeur or Orsières, though the Triolet Club hut now affords a resting-place.]

5 [Now there are at least three other outlets, not to speak of "traverses" across peaks.]

6 [See for further details the short note in *Alpine Journal*, vol. i. p. 374, and for a full account *Alpine Journal*, vol. ii. pp. 98-101, the latter article having been published in September, 1865, six months after that by Forbes.]

the Jardin, and ascending the Talèfre Glacier to its south-east angle he, with his companion Mr. Whymper [and three guides or porters], attained [by the steep Courtes Glacier] the Col de Triolet at 8.10 A.M. [the printed accounts say 8.5 and 8.30], an early hour considering the great height, which is 12,160 feet [really 12,110 feet]. The view must partake much of the nature of that from the Mont Dolent, already referred to, which is but a little way farther east, and only 400 feet [really 433 feet] higher. The descent from the col to the Glacier of Triolet is steep and difficult.[1] The more level part of the névé of the glacier was only reached at 10.50, and the moraine an hour later. The glacier is a long one, and in order to escape the torrent at its foot, the next higher glacier, that of Mont Dolent,[2] had to be used as a bridge. Finally the chalets of Pré de Bar were reached at 4, being 11½ hours from the Couvercle. To descend the valley to Courmayeur would take three hours more.

The remaining cols of the chain are those of Argentière, No. 19 [11,536 feet], from Chamouni to the La Fouly huts in the Swiss Val Ferret; of Chardonnet, No. 18 [10,909 feet], from Chamouni to Orsières; and that of the Fenêtre de Saleinaz, No. 21 [10,709 feet], in the same direction. Of these we have already said enough.[3] Not one of all these passes, excepting the two nearest the Col du Bonhomme, are under 11,000 English feet in height.[4] And here we must take leave, for the present, of Mr. Reilly and his map. He has generously made over all right of property in

[1] [In 1874 the present editor mounted from the Talèfre Glacier to the Col de Triolet, but owing to an inaccurate description of the descent by Mr. Reilly in Mr. Ball's *Western Alps*, 1866 edition, p. 217 (no mention being made of the rocks above the ice slope) was unable to proceed farther. In 1876, starting from a bivouac on the Jardin (after a long expedition on the previous day), the present editor reached the col at 6.25 A.M. (2¼ hours from the bivouac). A quarter of an hour over steep rocks was followed by steep snow and glacier slopes, the level Glacier de Triolet being attained in 1 hour 5 minutes from the pass. In 1 hour 10 minutes more a spring nearly in the level of the Italian Val Ferret was gained, and hence a steep traverse made to the left in order to gain the Petit Ferret pass, ¾ hour, 1¼ hour more being required to that pass, and Martigny reached the same evening past Orsières.]

[2] [Now called Pré de Bar Glacier, the name in the text being transferred to the first glacier on the other side of the Col Ferret. The Triolet club hut is above the left bank of the glacier, to the left of the route (when *descending* from the pass), and thence the Val Ferret can be gained in fifty minutes direct, there being no need to cross the tail of the Pré de Bar Glacier.]

[3] [Forbes oddly omits the easiest of all the snow passes in the chain, the Col du Tour, 10,762 feet, though it was crossed in 1858 by his friend Mr. (now Mr. Justice) Wills.]

[4] [But see the heights given under each, above.]

the latter to the Alpine Club, and the Club, by accepting the trust, have engaged that the public shall receive the benefit of Mr. Reilly's labours. The author having undertaken to reduce and redraw the map on a scale of 1/80,000 of nature, and to correct it throughout from his latest observations, this finished drawing—which is a masterpiece of its kind—has, we understand, been placed in the hands of a competent artist in lithography, and will be published in the course of two or three months.[1] The result, even after making some allowance for the lithography falling short of the original, will, we trust, justify the encomiums we have pronounced on Mr. Reilly's labours.[2] It will be a real boon to the tourist, the geographer, and the geologist. It will be by far the proudest trophy which the Alpine Club can show of the enterprise and devotion of its members. The junior but rival clubs of Switzerland, Vienna, and Turin[3] will find that the coronet of Alpine exploration has been secured for Britain.[4] It is certainly a remarkable fact that a mountain range so limited in extent as that of Mont Blanc, so remarkable by its elevation [and] so attractive by its scenery should have remained unsurveyed till the second half of the nineteenth century. It is still more remarkable that the three important States—France, Italy, and Switzerland—which share among them this stronghold of nature, should have been unable to agree to make a map of it on a common scheme,[5] and that it should have been left to a British amateur[6] to supply so glaring a deficiency.

[1] [The map was lithographed by Messrs. Kell Brothers, and was published in June, 1865. The original MS. was presented to the Alpine Club in 1887 by Mr. C. E. Mathews (*Alpine Journal*, vol. xiii. p. 292).]

[2] [It is indeed a beautiful map, and takes in the whole chain of Mont Blanc, but gives no heights whatsoever. In 1865 Captain Mieulet's map was also published; this does not take in the whole chain, but gives many heights. For a discriminating comparison of the two maps by the late Mr. R. C. Nichols—himself an experienced map maker—see *Alpine Journal*, vol. ii. p. 246. Viollet le Duc's map (1876, 1/40,000) is inconveniently large, but beautifully reproduced, though it is mainly based on earlier maps, and so contains many errors.]

[3] [The Viennese (Austrian) Club was founded in 1862, and those of Italy and Switzerland in the next year.]

[4] [But since 1865 the three clubs named have published far more and far finer maps than those issued by the English Alpine Club.]

[5] [This is *still* the case; some of the later Government maps of these States are on the same scale, though executed in different fashions, and especially without any agreement as to the names of peaks and passes on the frontier ridge. It is a disgraceful state of things.]

[6] [Forbes would have been still more astonished had he known that till 1896 no complete and perfect map of the entire chain would be given to the world, and

As to Mr. Reilly himself, we can only express the hope that his perseverance, skill, and taste, having found a fit field for their exercise, will continue to be further employed for the promotion of geography and the benefit of mountaineers.[1]

that when this took place it would be due to the combined efforts of an enterprising Swiss amateur (M. Kurz), of a skilled Swiss engineer (Herr Imfeld), and of a wealthy Swiss tradesman (M. Barbey). The map is called "La Chaine du Mont Blanc," is on a scale of 1/50,000, and costs ten francs unmounted, or twelve francs mounted on linen. It is most beautiful to look at, while it was engraved by the late Herr Leuzinger, who is responsible for many sheets of the wonderful Siegfried or Government Map of Switzerland, now in course of publication.]

[1] [Very probably these words of Forbes encouraged Mr. Reilly to continue his cartographical labours. At any rate he undertook a survey of a new district in 1865-66, and published the results in 1869 under the title of *The Valpelline, the Valtournanche, and the Southern Valleys of Monte Rosa* (scale 1/100,000), another great success for the modest amateur, whom the present editor had the pleasure of meeting in the Valpelline on July 28, 1866, while the survey was in progress.]

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THE END

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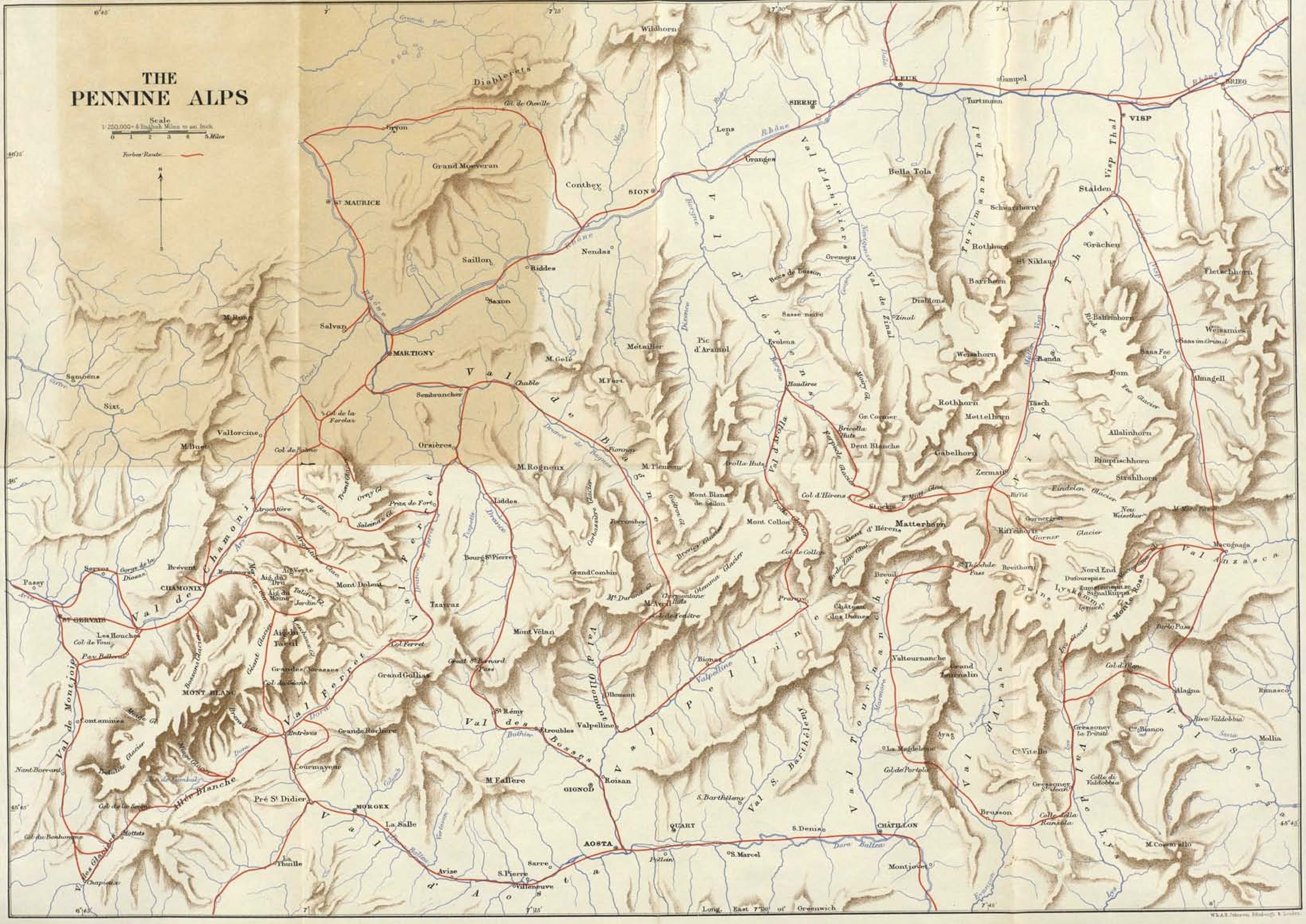
THE PENNINE ALPS
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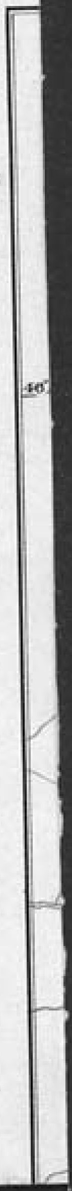
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