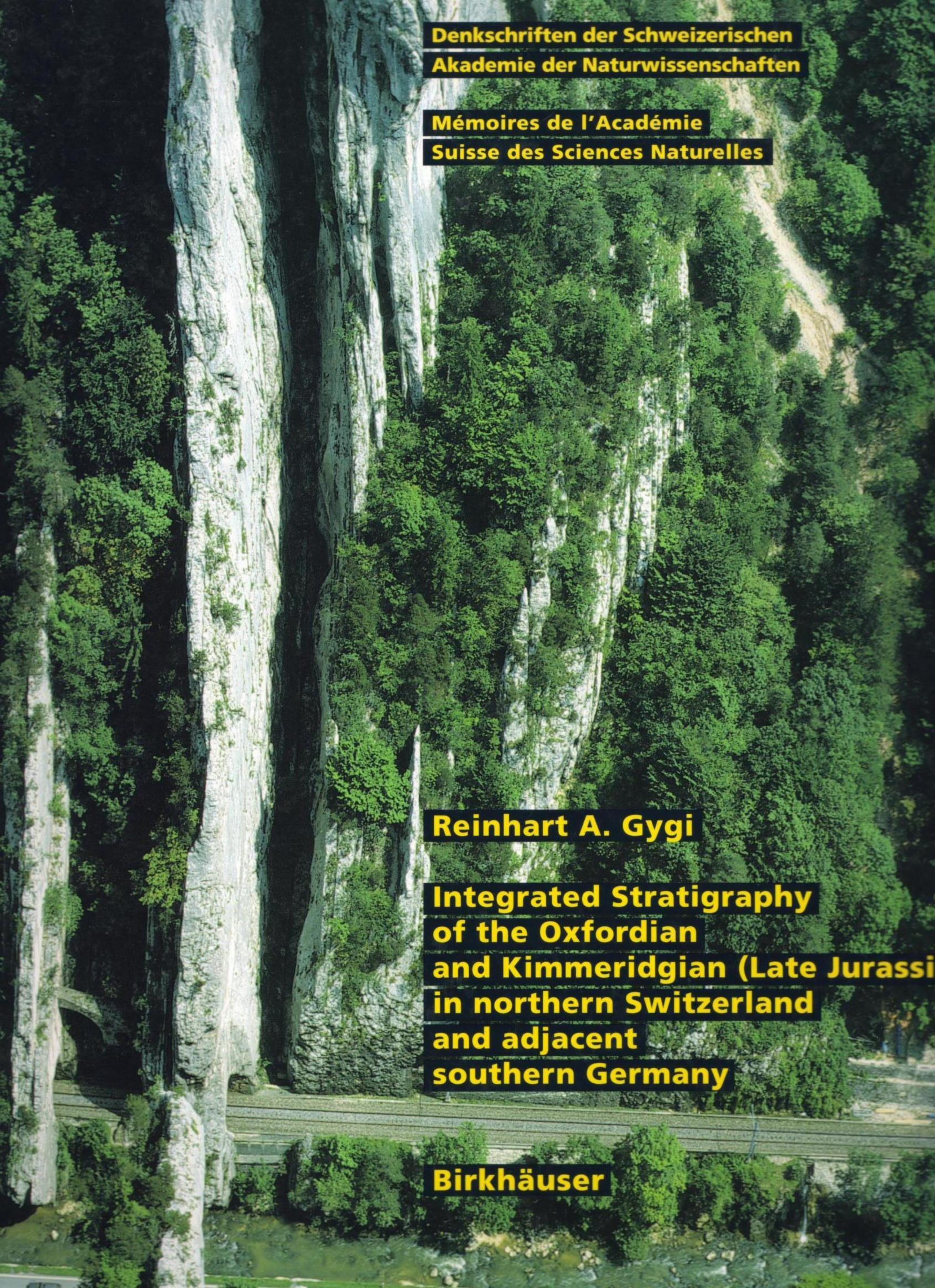

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Reinhart A. Gygi

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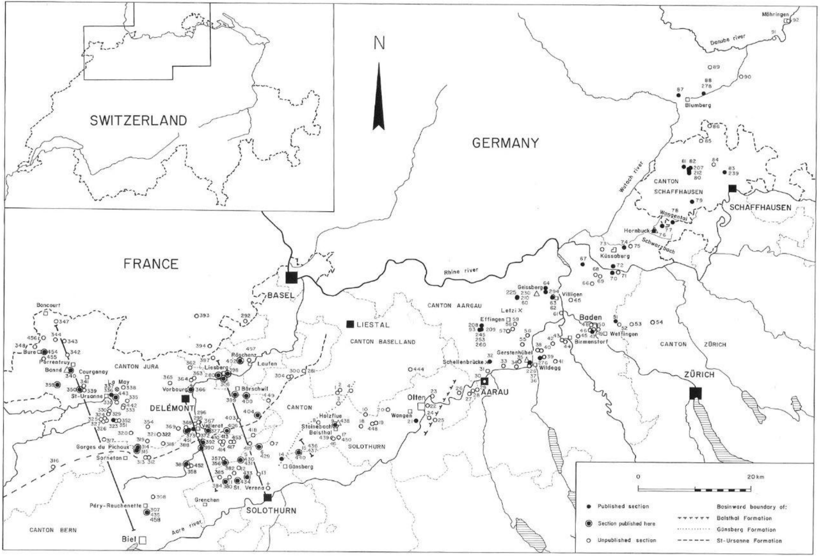
Contents


SWITZERLAND
N
GERMANY
FRANCE
BASEL
LIESTAL
CANTON BASELLAND
CANTON AARGAU
CANTON JURA
DELÉMONT
CANTON SOLOTHURN
SOLOTHURN
AARAU
Olten
CANTON SCHAFFHAUSEN
SCHAFFHAUSEN
CANTON ZÜRICH
ZÜRICH
CANTON BERN
Biel
Rhine river
Danube river
Wutach river
Aare river
Schwarzbach
Möhringen
Blumberg
Küssaburg
Hornbuck
Wangental
Geissberg
Villigen
Letzi
Effingen
Baden
Wettingen
Birmenstorf
Gerstenhübel
Schellenbrücke
Wildegg
Wangen
Holzflue
Steinebach
Balsthal
Günsberg
St. Verena
Grenchen
Péry-Reuchenette
Sornetan
Gorges du Pichoux
Vellerat
Börschwil
Liesberg
Röschenz
Laufen
Vorbourg
St-Ursanne
La May
Courgenay
Bonné
Porrentruy
Bure
Boncourt
0
20 km
Published section
Section published here
Unpublished section
Basinward boundary of:
Balsthal Formation
Günsberg Formation
St-Ursanne Formation

1 Introduction

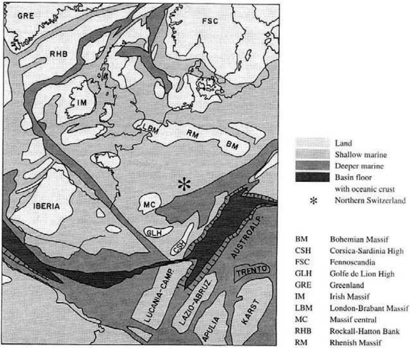
1.1 Geographical and palaeogeographical setting

The measuring of detailed sections and the excavation of fossils were done in an area which is confined to the west by a line between Boncourt in Canton Jura and Biel in Canton Bern (fig. 1). The belt of outcrops becomes narrower towards the east and then runs northeast from Canton Aargau to Möhringen on the Danube river in southern Germany. This whole area is where the Burgundy platform (Purser 1979) interfingers with sediments of the rhodano-swabian epicontinental sea which was situated adjacent to northern Tethys (fig. 63). The whole area was transformed into an epicontinental sea (fig. 2) by the worldwide Callovian transgression which also flooded the Dalle nacrée carbonate platform in the early Callovian.

1.2 Previous work

Stratigraphic exploration of the Swiss Jura range began before 1820. Merian (1821) described the Jurassic sediments in the area of Basel for the first time and gave a short and appropriate description of the principal lithostratigraphic units. Merian was aware that fossils were a means for correlation, but he stated that fossils were not known well enough at the time for this purpose. Therefore he correlated strictly lithostratigraphically. He correlated the marls of the Bärschwil Formation of the early and middle Oxfordian in the central Jura with the marls of the Effingen Member of the middle and late Oxfordian in the eastern Jura range (fig. 3). He also compared the coral limestones of the St-Ursanne Formation on the platform with the basinal micritic limestones of the Villigen Formation in Canton Aargau.

Fig. 2: Palaeogeographical overview of Europe in the Late Jurassic.
After Ziegler (1988, pl. 13), simplified.



◀ Fig. 1: Locations with the numbers of the sections measured between 1962 and 1995. Black circles are sections published in:

Gygi (1969):	RG 1–93	Gygi & Marchand (1982):	RG 207
Gygi (1973):	RG 226	Gygi (1990a):	RG 280, 307
Gygi (1977):	RG 51b, 81b, 208–210, 212, 230	Gygi (1990b):	RG 239
Gygi *et al.* (1979):	RG 276	Gygi & Marchand (1993):	RG 314, 373, 388, 399
Gygi (1982):	RG 280, 306, 307, 315, 336	This paper (see "contents")	RG 280 through 458

Empty circles are unpublished sections which are only described in the author's fieldbooks which can be seen at request in the Museum of Natural History Basel. Squares of different sizes are villages, towns or cities. Triangles are hills or mountains. A cross is a locality in the field.

Section no.		Township	Locality	Co-ordinates beginning of section	Co-ordinates end of section
RG	1	Reigoldswil BL	Hotel Wasserfalle	619.750/247.000	619.780/247.780
RG	2	Reigoldswil BL	Tunnel east of Schelmenloch	610.960/247.500	619.670/247.250
RG	3	Mümliswil SO	Gorge south of Genneten	619.830/245.300	619.880/245.010
RG	4 *	Waldenburg BL	Brocheni Flue	622.030/247.590	621.930/247.530
RG	5	Gänsbrunnen SO	Cantonal road and quarry	602.070/234.910	602.150/234.850
RG	6	Welschenrohr SO	Gorge south of Harzergraben	605.550/237.490	605.630/237.400
RG	7	Herbetswil SO	Upper Wolfschlucht gorge	608.190/238.120	608.280/237.930
RG	8	Laupersdorf SO	Mausteren	616.300/242.050	616.200/241.750
RG	9	Balsthal SO	Steinebach gorge	619.370/241.350	619.350/241.280
RG	10	Holderbank SO	Road bend south of Lochhus	624.880/243.190	624.850/243.130
RG	11	Selzach SO	Western cliff of Hasenmatt	600.700/232.180	600.760/232.160
RG	12	Oberdorf SO	Rüschgraben	602.100/233.680	601.940/233.750
RG	13	Oberdorf SO	Gorge east of Nesselboden	605.550/232.720	605.700/232.650
RG	14	Günsberg SO	Gschlief landslide	609.540/235.380	609.500/235.620
RG	15	Aedermannsdorf SO	Horngraben	613.120/236.790	613.050/236.870
RG	16	Balsthal SO	Von Roll quarry, Klus	619.030/239.370	618.950/239.450
RG	17	Balsthal SO	Chluser Roggen	619.780/239.320	619.770/239.370
RG	18	Oberbuchsiten SO	Mühlebach ravine	623.700/241.320	623.800/241.240
RG	19	Egerkingen SO	Flüeloch gorge	626.600/241.700	626.680/241.600
RG	20	Hägendorf SO	Road south of Allerheiligenberg	628.440/244.150	628.480/244.050
RG	21 *	Olten SO	Quarry on Mt. Born	633.900/242.280	634.080/242.300
RG	22	Olten SO	Hardflue	635.550/244.980	635.550/244.920
RG	23	Winznau SO	Cliff east of Aare bridge	636.480/246.500	636.550/246.500
RG	24	Aarburg AG	Säliflue	635.910/243.050	635.900/243.080
RG	25	Oftringen AG	Quarry south of Heidenloch	636.880/241.990	636.930/241.960
RG	26	Niedergösgen SO	Quarry west of church	641.620/246.970	641.630/246.980
RG	27	Schönenwerd SO	Cliff south of cemetery	643.200/247.100	643.200/247.060
RG	28	Schönenwerd SO	Quarry at Halden	643.700/247.660	643.690/247.670
RG	29 *	Wöschnau SO	Quarry in Roggenhausen valley	644.530/247.930	644.530/247.930
RG	30	Aarau	Exploration well near former post office	645.760/249.340	645.760/249.340
RG	31	Küttigen AG	Zurlinden quarry	646.550/251.000	646.620/251.030
RG	32	Küttigen AG	Road near Schellenbrücke	646.450/252.880	646.460/252.870
RG	33	Biberstein AG	Quarry east of Ihegi	649.230/251.760	649.240/251.750
RG	34	Auenstein AG	Quarry near public swimming pool	651.660/251.680	651.670/251.630
RG	35	Auenstein AG	Halden	652.140/252.760	652.130/252.750
RG	36	Auenstein AG	Quarry west of Fahr	653.550/251.880	653.600/251.870
RG	37	Auenstein AG	Quarry of Jakobsberg	653.900/252.400	653.780/252.030
RG	38	Schinznach-Bad AG	Waterfall west of Gupf	655.330/254.800	655.380/254.790
RG	39	Lupfig AG	Im Berg	656.230/253.490	656.230/253.490
RG	40	Scherz AG	Quarry of Scherzberg	655.750/255.200	655.780/255.220
RG	41	Brunegg AG	Brunegg castle	658.470/252.720	658.500/252.650
RG	42 *	Lupfig AG	Quarry of Guggerhübel	658.000/256.000	658.000/256.010
RG	43	Mülligen AG	Schämbelen	659.370/256.720	659.370/256.710
RG	44	Mülligen AG	Quarry east of Eiteberg	660.100/256.330	660.100/256.310
RG	45	Birmenstorf AG	Quarry northwest of Oberhard	662.000/257.220	661.980/257.200
RG	46	Baden AG	Quarry of Hundsbuck	664.670/258.230	664.700/258.200
RG	47	Baden AG	Railroad cut	664.750/258.050	664.910/258.100
RG	48	Baden AG	Martinsberg	664.900/259.360	664.880/259.380
RG	49	Baden AG	Road tunnel below Stein	665.420/258.450	665.400/258.350
RG	50	Baden AG	Quarry east of Landvogtei castle	665.780/258.420	665.800/258.380
RG	51	Oberehrendingen AG	Quarry of Hinterstein	669.090/260.070	669.090/260.070
RG	52	Unterehrendingen AG	Mt. Lägern, Burghorn	669.680/259.330	669.650/259.280
RG	53	Schleinikon ZH	Ruin of Altlägern	672.070/259.480	672.200/259.470
RG	54	Regensberg ZH	Quarry northeast of town	675.700/259.780	675.870/259.830
RG	55	Schinznach-Dorf AG	Grund	651.830/255.700	651.850/255.640
RG	56	Schinznach-Dorf AG	Mannlehen west of Wallbach	653.800/257.270	653.810/257.310
RG	57	Zeihen AG	Quarry at Laufacker	650.190/258.190	650.230/258.120
RG	58	Linn AG	Quarry at Hundruggen	650.950/258.650	650.960/258.620
RG	59	Effingen AG	Quarry beside Bözberg road	651.400/259.540	651.390/259.530
RG	60	Gansingen AG	Eisengraben	651.560/264.080	651.560/264.080
RG	61	Rüfenach AG	Quarry north of Lauffohr	659.730/261.950	659.740/261.980
RG	62	Villigen AG	Schrannechopf	657.680/264.020	658.100/264.000
RG	63 *	Villigen AG	Ravine west of Villigen	658.050/264.240	658.040/264.230
RG	64	Villigen AG	Mandacher Höhe	656.650/265.880	656.650/265.880
RG	65 *	Würenlingen AG	Former quarry	661.270/264.080	661.280/264.070
RG	66 *	Unterendingen AG	Tal	664.800/266.630	664.800/266.610
RG	67	Zurzach AG	Road southwest of town	663.200/269.980	663.200/269.980
RG	68	Rekingen AG	Exploration well Im Berg	665.500/268.500	665.500/268.500
RG	69	Baldingen AG	Waterfall of Bistig	666.280/268.160	666.250/268.140
RG	70 *	Mellikon AG	Large quarry	668.330/268.730	668.300/268.620
RG	71 *	Rümikon AG	Former quarry	669.280/268.700	669.280/268.700
RG	72	Reckingen D	Quarry of In den Mösern	668.450/269.840	668.450/269.840
RG	73	Dangstetten D	Berchenwald	666.500/272.750	666.500/272.750
RG	74	Geisslingen D	Steiggraben	670.480/273.080	670.600/273.010
RG	75	Geisslingen D	Road west of Egg	671.550/273.450	671.560/273.400

Section no.		Township	Locality	Co-ordinates beginning of section	Co-ordinates end of section
RG	76	Erzingen D	Hornbuck north of Riedern	675.650/276.100	675.700/276.120
RG	77	Weisweil D	Ravine southeast of village	677.430/276.860	677.440/276.530
RG	78	Wilchingen SH	Mülitobel south of Osterfingen	679.125/277.450	679.230/277.360
RG	79	Neunkirch SH	Quarry of Tenggibuck	682.470/281.100	682.480/281.100
RG	80	Siblingen SH	Siblingen, Schlossranden	682.000/286.160	682.000/286.160
RG	81	Gächlingen SH	Räckolterenbuck	680.980/287.240	680.980/287.240
RG	82	Siblingen SH	Steimürlichopf	682.130/287.060	682.210/287.300
RG	83	Schaffhausen	Summerhalde	688.080/286.340	688.080/286.340
RG	84	Hemmental SH	Quarry of township	686.450/287.830	686.430/287.850
RG	85	Beggingen SH	Im wisse Rise	684.300/291.600	684.340/291.620
RG	86	Bargen SH	Morgenhalde	685.700/294.580	685.530/294.650
RG	87	Achdorf D	Landslide west of Eichberg	680.230/300.430	680.300/300.460
RG	88	Blumberg D	Iron ore pit at Stoberg	684.240/300.210	684.230/300.220
RG	89	Fürstenberg D	Schächer	3.468.150/5.305.450	3.468.500/5.305.560
RG	90	Leipferdingen D	Quarry northeast of railway station	3.474.360/5.303.650	3.474.370/5.303.670
RG	91	Immendingen D	Hill south of railway bridge	3.480.470/5.310.840	3.480.430/5.310.730
RG	92	Möhringen D	Kreuzhalde	3.483.070/5.313.560	3.483.060/5.313.570
RG	93	Ueken AG	Iron mine of Herznach	ca. 645.250/258.550	645.250/258.550
RG	207	Siblingen SH	Water conduit in Churz Tal	682.130/287.060	682.130/287.060
RG	208	Ueken AG	Excavation on Brunnrain	645.480/259.180	645.480/259.180
RG	209	Ueken AG	Iron mine of Herznach	645.150/258.700	645.150/258.700
RG	210	Gansingen AG	Eisengraben	651.710/264.070	651.710/264.070
RG	212	Siblingen SH	Shooting range in Churz Tal	682.100/286.870	682.100/286.870
RG	226	Veltheim AG	Quarry of Unteregg and Steibitz road cut	653.950/253.000	654.000/252.420
RG	230	Gansingen AG	Excavation northwest of Eisengraben	651.500/264.130	651.500/264.130
RG	239	Schaffhausen	Summerhalde	688.070/286.340	688.070/286.340
RG	245	Herznach AG	Iron mine	645.055/258.345	645.075/258.335
RG	253	Herznach AG	Iron mine	644.930/258.370	644.930/258.370
RG	260	Herznach AG	Iron mine	644.940/258.335	644.940/258.335
RG	276	Holderbank AG	Quarry of Chalch	655.900/253.500	656.030/253.450
RG	278	Blumberg D	Iron ore pit at Stoberg	684.450/300.290	684.400/300.310
RG	**280**	**Liesberg BL**	**Clay pit of Ampthil**	**598.700/250.020**	**598.690/250.140**
RG	281	Nunningen SO	Gorge south of Lochmatt	613.630/251.000	613.650/250.920
RG	292	Leymen F	Quarry west of Landskronberg	603.400/259.850	603.370/259.930
RG	294	Villigen AG	Quarry of Gabechopf	656.550/264.900	656.500/264.880
RG	295	Vellerat JU	Champs de la Joux	594.680/241.500	594.670/241.510
RG	296	Vellerat JU	Road to Forêt de la Cendre	594.750/241.600	594.800/241.680
RG	300	Zullwil SO	Quarry at Eichlenberg	611.320/250.000	611.410/249.850
RG	304	Fehren SO	Ibach gorge	611.180/250.010	611.070/250.160
RG	**306** *	**Liesberg BL**	**Clay pit and quarry of Chestel**	**599.500/249.600**	**599.720/249.620**
RG	**307**	**Péry BE**	**Quarries of La Charuque-Reuchenette**	**585.750/225.500**	**585.900/226.330**
RG	308	Péry BE	Sous la Verrière	586.990/228.590	587.040/228.450
RG	309	Souboz BE	Le Beugle	585.600/235.150	585.580/235.180
RG	310	Souboz BE	Le Beugle	585.600/235.270	585.580/235.320
RG	311	Souboz BE	Combe des Raverattes	586.420/235.380	586.230/235.450
RG	312	Souboz BE	Montaigu	586.230/235.450	586.300/235.650
RG	313	Souboz BE	Noir Bos	585.480/235.400	585.480/235.520
RG	**314**	**Sornetan BE**	**Pichoux gorge**	**584.150/237.230**	**584.170/237.220**
RG	**315**	**Sornetan BE**	**Pichoux gorge**	**584.070/237.170**	**584.030/236.720**
RG	316	Le Bémont JU	Cras du Plainat	569.020/233.730	568.870/233.750
RG	317	Saulcy JU	Road to Lajoux	578.400/238.800	578.130/238.730
RG	318	Soulce JU	Vieilles Vies	588.650/237.860	588.760/238.140
RG	319	Soulce JU	Le Golat	585.980/238.290	585.850/238.360
RG	320	Undervelier JU	Montépoirgeat	582.600/240.120	582.900/239.820
RG	321	Soulce JU	Peute Côte, western slope	587.380/240.120	587.450/239.820
RG	322	Soulce JU	Peute Côte, eastern slope	587.760/239.680	587.700/239.660
RG	323	Glovelier JU	Foradrai	579.760/242.000	580.090/242.070
RG	324	St-Ursanne JU	Haute Côte	578.290/242.470	578.270/242.200
RG	325	St-Brais JU	Sous les Errauts	578.050/242.310	577.920/242.300
RG	326	St-Ursanne JU	Northwest of La Seigne Dessus	578.490/242.110	578.350/242.070
RG	327	St-Brais JU	Rock eastnortheast of Les Errauts	578.240/242.050	578.130/242.110
RG	329	St-Ursanne JU	West of La Seigne Dessous	579.200/243.320	579.150/243.150
RG	330	St-Ursanne JU	Above Plan du Noyer	579.100/243.470	579.180/243.650
RG	331	St-Ursanne JU	Road cut west of Montmelon	580.350/245.000	580.340/244.970
RG	333	Boécourt JU	Mont Russelin	581.550/244.250	581.700/244.450
RG	335	Boécourt JU	Cantonal road at Ordon	582.650/245.830	582.300/245.270
RG	336	St-Ursanne JU	Railway station and lime works	579.200/246.370	579.700/246.450
RG	337	St-Ursanne JU	La May	580.610/247.540	580.720/247.390
RG	338	Asuel JU	Côte du Frêne	581.930/248.050	581.770/247.880
RG	339	Courgenay JU	Road to Vacherie Mouillard	574.490/247.200	574.650/247.450
RG	**340** *	**Porrentruy JU**	**Quarry east of Le Banné hill**	**572.560/250.840**	**572.560/250.840**
RG	341	Courgenay JU	L'Alombre aux Vaches	574.800/248.200	574.800/248.200
RG	342	Courchavon JU	Sur le Tunnel	571.650/253.820	571.730/253.860
RG	343	Courtemaîche JU	Quarry east of railway station	571.300/256.250	571.300/256.240
RG	344 *	Courtemaîche JU	Quarry of Sur Montni	569.680/256.550	569.680/256.550

Section no.	Township	Locality	Co-ordinates beginning of section	Co-ordinates end of section
RG 347	Buix JU	Quarry of Les Creppes	569.650/259.740	569.630/259.800
RG 348	Bure JU	Quarry of Combes des Pierres	566.110/254.860	565.960/254.940
RG 350	**Courgenay JU**	**Chemin paulin road**	**573.790/247.100**	**573.950/247.430**
RG 351	Glovelier JU	Southwest of Côte du Crêt	580.420/241.880	580.500/241.830
RG 352	Glovelier JU	Côte du Crêt	580.840/241.900	581.150/242.120
RG 354	Bassecourt JU	Le Cantonnement	586.000/241.170	585.950/241.220
RG 356	**Grandval BE**	**Landslide of Morte Roche**	**599.670/234.490**	**599.750/234.370**
RG 357	Grandval BE	Peute Combe	599.640/235.200	599.620/235.240
RG 358	Moutier BE	Envers des Roches de Court	593.470/234.000	593.530/234.030
RG 359	**Bressaucourt JU**	**Drinking water well**	**569.980/248.480**	**569.980/248.480**
RG 362	Movelier JU	Hasenschell	593.650/251.290	593.980/251.230
RG 363	Soyhières JU	En Goulat	593.930/249.820	593.990/249.620
RG 364	Mettembert JU	Combe de Mettembert	593.990/249.490	593.520/249.470
RG 365	Delémont	Combe du Vivier	589.930/248.570	589.950/248.810
RG 366	**Delémont**	**Chapelle du Vorbourg**	**593.760/247.740**	**593.890/247.420**
RG 367	Vellerat JU	Les Esserteux	595.040/241.690	595.070/241.800
RG 368	Châtillon JU	Road to Forêt de la Cendre	592.740/240.910	592.740/241.060
RG 369	Courtételle JU	Gorge south of L'Essert Dessus	591.380/240.860	291.420/240.980
RG 372	Roches BE	Côte du Droit	594.450/239.290	595.140/239.540
RG 373	**Vellerat JU**	**Sous la Peute Roche**	**594.200/240.600**	**594.170/240.640**
RG 377	**Rebeuvelier JU**	**La Roche St. Jean**	**596.370/240.230**	**596.430/240.380**
RG 380	Selzach SO	Western cliff of Hasenmatt	600.700/232.130	600.760/232.150
RG 381	**Moutier BE**	**Court gorge, northern side**	**593.170/234.310**	**593.350/234.690**
RG 382	Selzach SO	Chessel	601.370/232.610	601.370/232.600
RG 384	**Selzach SO**	**Road through Lochbach gorge**	**599.950/231.400**	**600.020/231.210**
RG 385	Selzach SO	Road west of Stallberg	599.020/232.090	599.070/232.140
RG 388	Vellerat JU	Landslide Sous la Peute Roche	593.850/240.340	593.850/240.345
RG 389	**Vellerat JU**	**Sous la Peute Roche**	**594.080/240.540**	**594.050/240.530**
RG 390	**Moutier BE**	**Southern part of Moutier gorge**	**595.720/237.320**	**595.700/237.100**
RG 392	**Moutier BE**	**Arête du Raimeux**	**595.550/238.100**	**595.670/238.120**
RG 393	Fislis F	Quarry of Kalkofen	594.800/260.700	594.920/260.750
RG 394	Wolschwiller F	Road west of Dürrmattengraben	596.990/255.420	597.070/255.500
RG 397	Kleinlützel SO	Road west of castle rock	597.930/253.410	597.920/253.300
RG 398 *	**Liesberg BL**	**Limestone quarry of cement works**	**600.360/250.210**	**600.320/250.470**
RG 399 *	**Bärschwil SO**	**Landslide west of Vögeli farm**	**601.490/246.780**	**601.510/246.720**
RG 400	**Corban JU**	**Gorge northeast of La Providence farm**	**603.680/246.540**	**603.630/246.320**
RG 402	**Röschenz BL**	**Road to Müli**	**602.130/252.760**	**602.530/252.680**
RG 403	Vermes JU	Quarry west of village	602.180/242.100	602.290/242.060
RG 404	**Mervelier JU**	**Gorge of the Scheulte river**	**605.430/242.880**	**605.250/242.950**
RG 406	**Vermes JU**	**Ravine southeast of La Kohlberg farm**	**601.280/240.480**	**601.350/240.750**
RG 410	Grandval BE	Road south of Combe des Geais	598.980/238.300	599.020/238.220
RG 413	Grandval BE	Ravine south of Combe de la Hue	599.570/238.370	599.510/238.000
RG 414	Grandval BE	Road north of Point 976.5	599.320/238.180	599.390/238.130
RG 417	Crémines BE	Roches du Droit	600.890/238.380	600.490/238.200
RG 418	Vermes JU	La Rossmatte	604.680/239.450	604.620/239.330
RG 419	Seehof BE	Gorge south of Bächlen	604.160/238.300	604.200/238.300
RG 429	**Welschenrohr SO**	**Gorge south of Harzergraben**	**605.570/237.510**	**605.570/237.320**
RG 430	**Gänsbrunnen SO**	**Cantonal road and quarry**	**602.060/234.920**	**602.170/234.880**
RG 431	**Gänsbrunnen SO**	**Southern part of quarry**	**602.230/234.800**	**602.320/234.770**
RG 433	**Oberdorf SO**	**Gorge and quarry north of Wäberhüsli**	**603.990/232.230**	**603.950/232.040**
RG 434	**Lommiswil/Oberdorf SO**	**Quarries of Steingrueben**	**602.680/231.700**	**602.880/231.650**
RG 435	Péry BE	Quarry of La Charuque	585.950/225.600	585.970/225.800
RG 436	Aedermannsdorf SO	Horngraben	613.090/236.770	613.130/236.850
RG 437	Aedermannsdorf SO	Eggli	613.080/236.920	613.080/236.980
RG 438	**Balsthal SO**	**Road through Steinebach gorge**	**619.410/241.350**	**619.330/241.230**
RG 439	Balsthal SO	Innere Klus	618.900/239.570	618.900/239.590
RG 440	**Rumisberg BE**	**Rüttelhorn**	**612.850/236.600**	**612.840/236.650**
RG 442	Boécourt JU	Exploration well near Mt. Russelin	581.830/244.690	-
RG 443	**St-Ursanne JU**	**Exploration well near La Coperie**	**580.849/246.243**	**580.849/246.243**
RG 444	Häfelfingen BL	Exploration well east of village	632.790/251.725	632.790/251.725
RG 448	Egerkingen SO	Quarry of Mösliloch	625.820/241.500	625.800/241.430
RG 449	Erschwil SO	Road to Schemel	607.440/245.820	607.500/245.750
RG 450 *	Balsthal SO	Point 702 Chluser Roggen	619.710/239.380	619.710/239.380
RG 451 *	**Vellerat JU**	**Point 957.9 Peute Roche**	**594.030/240.520**	**594.030/240.530**
RG 452	Moutier BE	Exploration well of Combe des Billes	594.090/234.080	594.090/234.080
RG 453 *	Corcelles BE	La Côte aux Boeufs	601.630/238.430	601.710/238.500
RG 454	**Bure JU**	**Exploration well 2 for Transjurane**	**567.649/254.670**	**567.649/254.670**
RG 455	Bure JU	Exploration well 6 for Transjurane	567.897/253.184	567.897/253.184
RG 456	Bure JU	Exploration well National Sci. Found. 2	567.100/256.570	567.100/256.570
RG 457	Dittingen BL	Quarry Schmidlin in the Schachlete	604.530/253.070	604.510/253.080
RG 458	**Péry BE**	**Quarry of La Charuque**	**385.850/225.750**	**385.860/225.900**

Tab. 1: Coordinates of measured sections. The RG numbers with an asterisk are sections that have been partly or wholly measured on the rope. Sections printed in boldface are published here: Plates 16–44.

This proved later to be a grave miscorrelation that is perpetuated by some French authors to the present day, e.g. Chauve et al. (1985).

Gressly (1838–41) carried out extensive mapping in Canton Solothurn and in adjacent areas. He collected fossils in large numbers for the first time in Switzerland. It occurred to him by close observation of the coral bioherms of the St-Ursanne Formation near La Caquerelle and the coeval fine-grained sediments of the basin further east that the vertical and lateral succession of sediments is not random. He introduced the concept of facies into the geologic literature and recognized some common facies patterns (see Cross & Homewood 1997). In spite of the great effort in mapping, fossil collecting, and practical use of his excellent new stratigraphic method, Gressly, in his own opinion, did not achieve a satisfactory correlation between sediments from shallow water and those of deeper marine origin. Basically, he retained the correlation by Merian (1821).

The progress of stratigraphical palaeontology as pioneered by Oppel led to an important revision of Merian's correlation. Oppel (1856–58) introduced the biostratigraphical zone. He could prove with ammonites that the thick Renggeri Member and part of the Sornetan Member in the northwest thin out to the southeast and grade into what is now called the Schellenbrücke Bed (figs. 3 and 39). This is a ferriferous marly limestone with iron ooids which is on the average about 10 cm thick. Oppel cooperated with Moesch. One result of this was the definition of the Transversarium ammonite zone *sensu lato* (Oppel 1863, p. 165) that was published in its definitive form posthumously by Waagen (Oppel & Waagen 1866). The Transversarium Zone is the oldest well-documented ammonite zone.

Rollier (1888) mapped a large part of the Swiss Jura range and proposed a new correlation of the Oxfordian deposits. He correlated the Liesberg Member of the central Jura with the Birmenstorf Member of Canton Aargau (Rollier 1888, p. 87). He thought that the St-Ursanne Formation was the time equivalent of the Effingen and Geissberg Members (fig. 3). Rollier (1888) produced no evidence from ammonites of the shallow water realm to prove his assertion. Nevertheless, he reaffirmed his view in his publication of 1911 (fig. 54), and it remained unchallenged until 1967 when Bolliger & Burri proposed a new correlation.

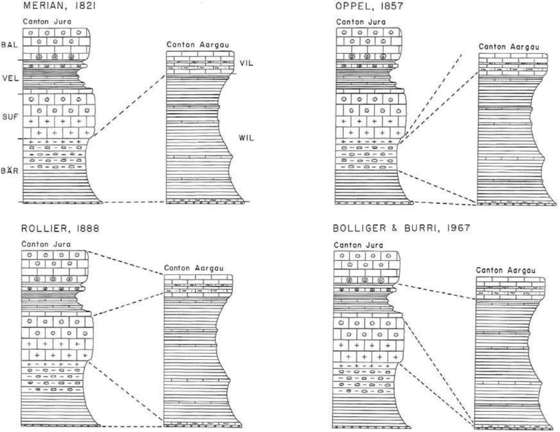


Fig. 3: Historical correlations within the Oxfordian of northern Switzerland.

BAL Balsthal Formation
BÄR Bärschwil Formation
SUF St-Ursanne Formation
VEL Vellerat Formation
VIL Villigen Formation
WIL Wildegg Formation

The significance of the important palaeontological work by De Loriol in relation to Rollier's correlation was not recognized by the stratigraphical workers of the time, because the systematics of the perisphinctids were then unresolved. In a short review, Arkell (1956, p. 95–96) threw some light on the stratigraphical implications of the ammonites published by De Loriol (1896) from the Sornetan Member of Liesberg by clearly stating that they are conspecific with some of the essential species of the English Plicatilis Zone. In the modern zonation, these ammonites indicate the Antecedens Subzone of the middle Transversarium Zone.

Ziegler (1962) studied the platform to basin transition of what are now the St-Ursanne and the Vellerat Formations (fig. 39). He did not question the correlation by Rollier (1888) of the St-Ursanne Formation with most of the Wildegg Formation (fig. 40). Ziegler (1962) paid special attention to the detrital quartz in the Röschenz Member (*olim* Natica Member). Some authors of the last century had already noted the occurrence of beds with a high detrital quartz content in the Röschenz and Effingen Members. Rollier (1898, p. 58) reported limestone bands in the Röschenz Member with sufficient fine-grained detrital quartz that they could be worked for grindstones from near Damvant west of Porrentruy. Ziegler (1962, p. 26, 42) concluded from the good sorting of this quartz and the fine grain size that it might be of eolian origin.

Bolliger & Burri (1967) took the aeolian origin of the quartz sand for granted and considered the vertical variation of the quartz content to be a reliable means of correlation between the platform and the basin. They arrived at a correlation of the Röschenz Member with the Effingen Member, and they consequently correlated the entire St-Ursanne Formation with only the thin Birmenstorf Member (see this paper, fig. 3).

Gygi (1969) studied the Oxfordian lithostratigraphy and ammonite biostratigraphy from Canton Solothurn in the west to the Danube River in the northeast. He found that the work by Würtenberger & Würtenberger (1866) in the Klettgau and Randen and by Moesch (1867) in Canton Aargau was reliable. He finished his manuscript in June 1967, prior to the completion and publication of the paper by Bolliger & Burri (1967) which was in fact published in January 1968. These authors did not discuss whether the climate was dry enough to make aeolian transport of detrital quartz at the observed scale possible. The rough surface textures of the quartz grains they figured in 1970 are mainly the result of diagenetic etching (Gygi 1969, p. 20), not aeolian frosting. Bolliger & Burri (1967, 1970) apparently did not recognize that the detrital quartz in the lower Effingen Member was concentrated by turbidites (Gygi et al. 1998, fig. 10) and in the upper Effingen Member by storms (Gygi 1986, fig. 7). Their correlation was plausible from the sedimentological point of view, but there were no ammonites nor other means of correlation to prove it.

A new tool for correlation was introduced to the Swiss Jura by Persoz & Remane (1976) and by Persoz (1982). They used clay minerals for correlation, because detrital clay minerals have the advantage that they are ubiquitous through the whole succession. Clay minerals are present even in winnowed deposits like carbonate oolite. The authors concluded that the vertical variation in the distribution of clay minerals, particularly the variation in kaolinite, could be used for stratigraphic correlation from terrestrial to deeper marine environments. Gygi & Persoz (1986) refined this method by combining it with ammonite biostratigraphy in the Oxfordian of Canton Aargau and of the central Jura. They first analyzed sections mineralogically in the basin (Canton Aargau) that are well calibrated biostratigraphically by thousands of ammonites. Then they correlated these sections using clay mineral marker horizons with others in the central Jura where few or no ammonites had been found. The few ammonites now known from the central Jura have since corroborated the mineralostratigraphic correlations (Gygi, 1995). The papers by Gygi & Persoz (1986) and Gygi (1995) showed that the correlations by Bolliger & Burri (1967) were essentially correct. Other results were that the Hauptmumienbank Member of Ziegler (1956) was indeed a useful marker unit, and that the base of the Reuchenette Formation coincided with the Oxfordian-Kimmeridgian boundary as it was traditionally placed in the ammonite facies of Central Europe (e. g. Cariou et al. 1991a). Gygi (1995) described and figured ammonites from Oxfordian and Kimmeridgian sediments of the shallow water realm in northwestern Switzerland.

1.3 Aim and structure of this paper

The principal aim of this paper is to present the most important Late Jurassic sections in the Central Jura that have been measured by the author since 1978. Ziegler (1956), Ziegler (1962) and Bolliger & Burri (1970) have already published some of these sections, but the thesis by Ziegler (1962) was not printed in a periodical and is not easy to obtain. In the second main part of this paper the ammonites which are relevant for zonation and international correlation are presented. This work also aims to summarize all of the important results which have been published over the past 25 years in different periodicals by the author and his co-authors.

1.4 Methods, classifications and terminology

Much emphasis was placed on detailed measuring of stratigraphical sections in the field. Each measured section was given an individual running number. Every bed more than 5 cm thick was numbered separately in the sections, sampled and briefly described in the fieldbook. When a bed was thicker than 1 m, several samples were taken at a vertical distance not exceeding 1 m. Samples large enough to prepare thin sections or polished slabs were only taken from representative rocks. Each rock sample, polished slab or thin section has been ascribed a number prefixed by the letters Gy to show that they are part of the author's collection. Additional samples were taken where necessary during the preparation of the interpreted sections. Therefore the Gy-numbers are not always in order in the sections. When the beds are horizontal or only slightly inclined, it is often not possible to measure the complete section from ground level. In these cases, a light steel rope with a comfortable seat attached was used (fig. 4). This made it possible to work with both hands free for a whole day on a quarry face or a natural cliff.

Only those samples that are kept in the Museum of Natural History Basel are recorded in the presented sections. The majority of the 3882 numbered samples or polished slabs are orientated. 2338 of these were processed to thin-sections. One half of the surface of each of the the thin-sections was stained with a mixture of alizarine red and potassium hexacyanoferrate in order to identify the different kinds of carbonate using the method described by DICKSON (1966). The several hundred polished slabs served to study stromatolites, oncolites and other large features that are too large to be easily seen in thin section.

One of the aims of this study was to collect and identify a sufficient number of ammonites for the full biostratigraphic calibration of the studied Upper Jurassic sediments. All well-preserved fossils were collected and are kept in the Museum of Natural History Basel. This served to characterize palaeoenvironments and mainly palaeodepth in the deep subtidal zone following GYGI (1986, fig. 6). All the well-preserved ammonites have an individual number preceded by a J. Only a limited number of fossils were found in natural outcrops or in quarries. Therefore it was necessary to excavate fossils systematically (fig. 5). After an excavation was opened up, where possible with a bulldozer or a mechanical shovel, the section was carefully measured and the beds were numbered. Then the beds were thoroughly searched for fossils. A jack hammer served to break up the beds before they were worked with the geological hammer. An Atlas Copco "Cobra" machine driven by a combustion engine was preferred for breaking up the beds because it could also be used in places inaccessible to vehicles. This hammer may be switched to a drilling machine to produce boreholes for blasting in order to remove hard overburden above the fossil beds. Blasting was sometimes necessary when excavations had to be done completely by hand as for instance on steep, forested slopes that were inaccessible to a mechanical shovel or a bulldozer.

A new laboratory was installed in the Museum of Natural History Basel for the preparation of fossils. About 5400 well-preserved ammonites had to be worked within a reasonable time span. The first step was to cut off as much rock as possible from the ammonite with a diamond saw. Tools driven by compressed air proved to be the most efficient and also the most precise for further processing. Very large specimens were first worked on an open sand-filled case with a large flat chisel held with both hands, then with a small flat chisel and finally with an engraving pen. Smaller specimens were prepared in a closed chamber (fig. 6) with a little flat chisel that can be held with one hand in order to uncover the ammonite to within about two millimeters from the surface. The final preparation was done with an Atlas Copco engraving pen which performs 450 small strokes per second. The exhaust of the tool aims at the point of the chisel so that dust and rock particles are constantly blown off. This makes precise working possible. Dust is removed from the chamber with vacuum.

The classification by DUNHAM (1962) served to describe carbonate rocks in the field. The depositional textures according to this author are also recorded in the lithostratigraphical sections presented. The extended classification of depositional textures according to EMBRY & KLOVAN (1971, fig. 2) was used when necessary. Carbonate rocks studied in thin section are named after

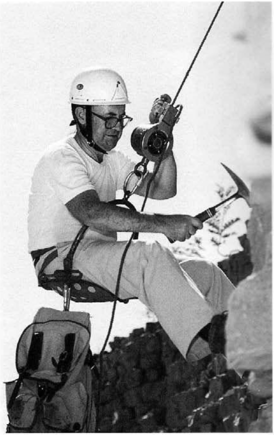


Fig. 4: Measuring a section on a light steel rope lined with nylon fabric. The steel seat is held steady by a clamp with wooden brake-shoes that may be fastened with a screw (lever held by the left hand). When descending, an automatic brake operating with the centrifugal force regulates the sinking speed to 1 m per second. This safety brake is in the circular casing beside the face. With this device it was possible to work with two free hands for measuring, taking samples and writing. When measuring long sections, a very high frequency (VHF) radio was used to dictate the text to be written into the fieldbook to S. Gygi (my wife).

FOLK (1962). Beds dominated by sedentary organisms are called biostrome (CUMINGS, 1932, p. 334). If beds with sedentary organisms swell to dome-like structures that had a primary elevation above the sediment around, they are called bioherm (CUMINGS & SHROCK, 1928). LOWENSTAM (1950, p. 433) recommended that the term reef be used only in cases where the sedentary organisms build a rigid, wave-resistant frame in a structure that rises above the sediment around it. Other geological terms are used according to the "Glossary of Geology" by BATES & JACKSON (1980).

The following abbreviations are used in the lithostratigraphic sections (pls. 16–44):

RS: rock sample
PS: polished slab
TS: thin section

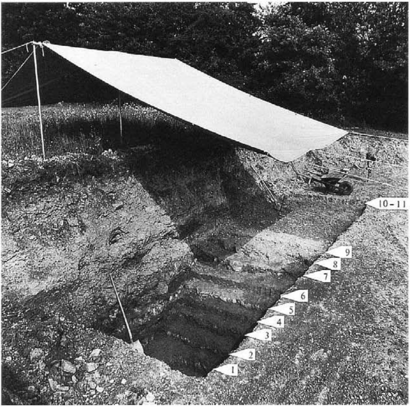


Fig. 5: Excavation RG 208 on Brunnrain near Ueken AG north of the Herznach iron mine. Beds no. 1–5 are of Callovian age, whereas beds 6–11 are of Oxfordian age. Beds 12–18 (see Gygi 1977, pl. 11) were excavated with a bulldozer as overburden, because they contain few fossils. Beds 1–11 were worked by hand. The hand-excavated beds had a surface of 120 square meters. They were worked in three parallel strips.

The sequence stratigraphical interpretation from Gygi *et al.* (1998) is shown in the sections of pl. 16-44. O1 to O8 refers to the eight Oxfordian sequence boundaries; K1 to K4 to the Kimmeridgian sequence boundaries.

The two letters used after the name of a village or a town are the official abbreviation for the canton that the settlement belongs to.

MNHB: Museum of Natural History Basel

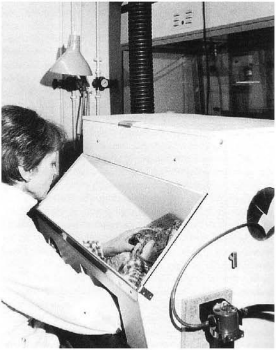


Fig. 6: Preparation of a smaller ammonite in a closed chamber with internal lighting. The compressed air is fed through an automatic oil lubrication device (on the outside of the chamber) to the engraving pen. Used air and dust are removed from the chamber by vacuum through the thick hose in the center.

2 Facies analysis

The lithostratigraphical units cited in the following text and their time-stratigraphical framework are listed in fig. 40. The field relations of the units are represented in fig. 39.

2.1 Lithofacies

2.1.1 Basinal facies

2.1.1.1 Basinal argillaceous mudstone (marl)

The best example of basinal argillaceous mudstone in the central Jura is the Renggeri Member. This rock consists mainly of clay minerals and calcium carbonate. According to PFRUNDER & WICKERT (1970, tab. 1) the carbonate content of this argillaceous mudstone is between 27 and 33 % near Liesberg BL. It is then, using the classification of PETTIJOHN (1957, fig. 99), a clayey marl. The blue-grey colour of the rock is probably caused by very fine-grained pyrite which is indicated by the relatively high iron content (see PFRUNDER & WICKERT 1970, tab. 1). This clayey marl is homogenous because of thorough bioturbation. Burrows filled with iron sulfide are very common (fig. 7). Lamination has never been observed.

The Sornetan Member consists of argillaceous mudstone with bands of limestone concretions and continuous beds of marly limestone. The total carbonate content of the member near Liesberg is around 54 % (PFRUNDER & WICKERT, 1970, tab. 1). The volume of limestone concretions and bands may be estimated to be about 15 % of the whole rock unit (see pl. 31). Therefore, the mudstone matrix of the Sornetan Member has a carbonate content of less than 50 % near Liesberg. The average content of detrital quartz of the whole rock unit must be less than 2 % judging from thin sections of carbonate bands and concretions.

Fig. 8: Basinal lime mudstone of the Gerstenhübel Beds in the lower Effingen Member. Quarry north of Mönthal AG. Scale bar is 1 m.

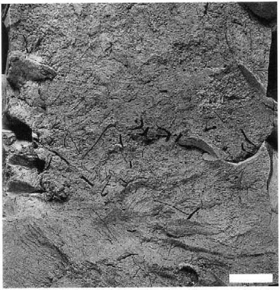


Fig. 7: Clayey marl of the Renggeri Member with burrows filled with iron sulfide. Section RG 280, Liesberg BL, bed 7, 2.3 m above the base. Sample Gy 3257. Scale bar is 2 cm.

The Effingen Member is a complicated succession of argillaceous mudstones interbedded with variably spaced beds with a higher carbonate content (GYGI 1969, pl. 17, section 37). The lowest carbonate content was recorded in the lower part of the member and is less than 40 %. The average carbonate content of the argillaceous mudstone in the Effingen Member is more than 50 %, mainly in the upper part of the member. Lime mud then predominated in the sediment of the Effingen Member over argillaceous mud.

2.1.1.2 Basinal lime mudstone

All the basinal limestones are mudstones which grade into peloidal wackestones or, in some cases, even to peloidal grainstones. GYGI (1969, p. 39–42) described some of these rocks in detail and figured them. Coccoliths are rare, if they are present, they are not or only slightly recrystallized. Therefore, there was probably only slight recrystallization of the rock after transformation of the lime mud to low magnesian calcite, and coccolithophorid micellae cannot have been a major constituent. Fossil detritus recognizeable under the petrographic microscope only forms about 10 % of the rock. Study of the grain-size fraction of below 25 microns under the transmission electron microscope revealed that less than 5 % of the particles were definitely fossil detritus. More than 80 % of the rock is then micrite of unknown origin. The sediment may be transformed to faecal pellets to the packstone concentration in some places (GYGI 1969, pl. 13, fig. 48). Basinal lime mudstones (calcilutites) are always well-bedded (fig. 8) into layers less than 1 m thick.

2.1.1.3 *Basinal iron oolite*

The oldest Oxfordian bed in northwestern Switzerland is a 20 cm to 30 cm thick clayey marl with some iron ooids. This bed is always present below the Renggeri Member and although thin, it is laterally continuous. It is the uppermost bed of the Herznach Formation (see definition below). The content of iron ooids decreases from about 5 % at the base to zero at the top of the bed where the facies of the Renggeri Member begins.

The Schellenbrücke Bed is another thin and widespread basinal iron oolite within the Herznach Formation. The mode of formation of this bed has been discussed in detail by GYGI (1981). The average content of iron ooids is only about 10 % (GYGI 1981, p. 239). The iron ooids are limonitic, chamositic or they have cortices of chamosite alternating with cortices of limonite. The matrix is a ferriferous lime mudstone (fig. 9). The bed is condensed, sometimes to the extent that only the limonitic/chamositic crust at its top is present (fig. 40). The bed occurs between the toe of the submarine bank of the Bärschwil Formation where the water depth is interpreted to have been about 80 m and grades in the distal direction into the thin Glaukonitsandmergel Bed where the water depth is calculated to have been around 100 m (GYGI 1981, fig. 4). An orebody of iron oolite which was mined until the beginning of this century exists in the uppermost Sornetan Member near Chamesol and Montécheroux (France), 25 km west of St-Ursanne. Near Bure JU in section RG 456 there is a 50 cm thick marly limestone that contains 10 % of limonitic iron ooids 3 m below the top of the Sornetan Member. No iron ooids have ever been found in the more distal part of the Sornetan Member that is coeval with the Schellenbrücke Bed and the overlying condensed bed at the base of the Birmenstorf Member that in some outcrops contains chamositic iron ooids. It is therefore impossible that the iron ooids of the Schellenbrücke Bed or the condensed bed at the base of the Birmenstorf Member were transported from shallower water to the basin. The Schellenbrücke Bed contains a rich and diverse ammonite fauna indicating a depth of deposition of between 80 and 100 m. Lenses of basinal iron oolite-rich clayey marl exist near Herznach and Gansingen below the Schellenbrücke Bed (section RG 208, bed 6, GYGI 1977, pl. 11, fig. 2, excavation on Brunnrain, and section RG 60, bed 3, GYGI 1966, fig. 1, Eisengraben, respectively).

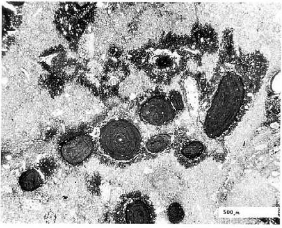


Fig. 9: Goethitic iron ooids in biomicritic matrix. Schellenbrücke Bed, early Oxfordian, Cordatum Subchron, Schellenbrücke near Küttigen AG. TS Gy 2712, section RG 32, bed 3 (see GYGI 1969, pl. 17).

2.1.1.4 *Basinal spongolite*

The most widespread basinal spongolite with wholly fossilized siliceous sponges is the Birmenstorf Member. This is described in section 2.2 Biofacies. Siliceous sponges may form as much as 30 % of the rock volume in this member (GYGI 1969, pl. 2, fig. 6). The matrix is lime mudstone or marl. Siliceous sponges can also be abundant in the lowermost Effingen Member (GYGI 1969, pl. 19) and in the distal part of the Crenularis Member near Mellikon (GYGI 1969, pl. 6, fig. 23, GYGI 1992, figs. 23–25). The matrix of the sponge bioherms in the Crenularis Member is lime mudstone. Siliceous sponges are less abundant in the Crenularis Member than in the Birmenstorf Member. The lowermost bed of the Pichoux Formation is, in some sections, a spongolite. At Péry BE it even contains small sponge bioherms with an elevation of 1 m above the surrounding sediment. Sponge bioherms are also found in the Hornbuck Member of Canton Schaffhausen and in the Knollen Bed near Küssaburg in southern Germany north of Zurzach (GYGI 1969, pl. 19), and at Immendingen and Möhringen in southern Germany. Siliceous sponges are abundant in the uppermost Letzi and Wangental Members and again in the lower Baden Member. The massive part of the upper Wettingen Member is a basinal spongolite, but occasionally giant sponges are found in the well-bedded lower Wettingen Member at Mellikon AG.

2.1.1.5 *Basinal oncolite*

Late Jurassic oncolites from the upper slope and from the basin in northern Switzerland were described by GYGI (1992). The most remarkable beds with basinal oncoids are the Mumienmergel and the Mumienkalk Beds of the Klettgau and Randen in Canton Schaffhausen. The oncoids of the Mumienkalk Bed are well-rounded and have a maximum diameter of 3.5 cm. They contain abundant glauconite and are slightly ferriferous (GYGI et al. 1979, fig. 14a, GYGI 1992, fig. 35). The matrix is glauconitic lime mudstone. The depth of deposition of the Mumienkalk Bed was estimated by GYGI et al. (1979, p. 946) at about 100 m. GYGI (1986, fig. 2) rated this depth at well over 100 m, because there are no signs that this bed was above storm wave base. GYGI et al. (1979, p. 942-946) described the Mumienkalk Bed in detail and discussed its mode of formation.

The Mumienmergel Bed below the Mumienkalk Bed has a matrix of glauconitic marl. This marl contains carbonate internal moulds of ammonites with a thick oncolitic crust. The ammonites are up to 25 cm in diameter. The sediments infilling the ammonite chambers prove that the ammonites have been overturned during fossilization. Some of the ammonite moulds are fractured. It can be excluded that currents overturned and frac-

Fig. 10: Submarine debris flow deposit with plastically deformed clasts of pelsparite with detrital quartz, partially burrowed. Polished slab of marl-limestone, bed no. 102 of section RG 37, upper Effingen Member, Auenstein AG. Refigured from GYGI & PERSOZ (1986). Scale bar is 2 cm.

tured the moulds. Currents strong enough to do this would have abraded the surface of the moulds and removed the argillaceous matrix. This is not the case. GYGI (1969, p. 105) assumed that animals in the search of food overturned the moulds, as Recent hogfish in the tropical West Atlantic overturn nodules of red algae (BÖHLKE & CHAPLIN 1970).

Oncoids that grew on the upper slope occur in the lime mudstones of the lower Baden Member in the southern quarry of Löchli at Däniken SO and in the section RG 28, bed 47 at Halden east of Schönenwerd SO (GYGI 1992, fig. 17). The oncoids have a diameter of up to 15 mm and contain glauconite. Glauconitic oncoids with a maximum diameter of 7 mm were found in the upper Crenularis Member which is exposed in the quarry adjacent to the public swimming pool near Auenstein AG. These oncoids occur in a matrix of lime mudstone (section RG 34, bed 25, samples Gy 587 and Gy 588, unpublished). The glauconitic oncoids found elsewhere in the upper Crenularis Member are even smaller (GYGI 1969, pl. 5, fig. 21).

2.1.1.6 Glauconitic rocks

Distinct glauconite pellets with a glossy surface are found only in sediments interpreted to have been deposited in water depths greater than 100 m (GYGI 1981, 1986). Abraded glauconite pellets are found in well-sorted, sandy turbidites where they have the same grain size as the detrital quartz. Glauconitic infillings of algal tubes or diffuse glauconitic impregnations in bioclasts occur in sediments interpreted to have been deposited in water depths of less than 100 m. Glauconitic impregnations are relatively easy to see with a hand lens, but they are only visible with difficulty in thin section with the petrographic microscope.

Pellets of glauconite occur within the basinal area for the first time in the Lamberti Subchron. The pellets are found within lenses of ferriferous marl with iron ooids near Gächlingen (section RG 81b, bed 10) and near Siblingen (section RG 212, at the top of bed 4, in GYGI, 1977, pl. 11). According to GYGI (1981), these lenses must have been deposited at a depth of about 100 m which is apparently the greatest depth at which iron ooids can be formed by being rolled. The greatest concentration of glauconite was found in the Glaukonitsandmergel Bed of the Klettgau and Randen (fig. 40). Up to 30 % of the volume of this rock is glauconite pellets. At least part of this glauconite is probably derived from the transformation of biotite, because some fresh biotite grains were found (GYGI & MCDOWELL 1970, p. 115). Glauconite is also abundant in the Mumienmergel and Mumienkalk Beds as well as in the glauconitic marl above the Mumienkalk Bed (fig. 40). The Knollen Bed sometimes contains abundant glauconite north of the Rhine.

In Canton Aargau clearly delimited glauconite pellets are present in the Birmenstorf Member. Glauconitization of biotite was demonstrated in one case in a sample from the condensed bed at the base of the Birmenstorf Member (section RG 73 in the Berchenwald near Dangstetten, southern Germany, bed 5, see GYGI 1969, pl. 3, fig. 9). The glauconite of the Crenularis Member (fig. 40) occurs mainly as a filling of algal tubes and an impregnation in small oncoids. The mineral is rare in the Knollen Bed (fig. 40). It sometimes occurs in the uppermost Letzi Member. The marly limestone of the lower Baden Member (fig. 40) contains glauconite pellets and glauconitic coatings of fossils.

In the West, glauconite pellets are often abundant in the lowermost bed of the Pichoux Formation (fig. 40). Faint and diffuse green impregnations which are probably glauconite were found in section RG 276 at Mont Chemin near Courrendlin JU in bed 15, a biopelmicrite; thin section Gy 6336, of the Vorbourg Member. This is unusual, because the Vorbourg Member was deposited in very shallow water, partially even in the intertidal zone. Authigenic glauconite normally occurs only in sediments from deeper water.

2.1.2 Facies of the carbonate platform slope

The average slope of the Pichoux Formation can be calculated to be 0.5°, when the decompaction and the differential subsidence of the basement under different sediment loads are taken into acount (see GYGI 1986, fig. 3).

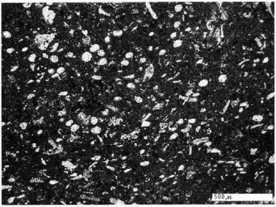


Fig. 11: Spiculite of the lower Pichoux Formation, ravine southeast of La Kohlberg farm, Vermes JU. TS Gy 7582, section RG 406, bed 2 (pl. 37).

2.1.2.1 Debris flows

Submarine debris flows were found mainly in the Effingen Member (GYGI 1969, pl. 4, fig. 13, GYGI & PERSOZ 1986, fig. 3, refigured here in fig. 10, GYGI & PERSOZ 1987, fig. 5), but they also occur in the distal part of the uppermost Effingen Member near Rekingen AG (section RG 68, bed 53, sample Gy 1409, GYGI 1969, pl. 19, fig. 1). The debris flows are often associated with intraformational truncation surfaces (GYGI & PERSOZ 1986, fig. 2). The flows are small-scale and local. The greatest depositional slope in parts of the Effingen Member must have been on average less than 1° since the proximal part of the member directly overlies the Pichoux Formation (GYGI & PERSOZ 1986, pl. 1). This is thought to be insufficient for the formation of debris flows, so it is postulated that the angle of the slope may have been locally augmented by growth faults (GYGI 1986, fig. 3D). A synsedimentary fault may be seen in GYGI & PERSOZ (1986, fig. 2). However, MULLINS & NEUMANN (1979, p.181) surmised the presence of debris flows on the slope off the northern margin of the Great Bahama Bank where the average angle of the slope is only 1.5° and where there are predominantly muddy deposits like pelagic carbonate oozes and muddy slope breccia (p. 182).

2.1.2.2 Spiculite

Spiculite, a lime mudstone with very abundant sponge spicula, is uncommon. Spiculites are present in the Sornetan Member and mainly in the Pichoux Formation. However, spicula may be common even in shallow-water coral biostromes (GYGI 1969, pl. 7, fig. 29). The spiculite figured here (fig. 11) from the section RG 406 near Vermes JU, bed 2 (pl. 37), is from the lower Pichoux Formation. It contains about 10 % sponge spicula in a micritic groundmass.

2.1.3 Facies of the carbonate platform margin

2.1.3.1 Coral bioherms

The coral bioherms of the platform margin grew within the distal part of the oolite shoals that rim the platform and also off the platform margin in somewhat deeper water, within the carbonate mud of the uppermost slope. The bioherms are typically mud mounds which had a slight relief above the sediment surrounding them. The coral content may be as low as 10 %. The bioherms all appear to be isolated, they were nowhere observed to coalesce into a barrier reef (see BOLLIGER & BURRI 1970, pl. 1, fig. 1). Some of the bioherms weather out and form topographical features with steep sides. The steep cliffs are formed by differential erosion between the well-cemented bioherm and the more friable sediment around it. The steep, eroded sides of the bioherms are not to be confused with the original relief which was probably very slight and of low angle. The bioherms that formed at this Jurassic platform margin are very different from Recent platform margin reefs (e.g. JAMES & GINSBURG 1979). The platform slope in the Late Jurassic of northern Switzerland had an angle of only about half a degree. This greatly reduced water circulation and the supply of food and oxygen to the bioherms. This might be the cause of the relatively weak development of the Jurassic platform margin bioherms.

The typical facies from the lower part of a coral bioherm is figured as a polished slab in fig. 12. The slab is from section RG 21, bed 35 in the quarry on Mt. Born near Olten SO (GYGI 1969, pl. 18). The corals, which probably belong mainly to the genus *Microsolena*, are dish-shaped and make up about 10 % of the rock volume. They are bored by the bivalve *Lithophaga*. The corals are partly dissolved and the cavities are filled with coarse-grained sparite or fragments of the encasing micrite. On top of the corals are faintly visible columnar stromatolites. The micritic groundmass was probably cemented early, or else it would not have fractured when entering the cavities in the partly dissolved corals. A thin-section of the same bed is figured in GYGI (1969, pl. 9, fig. 35).

2.1.3.2 Oolite bars

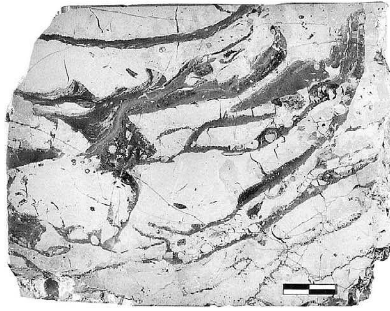
The rim of the platforms of the upper St-Ursanne Formation, the Günsberg Formation and the Balsthal Formation is formed by oolite bars. Part of these bars is cross-bedded, for instance bed 162 in the Günsberg Formation of section RG 307 near Péry or beds 1 to 3 in the lower Balsthal Formation of section RG 20 near Hägendorf SO. Such a cross-bedded oosparite from the Steinebach Member was described (p. 35) and figured in detail (pl. 8, figs. 32 and 33, pl. 9, figs. 34 and 36) by GYGI (1969).

2.1.4 Facies of the lagoon

2.1.4.1 Tidal deltas

The Steinebach Member in section RG 307 near Péry BE is the delta of a tidal channel emptying into the lagoon. The lowest bed number 193 (see pl. 22) is 2.4 m thick and had an internal depositional dip of 20° towards northnortheast. A thin-section from this bed (Gy 5467) is an oomicrite to oosparite with an average of about 75 % of primary micritic cement. In the mixed zones which contain primary micritic and secondary sparitic ce-

Fig. 12: Polished slab from the base of a coral bioherm of the platform margin of the Balsthal Formation. Plate-shaped colonies of mainly *Microsolena* in a micritic groundmass. On top of the corals are columnar stromatolites. The corals are bored by the bivalve *Lithophaga*. PS Gy 4903 from section RG 21 in the quarry on Mt. Born near Olten SO, bed 35, Olten Member, GYGI (1969, pl. 18). Scale bar is 2 cm.



ment the lime mud of the primary cement is found in geopetal cavities (fig. 13). The middle bed, number 194, is an oolitic packstone 1.4 m thick that had an internal depositional dip of 10° towards north-northeast. The upper bed, number 195, is 1.9 m thick and had a depositional dip of 20° towards west-northwest. It is an oolitic to fine-oncolithic packstone and partly even a wackestone although the intermittent tidal currents during its deposition must have been rather strong. Large burrows with a diameter of 2 to 3 cm penetrate up to 30 cm down from the upper bedding plane. The bedding plane is hummocky and covered with a limonitic crust that indicates an early cemented and mineralized hardground.

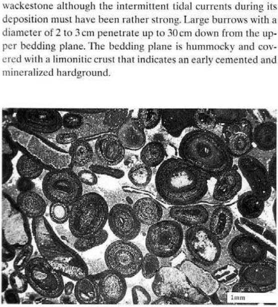


Fig. 13: Oomicrite with geopetal interstices filled with calcite spar, Steinebach Member, Péry BE. TS Gy 5467, section RG 307, bed 193 (pl. 22).

2.1.4.2 *Oncolite*

Some of the best examples of lagoonal oncolite are to be found in the Hauptmumienbank Member of the Vellerat Formation. The oncoids of the Hauptmumienbank Member grew to a diameter in excess of 4 cm (fig. 14) and were embedded in lime mud indicating a normally quiet depositional environment. The largest oncoids occur in the central belt of the elongate lagoon as for instance near Soyhières JU (see fig. 7 in GYGI 1990c). Towards the platform margin, the micritic matrix between the large oncoids becomes increasingly oolitic, and the size and the abundance of the oncoids diminish. The size and the abundance of the oncoids also decrease in the proximal direction, and there the core of the oncoids often contains calcite pseudomorphs after gypsum (GYGI & PERSOZ 1987, fig. 2C). Algal filaments of different species of *Girvanella* and occasional small thalli of an undescribed species of *Bacinella* RADOICIC occur in the crust of the oncoids of the Hauptmumienbank Member. The core of these oncoids is most often a small bioclast. The oncoids were lithified during growth. Evidence for this are common boring bivalves of the genus *Lithophaga* that are found within the oncoids. GASCHE (1956) described and figured these oncoids for the first time. ZIEGLER (1956, p. 46) discussed their environment of formation and concluded that the oncoids grew in the same place as the lime mud that forms the matrix was deposited. ZIEGLER (1956, p. 43) estimated the minimum areal extent of the algal biostrome of the Hauptmumienbank Member at more than 2000 km².

The oldest Oxfordian oncolites occur in the lower St-Ursanne Formation. This is the Caquerelle Pisolite of ZIEGLER (1962, p. 18). The typical facies of this unit is a well winnowed rudstone with oncoids of a diameter from about 0.5 mm to 1 cm. The best examples of this unit were found in the sections RG 338

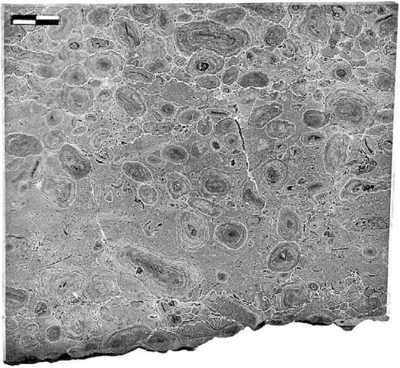


Fig. 14: Oncoids in a biomicritic groundmass. Polished slab cut perpendicularly to the bedding planes, PS Gy 4204, Hauptmumienbank Member, section RG 363 (unpublished), En Goulat near Soyhières JU, bed 47. Scale bar is 2 cm.

at Côte du Frêne near Asuel JU, bed 90, PS Gy 3899, TS Gy 5891, and in the section RG 397 in the gorge west of the Schlossfelsen near Kleinlützel SO, bed 27, PS Gy 4536, TS Gy 6492. These oncoids have not been studied by a specialist. Pümpin (1965, p. 817) thought he recognized *Girvanella pisolithica* Wethered in the crusts as well as encrusting foraminifera of the genus *Nubecularinella* and illustrated the unit in two figures (Pümpin 1965, figs. 6 and 7). There are patches with abundant 2 cm size oncoids in the section RG 336, bed 4, along the road from St-Ursanne JU to the railway station; these are enclosed in a bioarenitic grainstone with hermatypic corals. Another oncolite with a lime mud matrix occurs locally in the upper St-Ursanne Formation in a quarry at the western end of the Landskron range near Leymen F (section RG 292, bed 12h, PS Gy 3295, TS Gy 5272). This oncolite is also mentioned by Fischer (1965a, p. 22).

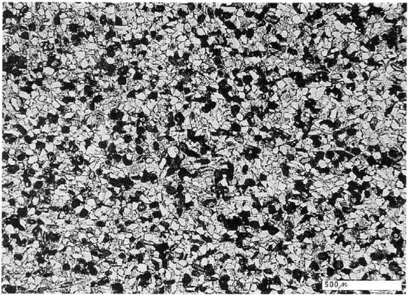
The oncolites of the Günsberg Formation are found mainly near Péry BE in the quarry of La Charuque (section RG 435, bed 9a, PS Gy 5059, TS Gy 7242). This is the Grüne Mumienbank of Ziegler (1956). The oncoids are spherical to lobate and are embedded in lime mudstone. They grew to a diameter of 5 cm (Gygi 1992, figs. 14 and 15). Other occurrences are at Peute Combe south of Grandval BE, section RG 357, bed 25a, PS Gy 4140, TS Gy 6101, at Roches du Droit north of Crémines BE, section RG 417, bed 45, PS Gy 4833, TS Gy 6766, and at Bächlen near Seehof BE, section RG 419, bed 68, PS Gy 4870, TS Gy 6802 (all the three sections unpublished). These oncolites were probably all formed at the same time.

The oldest oncolites of the Vellerat Formation are at different levels of the Vorbourg Member, for instance in section RG 320 at Montépoirgeat near Undervelier JU, bed 18, PS Gy 3674, TS Gy 5674, or on Mont Chemin near Courrendlin JU, section RG 376, bed 14, PS Gy 4372, TS Gy 6335, above the Dürrmattengraben near Wolschwiller F, section RG 394, bed 4, PS Gy 4513, TS Gy 6468, and on the Schützenebnetchopf near Kleinlützel SO, locality RG 396, PS Gy 4532, TS Gy 6487.

The oncolites of the younger Röschenz Member within the Vellerat Formation are also to be found at various levels, for instance in the beds 17, 28, 31 and 53 of section RG 300 at Eichlenberg near Zullwil SO. Particularly remarkable are the oncoids of bed 14 in the neighbouring section RG 304 at Fehren SO which reach a diameter of 6 cm (PS Gy 3411, TS Gy 5409). Other oncolites within the Röschenz Member are found near Souboz BE (section RG 312, bed 42), Undervelier JU (section RG 320, bed 58), Soulce JU (section RG 321, bed 19) and Châtillon JU (section RG 368, bed 80).

The oncolites of the Balsthal Formation are almost all in the Laufen Member. Oncolites are very common in this member. The oncoids can be embedded in lime mud as in bed 201 of section RG 307 near Péry BE (pl. 22). This unit is very similar to the Hauptmumienbank Member, but the evidence from mineral stratigraphy (Gygi & Persoz 1986) and sequence stratigraphy (Gygi *et al.* 1998) indicates that it is younger. The oncoids of the Laufen Member can grow large even if they are embedded in packstone like in bed 7b of section RG 436 in Horngraben near Aedermannsdorf SO (PS Gy 5082, TS Gy 7260, unpublished). An undescribed species of the alga *Bacinella* is abundant in

Fig. 15: Fine-grained peloidal, sandy quartz siltstone, Röschenz Member, gorge northeast of La Providence farm, Corban JU. TS Gy 6578, section RG 400, bed 50 (pl. 35).



these oncoids. The species was figured under the name *Bacinella irregularis* RADOICIC by BOLLIGER & BURRI (1970, pl. 9, fig. 3). The Verena Member rarely contains oncolites. One occurs in bed 94a of the section RG 320 at Montépoirgeat near Undervelier JU (PS Gy 3707, TS Gy 5711, unpublished). The other known occurrence was mentioned by FISCHER (1965a, p. 22).

In the Courgenay Formation, only a single oncolite was encountered in the La May Member northwest of La Seigne Dessus near St-Ursanne JU in bed 10 of the section RG 326 (PS Gy 3776, TS Gy 5774).

2.1.4.3 Coral bioherms

The coral bioherms of the lagoon differ from the ones at the platform margin in that they are much more densely colonized by corals. Massive and thickly branching coral colonies make up as much as 50 % of the volume of a coral bioherm in the quarry of St-Ursanne (bed 18 of section RG 336). The matrix of the reef core is micritic, but nevertheless this may be a true reef. One of these patch reefs near St-Ursanne was figured by GYGI (1986, fig. 5). The primary relief of the reefs and the slope of the reef detritus aprons was very subdued (see PÜMPIN 1965, fig. 14).

2.1.4.4 Sandy quartz siltstones

As BOLLIGER & BURRI (1967) have pointed out, detrital quartz and some feldspar are abundant in the Vellerat and in the Wildegg Formations and, more specifically, in the Röschenz and in the Effingen Members. It is interesting to note that there is little detrital quartz in the argillaceous Bure Member of the upper Vellerat Formation. There is obviously no simple relation between the clay mineral content and the detrital quartz content in these sediments. Detrital quartz and feldspar may make up more than 50 % of the rock volume in marls and limestones of the Röschenz Member. The quartzose limestones of this member are partly laminated and partly massive. ZIEGLER (1962, p. 26 and 42) considered that aeolian sedimentation of this quartz was a possibility because of its good sorting. BOLLIGER & BURRI (1970, p. 19) stressed that the detrital quartz and feldspar were transported by the wind. No sedimentary structures indicative of wind transport have ever been observed in supratidal sediments of the Röschenz Member. Evaporites are entirely absent in this member. Instead, limnic ostracods, lignite and gyrogonites of characean algae indicate the presence of fresh water pools or swamps and thus a humid climate (GYGI 1986, p. 486). GYGI (1986, p. 487) concluded that the ample supply of terrigenous sediment that led to the deposition of the Röschenz and Effingen Members was indicative of a relatively wet climate. Water transportation of the bulk of the terrigenous sediment must therefore be assumed, but aeolian transportation of a small quantity of detrital quartz cannot be ruled out. A large amount of clay minerals must have bypassed the site of deposition of the Röschenz Member judging from the much greater thickness of the argillaceous Effingen Member.

Bed 50 of section RG 400 (pl. 35) which is in the small gorge northeast of the farm La Providence near Corban JU is a sandy quartz siltstone. The bed is 0.35 m thick and is laminated in the lower part. The constituent particles are detrital quartz and feldspar as well as carbonate micritic peloids (fig. 15). The peloids are well rounded and have sizes between 40 and 70 microns. They make up about 10 % of the rock volume. The siliciclastic grains are about 50 % of the rock volume. About 90 % of them are angular quartz grains and 10 % angular feldspar grains. Their grain sizes range from 20 to 110 microns with an average around 50 microns. The pore space is filled with sparite cement in the lower part of the bed and in the upper part of the bed partly with lime mud and partly with sparite.

The angular shape of the coarsest siliciclastic grains suggests that they have been transported in water. KUENEN (1964, p. 279) stated that grains with a size of less than 250 microns are not rounded during transport in water. It is important to note that a large quantity of clay minerals was in suspension during the transport of the siliciclastic grains. The clay minerals further augmented the minimum size of grains that would be rounded. If the siliciclastic grains were transported by the wind as BOLLIGER & BURRI (1970) concluded, at least the coarsest grains of the fine sand fraction would be rounded (KUENEN, 1960, p. 51).

2.1.4.5 Dolosparite

Almost pure dolomites are uncommon and are restricted to the Günsberg and the Balsthal Formations. In the Balsthal Formation they occur both in the Laufen Member (for instance section RG 390 Moutier, Gorges de Moutier, southern part, pl. 27, bed 99, TS Gy 7032) and in the Verena Member. The figured dolosparite (fig. 16) is from bed 62, middle Verena Member, in section RG 381 in the Gorges de Court near Moutier BE (pl. 28). The anhedral dolomite grains form a panxenotopic mosaic. The average grain size is 80 microns. Some grain interstices and few larger patches are filled with undolomitized micrite that amounts to about 5 % of the rock volume. The bed has a thickness of 1.90 m and a few pores with a diameter of several millimeters. The rock has a saccharoidal appearance.

2.1.5 Tidal flat facies

2.1.5.1 Mudstone with prism cracks

Lime and argillaceous mudstones with prism cracks were found at several localities in the Vorbourg and in the Röschenz Members of the Vellerat Formation and in the Günsberg Formation. Prism cracks are conspicuous in lime mudstone (GYGI 1992, fig. 5), but if they occur in soft argillaceous mudstone, they are not easy to recognize because of the rapid weathering of marl. Prism cracks in marl may be preserved if pure lime mud was sedimented on top of the marl. In this case the imprints of the cracks are visible as positive ridges on the lower bedding plane of the lime mudstone overlying the marl. An example of this is the stromatolitic lowest part of bed 57 of section RG 320 at Montépoirgeat near Undervelier JU. The lime mudstone bed is partly laminated and contains birdseye pores and rootlets (RS Gy 3690). It is in the upper part of the Röschenz Member. The mud-cracked marl below is bed 56 which is 0.50 m thick and is a soft, grey-green marl with much detrital quartz.

The diameter of the prisms varies from 1 to 50 cm depending on the thickness of the cracked bed. The thickness of beds that are cracked from the top to the base may be as much as 60 cm as for instance bed 31 of section RG 417 near Crémines BE (GYGI 1992, p. 807) in the Günsberg Formation.

Recent mud cracks of the intertidal zone were reported from the Persian Gulf (KENDALL & SKIPWITH, 1968, fig. 5) and from the Bahamas (GINSBURG et al. 1977, fig. 4). Fossil prism cracks may be taken as evidence of the intertidal zone if the cracked bed contains birdseye pores, rootlets or mud pebbles. A lime mudstone with deep prism cracks was figured by GYGI (1992, fig. 6) from bed 21, Günsberg Formation, of section RG 414 near Grandval BE (RS Gy 4795, see also PS Gy 4794). According to GINSBURG et al. (1977, fig. 4) this is indicative of the lower intertidal zone.

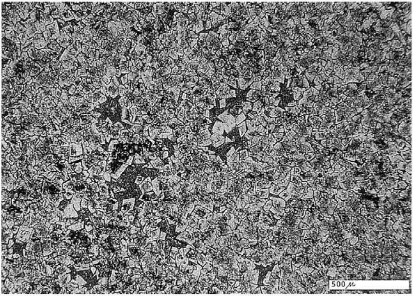


Fig. 16: Dolosparite with micritic, undolomitized patches, Verena Member, Court gorge, Moutier BE. TS Gy 7010, section RG 381, bed 62 (pl. 28).

2.2 Biofacies

2.2.1 Siliceous sponge assemblages

Siliceous sponge assemblages are typical for the deep neritic realm not only in the Late Jurassic on the northern margin of the Tethys (Reitner & Neuweiler, coord. 1995, fig. 2), but also in the Late Triassic of the Sichuan Basin, China (WU 1989). In northern Switzerland the sponge assemblages with wholly fossilized sponges are associated with an abundant and diverse ammonite fauna. In this region part of the sponges were wholly fossilized in water deeper than about 50 m. Only spicula survived in shallower water (see above). But this does not mean that dense growths of siliceous sponges did not exist in shallower water of the Late Jurassic. They are probably just not preserved. Sponge bioherms from shallow water have been found in the Callovian (Koenigi Subzone) near Ladoix in Burgundy, France (Floquet et al. 1991, p. 49, fig. 14, pl. 4E).

Even in their optimal depth range, special conditions were necessary for sponges to become fossilized. One of these conditions was the rate of mud sedimentation. If the rate was too low as for instance in the thin, deep neritic Mumienkalk Bed or in shallow, turbulent water, few or no sponges were wholly fossilized. If the rate of mud sedimentation became too high as in the lower Effingen Member, the sponges apparently became smothered when living and disappeared from the environment.

The richest and most widespread occurrence of siliceous sponges in northern Switzerland is in the Birmenstorf Member which is a very widespread, densely colonized sponge biostrome (fig. 17) that was deposited at a relatively low sedimentation rate. This facies extends from the Klettgau along depositional strike to the southern Jura in southeastern France (Enay 1966) and perpendicularly to the depositional strike to the autochthonous and parautochthonous facies realms as well as into the lower Helvetic nappes of the central and eastern Swiss Alps (Kugler 1987, p. 75). This author gave a short and appropriate description of the Birmenstorf Member in Canton Aargau (Kugler, 1987, p. 19–21) and figured (fig. B. 1. 7.) the upper bedding plane of bed 34 in the section RG 276 near Holderbank AG (in Gygi et al. 1979, fig. 3) that is covered with large dish-shaped siliceous sponges. Kugler noted that the majority of the sponges were overturned. Few specimens are embedded in life position. According to Gygi (1986), the depth of deposition of the Birmenstorf Member in Canton Aargau was greater than 100 m and less than 150 m. No sedimentary features that might be interpreted as tempestites have ever been observed in the Birmenstorf Member. Therefore it is probable that not currents, but animals overturned the sponges in search of prey animals hiding at the underside. In the Recent, rays and hogfish have been observed to overturn rocks and red algal nodules in the tropical western Atlantic (Böhlke & Chaplin 1970, p. 33, and Macintyre *et al.* 1987, fig. 12).

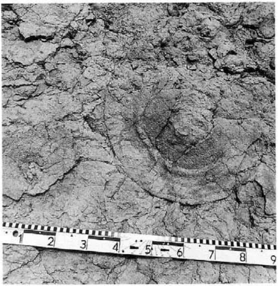


Fig. 17: Siliceous sponges of the genus *Discophyma* at the upper bedding plane of bed 34, section RG 276, quarry of Chalch, Holderbank AG (see Gygi *et al.* 1979, fig. 3). Upper Birmenstorf Member. The sponge on the left is in life position and the specimen on the right hand side is overturned. Scale is in decimeters.

2.2.2 Ammonite assemblages

There are faunal assemblages in the Late Jurassic of northern Switzerland in which ammonites are by far the most abundant element as for instance in the Schellenbrücke Bed of the early Oxfordian. This bed was deposited at a depth of 80–100 m (Gygi 1981, tab. 1, p. 243–244). Ammonites are classical guide fossils and were for a long time regarded to be relatively independent of facies. Ziegler (1963b, p. 238) denied this and claimed that ammonites were facies fossils as much as all others. Ziegler (1963a, p. 102) stated that most ammonites lived in close relation to distinct facies and therefore close to the sea bottom. The fact that this can be observed in the fossil record of the Late Jurassic in Central Europe implies that no large-scale transport of empty shells has taken place. Ziegler (1981, fig. 7) showed that ammonite diversity is at its optimum at moderate depths. Ziegler (1967, p. 449) established depth ranges for ammonite assemblages and other faunal assemblages of the Late Jurassic in Europe. He augmented and systematized the knowledge of earlier authors as for instance Kilian (in Bulot 1993, p. 246). Gygi (1986) calculated the depth of deposition of Late Jurassic sediments in northern Switzerland and showed how the composition of ammonite assemblages varied with depth (Gygi 1986, fig. 6), thus confirming and substantiating the results of Ziegler (1967).

Gygi et al. (1979, tab. 12, p. 942–946) analyzed the ammonite assemblage of the Mumienkalk Bed and discussed the palaeoecology in detail. The same was done with the Schellenbrücke Bed (R. Gygi, 1981). Other important ammonite assemblages are in the Birmenstorf and in the Baden Members. Egger (1991) made a study of the biota of the Birmenstorf Member near Holderbank AG. Other important ammonite assemblages are in the Crenularis Member in the region of Mellikon AG and in the Hornbuck Member. Siliceous sponges are present in all of these stratigraphic units, but they are quantitatively important only in the Birmenstorf and in the Hornbuck Members (see above). Ammonite-dominated assemblages lived in water that was more than 50 m deep (GYGI 1986, p. 480).

2.2.3 Bivalve assemblages

There are macrofaunas where bivalves are the dominant element of the assemblage. The Kimmeridgian Hypselocyclum Zone at Mt. Born near Olten where bivalves comprise 55 % of the macrofauna is such a case (GYGI 1986, fig. 6B). The water depth of this assemblage was about 30 m (GYGI 1986, fig. 6B). The next examples in descending stratigraphic order are the Wangen and the Crenularis Members in the region of Mt. Geissberg near Villigen AG and on Bözberg. Bed 30 (lower Crenularis Member) of section RG 63 which is a cliff above a ravine north of the ruin Besserstein near Villigen AG contains a bivalve assemblage that is dominated by very abundant *Pholadomya paucicosta* ROEMER. The Geissberg Member below includes an abundant and diverse bivalve assemblage that is dominated by *Pholodomya* and *Goniomya* (MOESCH 1867, p. 147). The abundance of *Pholadomya* both in the Geissberg and in the Sornetan Members convinced MOESCH (1867, p. 145) that the two members were of the same age. ETALLON (1862, p. 245) even proposed the stage name Pholadomyen based on the Sornetan Member. ROLLIER (1893b, p. 56) claimed that this stage name had been introduced by DE TRIBOLET). Bivalves are again very abundant in the Banné Member. GYGI (1986, p. 477) assumed that assemblages dominated by bivalves lived in water that was between 20 m and 50 m deep.

2.2.4 Coral assemblages

Solitary deep-water corals are very rare and are always of small size. One specimen of such ahermatypic corals has been found in the Schellenbrücke Bed and another in the lower Mumienkalk Bed in the section RG 212, bed 8 near Siblingen SH. A specimen from the Crenularis Member is figured in GYGI (1969, pl. 6, fig. 23) and in GYGI (1992, fig. 24). Two more specimens were collected from the lower Baden Member of Mellikon and from the lower Schwarzbach Formation in the section RG 239 at Summerhalde near Schaffhausen. The specimens from the Mumienkalk Bed and from the lower Schwarzbach Formation lived at a water depth of more than 100 m. The specimen from the Crenularis Member is from a depth of about 80 m (GYGI 1986, p. 479). These deep-water corals belong to undescribed species.

Colonial or hermatypic coral growth began at depths of less than 20 m. This can be calculated from section RG 306 at Hinter Chestel near Liesberg BL (GYGI & PERSOZ 1986, p. 412, see also INSALACO 1996, p. 184). The first hermatypic corals that appear in the Liesberg Member are flat and dish-shaped. They form a thickly colonized biostrome (fig. 32). Thin, dish-shaped colonies continue to a depth of about 10 m. In general, further up the succession the colonies become thicker like a loaf of bread, then dome-shaped to massive or branching and it is at this level that most coral bioherms begin to develop. No lateral zonation could be recognized in the studied coral bioherms due to insufficient outcrops. PÜMPIN (1965, p. 843) was in a position to make a zonation of the lagoonal coral reefs at St-Ursanne and to deduce a palaeocurrent from the southsouthwest.

The coral bioherms of the Late Jurassic of northern Switzerland are unlike Recent coral reefs. Most of them were much more like sponge bioherms; they had a mud matrix (GYGI 1986, p. 477) and a low relief above the surrounding sediment (PÜMPIN 1965, fig. 14). Their vertical extent did not exceed 30 m (GYGI & PERSOZ 1986, p. 413) and they have never been observed to coalesce into a barrier reef.

Fig. 18: *Cladocoropsis mirabilis* FELIX, section RG 431, quarry at Gänsbrunnen SO, bed 23, lower Reuchenette Formation, TS Gy 7181 (pl. 40).

2.2.5 *Cladocoropsis* assemblages

RENZ (1931) studied *Cladocoropsis mirabilis* FELIX (fig. 18) from the Swiss Jura Mts. for the first time. He made the observation that these organisms with an uncertain systematic position are often the only macrofossils that can be found in the rock (p. 2). They may be so abundant that they form a considerable part of the rock volume (RENZ 1931, pl. 1). This author figured *Cladocoropsis* from the Solothurn Turtle Limestone (see also THALMANN 1966, p. 104). *Cladocoropsis* has now been found in sediments as old as the lower St-Ursanne Formation, for instance in the drinking water well RG 359 near Bressaucourt JU, bed 13, TS Gy 6113 (pl. 18). The organisms also occur in the Vorbourg Member as in the quarry Sur Montni, section RG 344 near Courtemaîche JU, bed 25, TS Gy 6022. Another occurrence in the Vorbourg Member is in beds 42 and 53 of section RG 362 at Hasenschell near Movelier JU, TS Gy 6140–6142. *Cladocoropsis* was also found in the Hauptmumienbank Member of section RG 398, bed 21b in the limestone quarry of the former cement works at Liesberg BL, TS Gy 6524 (pl. 32). The last Oxfordian occurrence is in the lower Laufen Member in section RG 307, bed 203 in the quarry of La Charuque near Péry BE, TS Gy 5471 (pl. 22). *Cladocoropsis* is never abundant in the Oxfordian-age sediments of the Central Jura.

The first appearence of *Cladocoropsis* in the Kimmeridgian-age Reuchenette Formation is in section RG 433 in the quarry of Wäberhüsli above the railway station of Gänsbrunnen SO, in the uppermost part of bed 18 (pl. 41), about 4 m above the base of the formation. The first mass occurrence of *Cladocoropsis* in this formation is on Mt. Chamben near Herbetswil SO, 50 m east-northeast of point 1215.1, less than 10 m above the base of the formation (locality RG 432, coordinates 610.290/235.950, TS Gy 7182, PS Gy 4999). Very abundant *Cladocoropsis* are also found in section RG 433, bed 20, in bed 35 below the Solothurn Turtle Limestone and in bed 47 above that unit (pl. 41). Many *Cladocoropsis* were found in the quarry RG 434 of Steingrueben near Lommiswil SO, bed 8 (TS Gy 7217, pl. 42).

The habitat of *Cladocoropsis* was in very shallow-marine water and partially in lagoonal environments with possibly hypersaline conditions.

2.2.6 Microbialitic assemblages

Stromatolites and oncoids were for a long time believed to have originated only in the intertidal and in the shallow subtidal zones. Consequently, SZULCZEWSKI (1968, p. 89) interpreted the Jurassic stromatolites of Poland to have been formed in very shallow water. PLAYFORD & COCKBAIN (1969) proved that Devonian stromatolites of Australia had grown in the deep subtidal zone. GIZEJEWSKA & WIECZOREK (1977, p. 174) concluded that the late Callovian stromatolite of Zalas in southern Poland was a sediment of the deep subtidal zone. GYGI (1992) presented evidence that the stromatolites and oncoids from the Late Jurassic of northern Switzerland formed in environments ranging from the tidal flat down to the basin floor at nearly 150 m depth and figured pertinent examples from different depths.

2.3 Fossil-dominated sediments

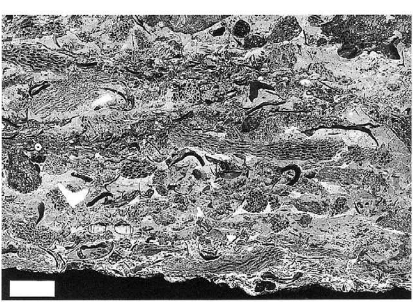
2.3.1 Siliceous sponge-dominated biostromes and bioherms

Siliceous sponges (entirely or partially fossilized sponges and tuberoids) can be an important rock-forming element. As mentioned above, they can amount to as much as 30 % of the rock volume in the Birmenstorf Member. Siliceous sponges also form an important portion of the rock volume in the sponge bioherms of the Crenularis Member of Mellikon AG. Where partly or wholly fossilized siliceous sponges dominate in the rock, ammonites are always present.

2.3.2 Coral-dominated biostromes and bioherms

Coral biostromes are found within the argillaceous mudstones of the Liesberg Member, in the proximal part of the uppermost Effingen Member and in a lime mudstone groundmass of the Günsberg Member (ZIEGLER 1962, fig. 7). The corals in these biostromes are mostly thin and flat, dish-like colonies. They form up to 30 % of the rock volume in the Liesberg Member. This biostrome is much more densely colonized than some coral bioherms at the margin of the St-Ursanne carbonate platform where small, massive coral colonies amount to only about 10 % of the bioherm volume (section RG 315, bed 34, in the Pichoux gorge near Sornetan BE, pl. 21). It is only in the lagoon of the St-Ursanne carbonate platform that corals form as much as 50 % of the bioherm volume (see above). The coral bioherms of St-Ursanne are therefore probably true reefs. Ammonites are very rare in coral biostromes. They have never been found within coral bioherms, but some occur in the inter-reef sediment near St-Ursanne (GYGI 1995, figs. 4 and 6).

Fig. 19: Limestone made up mainly of *Cycloserpula socialis* (GOLDFUSS) with some ostreids in a micritic matrix. Section RG 312 (unpublished), Montaigu near Souboz BE, bed 87, Laufen Member, PS Gy 3544, MNHB E 258/3. Scale bar is 1 cm.



2.3.3 Lagoonal fossil-dominated sediments

The proximal part of the Laufen Member and the distal part of the La May Member are in some places extremely fossiliferous. Small ostreid bivalves, the rhynchonellid brachiopod *Septaliphoria arduennensis* (OPPEL) and the worm *Cycloserpula socialis* (GOLDFUSS) may be very abundant. Crinoids are uncommon and nautiloids are rare. *Cycloserpula socialis* forms more than 50 % of the rock volume in bed 87 of section RG 312 (unpublished) on Montaigu hill near Souboz BE (fig. 19). The serpulids may be an indication of an episodically reduced salinity of the water.

2.4 Vertical and lateral facies successions

An idealized vertical facies succession in a shallowing-upward succession of the epicontinental basin of northern Switzerland has a thin bed of iron oolite with an ammonite-dominated macrofauna at the base. This is overlain by argillaceous mudstone which gradually becomes more calcareous upwards. At the base the macrofauna is composed of ammonites and siliceous sponges (as for instance in the Birmenstorf Member) or spicula (Sornetan Member), and further up mainly of bivalves. In the upper part of the mudstone succession the macrofauna is dominated by hermatypic corals. Coral bioherms can begin to grow without an initial biostrome stage as for instance in the Günsberg Formation. Above the corals there is usually a carbonate oolite. Some coral bioherms continue to grow within oolite banks like in the marginal part of the upper St-Ursanne Formation near Grellingen BL. Above the oolite are lagoonal and littoral facies like oncolite and stromatolites with prism cracks and fenestrae.

A typical lateral facies change from deep to shallow water can be seen in the coeval members of Hornbuck (lower part), Geissberg, Steinebach and Hauptmumienbank (see GYGI & PERSOZ 1986, pl. 1). The Hornbuck Member was sedimented on the basin floor at a depth of more than 100 m. It is a succession of marls and limestones with sponge bioherms and ammonites. The lower part of this member grades laterally into the micritic, bedded limestones of the Geissberg Member which contains a rich bivalve fauna. Near Olten the Geissberg Member is laterally superseded by coral bioherms at the margin of the carbonate platform of the Balsthal Formation. Behind these bioherms there is a wide belt of carbonate oolite. This oolite of the Steinebach Member grades laterally in the proximal direction into the lagoonal oncolite of the Hauptmumienbank Member.

The lateral facies transition of the lower Günsberg Formation to the lower Effingen Member can be followed in the field on the north slope of Mt. Raimeux west of the farm le petit Rambode. This is also visible on the topographic map Landeskarte der Schweiz 1 : 25 000, northwest corner of sheet 1107 Balsthal. The lateral facies transition of the upper Günsberg Formation with coral bioherms to the Effingen Member can be seen in the landslide of Gschlief near Günsberg (section RG 14, see GYGI 1969, fig. 3). The same facies change has already been observed by MÜHLBERG (in AMSLER & MÜHLBERG 1926, p. 687) east of the Chatzensteg gorge south of Ramiswil SO, Landeskarte 1 : 25 000, sheet 1087 Passwang, coordinates 616.750/243.300. This is represented on the Geological Atlas of Switzerland 1 : 25 000, sheet no. 3 Laufen-Bretzwil-Erschwil-Mümliswil (1936).

The basinward thinning of the St-Ursanne and Pichoux Formations can be followed north of Nunningen SO from west to east between the rocks west of Balm, the Langenberg and Dietelloch, or east of Erschwil SO between the rocks west of Titterten and Hohrüti west of Meltingerberg (Landeskarte, sheet no. 1087, Passwang).

3 Lithostratigraphy

3.1 The stratigraphical sections

The stratigraphical sections published in this paper are grouped into four transects each running from north-northwest to south-southeast, perpendicular to depositional strike (fig. 1). The sections east of Balsthal have been published by Gygi (1969) and elsewhere (see caption to fig. 1).

3.1.1 Transect Bure-Biel

The Bure-Biel transect is in the southwestern part of the study area and incorporates data from 8 sections.

3.1.1.1 Section RG 454 Bure JU, well BUR 2 (pl. 16)

An exploration well was drilled at the eastern margin of the village of Bure JU, coord. 567.649/254.670. At the base of the borehole at a depth of 60 m there is a peloidal packstone which forms part of the lower Vorbourg Member. The remainder of the overlying Vorbourg Member (beds 1 to 18) is mostly a micritic lime mudstone with marly intercalations. In the upper part of bed 7 and in bed 18 there are stromatolites (pl. 16).

The base of the Röschenz Member is marked by bed 19, a soft marl. Bed 22 is a lime mudstone with lithoclasts several centimetres in size. The marl of bed 27 also contains calcareous lithoclasts above a hiatus at the top of bed 26. The oolitic wacke- to grainstone of bed 38 is a regional marker bed. There are mud clasts several centimetres in size in the marl of beds 58 and 64. Beds 62 and 65 are lumachelles.

The base of the Hauptmumienbank Member is bed 67, a lime mudstone that contains less than 10 % oncoids with a diameter of up to 1 cm. In the upper part of bed 68 is a thin oolitic grainstone with angular micritic lithoclasts that have a diameter of up to 1.5 cm.

The base of the Bure Member is marked by bed 72 in which micritic limestone bands with a thickness of less than 10 cm alternate with marl bands of similar thickness. The member consists mainly of grey, homogenous marl of which bed 77 is a good example, and has a total thickness of 10.2 m. Bed 86 marks the base of the micritic, bedded limestone typical of the overlying La May Member of the Courgenay Formation. At the top of the borehole the succession is strongly weathered and is capped by soil at the surface.

3.1.1.2 Section RG 340 Porrentruy JU, quarry of Le Banné (pl. 17)

This section is located in the old quarry on the eastern slope of Le Banné hill. It was measured using a rope as described in section 1.4, therefore the beds are numbered from the top to the base. At the base of the section on the quarry floor is bed 88, a white, porous lime mudstone representing the upper part of the Porrentruy Member of the upper Courgenay Formation. 6.4 m above the base are angular lithoclasts, terebratulid brachiopods and solitary corals with a diameter of 1 cm. The uppermost 0.4 m of the bed is less porous. The uppermost 20 cm are thoroughly bioturbated. The upper bedding plane is covered with a thick limonite crust. Above the crust is a marly seam that marks the base of the Reuchenette Formation.

The lowest two beds of the Reuchenette Formation are micritic limestones with a thickness of only 5 cm each (not represented in pl. 17). Bed 85 is a peloidal wackestone with burrows. The succession above comprises lime mudstones up to bed 58. Within this succession there are two beds with lithoclasts of a diameter of less than 1 cm (beds 76 and 70). Bed 53 is a micritic limestone with conspicuous burrows with a diameter of 1 cm that penetrate downwards from the sharp upper bedding plane. There is a great number of corals, *Ceriomya* and nerineid gastropods in the pure white bed 46. The overlying bed 45 is a pure white, porous peloidal packstone with very fine-grained peloids. Beds 22 to 14 contain an abundant fauna of bivalves with some gastropods. It is at this level that several large nautiloids have been found around Porrentruy. The upper bedding plane of bed 6 is a bored hardground. The marly Banné Member probably begins directly above bed 1. Abundant bivalves and gastropods are scattered over the fields on the top of Banné hill.

3.1.1.3 Section RG 359 Bressaucourt JU, drinking water well (pl. 18)

A drinking water well was drilled on the bottom of the small valley south of the village of Bressaucourt to a depth of 150.2 m. The lowest beds numbers 1 to 3 represent the uppermost Liesberg Member of the Bärschwil Formation. These beds consist of marl and marly, partly dolomitic limestone with partly silicified fossils. Dish-like coral colonies are only abundant in bed 3.

Bed 4 marks the base of the St-Ursanne Formation, Grellingen Member (see below). It is a lime mudstone with discoid coral colonies. In bed 6 there are oncoids with a core of partially silicified bioclasts. The terebratulid brachiopods in bed 6 and the bivalves in bed 7 are also partially silicified. Bed 10 is an intercalation of oolitic pack- to grainstone. The lowest massive coral colonies occur in bed 13. Partially silicified serpulids occur as high up as in bed 14. The surface dividing the lower St-Ursanne Formation (Grellingen Member) from the upper St-Ursanne Formation (Buix Member, see below) is at the top of bed 17. There is no indication of a hiatus. At the base of the Buix Member there is a massive, well-cemented lime mudstone (bed 18). This is the lateral equivalent of the lowermost "chalky limestone of St-Ursanne" of Ziegler (1962) at St-Ursanne. Bed 19 is the lowest typical, almost pure white and porous "chalky limestone of St-Ursanne". Bed 22 is a yellowish white oolitic grainstone with large solitary corals and pectinid bivalves. The upper bedding plane of bed 23 is covered with a limonitic crust. This marks the upper boundary of the St-Ursanne Formation.

The base of the Vorbourg Member corresponds to bed 24 and the top to bed 41. The member consists of micritic, bedded limestone. There is a solitary coral in bed 29, together with ostreids (PS Gy 4160).

The first bed of the Röschenz Member is no. 42, a marly peloidal wackestone. This member mainly comprises variable marly limestones. The marl intercalations are subordinate. There are beds with much detrital quartz, for instance nos. 47 and 52. Stromatolites occur in beds 46, 56 and 58. Bed 73 is an oolitic wackestone, and is a regional marker bed that is also present in section RG 454 near Bure (see 3.1.1.1, bed 38). The Jurassic succession ends at the top of the marl of bed 79. Above is a conglomerate of Tertiary age.

3.1.1.4 Section RG 350 Courgenay JU, Chemin Paulin road (pl. 19)

The base of the section is 500 m northwest of Vacherie Mouillard farm. The section was measured along a forest road called Chemin Paulin (this name is not indicated on the Landeskarte der Schweiz 1:25 000, sheet 1085 St-Ursanne). The road runs through the forest of Montagne d'Alle southwest of Courgenay. The lowest bed shown on pl. 19 is no. 7 which is the tectonically sheared Hauptmumienbank Member. The oncoid content is about 30 % of the rock volume at the base of the bed where the diameter of the oncoids is less than 5 mm. 3.4 m above the base the largest oncoids have a diameter of 1 cm. Some of the oncoids have calcite pseudomorphs after gypsum forming their cores.

The soft, grey marl of the upper Bure Member was discontinuously exposed when the section was measured in 1981. Since then this part of the section has been completely overgrown by vegetation. The lower part of the La May Member is so thinly bedded that not all of the beds could be drawn on pl. 19. The member comprises a monotonous succession of lime mudstone. Bed 43 contains angular and rounded lithoclasts with a diameter of up to 2 cm. There are some calcite pseudomorphs after gypsum in the groundmass. Above bed 43 the thickness of the limestone layers increases. Bed 59 is a tectonically sheared marl with micritic limestone boudins.

Bed 79 forms a ridge around which the road bends. The rock is unbedded, micritic lime mudstone with a yellowish white colour. There are densely spaced, deformed joints. This is the characteristic Porrentruy Member, but here it is not chalk-like and porous as it is near Porrentruy.

The Reuchenette Formation begins with a monotonous succession of slightly darker, yellowish-grey lime mudstones. Bed 95 is a particularly resistant micritic limestone that forms a small ridge. From bed 106 upwards there are peloids. Bed 116 forms a ridge above the road and a small waterfall in the gully below. Angular and rounded lithoclasts with a diameter of up to 2 cm occur in bed 132 together with partly empty burrows with a diameter of as much as 1 cm. Above there are several beds with large bivalves.

The argillaceous Banné Member begins with bed 156. Bivalves are very abundant in beds 157 and 158. The soft marl 159 contains only few macrofossils. This is the uppermost bed of the Banné Member.

3.1.1.5 Section RG 443 St-Ursanne JU, exploration well near La Coperie farm (pl. 20)

The base of the section is at a depth of 162.6 m above a shear plane. Bed 1 is a soft grey-brown marl with a high content of detrital quartz and it forms the uppermost bed of the Röschenz Member.

The lowest bed of the Hauptmumienbank Member is no. 2, an oolithic-oncolithic grainstone containing bivalves and small gastropods. Bed 3 is an oosparite. Oncoids up to 2 cm in size reappear only in bed 4 where they form 10 to 20 % of the rock volume in a lime mud groundmass. The top of the Hauptmumienbank Member is bed 7.

The Oolithe Rousse Member is represented by beds 8 and 9 which are oopelmicrites. The Bure Member is characterized by marly limestones alternating with marls which contain very fine-grained detrital quartz. There are large parts of crinoid stems and brachiopods in this member.

The base of the La May Member is marked by bed 24, a lime mudstone. There are peloids in beds 31, 40 and 52 to 59. Oncoids occur in beds 32, 45 and 49. Most of the member consists of well-bedded lime mudstone. Angular lithoclasts with a size of up to 25 mm occur in bed 60.

The Porrentruy Member is bed 65. It is massive, yellowish-white, slightly porous and relatively soft. Brachiopods, ostreids and nerineids are fairly abundant. Oncoids reach a maximum diameter of 8 mm. The upper boundary of the bed is a horizontal stylolite.

The lower Reuchenette Formation is a monotonous succession of well-bedded, micritic limestones. Peloids are uncommon, but bed 80 is a pelsparite. There is an uneven erosional surface within bed 83. The Banné Member (bed 126) has a thickness of 3.5 m. Only the lowest 20 cm are very fossiliferous. The macrofauna is dominated by ostreids and *Trichites*.

3.1.1.6 Sections RG 314, 315 Sornetan BE, Pichoux gorge (pl. 21)

The lower section, RG 314, begins on the eastern bank of the Sorne creek northnortheast of the road tunnel. Bed 1 is a continuous band of fossiliferous, marly, blue-grey limestone. This is the regional fossil bed in the middle Sornetan Member (see Gygi & Marchand 1993, fig. 2). The section goes only to the nodular bed 5 at this location, then it is covered by drift. The section continues in a small landslide at coordinates 584.160/237.100 more than 100 m to the south, where beds 7 to 15 are exposed. Beds 16 to 18 had to be dug out at this location in order to make the contact between the Sornetan Member and the Pichoux Formation visible. The section continues more than 100 m to the north in a small gully through the lower escarpment of the Pichoux Formation. This is a succession of well-bedded, light brownish-grey micritic limestone. Above bed 44 the succession weathers back. The sections RG 314 and RG 315 overlap by more than 3 metres.

The base of section RG 315 is at a small shear plane on the roadside west of the Sorne creek. The bedding of the overlapping upper part of section 314 and the basal part of 315 could not be correlated between the opposite sides of the gorge. The link between the sections was therefore made according to the upper edge of the lowermost escarpment of the Pichoux Formation which is well recognizeable on both sides of the gorge. Beds 3 to 15 of section RG 315 are brownish-grey, micritic limestones that weather back. Bed 16 is more resistant, it forms an overhang above a cave. Bed 20, mainly the lowest 0.5 m of it, is marly and weathers back. The base of this bed is interpreted to correspond to the transgression surface near St-Ursanne where the coral bioherms of the upper St-Ursanne Formation start above the oolite of the lower St-Ursanne Formation. The northern entrance of the road tunnel is in the marly succession of beds 20 to 22. The succession is purely micritic up to the particularly resistant bed 28, the upper edge of which forms the upper waterfall of the Sorne. Bed 29 as well as beds 32a and b are wackestones with a high content of fine-grained bioclasts. The upper bedding plane of bed 32b is uneven. This is the top of the Pichoux Formation.

The Pichoux Formation is overlain by bioherms of the St-Ursanne Formation (beds 33 and 34). The bioherms weather out to the east of the road and the Sorne creek. Massive coral colonies are densely packed at the base of the bioherm on the western roadside. The base of the coral bioherms lies directly on the upper surface of bed 32b. There is no more than mud-grade bioherm-derived detritus between the bioherms. The coral colonies in the upper part of bed 33 and in bed 34 are mostly massive and only occasionally branching. The matrix of the bioherms is lime mudstone which forms about 90 % of the bioherm volume. The bioherms are dissected by numerous tectonic fractures. The upper surface of bed 34 is even and very well-defined.

At the base of the Günsberg Formation is a soft, yellowish marl that is only a few centimeters thick (lower part of bed 35). The bulk of bed 35 is a blue-grey micritic limestone with fine-grained detrital quartz. There are lenses of pelmicrite in the bed with as much as 10 % quartz. Bed 36 is a bioherm with a micritic groundmass at the base of which are thick discs of probably *Microsolena*. 3 m above the base of the bioherm the coral colonies become massive. The upper bedding plane is uneven. It is visible in the streambed of the Sorne, because a fault displaces the succession by 17.7 m. Beds 37 to 44 are mostly micritic limestones and resemble the Vorbourg Member. Beds 45 to 49 are calcarenites with inclined bedding. Bed 45 is a fine-grained oolitic pelsparite and bed 47 is very similar, but it is laminated and contains some detrital quartz. Bed 49 is a bioclastic calcarenite (biosparite), the upper 2.8 m of which are visible along the road.

A soft marl 10 cm thick forms bed 50. Beds 51 and 52 are both 10 cm thick and are stromatolites. The lower part of bed 56 is an oolitic biosparite. In the upper part of the bed there are branching corals and oncoids up to 2 cm in diameter enclosed in a lime mudstone groundmass. Bed 61 is 30 cm thick, and the entire thickness of it is dissected by prism cracks. The bed is a wavy laminated stromatolite. It's upper surface is an undulating erosion surface that intersects the wavy lamination. Beds 62 to 65 above are stromatolites. The stromatolite of bed 65 is crinkled and has been figured in GYGI (1992, fig. 12, Gy 4928). Bed 66 contains about 20 % oncoids with a diameter of up to 5 mm, fine desiccation cracks and birdseyes. The remainder of the Röschenz Member crops out above the road and is partly covered with drift and vegetation.

The succession resumes with the Hauptmumienbank Member whose lower part is exposed above the road. Only the upper part of the member is oncolitic: in bed 106b there are about 30 % oncoids with a diameter up to 2 cm, and in bed 107b there are about 30 % oncoids the maximum size of which is 25 mm.

The Oolithe Rousse Member goes from bed 108 to 111. Bed 108 is an oosparite with mostly micritized ooids and pseudomorphs of calcite after dolomite and sulfate within the intergranular cement. Bed 109 is an oomicrite with brown, micritized ooids in an olive-green groundmass. The groundmass was first partly dolomitized, then totally dedolomitized and contains some detrital quartz.

The base of the Laufen Member is marked by bed 112 in which there are very abundant ostreids and some pectinids. *Zeillerina astartina* (ROLLIER) and *Cycloserpula socialis* (GOLDFUSS) are associated with abundant ostreids in bed 113. Bed 115 is marly, weathers back and contains abundant detrital quartz.

The Verena Member is massive as usual. The lower part forms a high ridge whereas the upper part weathers back to form a hollow. Beds 120 and 121 are oobiomicrite, and no. 121 contains dedolomitized rhombs. Bed 122 is an oomicrite that was extensively dolomitized and then entirely dedolomitized. No. 123 is an oosparite with dedolomitzed rhombs. Oncoids up to 6 mm in diameter occur in a dedolomitized, oomicritic groundmass in bed 125. There are grapestones, nerineid gastropods and ostreid bivalves in the pelsparitic to oolitic bed 127. Bed 129 is an oosparite at the base, then an oolitic wackestone that grades into pure micrite at the top.

The lower Reuchenette Formation consists mainly of micrite with varying amounts of peloids, bioclasts and detrital quartz. Bed 137 is a conspicuous marl that dams up a spring at the eastern side of the gorge. The upper part of bed 153 and the whole of bed 154 are stromatolitic.

3.1.1.7 Sections RG 307, 458 Péry BE, La Charuque quarry (pl. 22)

The base of the section is exposed on the western side of the lower level of the quarry La Charuque where the uppermost part of the Callovienton Member crops out. The Dalle Nacrée Member (mainly bed 10) is a biosparite with inclined bedding. The bioclasts are mostly derived from echinoderms, but fragments of bryozoan colonies are also abundant. The upper surface of bed 10 is a planed and bored hardground with a limonitic crust.

The base of the Herznach Formation is marked by bed 11 which is 15 cm thick and contains abundant bivalves, bioclasts from echinoderms as well as iron ooids. The iron ooids are concentrated in the upper part of the bed. Beds 12 to 18 are a succession of marly limestones with limonitic iron ooids and marl with iron ooids. These are the "Anceps-athleta Beds" of previous authors. The upper bedding plane of bed no. 18 is covered with a thin crust of limonite. This is overlain by a clayey marl 15 cm thick with a brown-violet colour and 25 % limonitic iron ooids (no. 19). Characteristic of this rock are yellow-brown spots. Parts of crinoid stems, wood and belemnites are quite common. The ammonites of this bed are *Kosmoceras* sp., *Quenstedtoceras lamberti* (J. SOWERBY) and *Quenstedtoceras paucicostatum* LANGE (GYGI 1990a, pl. 3, fig. 12). The upper surface of bed 19 is very well-defined. Bed 20 is a brownish to dark-grey, clayey marl 25 cm thick. The iron ooid content decreases from 20 % at the base to zero at the top. At the base of the bed there are ammonites indicative of the Callovian Stage like *Quenstedtoceras lamberti* (GYGI 1990a, pl. 3, fig. 13) and *Quenstedtoceras leachi* (J. SOWERBY) (GYGI 1990a, pl. 3, fig. 10). In the upper part of the bed the first Oxfordian ammonites appear, for instance *Cardioceras (Scarburgiceras)* cf. *scarburgense* (YOUNG & BIRD) (GYGI 1990a, pl. 3, fig. 11). The Callovian/Oxfordian boundary is therefore within bed 20. The upper boundary of this bed is transitional; it is drawn where the iron ooids disappear.

The Bärschwil Formation is represented by bed 21 which is 3.3 m thick and is a blue-grey, homogenous clayey marl. This is the Renggeri Member in which ammonites are rare (see GYGI 1990a, pl. 6, fig. 3).

The Pichoux Formation begins with bed 22 above a hiatus of four ammonite subzones. The normal thickness of the bed is 0.8 m. It is a biopelmicrite with glauconite and siliceous sponges. Two small sponge bioherms were visible in this bed in the southern part of the quarry in 1980 which doubled the thickness of bed 22. *Perisphinctes (Dichotomosphinctes) antecedens* SALFELD was recovered from this bed (GYGI 1990a, pl. 5, fig. 4). Bed 27 is a glauconitic spiculite. There is a marly intercalation in the lower Pichoux Formation (bed 41) that can be correlated with section RG 315 (Pichoux gorge) and other sections. The upper part of the Pichoux Formation is well-bedded micritic limestone with some very fine-grained bioclasts. The upper bedding plane of the uppermost bed of the formation (no. 77) is hummocky and covered with a crust of limonite or iron sulfide.

At the base of the Wildegg Formation (Effingen Member) is a thin succession of micritic limestones (beds 78 to 83) with marly intercalations. This is overlain by a predominantly marly succession. Unit 92 is composed of micritic limestone beds with a maximum thickness of 30 cm each. *Larcheria subschilli* (LEE) has been recovered from the upper part of this unit. The thin and often laminated sandy intercalations in the Effingen Member are often dolomitized like bed 94 (thin section Gy 5440). These are probably small turbidites. A *Perisphinctes (Ampthillia) quadratus* ENAY has been found in the succession of unit no. 99 (GYGI 1990a, pl. 7, fig. 5) indicating the lower Bifurcatus Zone. Bed 102 is a very thick marl with some thin calcareous intercalations. In one of these intercalations *Perisphinctes (Dichotomoceras) bifurcatoides* ENAY has been found. Beds 103 to 109 clearly demonstrate a thickening-upward succession. The uppermost bed of succession no. 112 is conspicuous. This bed forms the base of section RG 458 which was measured in 1995 about 300 m south of the tunnel in the La Charuque quarry, because a part of section 307 was covered by debris in 1980. Beds 458/9 and 307/114 are the same. Section RG 307 continues with bed 114 in the upper part of bed 9 of section RG 458. Bed 307/119 is a hard, blue-grey limestone with a thickness of 0.9 m. In this bioarenitic wackestone are numerous druses with a diameter of up to 5 cm with calcite and celestite. BURKHARD (1978, p. 27, 79) reported very pure celestite from Péry, but he thought it was from "fossil-rich, grey limestone of the Sequanian" (= Günsberg Formation?). It is probable that his stratigraphic classification is erroneous and that the celestite bed of section RG 307, bed 119 and BURKHARD's bed are the same.

The abundance of tempestites in the uppermost part of the Effingen Member is interpreted to be an indication of relatively shallow water. A good example is bed 115, a laminated quartz arenite 20 cm thick with microsparitic cement and coarse-grained bioclasts at the base. This bed resembles bed 160e adjacent to a bioherm further up in the succession (GYGI 1986, fig. 7). A similar bed is no. 125 with planar lamination. The upper bedding plane is an erosional surface with coarse parallel grooves. The ridges between the grooves resemble ripples, but they are not ripples, because the lamination of the ridges is horizontal and is intersected by the groove casts of the overlying bed. The first hermatypic corals appear in bed 144. Beds 145 and 148 are proximal tempestites. Bed 145 is a marl with a thickness of 0.5 m. Embedded in the marl are nodules with a diameter of 20 cm. The nodules have a matrix of lime mud that was semi-consolidated at the time of the storm. Enclosed in the nodules is a complicated pattern of striated bioruditic floatstone.

The base of the Günsberg Formation is marked by the foot of the bioherms of bed 160 (GYGI 1992, fig. 19). The matrix of the bioherms is lime mudstone. The colonization by corals is in parts so dense that they form framestones. The coral colonies at the base of the bioherms are dish-shaped to massive. Further up, branching forms are intermingled with massive colonies. There are stromatolites adhering to the corals (GYGI 1992, fig. 20). The bioherms include large lenses of soft marl. Some massive coral colonies have been observed to be overturned. The top of the bioherm at the southern entrance of the tunnel is a corroded, rough surface covered with a limonite crust. Above the bioherm is the thick cross-bedded oosparite of bed 162. The upper boundary of this oolite is a corroded hardground. The hardground is in some places overlain by lenses of lignite with plant fragments (branches?) up to 25 mm in diameter and characean gyrogonites. Bed 163 is a petroleum-green oncolitic, mud-supported floatstone. The oncoids reach a diameter of as much as 5 cm (GYGI 1992, fig. 14). Nerinean gastropods sometimes form the oncoid cores. Massive and branching coral colonies are common. This is the "Grüne Mumienbank" (= green oncolite) of ZIEGLER (1956, pl. 2, fig. 1). The upper Günsberg Formation is a variable, partly oolitic succession with another lignitic intercalation (bed 178). There are three conspicuous layers of marl in the uppermost part of the formation: beds 186, 188 and 191.

Bed 192 marks the base of the Balsthal Formation and is a marly limestone with many fossils. The beds 193 to 195 are calcarenites with inclined bedding. The inclination of the internal layers of beds 193 and 194 is to the north-northeast and that of bed 195 to the west-northwest. These beds are interpreted to be part of a tidal delta which prograded into a lagoon. The currents must have been strong, but nevertheless the rock of bed 193 is an oomicrite with only occasional sparitic interstices (fig. 13). The upper bedding plane of bed 195 is a hummocky hardground that is covered with a limonitic crust. Beds 193 to 195 represent the Steinebach Member but are atypical facies.

Bed 196 is the lowermost of the Laufen Member. It is a limey marl with about 20 % dark green peloids and many fossils. Oncoids in a micritic matrix occur in beds 199 to 201. The oncoids in bed 201 are about 20 % of the rock volume and have a diameter of up to 35 mm. The succession from beds 197 to 202 might easily be mistaken for the Hauptmumienbank Member. The lower part of bed 212 is a lime mudstone with burrows that penetrate as deep as 70 cm from the upper part of the bed. Druses lined with calcite with a diameter of up to 10 cm are dispersed within the bed. Their origin is uncertain, because they are too large to be interpreted as open burrows. Pieces of plants several centimeters in size occur in the upper part of the bed.

The boundary between the bedded Laufen Member and the massive Verena Member is conspicuous. The rocks of the Laufen Member are light blue-grey to greenish-grey, whereas the limestone of the Verena Member is yellowish-white. Bed 227 is an oosparite with micritized ooids. 228b is a pure lime mudstone. Oncoids are to be found in bed 231 and mainly in bed 232. The upper bedding plane of 232 is a hummocky erosion surface. On top of it are 2 cm of soft, yellow-brown marl. In the lowermost part of bed 233 are blackened lithoclasts up to 8 cm in diameter. The larger lithoclasts are rounded, whereas the small ones are angular. The uppermost few metres of the Verena Member are pure lime mudstones. The member is nevertheless distinct from the overlying micritic lowermost Reuchenette Formation. At the boundary there is a marly seam about 1 cm thick. The limestone of the lowermost Reuchenette Formation is much thinner bedded than the massive Verena Member below, and it has a darker colour (light brownish-grey).

Bed 236 of the Reuchenette Formation is a stromatolite. Further up the rock contains varying percentages of peloids.

3.1.2 Transect Delémont-Grenchen

3.1.2.1 Section RG 366 Delémont, Vorbourg chapel (pl. 23)

Beds 1 and 2 of the lower St-Ursanne Formation, Delémont Member (see below) are an oomicrite with occasional small oncoids. The amount of micritic cement decreases upwards until the rock is an almost pure oosparite in bed 5. Bed 7 contains coral clasts and oncoids of probably foraminiferal origin with a diameter of up to 1 cm. Ooids are present in beds 1–9.

Bed 10, the lowest unit of the Buix Member (see below), is a bioarentic packstone to bioruditic floatstone with large, massive coral colonies. There is a small bioherm at this level above the road. A porous, white biomicrite forms the massive bed 11. Bed 12 is also massive, it is very resistant to erosion and forms the ridge on which Vorbourg chapel is built. Ziegler (1962, pl. II/15) included this unit into his Vorbourg Member. It is better to interpret it to be the uppermost part of the St-Ursanne Formation, because the well-bedded Vorbourg Member only begins above an even, corroded bedding plane at the top of bed 12.

The base of the Vorbourg Member is marked by bed 13 and the top by bed 24. Part of the well-bedded succession of mainly lime mudstone has been tectonically sheared (cf. Ziegler 1962, pl. II/15). Some of the partings between the limestone beds are marly. The member weathers back.

Ziegler (1962, pl. II/15) also included the lowermost Röschenz Member in his Vorbourg Member. The base of the Röschenz Member is marked by 0.5 m of soft marl (bed 25). Bed 31 is also marl. Such thick marls do not occur in the Vorbourg Member as it is conceived by most authors. Bed 35 is a peloidal sandstone. Most of the beds until no. 50 contain abundant detrital quartz. Bed 50 is a stromatolite. The uppermost thick marl is bed 65. Bed 66 is a marly limestone that becomes increasingly calcareous upwards.

The Hauptmumienbank Member begins with the peloidal biosparite of bed 67. The first oncoids with a diameter of up to 2 cm appear in bed 71 where they form about 20 % of the rock volume. In bed 73 the oncoids form 20 to 30 % of the rock volume and grow to a diameter of 3 cm. They weather out as knolls at the rock surface.

The Oolithe Rousse Member is primarily an oomicrite. The cement was thoroughly dolomitized and then entirely dedolomitized (TS Gy 6206). It has a greenish-grey colour, whereas the ooids are red-brown. The Oolithe Rousse Member encompasses beds 74 to 77.

The Bure Member begins with yellow-brown marl that alternates with light-grey marly limestone (bed 78). This bed contains brachiopods like *Zeillerina astartina* (Rollier) (= *"Zeilleria humeralis"* auctorum) and the rhynchonellid *Septaliphoria* cf. *semiconstans* (Etallon). The member ends with the biopelmicritic, marly limestone of bed 81.

The Laufen Member is relatively thin-bedded. Bed 85 is a micrite with some peloids. The groundmass has been intensely dolomitized and then completely dedolomitized. Bed 92 is similar, but it contains bioclasts instead of peloids.

The boundary between the Laufen and the Verena Members is well-defined. It is drawn at the base of the massive bed 103. The lowermost 40 cm of this bed are a wackestone with finely arenitic bioclasts. The Verena Member is made up mostly of oosparite, but beds 106 and 107 were primarily a lime mudstone. No. 106 was totally dolomitized and then entirely dedolomitized. It is now a calcitic sparite.

The base of the Reuchenette Formation is marked by a succession of relatively thin-bedded, micritic limestones. Further up, the bedding becomes thicker, and the rock contains varying amounts of peloids and fine-grained bioclasts. Greppin (1893, p. 16) called this succession with a thickness of about 26 m "Couches du Vorbourg". This term was not taken up by subsequent stratigraphers and has been forgotten. On the other hand, the Vorbourg Member of Ziegler (1962, p. 21) has been adopted in a restricted sense by several authors and is now well-established in the geological literature (Bolliger & Burri 1970, p. 72 or Heckendorn 1974, p. 11 and Geologischer Atlas der Schweiz, Blatt 1085 St-Ursanne 1963, Blatt 1067 Arlesheim 1984).

3.1.2.2 Sections RG 373, 389, 451 Vellerat JU, Peute Roche (fig. 20, pl. 24)

Section RG 373 begins in the larger, eastern of the two landslides ca. 170 m northeast of point 957.9, below Peute Roche southwest of the village of Vellerat JU. Beds 1 to 47 belong to the Sornetan Member. The main body of this member is a grey marl. Intercalated in the marl are bands of limestone concretions, the so-called "chailles". The lateral distance between these nodules varies widely, and the nodules may coalesce into continuous beds of limestone. Bed 10 is a massive limestone with a thickness of 0.6 m. This is a local marker bed (Gygi & Marchand 1993, fig. 2). The vertical distance of the nodule bands is also variable. There is a concentration of nodules

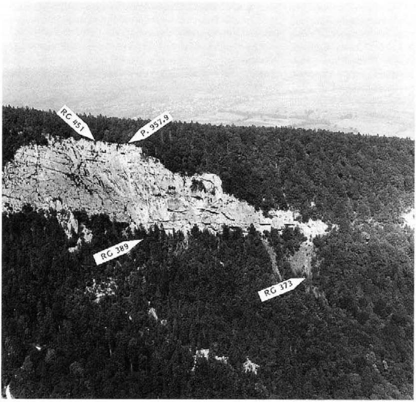


Fig. 20: Cliff of Peute Roche 1km southwest of Vellerat JU as seen from the south. Arrows indicate the location of sections RG 373, RG 389 and RG 451 (pl. 24).

around bed 28 which contains flattened nodules that are more than 1 m wide.

The base of the Liesberg Member is fixed at the level where the first hermatypic corals and silicified serpulids appear. The corals are mostly plate-like, but small solitary corals are also abundant. Spines of *Paracidaris florigemma* (Phillips) and calcareous sponges are quite common. In the middle of the member, in bed no. 2 of section RG 389, the coral colonies are cup-like. The uppermost part of the Liesberg Member is accessible at the foot of the cliff directly below point 957.9, ca. 170 m to the southwest, where section RG 389 has been measured.

The lower boundary of the overlying St-Ursanne Formation is transitional. It is drawn where the rock becomes calcareous enough to form a cliff. This is at the base of bed 6 of section RG 389. 30 to 40 % of the volume of this bed are flat or cup-like coral colonies that are up to 60 cm wide and 6 cm thick. The upper end of section RG 389 is at a conspicuous parting that is visible from a greater distance, at the top of bed 11. Bed 11 is the last one with flat coral colonies. The groundmass is a biomicrite. Section RG 451 begins about 45 m west of point 957.9 (fig. 20). Bed 1 of this section is a massive biomicrite with massive coral colonies. This is the typical facies of the Grellingen Member (see below). Bed 2 is an oosparitic intercalation. Bed 3 is again biomicrite with massive coral colonies and solitary corals. This is the upper part of the Grellingen Member. The Tiergarten Member of the upper St-Ursanne Formation is an unbedded, almost pure oosparite (bed 4) with peloids at the top (bed 5).

The lowermost part of the Vorbourg Member (4.3 m, beds 6 to 9) crops out in the uppermost part of the cliff. These four beds are micrite with some very fine-grained detrital quartz (thin-section Gy 7438, bed 8). The section ends with bed 9.

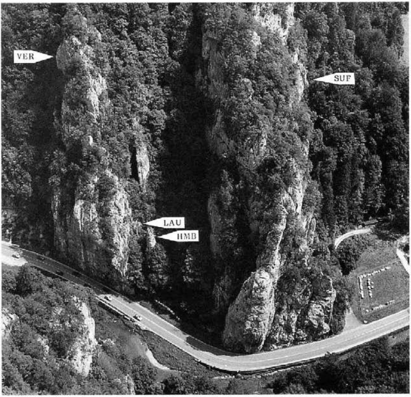
3.1.2.3 Section RG 377 Rebeuvelier JU, La Roche St-Jean (fig. 21, pl. 25)

The section begins with the St-Ursanne Formation that forms the high ridge of Les Ordons. This formation is sheared along several planes and cannot be measured in detail (fig. 21, on the right hand side). It is therefore not represented in pl. 25. The detailed section starts north of a 22 m wide gully that is filled with talus.

Beds 18 and 19 form a narrow, prominent ridge. This is the Hauptmumienbank Member of the Vellerat Formation. The oncoids grow to a diameter of 15 mm in the upper part of bed 18. 2.5 m above the base of bed 19 there are about 40 % oncoids with a diameter of up to 35 mm. To the north of this ridge is a deep, narrow (3.8 m) groove filled with talus.

The section resumes with a succession of relatively thinly-bedded limestone of the Laufen Member (beds 20 to 28). Bed 28 is a floatstone with ca. 30 % oncoids that have a diameter of 8 mm at most.

Fig. 21: Section RG 377, La Roche St-Jean southwest of Rebeuvelier JU as seen from the west. On the right hand side (south): sheared ridge of the St-Ursanne Formation. On the left (north): Hauptmumienbank Member (slender, low ridge), Laufen Member (vegetated notch) and Verena Member (high ridge). Compare with pl. 25. For key to abbreviations see caption to fig. 39.



The Verena Member forms a high ridge directly beside the road. 2.8 m above the base of bed 29 the rock is an oolitic packstone. The ooids are micritized, and the primarily micritic cement was almost totally dolomitized and is now completely dedolomitized. The surface of the ooids has been indented by the dolomitization process and looks blurred under the handlens. This is the typical facies of the Verena Member. 17.4 m above the base of bed 29 there is a biopelmicrite with some dedolomitized rhombs. 18.3 and 21.1 m above the base the rock is a pure lime mudstone. At 24.4 m above the base of the massive bed 29 is a fine-grained pelsparite. At 34.5 m is a pelmicrite with a few ooids and oncoids. 42.7 m above the base there are abundant foraminifers and some *Cladocoropsis* in a pelmicrite. The top of the Verena Member is marked by bed 31 which is a pelsparite in the middle. Oncoids with a maximum diameter of 5 mm are about 30 % of the rock directly above.

The base of the Reuchenette Formation is marked by relatively thin beds of micrite and biomicrite such as bed 33 which contains dedolomitized rhombs and ruditic bioclasts.

3.1.2.4 Section RG 392 Moutier BE, Moutier gorge, Arête du Raimeux (pl. 26)

This roadside section begins in the Laufen Member, in the middle of a bend of the road. Bed 1 is an oncolitic floatstone with about 25 % oncoids that grew around ostreid shells and gastropods to a size of 1 cm. The upper part of bed 2 is very similar.

The massive bed 5 is the first of the Verena Member. 2.8 m above the base there is an oomicrite with an almost totally dolomitized cement. The dolomite crystals indented the micritized ooids. Then the rock was entirely dedolomitized. Bed 6a forms a notch above the road and is only fully accessible about 18 m above the road. 3.8 m above the base there is a porous, fine-grained oosparite with some aggregates of gypsum crystals. The gypsum was dissolved during the early diagenesis when there was still a high porosity, because the vugs are partly filled with early vadose silt (see Dunham 1969, fig. 6B). The remainder of the Verena Member is mostly pelsparite. The upper boundary is hummocky and forms the lowest, very large bedding plane in the quarry above the road.

Above this bedding plane there is an abrupt change in lithology. The massive, light Verena Member is overlain by the darker micrite of bed 10, the lowest bed of the Reuchenette Formation. This formation is mainly micrite with some peloidal intercalations.

3.1.2.5 Section RG 390 Moutier BE, southern part of Moutier gorge (fig. 22, pl. 27)

At the base of the section is the Pichoux Formation. The outcrop begins beside the railway near the forward signal to

Moutier. Bed 1 is a marly bioarenitic wackestone. Bed 2 is a slightly marly spiculitic biomicrite. The marly micrite of bed 29 again contains abundant sponge spicula. Some spicula were also found in the micrite of bed 39.

The first hermatypic coral colonies of the St-Ursanne Formation appear in bed 44. The groundmass of the primarily biomicritic bed 45 is intensively dolomitized, but the bioclasts are calcitic. The dolomitization persists into the lower part of bed 46. The upper boundary of the St-Ursanne Formation is not visible. Above bed 52 there is a 7.6 m wide, channel-like hollow filled with talus. It is probable from a comparison with outcrops on the southern slope of Mt. Raimeux to the east that there is marl underneath the debris. If this is so, the succession 53 to 57 has to be assigned to the Günsberg Formation. There are perisphinctid ammonites in this succession, but they cannot be identified to the species level. Detrital quartz is also present, but it is so scarce that this is inconclusive of the presence of the Günsberg Formation.

To the south, above bed 57 there is a depression with a width of 22.2 m. The section continues ca. 20 m above the road with bed 58 that has a knobby aspect. It is a peloidic packstone with ruditic bioclasts, but it does not contain corals. These are present only in the overlying bed 59, where there are massive colonies from 1.7 m above the base. Massive coral colonies may make up 50 % of the volume of bed 60 to form a coral bioherm. Bed 61 with its inclined bedding forms a high ridge ("GÜN" on fig. 22). The upper part of bed 62, an oobiosparite, was exposed in a temporary excavation on the western side of the road which extended up to bed 82.

Bed 65 is a dolomitic, quartz-sandy microsparite. The foraminifer *Alveosepta* is very abundant in the sandy pelmicrite of bed 66. Bed 79 is a layer of calcrete nodules with a diameter between 4 and 10 cm in greenish-grey marl. The upper boundary of the marl of bed 80 is a lignite seam with a thickness of 1 mm to 3 cm.

The Hauptmumienbank Member forms a narrow, high ridge ("HMB" in fig. 22). The oncoids form up to 20 % of the rock volume in bed 86 and reach a maximum diameter of 2 cm at the base of bed 87. Bed 88 is supported by a masonry half arch above the railway. Bed 89 is a biopelmicrite with about 5 % fined-grained quartz sand. This marly limestone with a brown groundmass is a marginal facies of the Oolithe Rousse Member.

The Laufen Member ("LAU" in fig. 22) is characterized by extensive dolomitization and oncoids. Bed 94 is a partly dolomitized and partly dedolomitized oncolitic floatstone. There is only slight dolomitization, and no dedolomitization in bed 95.

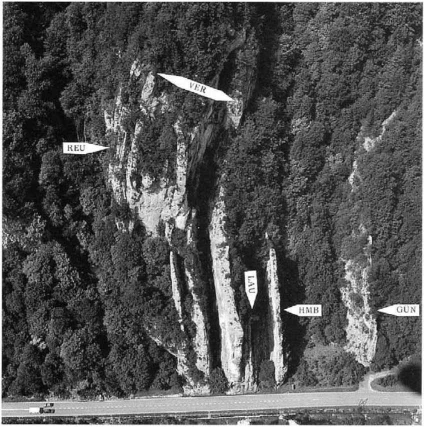


Fig. 22: Section RG 390 Moutier BE, Moutier gorge, southern part as seen from the east. Compare with pl. 27.

There is again almost no dedolomitization in the dolomitic, oncolitic floatstone of bed 97. The masonry half arch supporting bed 88 rests on the lower bedding plane of the dolomitic bed 98 which is very fossiliferous. 2.3 m above the base of this bed oncoids up to 3 cm in diameter make up as much as 40 % of the rock volume. Bed 99 is, 0.8 m above the base, a dolosparite with calcite spar in the dolomite interstices.

The Verena Member begins with bed 100, a massive limestone that forms a very high ridge (fig. 22). 3.6 m above the base it is an oomicrite with micritized ooids. The groundmass is almost wholly dolomitized and completely dedolomitized. The dolomite crystals indented the ooids and thus obscured the oolitic texture of the rock. The beds 101 and 102 form a deep notch. Bed 102 is an oosparite whose ooids often do not break under the hammer. Beds ns. 103 and 104 form high ridges. Above bed 104 the rock is tectonically disturbed and cannot be measured in detail.

3.1.2.6 Section RG 381 Moutier BE, Court gorge (pl. 28)

The section begins on the bank of the Birs River 20 m up river from where a thick pressurized water pipeline crosses the Birs River. In the lower part of bed 2 there are plate-like corals and in the upper part massive coral colonies. Bed 3 is only 15 cm thick. It contains massive coral colonies that are overgrown with ostreids, and many lignitic bioclasts up to several centimetres in size. There is again plant debris in bed 6. The upper part of bed 12 crops out beside the cantonal road. In 1958 the first fragment of a perisphinctid ammonite was found by the author in the upper half of bed 13. During a second visit with P. Allenbach more specimens were found, among them the *Perisphinctes (Dichotomosphinctes)* sp. indet. aff. *falculae* Ronchadze that has been identified by J. Callomon (see Ziegler 1962, p. 42). The upper surface of bed 14 is erosional with a relief of up to 15 cm. The upper parts of bed 15 and bed 17 are stromatolitic. Bed 21 is another stromatolite. There is a planed and bored erosion surface with encrusting ostreids on top of bed 28 (bed 10 of Ziegler 1956, p. 92) which in turn are overlain by a limonitic crust. This surface is easily visible south of the road. Beds 37 and 38 are an oosparite. There is some inconspicuous cross-bedding in no. 37. Bed 38 has an internal inclined bedding with a depositional dip of 15 to 20° to the north and northnortheast. The upper bedding plane is a hummocky erosion surface that cuts through the ooids (TS Gy 7005). The surface is covered by some ostreids and a brown crust. Bed 39 has a knobby weathering surface. It contains numerous large, mostly massive and some discoidal coral colonies that are bored by *Lithophaga* and another boring organism. The corals are recrystallized to white calcite spar. Many contain druses or may be entirely preserved as druses (see Ziegler 1956, p. 93, section 49, bed 15). The bed is a blue-grey peloidal, bioruditic floatstone with *Trichites*, rhynchonellids and sea urchin spines. Mainly in the upper part of the bed there are pockets of soft, grey marl. The lower part of the section ends where a retainig wall begins that partly covers bed 40 at coordinates 593.000/234.280.

The section continues to the northeast at coordinates 593.340/234.530 below a commemorative table at the cliff west of the road, about 60 m south-southwest of the southern end of the new bridge. Bed 42 marks the base of the Hauptmumienbank Member and contains 5 to 50 % oncoids with a diameter of less than 1 cm. The diameter of the few oncoids in bed 43 is up to 3 cm. The groundmass is micrite up to bed 45. It becomes partly sparite in bed 46, the last of the Hauptmumienbank Member. Bed 49 is an oomicrite with micritized ooids that are lined with a brown crust. The petroleum-green groundmass is mostly dolomitized and contains much detrital quartz with a grain size of up to 250 microns. This is the typical facies of the Oolithe Rousse Member.

The oldest bed of the Balsthal Formation (Laufen Member) is no. 50. It is an oncolitic floatstone with a dolomitized and dedolomitized micritic groundmass. Oncoids occur up to bed 54.

The base of the Verena Member is marked by the massive bed 58, an oolitic grainstone with micritized ooids that often do not break under the hammer. There are druses filled with calcite that are up to several centimeters across. These are calcite pseudomorphs after gypsum. An ill-sorted peloidal packstone with an ochre cement forms bed 61. The cement is probably dedolomite. This is the last bed (29) that Ziegler (1956, p. 93) assigned to the Verena Member. Bed 62 is a saccharoidal dolosparite with few, small patches of calcitic micrite that weather out as pores. Bed 63 has a thickness of ca. 28 m. 2 m above the base it is a pelmicrite with foraminifers and *Cladocoropsis* as well as calcite pseudomorphs after gypsum. 10 m above the base is a pelmicrite (packstone) with abundant *Cladocoropsis, Cayeuxia* and some *Thaumatoporella*. The rock 18 m above the base is a pelmicrite (wackestone). The upper part of the massive bed 28 weathers back, whereas the well-bedded Reuchenette Formation above forms again a cliff.

3.1.2.7 Section RG 384 Selzach SO, road through Lochbach gorge (pl. 29)

Ziegler (1956, pl. 8) and Burkhalter (1989, fig. 2–12) have previously described and figured this outcrop. The section begins in the streambed east of the northern end of the tunnel. At the base there is 3.5 m of soft, blue-grey marl (bed 1, Effingen Member). Bed 3 is a blue-grey marl with lenses of limestone that are up to 13 cm thick and 70 cm wide. The lenses are made up of biopelmicrite to biopelsparite. Below they contain coral debris with a diameter of up to 1 cm, and in the upper part there are flat colonies of what is probably *Microsolena* coral colonies. The lenses are therefore mini-bioherms. The stream flows along and over bed 4 that is a greenish-gray marl-lime mudstone with a thickness of 0.6 m.

The hummocky lower bedding plane of bed 5 forms a high cliff above the stream. The hummocks are up to 0.5 m high and 3 m apart. This is the base of the Günsberg Formation. At the base the rock is a bioruditic floatstone with large coral debris that are preserved as druses lined with calcite spar. There are also lenses of marly limestone, a fine-grained pelmicrite with about 5 % fine-grained detrital quartz. 8.3 m above the base the whole rock is a fine-grained pelmicrite with about 5 % quartz. The northernmost part of the tunnel (a length of 14.5 m) is now lined with concrete. This concrete lining was not yet there when Ziegler (1956, p. 78, section 27) measured the section. Beds 6 and 7 are fine-grained oosparite with large bioclasts of corals, gastropods and bivalves 17 m above the base of bed 7. Massive coral colonies reappear in the uppermost part of bed 8 (bed 6 of ZIEGLER 1956) where they are preserved as druses with a diameter of up to 8 cm. Bed 9 is a saccharoidal and olive-green dolosparite with some rusty-brown peloids. There are abundant flat and massive coral colonies. These are bored by *Lithophaga* and recrystallized to coarse-grained calcitic sparite with some interspersed dolomite rhombs (bed 7 of ZIEGLER 1956, p. 78). Bed 12 has a thickness of 1.8 m and is saccharoidal. 1 m above the base about 80 % of the rock is dolosparite with intermingled calcite spar. The calcite may be concentrated in patches that weather out as pores. The flat to massive coral colonies are intensively bored by *Lithophaga* and are about 10 % of the rock volume (bed 9 of ZIEGLER 1956). Bed 15 is a saccharoidal oobiomicrite that depositionally dipped 20° to the southwest. The cement is entirely dolomitized, whereas the ooids and bioclasts are replaced by an intergrowth of dolomite rhombs and xenotopic calcite spar. The last bed of the Günsberg Formation is no. 18. The fresh grey-green, saccharoidal rock weathers red-brown. It is a bioruditic floatstone with a mostly dolosparitic groundmass and calcitic bioclasts. About 3 m above the road there is a coral bioherm.

The Steinebach Member has a thickness of only 3.4 m (beds 19 to 21). Bed 21 (1.2 m above the base) is an oopelsparite.

Hermatypic corals reappear in bed 22, the first bed of the Laufen Member. Bed 28 has a dark olive-green colour and is a lime-marl with some detrital quartz. It was completely dolomitized and then entirely dedolomitized (bed 17 of ZIEGLER 1956). Oncoids with a maximum diameter of 2 cm in bed 30 and 3 cm in bed 31 form 20 % of the rock volume. These two beds are a local marker bed which also crops out at the upper end of the cliff west of Mt. Hasenmatt (section RG 380, bed 15).

The Verena Member begins with bed 33. An oosparite with inclined bedding forms the lower part of bed 34. In the upper part of the bed the original texture is obliterated by intense dolomitization followed by complete dedolomitization of the rock. Bed 37 is an oobiopelsparite with cross-bedding in the upper part. There are solitary corals, nerineid gastropods, large bivalve clasts and colonies of *Solenopora* in life position. Some of these colonies still have part of their original, purple colour. Rounded bioclasts of corals and some nerineids with a diameter of as much as 4 cm form 30 to 50 % of the oosparitic bed 40. There are also rounded lithoclasts of oomicrite. In bed 42 the ooid content decreases from grainstone concentration at the base to zero at the top.

The lowest beds of the Reuchenette Formation (43 to 46) are well-bedded micritic limestone with varying amounts of peloids. Bed 47 is massive lime mudstone.

3.1.3 Transect Liesberg-Solothurn

3.1.3.1 Section RG 280 Liesberg BL, clay pit of Ampthil (fig. 23, pl. 30)

This section has been described by GYGI (1990a, p. 179). It is refigured here in pl. 30. The clay pit of Ampthil is also visible in the upper part of fig. 24.

3.1.3.2 Section RG 306 Liesberg BL, clay pit of Hinter Chestel and quarry of Chestel (fig. 24, pl. 31)

The section begins on the floor of the clay pit at a shear plane above the Dalle Nacrée Member of the early Callovian. The first unit is the Renggeri Member which is here only 29.5 m thick (bed 1). This bed appears in the field to be wholly homogenous and cannot be easily subdivided. No ammonites have been found. It is therefore probable that bed 1 represents the upper part of the Renggeri Member that contains few ammonites (cf. GYGI 1990a, fig. 3).

The Sornetan Member is a succession of homogenous blue-grey marl with bands of tough, ellipsoidal limestone concretions ("chailles") located at varying lateral distances from each

Fig. 23: Section RG 280, clay pit of Ampthil, Liesberg BL, as seen from the east. Steeply dipping upper surface of Dalle nacrée Formation and thin Herznach Formation to the left (south), Renggeri Member in the center and banded Sornetan Member to the right. Photograph by A. L. Coe. See pl. 30.

Fig. 24: Section RG 306, clay pit of Hinter Chestel and quarry of Chestel, Liesberg BL, as seen from the east. The clay pit of Ampthil and the village of Liesberg are in the background. The ridge of the Hauptrogenstein Formation is to the left (south). The upper surface of the Calcaire roux sableux Member forms the southern boundary of the pit (in the shade). The Dalle nacrée Formation (DN) is visible as a thin ridge within the pit. The Bärschwil Formation (BÄR) is between the ridge of the Dalle nacrée Formation and the high ridge of the Chestel to the right which is formed by the St-Ursanne Formation (SUF). Compare with pl. 31.

other. There are also continuous layers of marly limestone or limestone of the same colour. The base of the member is clearly defined by the base of the lowest band of limestone concretions (bed 2). The bulk of the nodules in this member are microsparite that is indicative of diagenetic recrystallization. The fine-grained bioclasts in the nodules are partly or wholly replaced by iron sulfide. The iron sulfide outside of the bioclasts occurs as flakes with a diameter from 400 microns down to submicroscopic size. The submicroscopic grains probably give the rock its characteristic blue-grey colour. Detrital quartz forms less than 1 % of the nodules, and glauconite is rare. The continuous layers of marly limestone and limestone are also made up of microsparite with bioclasts and iron sulfide. The bioclasts of bed 85 are partly replaced by chert. Sponge spicula that are replaced by calcite are so abundant in bed 66 that it is a spiculite.

The *Cardioceras (Cardioceras)* cf. *ashtonense* ARKELL J 31550, found by A. L. Coe and identified by D. Marchand, is from bed 66. This ammonite is of the Cordatum Subzone. The lower boundary of this subzone probably coincides in northwestern Switzerland with the lower boundary of the Sornetan Member, because no ammonite older than the Cordatum Subchron has ever been found *in situ* in this member, and no ammonite younger than the Costicardia Subchron has been recorded from *in situ* in the Renggeri Member below. This means that more than the lower half of the Sornetan Member at Liesberg belongs to the Cordatum Subzone. The thickness of the Densiplicatum Subzone in this section cannot be evaluated exactly. The paucity of ammonites from this subzone in the Sornetan Member indicates that the subzone is here probably thin. The only ammonite of the Densiplicatum Subzone described from this section is the *Gregoryceras (G.) tenuisculptum* GYGI S 1874 in the Musée Jurassien des sciences naturelles at Porrentruy JU (see GYGI 1995, p. 8). The thickness of the lower part of the Antecedens Subzone in the upper Sornetan Member is greater judging of the number of ammonites known from this part of the section. ARKELL (1956, p. 96) identified three *Arisphinctes* that had been figured by DE LORIOL (1896, pl. 6, fig. 2, pl. 7, fig. 1 and pl. 8, fig. 1) as being from the Antecedens Subzone (ARKELL 1925–27, ARKELL 1935–48).

The sudden and massive advent of hermatypic corals at the base of bed 99 marks the beginning of the Liesberg Member. The corals of this bed are either thin, platy colonies or large solitary specimens with a diameter of up to 3 cm. The matrix is blue-grey marl like in the Sornetan Member, but it has a purple tinge. The limestone nodules in this marl have an irregular shape unlike in the Sornetan Member. There are serpulids that are partially white from silicification. A. L. Coe found a large *Perisphinctes (Arisphinctes)* sp. in the lower part of bed 101 whilst completing fieldwork with the author. This is the only ammonite that has ever been recorded from *in situ* in the Liesberg Member. The most abundant fossils of the Liesberg Member apart from corals are large pectinid bivalves, serpulids, small calcareous sponges as well as the echinoids *Glypticus hieroglyphicus* (GOLDFUSS) and *Paracidaris florigemma* (PHILLIPS) (mostly spines). Crinoids are mainly represented by *Liliocrinus munsterianus* (D'ORBIGNY) and these can be as much as 1 m tall. In the majority of these specimens only the rootstock is preserved in which very often the original purple dye of the animal is preserved (so-called fringelite, BLUMER 1951, p. 1052). The corals are by far the most abundant fossils of the member. In bed 106 the platy colonies become thicker, and massive colonies appear.

The base of the St-Ursanne Formation is marked by bed 107, a limestone with indistinct inclined bedding. It is a bioarenitic oncomicrite (packstone) with a partially dolomitized and entirely dedolomitized matrix. The diameter of the oncoids is less than 5 mm. There are massive coral colonies with a diameter of up to 30 cm. The abundance of the oncoids diminishes in bed 108 whereas ruditic coral clasts increase in abundance. In bed 109 the rock becomes an oosparite with only a few, small oncoids and solitary corals. Bed 110 is a pure oosparite. Beds 107 to 110 represent the Delémont Member. Bed 111 is a micrite that is mostly porous and white, but it can be locally well-cemented and then has a beige colour. The micrite contains up to 10 % arenitic bioclasts. To the west and to the east of the quarry there are coral bioherms in this level. Bed 111 is 35.5 m thick. In bed 112 the micrite is well-cemented and yellowish white. There is again a coral bioherm in bed 113 with branching and massive coral colonies as well as nodules of *Solenopora* with a pale violet colour. The section ends with bed 120, just short of the upper boundary of the St-Ursanne Formation.

The Vorbourg Member forms a distinct ridge of well-bedded limestone northwest of the quarry in the forest. This ridge becomes very subdued north of the quarry, still in the forest. Here it contains a conspicuous stromatolite with dewatering cracks and birdseye pores that was figured by GYGI (1992, fig. 10, PS Gy 4558).

3.1.3.3 Section RG 398 Liesberg BL, limestone quarry (pl. 32)

The section begins north of the cantonal road at point 382. Bed 2 is a 0.8 m thick pelmicrite with detrital quartz of the Röschenz Member. The upper bedding plane is a hummocky erosion surface with a relief of up to 15 cm. Bed 3a is a micrite with detrital quartz and rootlets (fig. 25, PS Gy 4561). The rootlets are replaced by calcite spar and lined with limonite (TS Gy 6514). In bed 3b there is a tidal channel that is at least 0.5 m deep. The upper bedding plane of bed 16 is a hummocky erosion surface. Bed 17 is a pelsparite with parallel lamination. This seems to be a sediment from the lower beach. Bed 18 is a cross-bedded pelsparite. Behind the crusher building the upper 0.9 m of the bed is a beige limey marl with wine-red patches.

The base of the Hauptmumienbank Member is marked by bed 19. The lower bedding plane is a planed erosion surface. The rock is an oncolitic wacke- to grainstone. The oncoids that have a diameter of up to 12 mm make up 5 % of the rock. At the base

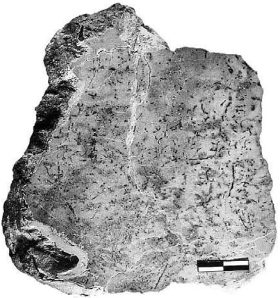


Fig. 25: Micrite with some detrital quartz and rootlets. Section RG 398, Liesberg BL, cantonal road near former cement works, bed 3a, Röschenz Member, PS Gy 4561, see pl. 32. Scale bar is 2 cm.

of bed 21 about 30 % of the rock are oncoids with a maximum diameter of as much as 5 cm. Nerinean gastropods, *Cladocoropsis* and coral debris are in the core and some *Bacinella* in the crust of the oncoids (PS Gy 4572). The matrix is biomicrite. *Cladocoropsis* form rods with a diameter of 4 to 5 mm and a length of more than 3 cm in the upper part of the bed where large burrows form about 10 % of the rock volume (TS Gy 6524). The upper bedding plane is a hummocky erosion surface with adhering ostreids.

The beds 24 and 25 are equivalents of the Oolithe Rousse Member. Bed 24 is a marly oomicrite with micritized and partly dolomitized, then dedolomitized, rusty-brown ooids in a dedolomitic, microsparitic matrix.

The first bed of the Laufen Member is no. 26, a marl-limestone (wackestone) with peloids and ostreids that have oncolitic crusts. Bed 28 is very fossiliferous: there are rhynchonellids *(Septaliphoria)*, ostreids, *Cycloserpula* and nerineid gastropods with an oncolitic crust (PS Gy 4576). The rest of the member is mostly micrite that was partly dolomitized and then entirely dedolomitized. It is in the upper part of this member that W. Hügli found the large *Paracenoceras* cf. *giganteum* (D'ORBIGNY) J 31651 on the roadside south of Cholplatz to the east of the quarry.

Bed 49, a peloidal packstone, is at the base of the Verena Member. 1 m below the top of the oosparitic bed 50 there is a 0.2 m thick layer where nerineid gastropods form up to 40 % of the rock volume. The oosparitic texture of bed 51 is hardly visible on a freshly broken rock surface where the interstices of the micritized ooids are filled with fine-grained peloids. Bed 53 was originally an oomicrite with micritized ooids. Then the matrix was completely dolomitized and then dedolomitized. There are

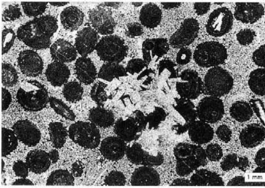


Fig. 26: Oolite with dolomitized and dedolomitized cement. Calcite pseudomorphs after sulfate in the center. Section RG 398, Liesberg BL, limestone quarry of the former cement works, bed 53, Verena Member. Thin section Gy 6532, pl. 32.

pseudomorphs of calcite after sulfate (fig. 26) like in the oosparite of bed 55. Bed 57 is a conspicuous white band in the quarry wall. It is a porous, chalk-like biomicrite. The lower part of bed 58 is a pelsparite with *Trichites* and *Diceras* as well as with nodules of *Solenopora* with a diameter of up to 15 cm.

The Reuchenette Formation forms the uppermost quarry wall above the second terrace. Bed 60 is a beige micrite that breaks along smooth planes. Bed 66 is an oosparite with micritized ooids. The micrite of bed 70 was partly dolomitized by tiny rhombs, then dedolomitized. Bed 79 is a biosparite with a corroded upper bedding plane. The lower part of bed 80 is a fine-grained pelsparite. The section ends with this bed at the upper edge of the quarry.

3.1.3.4 Section RG 402 Röschenz BL, road to Müli (pl. 33)

Bed 1 is a pelsparite and bed 2 is a biopelsparite of the upper St-Ursanne Formation. The lower part of bed 3 is oosparitic and the upper part a pelsparite. 4 m above the base of the bed are massive coral colonies with a diameter of up to 20 cm. The upper bedding plane is a hummocky hardground which is covered with a limonitic crust. Below the crust the rock has a rusty-brown colour to a depth of at least 5 cm. The uppermost 5 mm are an overcompacted peloidal packstone. The pore volume is reduced to almost zero by intergranular solution.

The base of the Vellerat Formation is marked by a pale wine-red, soft marl that has a thickness of only 5 cm (bed 4). Bed 7 is a peloidal packstone (pelmicrite) with about 5 % fine-grained detrital quartz, this is the facies of the Vorbourg Member. Bed 13 is a limey marl with biopelmicrite concretions that contain about 10 % detrital quartz. The top of the bed is micritic limestone that is covered with a limonitic crust. Bed 21 is composed of a well-laminated stromatolite with birdseye pores. Bed 23 contains stromatolites, the lamination of which is mostly obliterated by bioturbation. Angular lithoclasts occur with a diameter of up to 25 mm. Some of them are blackened.

The Röschenz Member is a very varied succession of limestones and marls. This is the only surface section where this member was completely visible during a few days in August 1983. The content of fine-grained detrital quartz may be as much as 30 % as in bed 36 or 52. The mean grain size of detrital quartz and feldspar in these beds is only 50 microns. Bed 57 has a thickness of 0.7 m and is entirely made up of stromatolites (PS Gy 4668, TS Gy 6612). Bed 67 is a quartz biopelsparite. A very fine-grained, partly cross-bedded oosparite occurs in bed 68. Bed 71 is a soft, yellow-brown marl with little detrital quartz. Its top is the top of the Röschenz Member.

The base of the Hauptmumienbank Member is marked by the oosparite with micritized ooids of bed 72. The lower part of bed 75 is an oolitic grainstone. At the top the bed is an oncolite with a biopelmicritic matrix. The oncoids form about 30 % of the rock and have a diameter of up to 25 mm.

Beds 77 and 78 of the lower Laufen Member contain a few percent of fine-grained detrital quartz. Bed 80 includes about 25 % oncoids with a diameter of up to 3 cm. The oncoids are intensively bored by the bivalve *Lithophaga*. The primarily micritic matrix is partly dolomitized and completely dedolomitized.

3.1.3.5 Section RG 399 Bärschwil SO, landslide west of Vögeli farm (fig. 27, pl. 34)

The lower part of the section (Sornetan and Liesberg Members) has been measured in the westernmost gully of the landslide and the St-Ursanne Formation using a rope in the central part (fig. 27).

The Sornetan Member is a homogenous, blue-grey marl with bands of limestone concretions. These nodule bands may pass laterally into continuous limestone beds. The nodules of bed 4 are made up of microsparite with flakes of iron sulfide that may be as large as 400 microns. The limestone bed 10 is also microsparite with flakes of iron sulfide and about 1 % of detrital quartz with a mean grain size of 40 microns. There are a few percent of sponge spicula in bed 46, together with *Thurmannella obtrita* (DEFRANCE) (= *thurmanni* VOLTZ), pectinids, *Pleuromya* and *Pholadomya exaltata* AGASSIZ as well as cardioceratid and perisphinctid ammonites (see GYGI & MARCHAND 1993, pl. 1, fig. 6, pl. 2, fig. 2 and pl. 3, fig. 5). In the nodules of bed 113 there are small chert concretions with a diameter of up to several centimetres and colonies of *Serpula (Cycloserpula) socialis* GOLDFUSS which are infilled with chert.

Bed 115 marks the base of the Liesberg Member. This bed is a microsparitic marly limestone with millimeter-size chert nodules, partly silicified bioclasts and *Serpula (Cycloserpula) socialis* GOLDFUSS. Bed 116 is a grey marl with limestone concretions that have a knobby surface. The nodules are distributed irregularly, and not in distinct bands as in the Sornetan Member. Some of the fossils in the nodules are partly silicified. There are calcareous sponges, *Cycloserpula, Glypticus hieroglyphicus* (GOLDFUSS), spines of *Paracidaris florigemma* (PHILLIPS) and a profusion of hermatypic corals that often have the shape of a flat bread loaf.

Beds 118 to 136 are a succession of marls and limestones. The limestones gradually become thinner and argillaceous from west to east or grade laterally into marl within the outcrop. This is a locality where the lower St-Ursanne Formation grades laterally into the Liesberg Member. It is noteworthy that

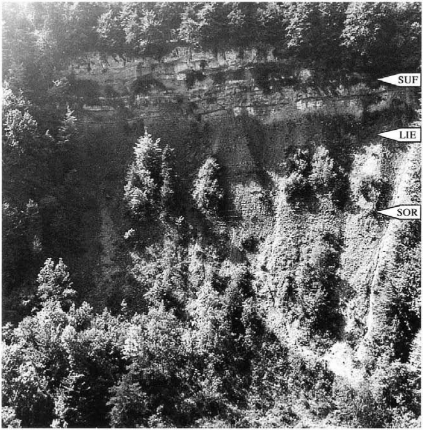


Fig. 27: Upper part of the landslide west of Vögeli farm, Bärschwil SO as seen from the north. The section RG 399 begins with the Sornetan Member of the Bärschwil Formation and ends with the lower St-Ursanne Formation. Eastsoutheast is to the left and westnorthwest is to the right. Compare with pl. 34.

the majority of the flat colonies of what is probably *Isastraea* at the base of bed 118 are overturned. On the other hand, a rootstock with its original purple colour of *Liliocrinus munsterianus* (D'Orbigny) has been found in life position in bed 121. This and other observations are an indication that no appreciable amount of sediment has been eroded and redeposited by currents during storms. It is most probable that the coral colonies have been overturned by animals in search of food. The base of the typical massive, pure limestone of the St-Ursanne Formation is marked by bed 137. 30 to 50 % of this rock are coral colonies with the shape of bread loafs. This is a coral bioherm. Bed 138, the uppermost of the outcrop, is an oncolitic biopelsparite.

3.1.3.6 Section RG 400 Corban JU, gorge northeast of La Providence farm (pl. 35)

The section begins at the end of the road with the Grellingen Member of the St-Ursanne Formation. Bed 1 is a biomicrite with coral colonies that have the form of small bread loafs. The bed forms a cliff facing north. The coral colonies in beds 2 and 3 are platy, branching and massive. Bed 4 is again a biomicrite. The massive bed 5 is probably a bioherm that contains massive and coarsely branching coral colonies.

The base of the Tiergarten Member is transitional and is in the lower part of bed 6. Most of this member is an oolitic grainstone which is often cross-laminated. The upper surface of bed 10 is a planar hardground with a brown limonitic crust. Bed 11 is a bioherm with platy, massive and branching coral colonies. The upper surface of bed 17 is covered with ostreids and other bivalves, this forms another hardground.

Beds 18 to 24 are peloidal and bioarenitic grainstones and are assigned to the Günsberg Formation. Bed 25 marks the base of the Vorbourg Member of the Vellerat Formation. This is a lime mudstone with birdseyes that is probably a thrombolite. The stromatolitic limestone with rootlets of bed 26 is figured in Gygi (1992, fig. 13, PS Gy 4621).

The lower part of the Röschenz Member is sparsely exposed along the creek. The member is as always a very varied succession of mainly arenitic limestones with some thin intercalations of marl. Fine-grained detrital quartz and feldspar are common, mainly in beds 41, 48 and 50. Bed 50 is a quartzpelsparite that is depicted in fig. 15. Oncoids occur in beds 43, 44, 81 and 88. Beds 55 and 60 are stromatolites. The upper bedding plane of bed 60 is covered with a carbonate-rich, pale wine-red crust. The hummocky crust is a hardground.

The Hauptmumienbank Member begins with bed 92, a peloidal bioarenitic wackestone. There are numerous elongate druses with calcite in this bed which were probably originally large nerineid gastropods. The oncoids of bed 93 have a diameter of up to 12 mm. They are embedded in a pelsparitic matrix.

Fig. 28: Steeply dipping Hauptmumienbank Member (bed 32) in section RG 404, Mervelier JU, gorge of the Scheulte river, western flank. See pl. 36.

In the upper part of bed 94 the oncoids grew to a diameter of 3 cm and form 10 to 20 % of the pelsparitic rock. The upper bedding plane of no. 94 is corroded and bored. It is covered by abundant ostreids that are sometimes also perforated. The rock surface and the ostreids are covered by a limonitic crust with a thickness of 1 mm.

Oncoids have also been found in the beds 95 to 97 of the lower Laufen Member. Some ooids in bed 95 indicate that it is the equivalent of the Oolithe Rousse Member. The oncoids in bed 96 reach a size of 25 mm and comprise about 30 % of the rock. Bed 101 is a partly dolomitized and then completely dedolomitized oomicrite with ostreids and *Cycloserpula.* Bed 106, an oosparite, has also been partly dolomitized and then entirely dedolomitized.

Bed 109 is massive and forms the base of the Verena Member. It is an oosparite that is partly recrystallized (dedolomite). The oosparite of bed 111 was thoroughly dolomitized and has then been completely dedolomitized. Part of bed 112 is oosparite (2.2 m above the base). 3 m above the base of bed 113 there is gypsum with a high carbonate content. The gypsum crystals have a diameter of 50 to 500 microns and make up at least 50 % of the rock. The section ends with this bed.

3.1.3.7 Section RG 404 Mervelier JU, gorge of the Scheulte river, western flank (pl. 36)

The section begins with the lower St-Ursanne Formation about 40 m north of the road at the base of the high cliff that is formed by bed 1. This is a biomicrite with platy coral colonies and spines of sea urchins. Beds 1 to 3 can be subdivided into thinner beds. Bed 4 is massive. It is probably a bioherm with a biomicritic matrix that in some places becomes biosparitic (TS Gy 6634). The coral colonies are platy, massive or branching. No zonation can be recognized. The upper boundary of the unit is a conspicuous parting. Bed 5 is again massive and probably a bioherm. 3.5 m above the base there is an oobiosparite to -micrite. Solitary corals are abundant at the base and 4.5 m above the base of the unit. The matrix of the bioherm is mostly biomicrite (TS Gy 6636).

The Günsberg Formation is characterized by two successions of coral limestone to arenitic limestone. The base of the formation is marked by a distinct boundary between the pure limestone of bed 7 and a marly seam at the base of bed 8. Bed 9 is a biomicrite with ruditic bioclasts of corals and ostreids that has been partly dolomitized and then completely dedolomitized. Bed 15 is an oosparite. The coral growth resumed in bed 16 which is a biosparite with ruditic bioclasts of corals. Beds 18 and 19 are formed by a coral bioherm with a biomicritic matrix. 4.5 m above the base of bed 18 more than 50 % of the rock is composed of platy coral colonies each with a thickness of about 1 cm. Bed 19 weathers with a knobby surface. About 50 % of this unit are massive coral colonies. Bed 21 is a coarsely-grained arenitic to ruditic biosparite. There are relatively few oncoids with a diameter of up to 8 mm in the oobiomicritic bed 24. The uppermost Günsberg Formation is a sandy calcarenite with inclined bedding (bed 31b).

The Hauptmumienbank Member is represented only by the bed 32. This projects subvertically like a plank south of the creek (fig. 28). In the lowermost 40 cm of the bed there are oncoids with a maximum diameter of 1 cm that do not form more than 10 % of the rock. Small nerineid gastropods are often in the core of the oncoids. Ostreids occur in the biopelmicritic matrix. There are hermatypic corals in the middle of the bed. The uppermost part of the bed is a fine-grained oolitic grainstone with rounded lithoclasts of lime mudstone.

The Laufen Member begins with a quartz-bearing pelmicrite (bed 33). Bed 44 contains about 10 % oncoids up to 6 mm in diameter. Bed 50 is a peloidal-oncolitic rudstone. In bed 53 the pale yellow oncoids with *Bacinella* form 20 to 30 % of the rock and have a maximum diameter of 5 cm. The matrix is a rusty brown biosparite with a dedolomitized cement. The upper boundary of the Laufen Member is an even, very conspicuous bedding plane on both sides of the Scheulte river.

The lowest unit of the Verena Member is the massive bed 66 that forms a high ridge which overhangs above the southern bank of the Scheulte River. Most of the rock was apparently originally an oomicrite (packstone). The matrix has been almost totally dolomitized, then entirely dedolomitized. The result of the process is that the micritized ooids are only clearly visible on weathered surfaces. Bed 68 is 12 m above the base a pelsparite with *Cayeuxia* and calcite pseudomorphs after sulfate. Bed 69 is a massive micrite and must therefore be assigned to the upper Verena Member.

A good outcrop of the lowermost Reuchenette Formation is to the south of the Scheulte River. Bed 70 is micrite with patches of pelmicrite. Flat-laminated stromatolites are in bed 72. Bed 75 is an apparently dedolomitized microsparite with some percent of fine-grained detrital quartz. Above the massive bed 76 the outcrop becomes poor. The following thickness of about 15 m of thickly-bedded limestone is partly covered by soil and vegetation.

3.1.3.8 Section RG 406 Vermes JU, ravine southeast of La Kohlberg farm (pl. 37)

The section has not been measured in full detail, because it is incompletely exposed, cliffs under waterfalls are inaccessible and a part of it is repeated by a folded overthrust that has already been noted by PFIRTER (1982, p. 91, section 601, p. 92). The thrust plane is not visible. Therefore, the section has been measured and the beds have been numbered as if there was no tectonic complication (pl. 37).

The section begins north of the road from Vermes to Raymontpierre castle in the western branch of the ravine of the Bie des rues creek. Ca. 15 m from the road there is a patchy outcrop of the Renggeri Member in the creek, this is followed by two outcrops of the Sornetan Member. The section drawn in pl. 37 begins with the hummocky base of the Pichoux Formation that is encrusted with limonite.

The lower half of the Pichoux Formation (bed groups 1 to 4) is relatively thin-bedded. The individual, mostly biomicritic beds have a thickness of between 10 and 80 cm. In the middle of the bed group 2 there is the spiculite which is represented in fig. 11 (TS Gy 7582). Sponge spicula and peloids are abundant in bed 3. The bedding of beds 5 and 6 of the upper Pichoux Formation is thicker. The rock is biopelmicrite with sponge spicula in TS Gy 7585. High ridges are formed by bed 5 on both sides of the ravine. The top of the Pichoux Formation is not easily recognizeable.

The base of the Günsberg Formation is assumed to be where detrital quartz begins to form more than a few percent of the rock (TS Gy 7588, pl. 37), this is when it can be detected in the field by scratching a hammer. Bed 7 is a pelmicrite with much detrital quartz. There are two marly intercalations in the pelmicrite with some detrital quartz of bed 8. Silicified bioclasts and the first hermatypic corals occur in bed 9 which forms the second waterfall (as counted from the top) of the creek. Bed 10 crops out along the old road and contains small chert nodules with a diameter of up to 5 cm. A triple waterfall is formed by bed 11 that is an oosparite 8.5 m above the base. At the base of the waterfall, the third from the top, a thickness of 6.2 m of strata is covered by pebbles and debris. Then there is a forth, small waterfall and another break in the section because of debris in the creek. Downstream follow an oolite and the oncolite of the Hauptmumienbank Member. The Laufen Member forms a high, perpendicular waterfall. At the base of this fifth waterfall there is a thrust plane that repeats the section.

The section of the middle Günsberg Member resumes at the foot of the fifth waterfall after a short break of 1.5 m that is covered with limestone debris. Bed 32 is a bioclastic rudstone with massive coral colonies in life position. Above is a coral bioherm (bed 33) that forms the sixth waterfall. It is a boundstone with a quartzose micritic matrix in the lower half (TS Gy 7596) and contains biopelsparitic grainstone in the upper half (TS Gy 7597). The beds 34 to 38 in the creek are laterally replaced by another bioherm with massive coral colonies that is intersected by the road. The wavy laminated stromatolite of bed 47 is conspicuous on the right bank of the creek where it forms a projection. Bed 48 is another stromatolite with mostly even lamination. The base of bed 49 is very uneven. Bed 49 is a conglomerate with blackened lithoclasts in a pelmicritic, slightly quartzose matrix (TS Gy 6677). Many of the clasts are laminated bits of a stromatolite. Blackening of the clasts and abundant nerineid gastropods are evidence that the deposit is marginal marine (GYGI & PERSOZ 1986, fig. 5, PS Gy 4735, see also STRASSER & DAVAUD 1983). The upper bedding plane is a planed erosion surface that intersects the clasts. This surface is encrusted with large, thick-shelled ostreids (D in fig. 5 by GYGI & PERSOZ, 1986). The bedding plane and some of the ostreids are bored. Above this characteristic bedding plane are 8.5 m of marl that is mostly covered with talus.

The Hauptmumienbank Member begins with the peloidal wackestone of bed 51 in which massive coral colonies form a densely colonized biostrome. The lowermost two beds of unit 52, both 0.25 m thick, are a bioclastic rudstone. Above, the rock is a cross-bedded calcarenite (oosparite, TS Gy 7599). Unit 53 is indistinctly and thickly bedded. At the base it is a peloidal/ooidal wackestone. In the middle are about 10 % oncoids with a diameter of up to 25 mm. Some of the oncoids have a drusy cavity in the core and one includes a *Cladocoropsis* colony. *Paraurgonina* occur in the micritic matrix as well as calcite pseudomorphs after gypsum.

At the base of the Laufen Member there is a soft, yellowish-brown marl with detrital quartz and a thickness of 0.5 m. It is only visible beside the old road. Bed 55 above is a limestone with a micritic matrix that includes oncoids and some massive coral colonies. Bed 56 is massive and forms the upper part of waterfall no. 7. The upper Laufen Member is oolitic and has been measured along a footpath that ends beside the upper edge of waterfall 7. The top of the member is marked by the uppermost distinct parting at the top of bed 74.

The Verena Member crops out mostly in the creek. Bed 75 is an oolite with micritized ooids in a dedolomitized matrix that is partly micritic and partly sparitic. The upper part of bed 76 is an oomicrite with micritized ooids that has been partly dolomitized and then entirely dedolomitized. The upper part of bed 77 is a pelsparite with a few dedolomite rhombs. The middle part of bed 78 is an oncomicrite. In the middle of bed 79 there is a pelsparite. 2 m below the top of this bed the rock is a dedolomitized pelmicrite. The top of the Verena Member is indicated by a distinct parting that is best seen in the eastern branch of the creek about 70 m to the east.

At the base of the Reuchenette Formation there is pure micrite (TS Gy 6685). Further up the content of peloids and bioclasts increases. The measuring of the section ends at the top of waterfall 11 which is the lowermost in the ravine.

3.1.3.9 Section RG 356 Grandval BE, landslide of La Morte Roche (fig. 29, pl. 38)

The measurement of the section began ca. 80 m to the west of the gully below the western part of the landslide, at the foot of the cliff of the Pichoux Formation (fig. 29). The contact with the underlying Sornetan Member is not exposed. Bed 2 is a spiculitic biomicrite with about 1 % fine-grained glauconite. Above is relatively thinly-bedded micrite of the lower Pichoux Formation. The section, beginning with bed 17, continues in the western gully. Beds 24 to 34 are more or less marly. The upper part of the Pichoux Formation has a much thicker bedding than the lower part and it is mostly pure micrite (TS Gy 6324, pl. 38).

The top of the Pichoux Formation is a distinct bedding plane.

The Wildegg Formation (Effingen Member) is about 100 m thick. The middle part is covered by a small landslide and the upper part by talus from the Günsberg Formation above. The Wildegg Formation is a succession of blue-grey marl with intercalations of marly limestone and limestone. Some of the micritic limestone beds (126, TS Gy 6325) and probably also the marl contain several percent of very fine-grained detrital quartz. In the upper part of the formation there are bands of carbonate nodules in marl that resemble the Sornetan Member. The fossils of the Effingen Member are also similar: mainly ammonites and bivalves. Bed 224 is a laminated quartz siltstone (TS Gy 6328). A lumachelle of mainly small ostreids in a dedolomitized micritic matrix forms bed 226 (TS Gy 6329).

The Günsberg Formation begins with greenish-grey, slightly marly biopelmicrite with some detrital quartz (TS Gy 6331). Embedded in this sediment are small coral bioherms with platy and massive coral colonies (bed 228). The small bioherms are superimposed (bed 230). At the base of a vertical cliff formed by the Günsberg Formation there is a slightly quartzose biopelsparite (bed 231). The cliff is about 35 m high and inaccessible. It has not been measured, because this unit is easily accessible 2.5 km to the east at Gänsbrunnen (section RG 430, pl. 40).

3.1.3.10 Section RG 429 Welschenrohr SO, gorge south of Harzergraben (pl. 39)

The section begins 50 m west of the bridge north of the streambed. The Effingen Member is represented by the blue-grey marls and limestones of beds 1 to 7.

The Günsberg Formation begins with a thin bed (5 cm, no. 10) of marly, bioruditic floatstone with abundant branching corals, ostreid bivalves, serpulids and a few percent of fine-grained, angular detrital quartz. Bed 12 contains about 10 % detrital quartz and is a biopelmicrite with rhombs of ferroan dolomite and nodules of iron sulfide up to 5 mm in diameter. There are massive coral colonies in beds 15 and 18, but no bioherm was found. The bulk of the Günsberg Formation is biopelsparite (bed 22) and oobiopelsparite (bed 23). In the upper part of bed 23 there are coral bioclasts up to several centimetres in diameter. Bed 24 contains grapestones and some small oncoids.

The first bed of the Steinebach Member is a massive, yellowish-white oosparite which is very well-sorted. It weathers back as a hollow. Bed 29 is an oosparite that has been partly dolomitized and then totally dedolomitized. The surface of the micritized ooids is indented by primarily dolomite rhombs. There is some detrital quartz with the unusually large grain size

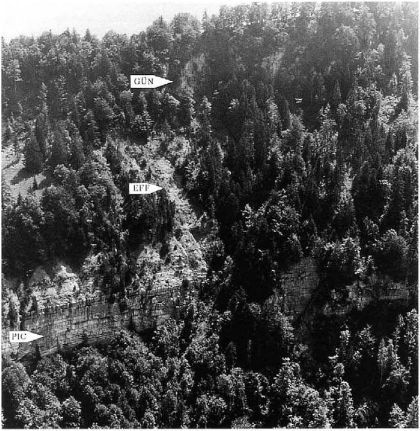


Fig. 29: Section RG 356 Grandval BE, landslide of Morte Roche as seen from the north. The cliff below is the upper part of the Pichoux Formation. The Wildegg Formation (Effingen Member) is in the center. Above is the cliff of the lower Günsberg Formation. See pl. 38.

of up to 250 microns within the ooids. The upper bedding plane of bed 30 is corroded. The bed itself has a knobby weathered surface. The ooids as well as the groundmass have recrystallized as microsparite. The rock was apparently totally dolomitized and then dedolomitized. The upper bedding plane is probably an emersion surface.

The Laufen Member forms a high ridge, and bed 34 forms the principal waterfall in the gorge. Bed 32 is a characteristic, very tough limestone. Its groundmass and some of the peloids have partly been dolomitized and were then entirely dedolomitized. About 25 % of the rock are oncoids with a diameter of up to 25 mm (PS Gy 4945). Bed 35 is an oosparite with some large oncoids of *Bacinella*, the cores of which are composed of pseudomorphs of calcite after calcium sulfate. It has been partly dolomitized and then completely dedolomitized. The upper bedding plane is a paleokarst surface from which pockets with a filling of clay reach as far as 1 m down to the base of the bed.

The Verena Member begins with the oosparite of bed 36. The rock is oosparite to the top of bed 38. 1 m above the base of the massive bed 39 there is microsparitic dedolomite with patches of up to 1 cm in diameter of coarse calcite spar that are probably calcite pseudomorphs after sulfate. A sample from 1.8 m above the base of bed 39 is micrite that has been replaced by about 50 % of coarse-grained dolomite rhombs, it then has been completely dedolomitized (fig. 30). The upper part of bed 39 is pure micrite. The upper boundary of the member is an even, well-defined parting.

The lowest bed (no. 40) of the Reuchenette Formation is 0.8 m thick. It is a succession of plates and laminae of micrite that contains birdseyes 0.15 m above the base of the bed. The base of bed 41 is a stromatolite with dewatering cracks (PS Gy 4957). The lamination is fine and indistinct and can only be seen in the upper part of the thin section Gy 7139. Bed 50 is also indistinctly laminated and contains birdseye pores that are filled with calcite spar. The upper bedding plane is rough and is covered with a yellowish limonite crust. The lowermost 20 cm of bed 52 are a pelsparite with lithoclasts of micrite with a diameter of as much as 2 cm. Smaller lithoclasts are grey to black. The

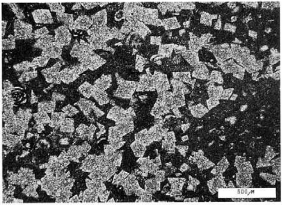


Fig. 30: Micrite with dedolomitized rhombs. Section RG 429, bed 39b, middle Verena Member, gorge south of Harzergraben, Welschenrohr SO. Thin section Gy 7136, pl. 39.

upper part of what is preserved of the Reuchenette Formation is mostly pel- and oosparite.

3.1.3.11 Sections RG 430 and 431 Gänsbrunnen SO, cantonal road and quarry (pl. 40)

The section RG 430 begins at the southern end of a retaining wall along the cantonal road about 80 m south of the main building of the railway station of Gänsbrunnen. In bed 2 of the lower Günsberg Formation there is a coral bioherm above the road. Another small coral bioherm has been found in bed 10 west of the Raus brook directly north of the exit of the deviation tunnel. Most of the limestone beds in the succession 1 to 10 are more or less dolomitic. Bed 11 is a coral bioherm that is intersected by the road. Beds 1 to 11 are the "Crenularis-Schichten" of Buxtorf (1907, p. 54). Neither the facies nor the age of these beds have anything to do with the Crenularis Member of Canton Aargau which is of Bimammatum Age. Above is a thick succession of peloidal and oolitic grainstone (beds 12 to 16). The uppermost part (0.5 m) of bed 16 is an oomicrite (packstone) with subangular lithoclasts of the same material as the matrix that may have a diameter of more than 10 cm. The clasts are darker than the beige matrix and some are black. The upper bedding plane of no. 16 is a limonitic crust which is covered with a 5 mm thick layer of marl. The sandy marl of bed 25 is locally as black as coal and contains lignite. At the top of the stromatolitic bed 29 are rounded black pebbles with a diameter of up to 2 cm.

The lowermost unit of the Balsthal Formation is the massive bed 35 which is now recognized as being the Steinebach Member. This is a yellowish-white oosparite which resembles the Verena Member (TS Gy 7170). Ziegler (1956, p. 96) assigned the unit to the Verena Member, and Gygi (1969, pl. 19, fig. 2, section 5) followed him. This error goes back to Buxtorf (1907, p. 54).

The Laufen Member is incomplete. The first bed, no. 36, contains about 20 % of intensely bored oncoids with a diameter of up to 3 cm in a biomicritic matrix. There are also some hermatypic corals that are partly dissolved. Oncoids of the same size are about 15 % of bed 37. They have often a druse filled with calcite in the interior. The matrix of this bed is biopelmicrite. Dedolomitized rhombs occur in bed 40. Beds 41 to 43 are pure micrite. The upper part of the Laufen Member is cut off by an overthrust plane that dips steeply to the south. Above is a sheared zone that is more than 4 m thick. A thickness of 2.9 m of greenish-grey dedolomitized limestone of the uppermost Laufen Member crops out south of the sheared zone. This is overlain by fractured limestone of the Verena Member that forms the principal ridge above the quarry.

Buxtorf (1907, p. 58) assigned the whole of the Verena Member to the Kimmeridgian (in the sense of a formation) and stated that the total thickness of the Kimmeridgian limestones was 130 m. The Reuchenette Formation has been measured to be less than 13 m thick in the section RG 431 (pl. 40). The thickness of the fractured Verena Member between the top of the Laufen Member and the shear plane at the foot of section RG 431 cannot be measured, but it is of the order of 35 m. The thickness of the Verena Member measured in the neighbouring section RG 429 (Welschenrohr) is 32.3 m. The minimum primary thickness of this member in section RG 431 must then be about 35 m. The maximum is less than 60 m, because 57.2 m is the greatest thickness (section RG 404, Mervelier JU, pl. 36) that has been measured anywhere in a tectonically undisturbed section of the Verena Member. The lithology of the Verena Member is the usual: biopelmicrite (TS Gy 7171), biopelsparite (TS Gy 7172) and pelsparite (TS Gy 7175). Dedolomitized calcite rhombs occur in beds 1 and 4. The upper boundary of the Verena Member is a smooth, conspicuous parting with an undulating relief of about 20 cm.

The Reuchenette Formation begins with relatively thin-bedded calcilutite (micrite, TS Gy 7176). Bed 13 includes grey to almost black, rounded lithoclasts with a diameter of up to 25 mm. A stromatolite with unusually large birdseye pores forms bed 22. The uppermost bed of the section, no. 23, is again a calcilutite (micrite). 0.8 m above the base of the bed there are abundant *Cladocoropsis* (TS Gy 7181, fig. 18). The same bed with very abundant *Cladocoropsis* reappears on Mt. Chamben 3 km southwest of Herbetswil SO ca. 50 m eastnortheast of point 1251.1, about 8 m north of the footpath. This is locality RG 432 with PS Gy 4999.

3.1.3.12 Section RG 433 Oberdorf SO, gorge and quarry north of Wäberhüsli (pl. 41)

The continuous part of the section begins about 40 m south of the northern end of the gorge on the right (western) side of the creek, at the southern margin of a slope covered with talus. Pelsparite with dedolomite rhombs forms bed 2. Beds 1 to 3 are assigned to the uppermost Günsberg Formation.

Bed 4 forms the bulk of the Steinebach Member. 9 m above the base this is a fine-grained pelsparite with a high content of arenitic echinoderm bioclasts.

The Laufen Member begins with the thin bed 6 that weathers with a knobby surface. Bed 7 is a bioruditic floatstone that contains oncoids the size of a few millimeters and rhombs of dedolomite. Corals are only represented as ruditic bioclasts. Bivalves are very abundant in the middle part of the Laufen Member (bed 11). The upper boundary of bed 13, a pelsparite, is an even, conspicuous parting. This parting is interpreted to be the sequence boundary O8 (Gygi *et al.* 1998) and the upper boundary of the Laufen Member.

The massive lower half of the Verena Member forms the ridge north of the quarry. The upper bedding plane of bed 14 formed a vast surface at the northern margin of the quarry in 1986. The upper half of the Verena Member, bed 15, crops out within the quarry. In the lowermost 3 m it is an oosparite. The bivalve *Diceras* and coarse-grained debris of corals were found in the middle part of the bed. The upper part of bed 15 is pure micrite (TS Gy 7191). There is a marked contrast between the thicknesses of the Verena Member north and south of the Weissenstein range: less than 28 m near Oberdorf and an estimated minimum of 35 m near Gänsbrunnen. The upper bedding plane of bed no. 15 is hummocky. Above is a 2 cm thick marly seam that forms a conspicuous parting. This is the boundary with the Reuchenette Formation.

The sedimentation of the Reuchenette Formation began with pure lime mud of a markedly darker colour than the Verena Member below. Bed 16 is micrite with some rhombs of dedolomite (TS Gy 7192). Bed 17 is micrite which was intensively dolomitized and then entirely dedolomitized. The upper boundary of bed 19 is even and bored. This is interpreted to be sequence boundary K1 (Gygi *et al.* 1998). Above are 5 mm of marl. Bed 20 is a dedolomitized micrite with up to 10 % of oncoids with a maximum diameter of 1 cm and many *Cladocoropsis* (PS Gy 5014). *Clypeina* and other calcareous algae occur in the thick bed 32. The very resistant beds 27 to 32 form the crest of Mt. Geissflue west of the quarry. There is a mass occurrence of *Cladocoropsis* in the middle of bed 35 (TS Gy 7201, PS Gy 5019). Above bed 43 there is a layer of soft marl with a thickness of 3 cm. This conspicuous parting is sequence boundary K3 (Gygi *et al.* 1998).

The equivalent of the Solothurn Turtle Limestone is represented by the beds 46 to 49. The mud matrix of the pelmicritic beds 46 and 47 is dolomicrite.

The thin-bedded micrite of beds 52 to 54 is what Buxtorf (1907, p. 58) called *Exogyra virgula* Beds. The characteristic ostreid that is now called *Nanogyra striata* (Smith, 1815) (see Enay & Boullier 1981, p. 742) could not be found. Buxtorf assigned these micrites and the remainder of Jurassic limestone above to the Portlandian. Allenbach (1994, p. 118) thought that the thin-bedded micrite in the upper Chuchigraben to the northwest of Rüttenen SO belonged to the Twannbach Formation that is of Tithonian age. The ammonite *Aulacostephanus (Aulacostephanoceras) autissiodorensis* (Cotteau) no. 10 842 in the Museum of Natural History Solothurn (see Gygi 1995, fig. 24) proves however that the "Virgula Beds" near Solothurn are of late Kimmeridgian age. There is a thickness of about 15 m of well-bedded limestones above bed 59. These could not be measured in detail, because the southern quarry wall is too steep.

3.1.3.13 Section RG 434 Lommiswil SO/Oberdorf SO, Steingrueben quarries (pl. 42)

The lower part of the section was measured in the western quarry near Lommiswil, and the upper part in the adjacent eastern quarry that is in the township of Oberdorf. The base of the thick, massive bed 1 of the Reuchenette Formation is not exposed. 2 m above the base of the quarry the rock is a yellowish-white biomicrite with *Clypeina* and *Cladocoropsis* as well as some dedolomitized rhombs of calcite. 5.7 m above the base is fine-grained pelsparite. The upper bedding plane of bed 5 is covered with a limonitic crust with about 1 cm of soft marl above. Some of the grains in the upper part of bed 6 and in the stromatolite at the base of bed 7 are blackened.

The numerous mostly horizontal branchlets of *Cladocoropsis* at the upper boundary of bed 12 weather out. This bedding plane is hummocky and covered with a limonitic crust. The crust forms a major surface in the eastern quarry. Beds 17 to 19 were quarried here as building stone at the time of measuring the section. The upper surface of bed 17 is covered with limonite. The uppermost decimeter of the sediment is thoroughly bioturbated. At the surface are few circular, very distinct imprints of sauropods with a diameter of 0.5 to 0.7 m. Around the margin of the imprints are rings of sausage-like mud bulges with a diameter of 6 to 8 cm. This sauropod track was removed some time after it was observed on July 24, 1986. Beds 16 and 17 were quarried away exposing further tracks on the upper surface of bed no. 15. This bedding plane is now by far the vastest in the quarry. The tracks on the bedding plane of no. 15 were discovered by MEYER in February 1987 and published by him in 1990 (p. 391). Traces of cloudy glauconite impregnations have been found in the uppermost part of bed 18. The glauconite is best visible with a hand lens. Under the microscope it takes a magnification of at least 300 to see it well. Bed 18 might be the equivalent of the glauconitic marker bed at the base of the Eudoxus Zone in southern Germany at the boundary between the White Jurassic δ 3 and δ 4.

Beds 23 to 29 are thin-bedded (0.05 to 0.25 m) micrite with burrows. This is the "Portlandian" of BUXTORF (1907). The "*Exogyra virgula*", now *Nanogyra striata* (SMITH), that LANG (1863, p. 22) mentioned from this locality could not be found. The mud pebbles in bed 31 are argillaceous and weather out as centimeter-sized pockets. Bed 42 is a wavy laminated stromatolite. The peloidal wackestone of no 46 is the uppermost bed that is visible along the road south of the quarry.

3.1.4 Region of Balsthal

3.1.4.1 Section RG 440 Rumisberg BE, Rüttelhorn, gully east of summit (pl. 43)

The section begins at the lower end of a steep gully about 100 m to the east of the summit of Mt. Rüttelhorn. It is the middle one of three gullies that best exposes the Balsthal and the lower Reuchenette Formations. It is not clear in which member of the Balsthal Formation the section begins. To judge from the thickness of the exposed part of the formation, one would expect that the Steinebach Member is represented in the lowermost part of the section. But this is uncertain, because the Steinebach Member can be easily recognized in the section RG 436 near Aedermannsdorf in the Horngraben gorge below Eggli cliff which is only about 350 m to the northeast. The upper boundary of the Steinebach Member is there a characteristic paleosol with micritic nodules covered with acicular calcite ("raggioni" of MUTTI 1994, fig. 8B). In the section RG 436 the upper Balsthal Formation is dissected by a major fault and therefore the total thickness of the formation cannot be measured exactly.

The base of bed 1 of the section RG 440 is covered by talus. The bed contains oncoids with a diameter of up to 2 cm, small gastropods, echinoderm bioclasts and coral clasts the size of several centimeters in a dedolomitized lime mud matrix. The large oncoids and the corals are an indication that this bed is at the base of the Holzflue Member. The dedolomitized calcite in the matrix is ferroan similar to bed 2. Oncoids have been found as high up as bed 7 indicating that the beds 1 to 7 are lateral equivalents of the Laufen Member. Bed 8 is a massive oolite that has been almost totally recrystallized by dolomitization and subsequent dedolomitization 5.8 m above the base. This is the facies of the Verena Member with its hidden oolitic texture. The ooids can often only be seen on weathered surfaces. The oolitic texture with partly recrystallized rock (dedolomite, pseudomorphs of calcite after sulfate) continues to the upper boundary of bed 12. Bed 13 is a micrite with recrystallized ooids (sparite and micrite) at the base and rhombs of dedolomitized calcite in the middle. Near the upper boundary of the bed there are nodules of limonite with a diameter of up to 1 cm. The typical facies of the Verena Member reappears in bed 14 that was originally an oolitic grainstone (TS Gy 7330) with most ooids now being micritized. In the middle part the rock has been dolomitized and then dedolomitized. The lower boundary of the bed forms an overhang in the cliff south of the summit of Mt. Rüttelhorn. In the upper part of the bed there are small limonite nodules within the ooids and in between them. The nodules may be as large as 12 mm in the uppermost 10 cm of the bed. The upper boundary is an even, conspicuous parting.

The lowermost few meters of the Reuchenette Formation are well-bedded micrite. There are tiny bivalves with a length of about 0.5 mm, probably of the genus *Bositra*, in bed 15. A stromatolite with a thickness of 0.6 m forms bed 20 which weathers back. The wavy layers are between 5 and 30 mm thick. There are thin dewatering cracks being parallel and perpendicular to the layers as well as birdseyes. The upper boundary of the bed has a relief of up to 15 cm. The layers are intersected by this erosion surface at the top of the stromatolite that is interpreted to be sequence boundary K1 (GYGI *et al.* 1998). Bed 30 is a pelmicrite with foraminifera. The lower part of bed 33 is oncolitic, whereas the upper part is a saccharoidal, microsparitic dedolomite. Strongly dolomitized and entirely dedolomitized pelmicrite occurs in bed 34 (TS Gy 7335). The section ends with the massive, bioclastic-oolitic bed 37.

3.1.4.2 Section RG 438 Balsthal SO, road through Steinebach gorge (pl. 44)

The section begins at the northern margin of a small quarry above the road at the northern entrance to the Steinebach gorge north of the old church of Balsthal. The base of bed 1 is covered by talus. The bed is a slightly marly, laminated biopelmicrite with about 10 % of fine-grained, angular detrital quartz. Glauconite, of the same grain size as the quartz, forms less than 1 % of the rock, but it is not rare. This led GYGI (1969, pl. 18, section 9) to interpret the sandy succession at the base of the Steinebach Member as a time equivalent of the Crenularis Member. However, the mineralostratigraphic analysis of the sediments (GYGI & PERSOZ, 1986) revealed that this was an error and that the Steinebach Member was the time equivalent of the Geissberg Member. The saccharoidal bed 7 is a partly dedolomitized dolomite (microsparite). Part of the dedolomitized calcite is ferroan (TS Gy 7284). The slightly marly beds 1 to 11 are transitional between the Effingen Member below and the Steinebach Member above. The predominantly calcareous facies and the high peloid and ooid content indicate that beds 1 to 11 are rather to compare with the grainstones of the Steinebach Member than with the argillaceous mudstones of the Effingen Member below.

The Steinebach Member proper is an oosparite with some cross-bedding and a total thickness of 13 m. Small oncoids with a diameter of up to 6 mm appear in bed 14. In bed 23 the oncoid content may be up to 30 % and the diameter of the oncoids up to 20 mm (PS Gy 5112). Oncoids up to 20 mm in size form as much as 20 % of the rock in the upper part of bed 24. This bed grades upward into a porous, yellowish-white oosparite with thin cross-bedding. The ooids do not break under the hammer, and the rock weathers back in a hollow. This unit has already been noted by GERTH (DELHAES & GERTH 1912, p. 18) and forms a local marker bed between Mt. Holzflue north of Balsthal and the cliff of Chluser Roggen (section RG 450, bed 2). The upper boundary of the bed is transitional.

The first bed of the Holzflue Member (no. 26) is in its upper half a saccharoidal oncolite that has been strongly dolomitized and then almost entirely dedolomitized. The diameter of the oncoids is as much as 12 mm. Fine-grained detrital quartz forms about 1 % of the rock. Oncoids with abundant *Bacinella* up to 10 mm in size form about 20 % of bed 27 which has been partly dolomitized and then mostly dedolomitized (PS Gy 5116). There is also some detrital quartz in TS Gy 7293. Some dolomitization and partial dedolomitization has occurred in the oncolitic bed 29. Above bed 29 there are no more oncoids except in bed 37. Bed 32 is primarily an oosparite which has been strongly dolomitized and then completely dedolomitized. The dedolomitized calcite in the interior of ooids is partially ferroan. The dedolomitized oosparite facies continues upward to bed 41. There are pseudomorphs of calcite after sulfate in bed 40. Above bed 42 the sediment becomes more and more muddy. TS Gy 7301 in the lowermost part of bed 44 is primarily an oomicrite. The saccharoidal matrix has a finely-grained pseudopelsparitic texture. The ooids are replaced by calcitic sparite. This characteristic unit has been figured by Tschumi (1983, fig. 21). The major part of bed 44 is micrite. Above is a hollow filled with talus that corresponds to a concealed thickness of 6.9 m. The succession continues with mostly oosparite to the upper boundary of bed 49 which is an indistinct parting. This is now assumed to be the upper boundary of the Balsthal Formation (but for a different view see Gygi 1969, pl. 18, section 9).

As Gygi (1995, p. 15) remarked, the boundary between the Balsthal and the Reuchenette Formations cannot be defined satisfactorily near Balsthal. An ammonite that B. Martin and P. Tschumi found *in situ* in 1980 at Innere Chlus near Balsthal gives a biostratigraphic point of reference (see Martin 1984, section 18). The specimen was recently described and figured by Gygi (1995, p. 42 and fig. 19). F. Atrops (Lyon) has identified it as *Lithacosphinctes evolutus* (Quenstedt) and stated that it was from the lowermost Platynota Zone. The ammonite was collected about 2.5 m below a palaeosol in the lowermost Reuchenette Formation that forms a local marker bed. This marker bed occurs in section RG 438, bed 52 (pl. 44) in the Steinebach gorge, in section RG 439, bed 9 at Innere Chlus (unpublished) and in section RG 450, bed 7 at the cliff of Chluser Roggen (unpublished). The palaeosol is probably time-equivalent with the stromatolite in section RG 440, bed 20 at Mt. Rüttelhorn (pl. 43). Another local marker bed is the mostly micritic bed 44 in section RG 438, Steinebach gorge (pl. 44). This micritic bed is also present in section RG 450 at Chluser Roggen (bed 4) and in section RG 440 at Mt. Rüttelhorn (bed 13). At Mt. Rüttelhorn the boundary between the Balsthal and the Reuchenette Formations can be drawn with confidence between the oosparitic bed 14 and the micritic bed 15 (pl. 43), 3.5 m below the stromatolite. In the Steinebach gorge, the base of the formation as proposed above is 1.9 m below the palaeosol and is possibly coeval with the boundary at Mt. Rüttelhorn. But it must be noted that the boundary between the oosparite of bed 49 and the micrite of bed 50 in section RG 438 of the Steinebach gorge cannot be correlated with the sections 439 and 450 near Balsthal. Moreover, the formation boundary as defined above may be one or two meters too high. The *Lithacosphinctes* J 30530 from Innere Chlus that is from the lowermost Platynota Zone, has been found 2.5 m below the palaeosol, and the distinct lower boundary of the Reuchenette Formation at Mt. Rüttelhorn is 3.5 m below the stromatolite (section RG 440, bed 20).

The palaeosol in the Steinebach section RG 438 (bed 52) is exposed in the middle of a tunnel. The matrix is a pale-green, soft marl with decimeter-size, saccharoidal calcareous nodules. The upper boundary of bed 55 is a wavy, distinct parting that might be sequence boundary K2. Clasts of hermatypic corals with a diameter of up to several centimeters appear in bed 58. They are in a matrix of oolitic grainstone. Bored coral colonies occur in a matrix of bioarenitic wackestone in bed 59. Corals form small bioherms at about this level below Alt Falkenstein castle at Innere Chlus not far to the south. 0.65 m above the base of bed 63 there is a small amount of glauconite which has a maximum grain size of 70 microns. In thin section Gy 7311 the glauconite is only clearly visible under high magnification. Massive coral colonies form a densely colonized biostrome 3.5 m above the base of bed 67. The section ends with bed 71 that is a bioarenitic wackestone near the base and an almost pure lime mudstone above.

3.2 Formations and members

The formations and members of the Oxfordian in Canton Aargau and Canton Schaffhausen have been described by Gygi (1969) and again by Gygi & Persoz (1986). Only the formations and members of northwestern Switzerland will be described here.

The synonymy lists are not complete. Old names that are no longer used are only mentioned if they are relevant.

3.2.1 Herznach Formation (new)

Synonymy:
Couches de Clucy Rollier (1888, p. 31, 1893a, p. 64)
Fer sous-Oxfordien Laubscher (1948, p. 7) and by other authors, name adopted from Marcou (1848, p. 84)
Eisenoolithische Schichten des Mittel- und Ober-Callovian Stäuble (1959, p. 64)
Anceps-Athleta-Schichten Fischer (1965a, p. 11)

A thin, but apparently continuous unit of iron oolitic marl and limestone occurs in northwestern Switzerland between the underlying Dalle nacrée Formation and its lateral equivalents and the overlying Renggeri Member of the Bärschwil Formation. Stäuble (1959, p. 64) named these strata rather neutrally "Eisenoolithische Schichten des Mittel- und Ober-Callovian". Other authors have named the beds differently (see above). The only previously proposed name that is acceptable after the modern rules of stratigraphic nomenclature (American Commission on Stratigraphic Nomenclature, 1961) is the "Couches de Clucy" of Rollier (1888, p. 31). But it is impossible to use this name, because Rollier neither stated where the type locality was nor gave a definition of his new member. It appears to be advisable to give a new name to the widespread unit in the sense of Stäuble (1959) that has been mined for iron at many localities in the Jura in the past and has even given rise to local names like "Erzberg" east of Schelten Pass. The best-known iron mine in this unit is the one near Herznach AG that has been worked mainly during the second world war. It is therefore proposed that the unit is named Herznach Formation.

The Herznach Formation includes the whole of the iron oolitic succession that was exposed in the disused Herznach iron mine. The small thickness of the unit (ca. 1 m in northwestern Switzerland, 3.4 m near Herznach) is rather at the scale of a member. Nevertheless, it is recommended to classify the unit as a formation because of its great temporal and regional extent. The type section is the one figured by Jeannet (1951, fig. 2) in the iron mine of Herznach. The mine has not been accessible since 1976. This disadvantage is outweighed by the detailed lithologic and palaeontologic work that has been published by Jeannet (1951) (see also Gygi & Marchand, 1982). The lower boundary of the new formation in the type section is at the top of bed A4 and the upper boundary at the top of bed F3 in fig. 2 by Jeannet (1951). In northwestern Switzerland, in section RG 280 in the clay pit of Ampthil near Liesberg BL as figured by Gygi (1990a, fig. 2), the formation begins at the base of bed 4 and continues to the top of bed 6. The eastern boundary of the formation is beyond the border of Canton Schaffhausen with Germany. The western boundary is beyond the border of northwestern Switzerland with France.

Ammonites are the dominant element of the macrofauna in this unit, an these are taken as evidence that the formation has been laid down in relatively deep water (according to Gygi, 1986, fig. 6).

3.2.2 Bärschwil Formation

Synonymy:
Marnes oxfordiennes proprement dites Marcou (1848, p. 84)
Lower Rauracien of older Swiss authors *pro parte*
Oxfordien of older authors (see for instance Laubscher 1948, p.8)
Bärschwil Formation Gygi & Marchand (1993, p. 998)

The Bärschwil Formation is a succession of clayey marl and marl with bands of calcareous nodules and limestone beds in its upper part. It includes the Renggeri Member at the base, the Sornetan Member in the middle and the Liesberg Member at the top. It occurs in a vast area in eastern France (Contini 1976, fig. 3) and in northwestern Switzerland (Gygi 1990c, figs. 2 and 3). The only locality where the formation actually is completely exposed is section RG 280 in the clay pit of Ampthil near Liesberg BL. However, the formation cannot be named after Liesberg, because this name has already been given to its uppermost member. Another good outcrop is the section RG 399 in the upper part of the landslide west of Vögeli farm near Bärschwil SO although the Renggeri Member is covered by mud and debris at this locality. This natural outcrop will probably remain relatively fresh for a long time and is proposed here to be designated as the type section of the Bärschwil Formation (pl. 34).

The lower boundary of the formation can actually best be studied in the section RG 280 near Liesberg (pl. 30). The base is taken at the contact between beds 6 and 7, that is at the point where the iron ooid content of bed 6 has decreased upwards to zero (see Gygi 1990a, fig. 2). The age of the lower boundary is the early Scarburgense Subchron (fig. 40), because *Cardioceras (Scarburgiceras)* cf. *scarburgense* J 30717 has been found in the upper part of the iron oolitic bed 20 in section RG 307 in the quarry of La Charuque near Péry BE (Gygi 1990a, p. 183). This is the uppermost bed of the Herznach Formation at that locality. The term chron (and the term subchron derived from it) is used here according to Hedberg (1976, p. 68). The upper boundary of the Bärschwil Formation is transitional in the type section RG 399 (pl. 34). It is drawn at the base of the first thick limestone bed of the St-Ursanne Formation (no. 118) which grades laterally into marl. Generally the upper boundary can be drawn at the base of the cliff formed by the limestone of the St-Ursanne Formation above. Where the Bärschwil Formation intersects the surface in the folded Jura it is characterized by extensive natural depressions in the landscape (combes oxfordiennes of Greppin 1870, p. 61).

3.2.2.1 Renggeri Member

Synonymy:
Marnes oxfordiennes Thurmann (1830, p. 26)
Couches à *Ammonites renggeri* Choffat (1878, p. 115)
Renggeriton Fischer (1965b, fig. 5)
Renggeri Member Gygi & Persoz (1986, p. 394)

The Renggeri Member is named after the ammonite *Creniceras renggeri* (Oppel) that occurs in the lower part of the member (Gygi 1990a, fig. 3, pl. 4, figs. 19, 20, 23, 24). The member is a homogenous, blue-grey clayey marl without calcareous or sandy intercalations. It lies between the iron oolite of the Herznach Formation below and the lowermost nodule band or limestone bed of the Sornetan Member above. The Renggeri Member cannot be subdivided lithologically. The only subdivision that has been made so far is biostratigraphic (Gygi 1990a, fig. 3). The age of the member ranges from the beginning of the Scarburgense Subchron to the end of the Costicardia Subchron. There is only one section where the member is actually completely exposed at its normal thickness; this is the clay pit of Ampthil (RG 280, pl. 30) near Liesberg BL. Bed 7 of the section RG 280 is therefore designated as the type section of the Renggeri Member. The member thins and wedges out completely towards the south and east (Gygi 1990a, fig. 4, 1990b, fig. 2 and this paper fig. 39). The facies of the member is very uniform throughout its range. Slopes on top of the Renggeri Member give rise to landslides. The macrofauna of the member is dominated by ammonites. There is some benthos, but it is rare. This and the bioturbation of the sediment (see fig. 7) are evidence that the Renggeri Member was not deposited in anoxic, but rather in dysaerobic conditions. The ammonite fossils are almost invariably small and preserved as iron sulfide.

3.2.2.2 Sornetan Member (new)

Synonymy:

Terrain à chailles THURMANN (1830, p. 23)
Argovien MARCOU (1848, p. 88)
Pholadomyen DE TRIBOLET in ETALLON (1862, p. 245)
Terrain à chailles marno-calcaire GREPPIN (1867, p. 64)
Terrain à chailles LINIGER (1925, p. 2)
Terrain à chailles FISCHER (1965b, fig. 5)

This member is a succession of blue-grey marl with a maximum thickness of more than 50 m (GYGI 1990b, fig. 4). Intercalated in the marl are bands of tough, ellipsoidal, carbonate concretions ("chailles") at varying lateral distances (fig. 31). There are also some continuous beds of more or less marly limestone. Both the concretions and the continuous limestone beds are microsparitic. The concretions of a distinct horizon in the distal part of the member contain abundant macrofossils as recorded by GYGI & MARCHAND (1993, p. 999). LINIGER (1925, p. 2) thought he could subdivide the member into a lower part with "*Rhynchonella thurmanni* VOLTZ", now: *Thurmannella obtrita* (DEFRANCE), see BOULLIER (1993), and an upper part with *Pholadomya exaltata* AGASSIZ. This is impracticable, because *Thurmannella obtrita* occurs also in the upper part of the member. The member has about the same geographic extent as the Renggeri Member.

The name Terrain à chailles by THURMANN (1830) is misleading, because he cited THIRRIA (1830) to be the author. The pertinent paragraph by THIRRIA (1830, p. 19) is about an "argile à madréporaires avec chailles", a clay with corals and chert nodules. THIRRIA stated that this clay was below the "calcaire compacte avec *Nerinea*". If this were the case, the "calcaire avec *Nerinea*" might be the equivalent of the St-Ursanne Formation and the "argile à madréporaires avec chailles" the equivalent of the Liesberg Member. But on p. 21, THIRRIA claims that the "argile à madréporaires avec chailles" was above the "calcaire à *Nerinea*", and on p. 25 that the "argile avec chailles" was immediately below the "calcaire à *Astarte* ". The "argile à madréporaires avec chailles" by THIRRIA might therefore be the equivalent of the Humeralis marl of the Swiss authors as for instance of ZIEGLER (1956, fig. 14) or of GYGI & PERSOZ (1986, pl. 1) and would then be much younger that the "Terrain à chailles" by THURMANN. To judge from the section described by CHOFFAT (1878, p. 121) it is probable that the "argile à madréporaires avec chailles" of THIRRIA is the equivalent of the Liesberg Member of ROLLIER (1888).

THIRRIA (1830, p. 21) wrote that his "chailles" were "boules de calcaire siliceux", nodules of siliceous limestone. The microsparitic limestone concretions of the Terrain à chailles of modern Swiss authors are however not siliceous. Neither are the limestone concretions of the Liesberg Member, but these contain partly silicified fossils. Modern French authors use the term "chailles" for chert nodules. Tough carbonate nodules like those found in the unit that is described and proposed as the Sornetan Member are referred to as "sphérites" by ENAY (1966, p. 210). THURMANN (1830, p. 23) himself called the nodules of his Terrain à chailles "sphérites".

A further source of confusion is the fact that GREPPIN (1867, p. 64) introduced the name "Terrain à chailles siliceux" for what ROLLIER (1888, p. 71) later called "Couches de Liesberg" and even wrote of a "terrain à chailles oolithique" (GREPPIN 1870, p. 79) that he did not define. Fortunately, both names are not used any more by modern authors and may be rated to be forgotten. Modern Swiss authors are unanimous about what is to be understood by "Terrain à chailles", as for instance GYGI & PERSOZ (1986, p. 395). Nevertheless, it is proposed here to abandon this name because of its ambiguity. In the French speaking part of Switzerland, it should at least be replaced by "Terrain à sphérites". A better solution is probably to replace it by a formal new name based on it's geographical occurrence as has been proposed above.

There is only one section where the Sornetan Member was ever exposed cleanly and completely. This is RG 306 in the clay pit of Hinter Chestel near Liesberg BL (pl. 31). Another good outcrop is section RG 399 in the landslide west of Vögeli farm near Bärschwil SO (pl. 34), but there, the boundary with the Renggeri Member is covered by talus. More exposures occur below the cliff of the St-Ursanne Formation at Sous la Peute Roche west of Vellerat (section RG 373, pl. 24). However, Vellerat is a formation name that has been introduced by BOLLIGER & BURRI (1970, p. 71). Another fairly good section is the lower part of RG 314 in the Pichoux gorge near Sornetan BE. Bed 1 of this section is the fossil bed of the middle Sornetan Member (see GYGI & MARCHAND 1993, p. 999). It is therefore proposed here to call beds 1 to 15 in section RG 314 Sornetan Member (pl. 21) and to designate section RG 306 near Liesberg (beds 2 to 98) as the reference section (pl. 31). The lower boundary of the member is taken where the first band of limestone concretions or the first limestone bed appears above the Renggeri Member. The upper boundary is fixed where her-

Fig. 31: Marl of the middle Sornetan Member with ellipsoidal carbonate concretions. Section RG 399, beds 85–91, landslide west of Vögeli farm, Bärschwil SO. Scale is 1 m. See pl. 34.

matypic corals appear in great numbers and the limestone concretions begin to have an irregular, non-ellipsoidal shape.

The macrofaunal assemblage of the Sornetan Member comprises brachiopods, bivalves and ammonites. Ammonites dominate in the lower half of the member and brachiopods and bivalves in the upper half. This is interpreted as an overall shallowing of the water during the sedimentation of the member. The age of the member ranges from the beginning of the Cordatum Subchron to the early Antecedens Subchron.

3.2.2.3 Liesberg Member

Synonymy:
?Argile à madréporaires avec chailles THIRRIA (1830, p. 19)
Glypticien ETALLON (1862, p. 63)
Terrain à chailles siliceux GREPPIN (1867, p. 64)
Couches de Liesberg ROLLIER (1888, p. 71)
Liesberg-Schichten ZIEGLER (1962, p. 29)
Liesberg-Schichten BOLLIGER & BURRI (1970, p. 69)
Liesberg Member GYGI & PERSOZ (1986, p. 395)

The Liesberg Member is typically a grey marl with bands of limestone concretions or beds of marly limestone. The nodules have an irregular shape unlike the ellipsoidal concretions in the Sornetan Member. Up to 30 % of the rock volume may be hermatypic corals (fig. 32) that are dish-shaped in the lower part of the member and mostly ellipsoidal in the upper part. The corals and the other, abundant macrofossils may be partly silicified. The carbonate content of the rock increases upward, so that the upper boundary of the member can be transitional.

The most proximal occurrence of the member has been recorded near Bure JU (section RG 456, beds 13 to 15, unpublished). The greatest thickness of 25 m was measured in section RG 306 near Liesberg BL (pl. 31). The position of the distal boundary of the member is not exactly known. The unit probably wedges out below the marginal coral bioherms of the St-Ursanne Formation (GYGI & PERSOZ 1986, pl. 1).

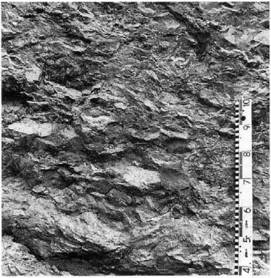


Fig. 32: Marl of the upper Liesberg Member with abundant dish-like coral colonies. Section RG 306, clay pit of Hinter Chestel, bed 105, Liesberg BL. Scale is decimeters. See pl. 31.

A complete, easily accessible section of the member is RG 306 in the clay pit of Hinter Chestel near Liesberg BL. It is therefore proposed to designate the beds 99 through 106 of RG 306 as the type section of the Liesberg Member (pl. 31).

The lower boundary is drawn where hermatypic corals appear suddenly in great numbers above the Sornetan Member. The upper boundary is where the carbonate content of the rock becomes sufficient to form an uninterrupted cliff.

By far the most abundant fossils in the Liesberg Member are hermatypic corals. There are also echinoids like *Paracidaris florigemma* (PHILLIPS), thus the old name Florigemma Beds, large crinoids like *Liliocrinus munsterianus* (D'ORBIGNY) that have often the original purple colour in their rootstocks (fringelite, see BLUMER 1951), bivalves (mainly pectinids) and brachiopods.

Ammonites from the Antecedens Subchchron of the Transversarium Chron have been found below and above the Liesberg Member (GYGI 1995, fig. 2, 14 and 25). Thus, the Liesberg Member represents only a part of the Antecedens Subzone.

3.2.3 St-Ursanne Formation

Synonymy:
Oolite corallienne and calcaire à nérinées THURMANN (1830)
Terrain corallien ou rauracien GRESSLY (1864, p. 96)
Mittleres und oberes Rauracien KOCH (1923, p. 2)
St-Ursanne-Formation BOLLIGER & BURRI (1970, p. 69)
St-Ursanne-Formation HECKENDORN (1974, p. 11)
St-Ursanne Formation GYGI & PERSOZ (1986, p. 395)

The St-Ursanne Formation is a succession of shallow-marine limestones that are underlain by the Bärschwil Formation and overlain by the Vellerat Formation. The St-Ursanne Formation can be subdivided into the Grellingen, Delémont, Buix and Tiergarten Members (see below). The geographic range of the formation is northwestern Switzerland, where the shallowing-upward Bärschwil Formation below has a thickness of 100 m or more (GYGI 1990c, figs. 2, 4 and 5). The only section where the St-Ursanne Formation is completely exposed is at the cliff of Peute Roche near Vellerat JU (sections RG 389 and 451, fig. 20, pl. 24). It is proposed here to designate the cliff of Peute Roche below P. 957.9, 900 m west-southwest of Vellerat JU as the reference section of the St-Ursanne Formation. In section RG 389 the base of the formation is marked by the base of bed 6. The top of the formation is defined in section RG 451 as the top of bed 4. The lower part of the Formation (Grellingen Member) and the upper part (Tiergarten Member) are easily accessible along the forest road to the Forêt de la Cendre 700 m to the north of Vellerat JU (section RG 296, unpublished). The best-known section of the St-Ursanne Formation is along the road near the railway station of St-Ursanne and in the quarry of the former lime works close by (PÜMPIN 1965, pl. 1, section 2, section RG 336 in

Fig. 33: The St-Ursanne Formation near St-Ursanne JU. On the left: cliff of the older Delémont Member below, coral reef of the younger Buix Member above. The tunnel entrances of the lime works are in the middle Buix Member. The section ends with the well-bedded Vorbourg Member of the lower Vellerat Formation.

GYGI 1982, fig. 4 and this paper, fig. 33). BOLLIGER & BURRI (1970, p. 69) have designated this as the type section.

The lower boundary of the St-Ursanne Formation is transitional (see above). The thickness of the formation varies greatly over short distances: 35 m near Kleinlützel SO (section RG 397) and 95 m near Liesberg (section RG 306, pl. 31). The upper boundary is where the massive, often porous lime mudstone of the Buix Member or the oolite of the Tiergarten Member becomes a well-bedded lime mudstone with a low porosity (Vorbourg Member). This boundary can again be a transition. The distal edge of the formation is the belt of coral bioherms at the margin of the carbonate platform as it may be seen in the Pichoux gorge near Sornetan BE (section RG 315, pl. 21). The Delémont and the Grellingen Members are erosion-resistant and form cliffs, whereas the Tiergarten and especially the Buix Members weather back. The fossils of the St-Ursanne Formation are predominantely hermatypic corals. The corals form mainly biostromes in the Grellingen Member and bioherms at the platform margin and in the lagoonal Buix Member. Regular echinoids can be abundant adjacent to lagoon reefs. The nerinean gastropods that gave rise to the name "calcaire à nérinées" are uncommon. The age of the St-Ursanne Formation is from the late Antecedens Subchron to the Luciaeformis Subchron (GYGI 1995, fig. 2).

3.2.3.1 Grellingen Member (new)

It is proposed here to call the lower part of the St-Ursanne Formation in the proximal and in the distal areas Grellingen Member. The member is chiefly a coral biostrome with a micritic or bioarenitic matrix. Coral bioherms are uncommon; they occur at Sous les Cantons northwest of Buix JU (see LINIGER 1970, p. 7), below (south of) point 1030 at the southern tip of Forêt de la Cendre west of Vellerat JU and at the foot of the cliff of Montchemin south of Courrendlin JU. The Grellingen Member forms the cliffs in the lower part of the St-Ursanne Formation near Grellingen BL, mainly at Falkenflue, Eigenhollen and Chastelberg west of the Chastelbach. A complete, easily accessible section is RG 296 north of Vellerat along the road to Forêt de la Cendre.

3.2.3.2 Delémont Member (new)

Synonymy:

Oolite corallienne THURMANN (1830, p. 17)
Blauenschichten TOBLER (1905, tab. 5a)
Blauen-Schichten KOCH (1923, p. 2)
pars Caquerelle Pisolite ZIEGLER (1962, p. 18)

The Delémont Member is mainly a carbonate oolite. It makes up the lower half of the St-Ursanne Formation in a narrow belt. Hermatypic corals are fairly common, chiefly in the lower part of the member. Oncoids are abundant and range in size from less than 2 mm to 2 cm. Pümpin (1965, p. 816) concluded that the oncoids had been formed by cyanobacteria and foraminifera. They are unlike the larger oncoids in the Röschenz, Hauptmumienbank and Laufen Members. The oncoids of the Delémont Member can be concentrated enough to form true oncolite near St-Ursanne. This is the local facies of the "Caquerelle-Pisolith" of Ziegler (1962, p. 18) which is named after the farm La Caquerelle in the township of Asuel JU.

The Delémont Member forms a belt with a width of 4 to 8 km. This belt runs from Ocourt JU on the Doubs river to St-Ursanne, Delémont, Liesberg, Dittingen and Blauen BL. The member is completely exposed in section RG 306, beds no. 107 to 110 (pl. 31), in the quarry of Chestel, Liesberg BL. This quarry can be considered as the reference section of the member. The name of the member refers to section RG 366, Vorbourg chapel, beds 1 to 9 (pl. 23) near Delémont. The synonym Blauen-Schichten Tobler (1905, tab. 5a) is forgotten and should not be revived, because there is no good section of the unit near Blauen BL. The best outcrop of the Caquerelle oncolite is in the unpublished section RG 338, Côte du Frène, bed 90 (PS Gy 3899) near Asuel JU (see Ziegler, 1962, fig. 1, Pümpin, 1965, figs. 6 and 7). The Caquerelle oncolite of Ziegler (1962) in the lower St-Ursanne Formation should not be confused with the Couches de la Caquerelle of Rollier (1892, p. 282) in the upper St-Ursanne Formation that are mentioned by Waibel in the Lexique Stratigraphique International (1960).

The delineation of the Delémont Member is neither vertically nor laterally clear-cut. The lower boundary with the Liesberg Member is transitional. Oncoids are locally also present in the Liesberg Member. The Delémont Member interfingers laterally with the Grellingen Member.

3.2.3.3 Tiergarten Member

Synonymy:

Tiergarten-Oolith Bolliger & Burri (1970, p. 71)

Bolliger & Burri (1970) introduced the term Tiergarten oolite for all the oolites in the St-Ursanne Formation, consequently also for what is called here Delémont Member. Their term is therefore too loose. Nevertheless, it is proposed here to retain the name and to give it the following, new definition: The Tiergarten Member includes the oolite of the upper St-Ursanne Formation between the distal Grellingen Member below and the Vorbourg Member or the Günsberg Formation, respectively, above. The Tiergarten Member (named after a poor outcrop in the Tiergarten gorge west of Vermes JU) is the distal time equivalent of the Buix Member (see below).

The Tiergarten Member forms a belt 6 to 9 km wide between the Buix Member and the string of coral bioherms at the platform margin of the St-Ursanne Formation. Coral patch reefs are quite common in the distal part of the Tiergarten Member, mainly near Grellingen. A particularly good example is to the west of the creek at Eigenhollen, coordinates 612.950/253.600, National Map 1 : 25 000, sheet 1087 Passwang.

The name Tiergarten Member refers to the Tiergarten Gorge of the Gabiaire Creek between Vermes JU and Vicques JU, but the exposure of the member is very incomplete at that location (see section 9 by Bolliger & Burri 1970, pl. 16). It is therefore proposed to designate bed no. 4 in the section RG 451 at the cliff of Peute Roche near Vellerat (pl. 24) as the type section of the Tiergarten Member. A good, easily accessible section close by is RG 367 along the road from Vellerat to Courrendlin at Les Esserteux (see section no. 8 by Bolliger & Burri 1970, pl. 16).

3.2.3.4 Buix Member (new)

Synonymy:

Calcaire à nérinées Thirria in Thurmann (1830, p. 16)
Calcaire à nérinées Greppin (1870, p. 85)
Couches de la Caquerelle Rollier (1892, p. 282)
Caquerelleschichten Tobler (1905, tab. 5a)
Rauracien crayeux Liniger (1925, p. 2)
Caquerelleschichten Waibel (1960, p. 39 and 49) in Lexique Stratigraphique International
Kreide von St. Ursanne Ziegler (1962, fig. 1)
Caquerelle-Schichten Hess (1975, tab. 2)

The Buix Member is a massive, yellowish-white to pure white, more or less porous limestone. It can be so friable in some places that it can be pulverized by rubbing a piece of the rock between the fingers. Coral bioherms occur in this unit near Leymen F, Flüh BL, Delémont, St-Ursanne JU and Buix JU. Locally, the limestone was originally slightly dolomitic, but the euhedral dolomite crystals have been dissolved and left empty pores (unpublished section RG 344, beds 3 and 8, Courtemaîche JU). In this case, the rock weathers in perpendicular rods as Liniger (1970, p. 7) has observed. Chert nodules occur in the upper Buix Member near Courtemaîche (sections RG 343, 344). The uppermost part of the member is oolitic near Liesberg (section RG 306, pl. 31) and near Blauen BL (Koby 1892, p. 404).

The Buix Member is a lagoonal sediment that was deposited in the proximal area behind the oolite bar of the Tiergarten Member which rimmed the carbonate platform of the upper St-Ursanne Formation. Typical outcrops are found in Canton Jura near St-Ursanne and north of Porrentruy. The best, complete outcrops of the member are in the quarry and the tunnels of the former lime works near the railway station of St-Ursanne. Another good outcrop with a coral bioherm is in the quarry of Les Creppes near Buix JU (section RG 347, unpublished) which is easily accessible. Section RG 336 at St-Ursanne is proposed as the reference section of the member (see Pümpin 1965, pl. 1, section 2, beds 8 to 10 and Gygi 1982, fig. 4).

Caquerelle Member would be a suitable name for the unit although Rollier (1892) gave neither a type locality nor a definition of the member. Neither the mapping geologists nor the stratigraphers like Ziegler (1962) and Gygi & Persoz (1986) have adopted the name. It is therefore rated as an obsolete term even though Hess (1975, tab. 2) has mentioned it again. Renewed use of the name might lead to confusion with the Caquerelle oncolite of Ziegler (1962, p. 18). It is therefore proposed here to retain the Caquerelle oncolite of Ziegler and to give the Caquerelle Member of Rollier (1892) a new name. The best section after which the member can be named is the quarry of Les Creppes (section RG 347) near Buix JU.

3.2.4 Pichoux Formation

Synonymy:
Calcaires du Pichoux GREPPIN (1870, p. 80)
Übergangskalke and Birmenstorfer-Kalke ZIEGLER (1962, p. 34 and 35)
Pichoux-Kalke BOLLIGER & BURRI (1970, p. 71)
Übergangskalke GYGI (1982, figs. 5 and 6)
Pichoux limestone GYGI & PERSOZ (1986, p. 398)
Pichoux Formation GYGI (1995, p. 10)

The Pichoux Formation is a succession of biomicritic and micritic, bedded limestones that lie between the older, argillaceous Bärschwil Formation and the younger, marly Wildegg Formation (fig. 34). The Pichoux Formation is at its thickest adjacent to the coeval St-Ursanne Formation. The Pichoux Formation thins out towards the basin and has a minimum thickness where it grades laterally into the Birmenstorf Member of the lower Wildegg Formation (fig. 39). GRESSLY (1864, p. 103) already noted this facies transition.

Good outcrops of the Pichoux Formation are found in the Pichoux gorge (sections RG 314 and 315, pl. 21) near Sornetan BE, in the Combe des Geais (unpublished section RG 410) near Grandval BE (GYGI & PERSOZ, 1986, fig. 6), in a ravine near Vermes JU (section RG 406, pl. 37) and in the Court gorge near Moutier BE. A good and complete section of the formation is the one on the eastern slope of the Court gorge (fig. 34). ZIEGLER (1962, section 23) has given a schematic drawing of this outcrop which can only be measured using a rope. An exploration well for the Transjurane highway (section RG 452) provided a complete section of the Pichoux Formation in the Court gorge. So it was unnecessary to measure the outcrop depicted in fig. 34 on the rope. The thickness of the Pichoux Formation in the well is 60 m, not 41.5 m as indicated by ZIEGLER (1962). A large part of the formation is accessible close by in a road tunnel at coordinates 592.870/233.500.

The type section of the Pichoux Formation has been designated by BOLLIGER & BURRI (1970) to be in the Pichoux gorge. This is unfavorable, because the upper St-Ursanne Formation progrades in that section (RG 315, pl. 21) over the Pichoux Formation. The Pichoux Formation is thus incomplete at that locality. A complete outcrop of the formation is in section RG 406 in a ravine near Vermes JU (pl. 37) on the north slope of Mt. Raimeux. The beds 1 to 6 of section RG 406 are a good reference section of the Pichoux Formation, although the upper boundary of the formation cannot be easily defined. The boundary is drawn where detrital quartz appears in the limestone of the lower Günsberg Formation.

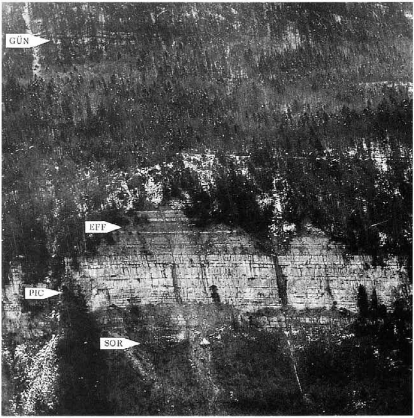


Fig. 34: The Pichoux Formation on the eastern slope of Court gorge near Moutier BE. The Sornetan Member at the base is covered by talus. The argillaceous Effingen Member is visible above the clear-cut upper boundary of the Pichoux Formation. Above in the forest are limestones of the lower Günsberg Formation.

3.2.5 Vellerat Formation

Synonymy:
Couches d'Angolat ROLLIER (1888, p. 60)
Couches de l'Angolat GREPPIN (1893, p. 8)
Vellerat-Formation BOLLIGER & BURRI (1970, p. 71)
Vellerat Formation GYGI & PERSOZ (1986, p. 398)
Vellerat Formation GYGI (1995, p. 10)

ROLLIER (1888, p. 60) was the first author who recognized that the sediments that form a depression between the underlying St-Ursanne Formation and the overlying Courgenay Formation are a mappable unit and need a name. He proposed "Couches d'Angolat" and referred to a small gorge called "En Goulat" by the inhabitants of Soyhières JU which is the type locality. GREPPIN (1870, p. 92) gave a section of the locality that is 1 km to the northwest of Soyhières. Neither the mapping geologists of the University of Basel as for instance LINIGER (1925) nor ZIEGLER (1956) used ROLLIER's term, and it must therefore be considered to be forgotten.

More than 80 years later, BOLLIGER & BURRI (1970, p. 71) renamed these sediments Vellerat Formation without reference to ROLLIER. This would be a useful term if it had been limited to the deposits above the St-Ursanne Formation. But the authors included the more distal Günsberg and the Steinebach Members in their new formation which consequently overlaps with the Balsthal Formation of GYGI (1969). GYGI & PERSOZ (1986, p. 398) retained the Vellerat Formation in spite of this ambiguity, but restricted it to the sediments above the St-Ursanne Formation (see GYGI 1990b, fig. 5), this is to say the Vorbourg Member, the Natica (now: Röschenz) Member, the Hauptmumienbank Member and the Humeralis Marl (now: Bure Member).

Complete sections of the Vellerat Formation are always temporary. A major problem is where to place the lower boundary of the formation. GREPPIN (1870) included what is now the Vorbourg Member in the St-Ursanne Formation. LINIGER (1925, p. 2) did the same with the argument that the Vorbourg Member forms an escarpment or cliffs together with the St-Ursanne Formation. GYGI & PERSOZ (1986, pl. 1) assigned the Vorbourg Member to the Vellerat Formation, because the Vorbourg Member could be correlated with the lower Effingen Member. The upper boundary of the Vellerat Formation is where cliff-forming limestones appear above the Bure Member. The correlation and the age of the Vellerat Formation are indicated in fig. 40.

3.2.5.1 Vorbourg Member

Synonymy:
non Couches du Vorbourg GREPPIN (1893, p. 16, pl. 8, fig. 2)
Plattige Kalke LAUBSCHER (1948, p. 9)
Plattenkalke ZIEGLER (1956, p. 51)
pars Vorbourg-Kalke ZIEGLER (1962, p. 21)
Vorbourg-Kalke LINIGER (1970, p. 9)
Vorbourg-Kalke BOLLIGER & BURRI (1970, p. 72)
Vorbourg-Kalke HECKENDORN (1974, p. 11)
Vorbourg Member GYGI & PERSOZ (1986, p. 399)
Vorbourg-Kalke BITTERLI & FISCHER (1988, p. 18)
Vorbourg-Schichten GYGI (1995, p. 10)

The Vorbourg Member as renamed by ZIEGLER (1962) is interpreted here in the restricted sense of LINIGER (1970). It is a succession of thick-bedded, micritic limestones 10–15 m thick that lies above the Buix Member and partly above the Tiergarten Member of the upper St-Ursanne Formation below. The Vorbourg Member is overlain by the limestones and marls of the Röschenz Member. The type section is RG 366, Vorbourg chapel near Delémont (pl. 23).

It can be read from the above synonymy list that the term Couches du Vorbourg by GREPPIN (1893) is forgotten. It was proposed for a succession of bedded limestones in the lowermost Reuchenette Formation between the massive limestone of the Verena Member below and the argillaceous Banné Member above. This was ignored by subsequent authors. Today only the Vorbourg Member of ZIEGLER (1962) is used. FISCHER (1965a, p. 17) has remarked that the Vorbourg Member of M. ZIEGLER (1962) overlapped with the lower Röschenz Member. GYGI & PERSOZ (1986, p. 399) have stated that the Vorbourg Member of ZIEGLER (1962) at the type section also includes the uppermost massive part of the St-Ursanne Formation (bed 12 of section RG 366 in this paper, pl. 23). Modern authors agree that the Vorbourg Member should be used in a revised sense (beds 13 to 24 in the type section, pl. 23, see also fig. 33).

3.2.5.2 Röschenz Member

Synonymy:
Calcaires à Natices THURMANN & ETALLON (1864, pl. C)
Naticaschichten LINIGER (1925, p. 2)
Natica-Mergel ZIEGLER (1956, p. 52, fig. 14)
Naticamergel ZIEGLER (1962, p. 26, fig. 1)
Naticaschichten FISCHER (1965a, p. 17)
Natica-Schichten BOLLIGER & BURRI (1970, p. 72)
Natica Member GYGI & PERSOZ (1986, p. 410)
Röschenz-Schichten GYGI (1995, p. 11)

The Röschenz Member is a very variable succession of limestones and marls that is underlain by the Vorbourg Member and overlain by the Hauptmumienbank Member. The lower boundary of the Röschenz Member is often transitional and is drawn where the first marl intercalation more than 5 cm thick or marly limestone appears above the Vorbourg Member. The Röschenz Member is most argillaceous in the proximal realm (Ajoie, Canton Jura) and grades in the distal direction into the limestone of the Günsberg Formation. The mean thickness of the Röschenz Member is about 35 m.

The Röschenz Member can be subdivided near St-Ursanne and in the Ajoie into a lower and an upper part. The intervening bed is an erosion-resistant oolite with light ooids in a blue-grey or rusty-brown matrix that has already been noticed by LAUBSCHER (1948, p. 9). This is bed 73 in section RG 359 near Bressaucourt JU (pl. 18) and bed 38 in section RG 454 near Bure JU (pl. 16). This might be the equivalent of the Grüne Mumienbank of ZIEGLER (1956) and of the Gerstenhübel Beds in the Effingen Member of the basin (see GYGI & PERSOZ 1986, pl. 1).

Complete sections of the Röschenz Member are RG 402 near Röschenz BL (pl. 33) and RG 454 near Bure JU (pl. 16). Section RG 402 was a clean outcrop in the summer of 1983 during a renovation of the road from Röschenz to the Müli. It is therefore designated as the type section of the Röschenz Member. The member begins with bed 24 and ends with bed 71 in the type section. Gygi (1995, p. 11) gave the reason why the unit cannot be called Natica Member any more.

3.2.5.3 Hauptmumienbank Member

Synonymy:

Oolite grossière Gressly (1864, p. 99)
Calcaires blanchâtres à grosses oolithes Rollier (1888, p. 61)
Mumienbank Rothpletz (1933, p. 25)
Hauptmumienbank Ziegler (1956, p. 63, figs. 12 and 14)
Hauptmumienbank Ziegler (1962, p. 27)
Hauptmumienbank Heckendorn (1974, p. 11)
Hauptmumienbank Member Gygi & Persoz (1986, p. 400)
Hauptmumienbank Gygi (1995, p. 11)

This member is an excellent marker unit between the partially argillaceous Röschenz Member below and the marl of the Bure Member above. It has been described by Ziegler (1956, p. 57) and again in detail by Gygi & Persoz (1986, p. 400). This limestone succession weathers out in the platform interior as an escarpment (fig. 35) when the beds are flat or forms a prominent ridge where the succession is tectonically tilted (fig. 28).

Ziegler (1956, fig. 12) gave a paleogeographic map of the areal extent of the Hauptmumienbank Member. In fact the unit extends further north and northeast than this author indicated (cf. Gygi, 1990c, fig. 7). Ziegler (1956) has not designated a type section. This ought to be in the Franches Montagnes in Canton Jura where the member grows to its greatest thickness. A good reference section is RG 366 at Vorbourg chapel near Delémont (beds 67 to 73 in pl. 23).

Gygi & Persoz (1986, pl. 1) proved with clay minerals that the Hauptmumienbank Member grades distally into the Steinebach Member and that this member passes laterally into the Geissberg Member. The age of the Geissberg Member could be fixed with an ammonite to be of the late Hypselum Subchron by Gygi (1995, figs. 2 and 23).

3.2.5.4 Bure Member

Synonymy:

Humeralis-Schichten (Mergel) Ziegler (1956, fig. 14)
pars Humeralisschichten Fischer (1965, p. 19)
pars Humeralis-Schichten Bolliger & Burri (1970, p. 72)
pars Humeralis-Schichten Heckendorn (1974, p. 12)
Humeralis marl Gygi & Persoz (1986, p. 401)
Bure-Schichten Gygi (1995, p. 11)

Ziegler (1956, fig. 14) is the first author who stated unequivocally what he meant by Humeralis-Schichten: first the marl above the Hauptmumienbank Member (now Bure Member) and, second, the limestones between the Bure Member below and the Verena Member above (now La May Member, see below). The lower, argillaceous part of Ziegler's Humeralis Beds are therefore part of the upper Vellerat Formation. The upper, carbonate-rich part belongs to the lower Courgenay Formation and forms steep cliffs. The name of Ziegler's unit is derived from the smooth brachiopod "*Zeilleria humeralis* (Roemer)" that is at present called *Zeillerina astartina* (Rollier) as indicated by Enay et al. (1988, p. 314) and figured by Boullier (1993, pl. 1, fig. 5). *Zeillerina astartina* (Rollier) is a poor guide fossil, because it has also been found in the upper Röschenz Member, as in bed 59 of section RG 312 near Souboz BE, bed 38a of section RG 363 near Soyhières JU and in bed 93 of section RG 368 near Châtillon JU. The name Humeralis Beds is also ambiguous, because it has been used by several authors both for the argillaceous succession above the Hauptmumienbank Member and for the limestones below the Verena Member. It was therefore necessary to find new geographical names for these two members.

The predominantly marly unit between the Hauptmumienbank Member below and the carbonate La May Member above is called Bure Member after section RG 454 (pl. 16) in the exploration well BUR 2 for the Transjurane highway near Bure JU. This inaccessible type section is selected, because the outcrops of the Bure Member are always artificial and never exposed for long. The member begins in section RG 454 with bed 72 and ends with bed 85.

The base of the Bure Member in the type section is transitional. In effect it is a paraconformity that cannot be recognized in many sections. Fischer (1965a, p. 20) mentioned a quarry near Raedersdorf F where the upper surface of the Hauptmumienbank Member is encrusted by large ostreid bivalves. The top of the Bure Member may also be transitional. It is where the rock becomes calcareous enough to form cliffs. In the distal direction the Bure Member grades into the Oolithe Rousse Member. First red-brown oolite appears at the base of the Bure Member. The thickness of the marl diminishes in the distal direction while the oolite replaces ever higher parts of the marl until the Oolithe Rousse Member replaces the whole Bure Member (see Gygi & Persoz 1986, pl. 1).

3.2.5.5 Oolithe Rousse Member

Synonymy:

Oolithe rousse Rollier (1888, p. 61)
Oolithe rousse Ziegler (1956, p. 8 and fig 12)
Oolithe rousse Gygi & Persoz (1986, p. 401 and 413)
Oolithe rousse Gygi (1995, p. 11)

Rollier (1888, p. 61) and Ziegler (1956, p. 8) gave a good macroscopic description of this characteristic member. Gygi & Persoz (1986, p. 413) provided a microscopic description. Ziegler (1956, p. 8) gave a reference section for the member and figured its geographical range (fig. 12). The Oolithe Rousse Member is the lateral equivalent of the Bure Member.

3.2.6 Günsberg Formation (new in the rank of a formation)

Synonymy:

Couches de Châtelu Rollier (1888, p. 61)
pars Günsberger Schichten Gygi (1969, p. 83)
Günsberg-Schichten Bolliger & Burri (1970, p. 73)
Günsberg Member Gygi & Persoz (1986, p. 401)
Günsberg-Schichten Gygi (1995, p. 13)

The Günsberg Formation was deposited in a narrow belt along the carbonate platform that grades in the proximal direction into the Vorbourg and Röschenz Members and in the distal direction into the basinal Effingen Member (Gygi & Persoz 1986, pl. 1). The main body of the Günsberg Formation is oolitic and rimmed the platform deposits of the adjacent Vorbourg and Röschenz Members. In the distal direction the oolite bars contain coral bioherms that grew in somewhat deeper water. Because of the progradational geometry of the formation the coral bioherms cover almost the whole width of the platform at the base of the formation, and the oolite overlies them (fig. 39). Due to the fact that the Günsberg and laterally equivalent Vorbourg and Röschenz members all prograded basinward their relationship to each other and the underlying formations is complex (fig. 39). The proximal part of the lower Günsberg Formation rests on the distal St-Ursanne Formation. The Günsberg Formation then prograded over the Effingen Member so that the distal part of the lower Günsberg Formation rests on top of the Effingen Member. In addition, the Röschenz Member prograded over the proximal Günsberg Formation. Consequently, the upper boundary of the proximal Günsberg Formation is overlain by the upper Röschenz Member and the Hauptmumienbank Member and further in the distal direction by the Steinebach Member (fig. 39).

Gygi (1969) classified the Günsberg Formation as a member of the Balsthal Formation. The reason was that the Günsberg Formation is difficult to delineate from the Balsthal Formation in the southernmost Jura range between Mt. Hasenmatt and Mt. Weissenstein (cf. section RG 384, pl. 29, see also Burkhalter 1989, p. 148 and fig. 2–12). Bolliger & Burri (1970, p. 73) separated the Steinebach Beds of Gygi (1969) from the Günsberg Member and included the Günsberg Member in the Vellerat Formation. It is probably better to interpret the Günsberg unit as a separate formation between the lagoonal Vellerat Formation and the basinal Wildegg Formation (see fig. 39). The composition of the Günsberg Formation is so complex that a subdivision into members is not recommended. The name "Moutier-Korallenkalke" (Moutier coral-limestone) of Bolliger & Burri (1970, p. 72) for part of the Günsberg Formation is therefore rejected. Hermatypic corals occur both at the base, at the distal margin and within the Günsberg Formation (section RG 381, Court gorge near Moutier BE, pl. 28).

Rollier (1888, p. 62) paid special attention to the coral bioherms in the Rondchâtel cluse near Péry BE (section RG 307, bed no.160, pl. 22) and compared them with a unit containing hermatypic corals that lies above the Effingen Member and had been described by De Tribolet (1872) from Mt. Châteleu in France near the Swiss border (see Swiss National Map, sheet 1163, Travers, 2.5 km westnorthwest of La Brévine NE). Rollier's name Couches de Châtelu, a senior synonym of Günsberg Formation, has never been used again by either French or Swiss authors and is therefore forgotten.

The type section of the Günsberg Formation is section RG 14 in the Gschlief landslide above Günsberg SO. This is at the distal margin of a narrow carbonate platform where the Günsberg Formation grades laterally into the Effingen Member. The facies of the formation is therefore atypical at that locality. A good reference section is in the quarry of La Charuque near Péry BE (section RG 307, pl. 22).

The age of the Günsberg Formation varies from the proximal to the distal realm (fig. 40). This can be seen in fig. 39 and in Gygi & Persoz (1986, pl. 1). In the distal realm, the age ranges from the late Bifurcatus Chron (Gygi, 1995, fig. 17/2) to the Hypselum Subchron (Gygi, 1995, fig. 18).

3.2.7 Courgenay Formation

Synonymy:
Oberste Zone des Sequans Hummel (1914, p. 216)
Courgenay Formation Gygi (1995, p. 12)

The Courgenay Formation is a succession of bedded and massive limestones that is underlain by the argillaceous Bure Member and overlain by the well-bedded limestones of the Reuchenette Formation.

The lower boundary of the formation is taken where the carbonate content of the succession increases sufficiently so that the limestone forms cliffs or an escarpment. The distal boundary is where the micritic limestone grades into oolite. The upper boundary is less evident. Hummel (1914, p. 12) distinguished a bed of white limestone with a thickness of 3 to 4 m with abundant fossils. This probably corresponds to the beds 45 and 46 of section RG 340 in the quarry east of Le Banné hill at Porrentruy JU (pl. 17). Hummel regarded this to be the uppermost bed of his "Sequan" (Upper Oxfordian). Tschopp (1960, p. 9) called that bed "Bank B". It is uncertain what Tschopp meant by his "Bank A" that he states also to be a white limestone with a thickness of 3 to 5 m. He thinks this is 40 to 45 m above the Bure Member. Gygi found a porous white limestone with a thickness of 12.7 m about 30 m above the Bure Member in his section RG 350, bed 79, along the Chemin Paulin road near Courgenay JU (pl. 19). Gygi & Persoz (1986) proved by clay mineral correlations that the upper boundary of bed 79 in section RG 350 was coeval with the upper boundary of the Verena Member and thus with the upper boundary of the Oxfordian Stage as it was conventionally conceived in Central Europe. Bed 79 of section RG 350 at Courgenay JU (pl. 19) corresponds to bed 88 of section RG 340 at Porrentruy JU at the base of the quarry (pl. 17). In section RG 340 at Porrentruy, the base of bed 88 is not exposed, but there is a conspicuous limonite crust at its top. It is this bed (340/88, 350/79) of white, chalk-like limestone that can be followed through the whole of the Ajoie as far as Montbéliard in adjacent France where it is called "Calcaire crayeux à *Cardium*" (Gygi 1995, p. 12).

Laubscher (1948, p. 10), Schneider (1960, p. 8) and Tschopp (1960, p. 9) were of the opinion that it was impossible to distinguish what Gygi (1995, p. 12) called Courgenay Formation from the lower Reuchenette Formation. They consequently mapped the two formations together. It is true that it is impossible to distinguish the limestones of the La May Member (Gygi 1995) from most limestones of the lowermost Reuchenette Formation below the Banné Member in the Ajoie at small outcrops. But it is necessary to have a name for the limestone succession between the Vellerat Formation below and the Reuchenette Formation above that both can be easily distinguished in the Ajoie region of northwestern Switzerland. This is why GYGI (1995, p. 12) proposed the name Courgenay Formation for beds 14 to 79 in section RG 350 (pl. 19) along Chemin Paulin road near Courgenay JU. The Chemin Paulin is the type section of the formation. The formation can be followed from St-Ursanne into adjacent France. GYGI (1995, p. 12) distinguished two members. The age of the formation ranges from the late Oxfordian Hauffianum Subchron to the Planula Chron of the early Kimmeridgian (fig. 40).

3.2.7.1 La May Member

Synonymy:
Humeralis-Schichten (Kalke) ZIEGLER (1956, fig. 14)
Calcaire à Térébratules CHAUVE et al. (1985, p.14)
Humeralis limestone GYGI & PERSOZ (1986, p. 401)
La May-Schichten GYGI (1995, p. 12)

The La May Member is a succession of well-bedded, micritic limestones that are underlain by the argillaceous Bure Member and overlain by the massive white limestone of the Porrentruy Member. Peloids, oncoids, bio- and small lithoclasts may occur in the micrite.

The La May Member is found in the whole of the Ajoie region and near St-Ursanne. Southeast of St-Ursanne it interfingers with the Laufen and Verena Members (fig. 39).

GYGI (1995, p. 12) named the member after a section along a forest road south of La May 2.5 km eastnortheast of St-Ursanne (section RG 337, unpublished) and proposed that the exploration well RG 443 near the farm La Coperie 2.25 km east of St-Ursanne be the type section (beds 24 to 64, pl. 20), because there is no complete natural outcrop of the member. A good reference section is the outcrop along Chemin Paulin road (section RG 350, pl. 19) near Courgenay JU.

3.2.7.2 Porrentruy Member

Synonymy:
pars "Bank A" TSCHOPP (1960, p. 9)
Calcaires à *Cardium* CHAUVE et al. (1985, p. 14)
Chalk-like limestone GYGI & PERSOZ (1986, tab. 2)
Porrentruy-Schichten GYGI (1995, p. 12)

The Porrentruy Member is a massive, yellowish-white to pure white limestone that is often porous and chalk-like. It is underlain by the bedded, mostly micritic limestones of the La May Member and overlain by the bedded limestones of the lower Reuchenette Formation.

The Porrentruy Member has a mean thickness of about 15 m. It can be followed from St-Ursanne through the Ajoie to at least as far as Montbéliard in France. The best section is RG 350 near Courgenay JU (pl. 19). The Porrentruy Member is bed 79 of section RG 350 that is designated here as the type section. The name of the member is derived from bed 88 in the section RG 340 (pl. 17) near Porrentruy where the uppermost 7.8 m of the member crop out.

3.2.8 Balsthal Formation

Synonymy:
Balsthaler Formation GYGI (1969, p. 83)
Court-Formation BOLLIGER & BURRI (1970, p. 73)
pars Vellerat-Formation BOLLIGER & BURRI (1970, p. 71)
Balsthal-Formation TSCHUMI (1983, p. 43)
Balsthal-Formation MARTIN (1984, p. 192)
Balsthal Formation GYGI & PERSOZ (1986, p. 401)
Court Formation GYGI & PERSOZ (1986, p. 401)
Obere Balsthaler Formation BURKHALTER (1989, p. 145)
Balsthal-Formation BALMER (1989, p. 88)
Balsthal Formation ALLENBACH (1994, p. 85)

The Balsthal Formation comprises the limestones that are underlain by the Günsberg Formation and the Effingen Member and overlain by the Reuchenette Formation. Proximally it grades into the upper Vellerat Formation and the Courgenay Formation. The basinal time-equivalent is the Villigen Formation (fig. 39).

The proximal part of the Balsthal Formation can be subdivided into the Steinebach Member below, the Laufen Member in the middle and the Verena Member above. The Steinebach, Olten and Holzflue Members can be distinguished in the distal part of the Balsthal Formation.

The Balsthal Formation extends from a line Glovelier JU – Delémont to Olten SO. BOLLIGER & BURRI (1970, p. 73) proposed the term Court Formation for the sediments between their Vellerat Formation and the Reuchenette Formation. The Court Formation of these authors includes the Balmberg oolite, the Hautes-Roches-Algenkalke and the Verena oolite. There are three main types of facies in the late Oxfordian sediments of northern Switzerland: the proximal, lagoonal lime mudstones, the oolite bars of the carbonate platform margin and the basinal lime mudstones (fig. 39, see also GYGI & PERSOZ, 1986, pl. 1). The Courgenay, the Balsthal and the Villigen Formations have been introduced for these facies belts. The Court Formation is mostly oolitic like the Balsthal Formation. It is therefore to be regarded as a junior synonym of the Balsthal Formation and is rejected as being superfluous.

3.2.8.1 Steinebach Member

Synonymy:
Steinibach-Schicht GYGI (1969, p. 85)
Steinibach-Schicht BOLLIGER & BURRI (1970, p. 73)
non Steinibach-Schichten PFIRTER (1982, p. 28)
Steinibach Beds GYGI & PERSOZ (1986, p. 402)
Steinibach Beds ALLENBACH (1994, p. 91)
Steinebach-Schichten GYGI (1995, p. 11)
non Couches de Steinibach PITTET (1996, fig. 19b)

The Steinebach Member is an oolite (mostly oosparite) with a thickness from 4.5 m to 21.3 m. It was only possible using clay mineralogy to correlate this unit with the proximal Hauptmumienbank Member and the distal Geissberg Member. No ammonites have as yet been found in the Steinebach Member. The upper part of the member may contain oncoids as for instance in the type section RG 438 (pl. 44) in the Steinebach gorge near Balsthal SO. Near Gänsbrunnen SO there are corals and abundant nerineid gastropods in this unit. The Steinebach Member occurs in the sections RG 430, Gänsbrunnen SO (pl. 40), RG 429, Welschenrohr SO (pl. 39), RG 384, Selzach SO (pl. 29), RG 14, Günsberg SO (GYGI, 1969, pl. 18), RG 438, Balsthal SO (pl. 44) and RG 448, Egerkingen SO (unpublished, see fig. 1). The unit has been sedimented during the late Hypselum Subchron (GYGI, 1995, fig. 23).

3.2.8.2 Laufen Member

Synonymy:

Humeralis-Schichten (Kalke) ZIEGLER (1956, fig. 14)
pars Hautes-Roches-Algenkalke BOLLIGER & BURRI (1970, p. 74)
Humeralis limestone GYGI & PERSOZ (1986, p. 401)
Laufen-Schichten GYGI (1995, p. 13)

No satisfactory name has been proposed by the earlier stratigraphers for this transitional, very variable member that is underlain by the Oolithe Rousse Member and the Steinebach Member and overlain by the Verena Member. In the proximal direction it grades into the Oolithe Rousse Member and the micritic La May Member. The distal time equivalent is the oolitic lower Holzflue Member (fig. 39). The Laufen Member can contain micrite, pelmicrite, oncolite, oolite, oolitic oncolite, dolomitic oncolite or coral limestone. GYGI (1995, p. 13) preferred to introduce a new name, because the Hautes-Roches-Algenkalke of BOLLIGER & BURRI is ambiguous. These authors included at their type locality the well-defined Hauptmumienbank Member in the unit. Moreover, oncoids are by no means ubiquitous in the Hautes-Roches-Algenkalke (HECKENDORN, 1974, p. 12). GYGI (1995) has based his new name on the town of Laufen BL, where the upper part of this unit has been worked for a long time and is a well-known building stone in a widespread area. Good reference sections are in the Schachlete valley near Dittingen BL, but only the upper Laufen Member crops out in the quarries in that valley. Therefore, the limestone quarry of the former cement works of Liesberg BL is proposed as type section of the Laufen Member (RG 398, beds 27 to 48, fig. 35 and pl. 32).

3.2.8.3 Verena Member

Synonymy:

Calcaire blanc de Ste-Vérène DESOR & GRESSLY (1859, p. 75)
Höhlenkalk LANG (1863, p. 22)
Calcaire oolithique de Ste-Vérène GREPPIN (1870, p. 96)
non Verena-Schichten BUXTORF (1907, p. 54)
Couches de St-Vérène JUILLERAT (1907, p. 72)
Verena-Oolith ZIEGLER (1956, p. 56)
Verena-Schicht GYGI (1969, p. 86)
Verena-Oolith BOLLIGER & BURRI (1970, p. 74)

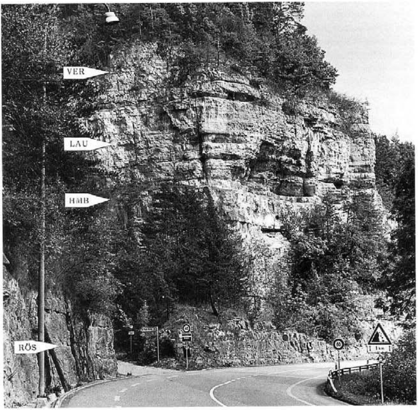


Fig. 35: Entrance to the limestone quarry of the former cement works of Liesberg as seen from the cantonal road. RÖS: Röschenz Member, HMB: Hauptmumienbank Member, LAU: Laufen Member, VER: Verena Member. Section RG 398, compare with pl. 32.

Verena-Oolith HECKENDORN (1974, p. 12)
Verena Member GYGI & PERSOZ (1986, p. 402)
Verena-Schichten GYGI (1995, p. 14)

The Verena Member is a massive, yellowish-white oolite with a mean thickness of about 45 m. It is above the Laufen Member and below the Reuchenette Formation. The Verena Member grades proximally into the upper La May and the Porrentruy Members and distally into the upper Holzflue Member. Its lithology is distinctive; the ooids are mostly micritized (GYGI, 1969, pl. 13, fig. 47) and oncoids are quite common. The rock has a complicated diagenetic history of partial dolomitization, replacement by calcium sulfate in small patches, and dedolomitization of the whole rock except for occasional small relicts of anhedral dolomite (GYGI, 1969, p. 78). The primary oolitic texture was partially destroyed in the process. The micritized ooids are easily visible on clean, weathered surfaces, but they are difficult to discern on a freshly broken surface. Large pockets of the rock as much as 10 or 20 m across may be porous and weather out as hollows and caves as for instance behind the Verena chapel near Solothurn, the type locality of the Verena Member (fig. 36). Such pockets occur in any level of the member. Unaltered, cross-bedded oolite is uncommon.

There is considerable disagreement between authors about how to interpret the Verena Member at different localities. BUXTORF (1907, p. 54) and with him ZIEGLER (1956, p. 96) and GYGI (1969, pl. 19, section 2) have mistaken the Steinebach Member in section RG 430 at Gänsbrunnen (bed 35, pl. 40) as the Verena Member. Therefore, BUXTORF (1907, p. 58) greatly overestimated the thickness of the Reuchenette Formation at that locality (130 m instead of 13 m, see this paper, pl. 40). WIEDENMAYER (1923, p. 4) and STAEHELIN (1924, p. 4) assumed that the thickness of the Verena Member was only 15 m, and GYGI (1969, p. 87) followed them in this interpretation. BOLLIGER & BURRI (1970, p. 74) pointed out that the thickness of the member could be up to 50 m. The new measurements of sections confirmed this: in section RG 404 near Mervelier JU the thickness of the Verena Member is as much as 57 m (pl. 36). Only the upper part of the member crops out at the type locality of St. Verena north of Solothurn (fig. 36). Complete sections are near Moutier BE (RG 392, pl. 26), Rebévelier JU (RG 377, pl. 25), Delémont (RG 366, pl. 23) and Sornetan BE, Pichoux gorge (RG 315, pl. 21). An easily accessible reference section of the Verena Member is RG 392 in the northern part of Moutier gorge north of Moutier BE.

Fossils are uncommon in the Verena Member. There are occasionally abundant nerinean gastropods or coral clasts. Coral bioherms have been found near Lommiswil SO (RG 383, PS Gy 4408–4410, ca. 110 m east of point 1299 on the crest of the ridge east of Mt. Hasenmatt, about 10 m above the base of the Verena Member) and near Seehof BE (section RG 419, in the middle of the Verena Member). There is no record of ammonites in this member. It is only through clay mineral correlations that it could be established that the Verena Member is the time equivalent of the Letzi Member and thus belongs to the Planula Chron (GYGI & PERSOZ, 1986, tab. 2).

Fig. 36: Hermitage of St. Verena, Rüttenen SO, 2 km north of Solothurn. Massive oolitic limestone of Verena Member, type locality of the member. The distinct bedding plane above the chapel is the upper boundary of the Verena Member and therefore the boundary between the Balsthal Formation and the Reuchenette Formation.

3.2.8.4 Holzflue Member

Synonymy:

Holzflue-Schichten GYGI (1969, p. 86)
pars Holzflue-Schichten TSCHUMI (1983, p. 54)
pars Holzflue-Schichten MARTIN (1984, p. 192)
Holzflue-Schichten GYGI & PERSOZ (1986, p. 402)
Holzflue-Schichten BALMER (1989, p. 100)
Holzflue Member ALLENBACH (1994, p. 94)
Holzflue-Schichten GYGI (1995, p. 14)

The Holzflue Member is a succession of yellowish-white, massive oolitic or micritic limestone that lies between the older Steinebach Member and the younger Reuchenette Formation. The upper part of the Holzflue Member has the same facies as the Verena Member. The lower part is very similar, but it can contain oncolitic intercalations. Near Günsberg there are hermatypic corals at the base of the member.

Near Delémont (section RG 366, pl. 23) and Moutier BE (section RG 390, pl. 27), the Laufen and the Verena Members can be easily distinguished. When one looks north from point 845.1 on the eastern slope of Moutier gorge, a cliff of the Balsthal Formation is visible on the northern limb of the fold. It can be seen from a distance of about 600 m that the Laufen Member is indistinctly bedded and weathers with a light brownish tinge, whereas the Verena Member above is massive and almost white. In the Weissenstein range east of Solothurn the two members cannot be distinguished any more. A particular name is therefore needed for the region where the two units have to be lumped together. GYGI (1969, p. 86) has proposed the name

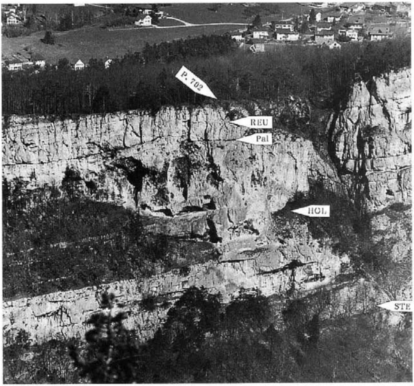


Fig. 37: Cliff of Chluser Roggen near Balsthal SO below point 702 as seen from Wannenflue at coordinates 618.900/237.810, looking north. STE: Steinebach Member, HOL: Holzflue Member, REU: Reuchenette Formation, Pal: Palaeosol in the lowermost Reuchenette Formation. Section RG 450, unpublished.

Holzflue Member after the rocky mountain directly north of Balsthal.

The lower Holzflue Member includes oncoids at varying levels. The oncoid content may attain 20 % of the rock or more in several sections. The lower Holzflue Member thus cannot be clearly delineated from the Laufen Member nor from the upper part of the Steinebach Member.

WIEDENMAYER (1923, p. 4), STAEHELIN (1924, p. 4), GYGI (1969, p. 86) and ALLENBACH (1994, p. 96) distinguished a Verena Member about 15 m thick east of Solothurn at the top of the Holzflue Member that weathers back to form a hollow when the strata are steeply dipping. It is advocated here to discard this member of the eastern Weissenstein range, because its lower boundary cannot be satisfactorily defined. Near Balsthal also the upper boundary is indistinct (see below).

The lower boundary of the Holzflue Member in the Steinebach gorge, which is the type locality, is best placed at the top of bed 25 of section RG 438 at Balsthal (pl. 44, this is the same section as RG 9 in GYGI, 1969, pl. 18). The pure white bed RG 438/25 weathers back to form a hollow and separates the low ridge of the Steinebach Member from the high ridge of the Holzflue Member. The upper boundary of the Holzflue Member cannot be clearly defined near Balsthal, because the lower Reuchenette Formation is also oolitic in that region. According to an ammonite figured by GYGI (1995, fig. 19), the boundary must be a few meters below a palaeosol in the lowermost Reuchenette Formation (bed 52 in section RG 438 at Balsthal, pl. 44, see also fig. 37 and discussion of the boundary in GYGI, 1995, p. 15). East of Mt. Roggen the micrite content of the Holzflue Member increases. The unit is mostly micrite where it is in contact with the Olten Member in the east (GYGI & PERSOZ, 1986, pl. 1).

3.2.8.5 Olten Member

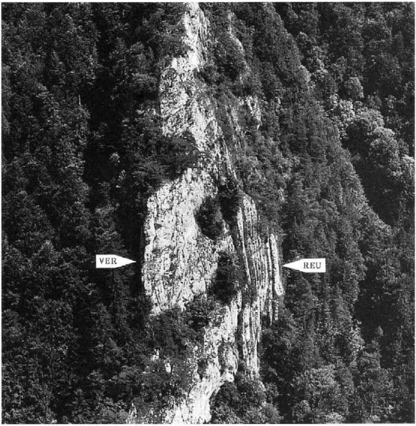
Synonymy:
Crenularisschichten KEHRER (1922, p. 14)
Oltener Korallenkalk GYGI (1969, p. 94)
Olten coral limestone GYGI & PERSOZ (1986, tab. 2)
Olten-Schichten GYGI (1995, fig. 2)

The Olten Member is a massive limestone with hermatypic corals and a mostly micritic matrix. The coral colonies are typically dish-like and are most often preserved as fine-grained sparite. The most common corals are *Stylina, Dimorphoseris* and microsolenids. The corals formed small bioherms north of Wangen SO. Near Olten they apparently grew in a vast biostrome.

The Olten Member begins in the distal Steinebach Member and rises diachronously to the upper Holzflue Member in the distal direction (GYGI 1969, pl. 19 and this paper, fig. 39).

The best section of the member is in the quarry of the Olten cement works on the north slope of Mt. Born (section RG 21, beds 29 to 38 in GYGI 1969, pl. 18).

Fig. 38: Rock of Rouge Pertuis north of Undervelier JU as seen from the west. Massive oolitic Verena Member (left) and bedded, mostly micritic lower Reuchenette Formation (right). The strata are vertical.



3.2.9 Reuchenette Formation

Synonymy:
Reuchenette-Formation THALMANN (1966, p. 32)
Reuchenette-Formation SCHÄR (1967, p. 11)
Reuchenette-Formation PFIRTER (1982, p. 32)
Reuchenette-Formation TSCHUMI (1983, p. 61)
Reuchenette-Formation MARTIN (1984, p. 194)
Reuchenette Formation GYGI & PERSOZ (1986, p. 403)
Reuchenette-Formation BALMER (1989, p. 111)
Reuchenette-Formation BURKHALTER (1989, p. 177)
Reuchenette Formation ALLENBACH (1994, p. 108)
Reuchenette-Formation HAUSER (1994, p. 46)
Reuchenette-Formation GYGI (1995, p. 14)
Kimméridgien MOUCHET (1995)

The Reuchenette Formation is a thick succession of carbonate platform sediments ranging from pure micrite to oosparite. Coral bioherms are few and of a small size, and they mainly occur at the platform margin near Balsthal SO (GYGI & PERSOZ, 1986, pl. 1B). No complete section of the formation is presented in this paper.

The boundary between the massive Verena Member and the well-bedded Reuchenette Formation may be conspicuous at some localities (fig. 38). Several authors have distinguished members in the Reuchenette Formation (fig. 40). However, these members cannot be correlated over greater distances. The type section of the Reuchenette Formation is near La Reuchenette at Péry BE (THALMANN 1966, fig. 5). The ramp facies with ammonites between Balsthal SO and Schönenwerd SO in the east is included in the Reuchenette Formation in order to avoid having to give a new name to this erosion relict.

The age of the base of the Reuchenette Formation corresponds to the base of the Baden Member in Canton Aargau. This coincides with the beginning of the Platynota Chron (fig. 40). The correlation is based on clay minerals (GYGI & PERSOZ 1986) and is corroborated by ammonites (GYGI 1969, pl. 17, section RG 70, GYGI 1995, fig. 19). The boundary between the Oxfordian and the Kimmeridgian Stages was conventionally assumed to be between the Planula Zone, Galar Subzone, and the Platynota Zone in Central Europe (MOUTERDE *et al.*, 1971). This boundary had the advantage that it was mappable throughout northern Switzerland. But following a paper by SCHWEIGERT & CALLOMON (1997) the boundary has now to be drawn deeper down (see paragraph 5.6 below).

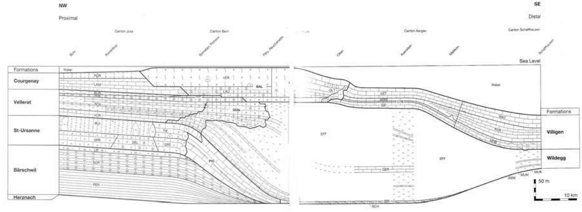
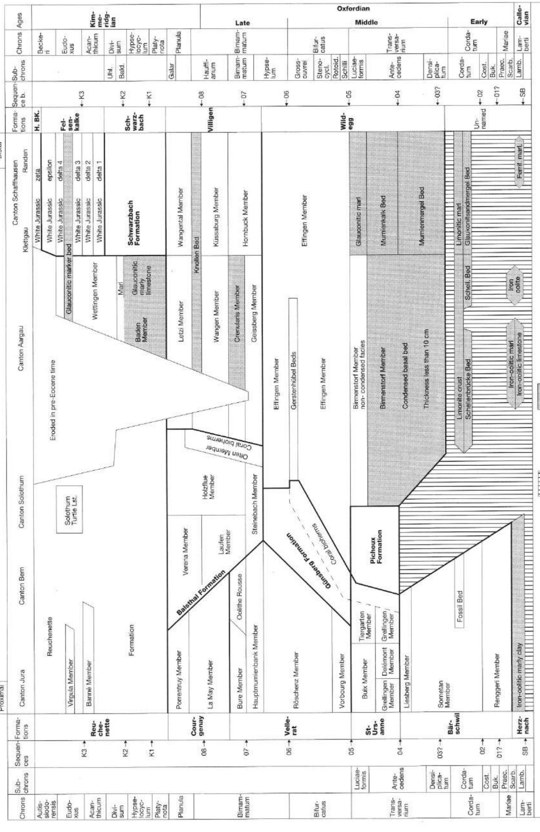


Fig. 39: Section perpendicular to depositional strike of the formations and members of the Oxfordian Stage in northern Switzerland. The upper surface of the section shows the calculated depositional profile at the end of the Oxfordian according to Gygi (1986). The depositional profile at the beginning of the Oxfordian was relatively flat and is represented in fig. 3A by Gygi (1986). The profile of the bottom of the section as drawn in this figure is the result of differential subsidence under a varying amount of sediment (Gygi 1986, fig. 3). Thicknesses are averaged and compacted. The age of the formations and members is indicated in fig. 40.

BAL Balsthal Formation
BIR Birmenstorf Member
BUI Buix Member
BUR Bure Member
CRE Crenularis Member
DEL Delémont Member
EFF Effingen Member
GEI Geissberg Member
GER Gerstenhübel Beds
GRE Grellingen Member
GSM Glaukonitsandmergel Bed
GÜN Günsberg Formation
HMB Hauptmumienbank Member
HOB Hornbuck Member
HOL Holzflue Member
KÜS Küssaburg Member
LAM La May Member
LAU Laufen Member
LET Letzi Member
LIE Liesberg Member
MUK Mumienkalk Bed
MUM Mumienmergel Bed
OLT Olten Member
OOR Oolithe rousse Member
PIC Pichoux Formation
POR Porrentruy Member
REN Renggeri Member
RÖS Röschenz Member
SCH Schellenbrücke Bed
SOR Sornetan Member
STE Steinebach Member
TIE Tiergarten Member
VER Verena Member
VOR Vorbourg Member
WAN Wangen Member
WAT Wangental Member
WIL Wildegg Formation

Fig. 40: Chronostratigraphic position of the formations, members and beds. Sequence boundaries from Gygi *et al.* (1998), where the full sequence stratigraphical interpretation can be found.



Chrons
Sub-chrons
Sequences
Formations
Proximal
Canton Jura
Canton Bern
Canton Solothurn
Canton Aargau
Canton Schaffhausen
Klettgau
Randen
Distal
Formations
Sequence b.
Sub-chrons
Chrons
Ages
Kimmeridgian
Oxfordian
Late
Middle
Early
Callovian
Autissiodorensis
Eudoxus
Acanthicum
Divisum
Hypselocyclum
Platynota
Planula
Bimammatum
Bifurcatus
Transversarium
Cordatum
Mariae
Lamberti
Luciaeformis
Antecedens
Densiplicatum
Cost.
Buk.
Praec.
Scarb.
Lamb.
Beckeri
Uhl.
Bald.
Galar
Hauffianum
Hypselum
Grossouvrei
Stenocycl.
Rotoid.
Schilli
K3
K2
K1
08
07
06
05
04
03?
02
01?
SB
Reuchenette
Courgenay
Vellerat
St-Ursanne
Bärschwil
Herznach
H. BK.
Felsenkalke
Schwarzbach
Villigen
Wildegg
Unnamed
Reuchenette Formation
Virgula Member
Banné Member
Solothurn Turtle Lst.
Eroded in pre-Eocene time
Porrentruy Member
La May Member
Verena Member
Laufen Member
Holzflue Member
Balsthal Formation
Olten Member
Coral bioherms
Bure Member
Hauptmumienbank Member
Oolithe Rousse
Steinebach Member
Röschenz Member
Vorbourg Member
Günsberg Formation
Coral bioherms
Gerstenhübel Beds
Effingen Member
Buix Member
Grellingen Member
Delémont Member
Tiergarten Member
Grellingen Member
Pichoux Formation
Liesberg Member
Fossil Bed
Sornetan Member
Renggeri Member
Iron-oolitic marly clay
Letzi Member
Wangen Member
Crenularis Member
Geissberg Member
Baden Member
Glauconitic marly limestone
Marl
Wettingen Member
Glauconitic marker bed
Knollen Bed
Wangental Member
Küssaburg Member
Hornbuck Member
Schwarzbach Formation
White Jurassic zeta
White Jurassic epsilon
White Jurassic delta 4
White Jurassic delta 3
White Jurassic delta 2
White Jurassic delta 1
Birmenstorf Member non-condensed facies
Birmenstorf Member
Condensed basal bed
Thickness less than 10 cm
Glauconitic marl
Mumienkalk Bed
Mumienmergel Bed
Limonite crust
Schellenbrücke Bed
Limonitic marl
Glaukonitsandmergel Bed
Schell. Bed
Iron oolite
Iron-oolitic marl
Iron-oolitic limestone
Ferrif. marl.
Caption:
Formation boundary
Member or bed boundary
Hiatus
Condensed Bed

4 Biostratigraphy

4.1 Stratigraphically significant ammonite taxa

The following ammonite descriptions are short, because most of the taxa are well-known. There are no revisions of species. The descriptions relate exclusively to the figured specimens. The synonymy lists include only the principal ammonite figures in the literature. If a modern revision of an ammonite group is available, the synonymy list only goes back to that publication.

Suborder Ammonitina Hyatt 1889
Superfamily Haplocerataceae Zittel 1884
Family Oppeliidae Bonarelli 1894
Subfamily Glochiceratinae Hyatt 1900
Genus *Ochetoceras* Haug 1885

Type species: *Ammonites canaliculatus* von Buch 1833, designated by Munier-Chalmas (1892, p. CLXXI).

Gygi & von Hillebrandt (1991, p. 148) stated that the holotype of von Buch is from Erlinsbach, Canton Aargau. It is from the non-condensed, normal facies of the Birmenstorf Member and therefore from the Luciaeformis Subzone. It has, as indicated by Oppel (1862, p. 158), three keels. A plastic cast (J 31177) of the lost holotype is kept at the Museum of Natural History, Basel (MNHB).

Subgenus *Ochetoceras* Haug 1885

Subgeneric type species: *Ochetoceras (Ochetoceras) canaliculatum* (von Buch 1831).

4.1.1 *Ochetoceras (Ochetoceras) hispidum* (Oppel 1863)
Pl. 3, fig. 3

Synonymy

1964 *Ochetoceras (Ochetoceras) hispidum* (Oppel) – Höroldt, p. 55, pl. 3, fig. 3, 4, with synonymy
1974 *Ochetoceras hispidum* (Oppel) – Barbulescu, pl. 36, figs. 5, 10
1977 *Ochetoceras hispidum* (Oppel) – Ziegler, pl. 1, fig. 2
1991 *Ochetoceras (Ochetoceras) hispidum* (Oppel) – Schlampp, pl. 33, fig. 2
1994 *Ochetoceras (Ochetoceras) hispidum* (Oppel) – Schlegelmilch, p. 47, pl. 14, fig. 8

Material: MNHB J 25901

Locality: section RG 81b, Gygi (1977, pl. 11, fig. 6), excavation below Räckolterenbuck, Gächlingen SH, bed 14b, upper Mumienkalk Bed.

Description:				
	Diameter	D	58 mm	
	Whorl height	Wh	33 mm	57 %
	Whorl thickness	Wt	18 mm	31 %
	Umbilicus	U	–	14 %

The glauconitic, carbonate internal mould (steinkern) is wholly septate. The lateral groove is first conspicuous and then fades away in the course of ontogeny. There is a single median keel on the siphuncular side that is minutely serrated. The strong, slightly arcuate primary ribs are completely interrupted where the lateral groove is deep. The secondary ribs are somewhat broader than the primaries. The greatest whorl thickness is near the umbilical margin.

Age: late Antecedens Subchron of the Transversarium Chron.

Genus *Neoprionoceras* Spath 1928

Type species: *Oppelia girardoti* de Loriol 1902

4.1.2 *Neoprionoceras delmontanum* (Oppel 1863)
Pl. 2, fig. 9

Synonymy

1961 *Campylites (Campylites) delmontanus delmontanus* (Oppel) – Christ, p. 293, pl. 17, fig. 2, with synonymy
1963 *Campylites delmontanus* (Oppel) – Malinowska, p. 37, pl. 8, fig. 54, pl. 9, figs. 56–57
1977 *Campylites (Campylites) delmontanus delmontanus* (Oppel) – Bourseau, p. 96, pl. 9, fig. 5
non 1991 *Ochetoceras (Campylites) delmontanum* (Oppel) – Page, p. 94, pl. 13, figs. 5,6
1991 *Campylites (Campylites) delmontanus* (Oppel) – Schlampp, pl. 33, fig. 10

Material: MNHB J 25052

Locality: section RG 208, Gygi (1977, pl. 11, fig. 2), excavation on Brunnrain, Üken AG, bed 9, upper Schellenbrücke Bed.

Description:			
Dimensions	D	42 mm	
	Wh	20 mm	48 %
	Wt	11 mm	26 %
	U	11 mm	26 %

The iron oolitic, carbonate internal mould is wholly septate. The greatest thickness of the whorl is near the rounded umbilical margin. The strong, almost straight primary ribs are prorsiradiate and fade out completely along a narrow smooth band slightly below the middle of the whorl sides. There are two slightly arcuate secondary ribs per primary. The secondaries become stronger and broader towards the siphonal side and touch the well-developed marginal keels. The median keel is only a little higher than the marginal ones.

Age: late Cordatum Subchron of the Cordatum Chron.

Genus *Trimarginites* ROLLIER 1909

Type species: *Ammonites trimarginatus* OPPEL 1863, designated by ROLLIER (1911, p. 309), see also discussion by CHRIST (1961, p. 283).

4.1.3 *Trimarginites trimarginatus* (OPPEL 1863)
Pl. 7, fig. 4

Synonymy

1961 *Trimarginites trimarginatus* (OPPEL) – CHRIST, p. 286, pl. 16, fig. 1, with synonymy
1963 *Trimarginites trimarginatus* (OPP.) – MALINOWSKA, p. 39, pl. 10, fig. 60
1973 *Trimarginites trimarginatus* (OPPEL) – SAPUNOV, p. 108, pl. 1, fig. 6
1974 *Trimarginites trimarginatum* (OPPEL) – BARBULESCU, pl. 36, fig. 1
1977 *Trimarginites arolicus* (OPPEL) – ZIEGLER, pl. 1, fig. 5
1991 *Trimarginites* cf. *trimarginatus* (OPPEL) – SCHLAMPP, pl. 34, fig. 2
1994 *Trimarginites trimarginatus* (OPPEL) – SCHLEGELMILCH, p. 47, pl. 14, fig. 5

Material: MNHB J 25924

Locality: section RG 81b, GYGI (1977, pl. 11, fig. 6), excavation below Räckolterenbuck, Gächlingen SH, bed 14b, upper Mumienkalk Bed.

Description: Dimensions

D	62 mm		
Wh	33 mm	53 %	
Wt	15 mm	24 %	
U	8 mm	13 %	

Superfamily	Family	Subfamily	Genus	Subgenus
Haplocerataceae	Oppeliidae	Glochiceratinae	*Ochetoceras*	*Ochetoceras*
			Neoprionoceras	
			Trimarginites	
		Taramelliceratinae	*Taramelliceras*	*Proscaphites*
				Metahaploceras
			Creniceras	
		Streblitinae	*Streblites*	
Stephanocerataceae	Cardioceratidae	Cardioceratinae	*Quenstedtoceras*	
			Cardioceras	*Scarburgiceras*
				Pavloviceras
				Cardioceras
				Subvertebriceras
				Maltoniceras
				Miticardioceras
			Amoeboceras	
Perisphinctaceae	Perisphinctidae	Perisphinctinae	*Perisphinctes*	*Neomorphoceras*
				Otosphinctes
				Arisphinctes
				Dichotomosphinctes
				Dichotomoceras
			Subdiscosphinctes	*Subdiscosphinctes*
				Aureimontanites
			Larcheria	
			Passendorferia	*Passendorferia*
				Enayites
			Wegelea n. g.	
		Idoceratinae	*Idoceras*	
			Subnebrodites	
	Ataxioceratidae	Ataxioceratinae	*Orthosphinctes*	*Orthosphinctes*
				Praeataxioceras
			Ataxioceras	*Parataxioceras*
	Aulacostephanidae	Pictoniinae	*Ringsteadia*	
		Aulacostephaninae	*Rasenia*	*Eurasenia*
			Sutneria	*Sutneria*
	Pachyceratidae		*Protophites*	
	Aspidoceratidae	Peltoceratinae	*Gregoryceras*	*Pseudogregoryceras*
				Gregoryceras
		Euaspidoceratinae	*Euaspidoceras*	
			Epipeltoceras	
		Aspidoceratinae	*Orthaspidoceras*	

Tab. 2: Systematic overview of the figured ammonite genera and subgenera. Mainly after ARKELL *et al.* (1957) and DONOVAN *et al.* (1981).

The glauconitic, carbonate internal mould is wholly septate. The slightly convex whorl sides have a hardly perceptible lateral canal. The delicate, almost invisible primary ribs end at this canal. These faint features can only be discerned on particularly well-preserved specimens and have not been described by earlier authors. The secondary ribs are low and broad. There are eight secondaries on the last half whorl. The greatest whorl thickness is between the umbilical margin and the lateral canal. The umbilical margin is a conspicuous edge. The median keel is only slightly higher than the marginal keels.

Age: late Antecedens Subchron of the Transversarium Chron.

4.1.4 *Trimarginites stenorhynchus* (Oppel 1863)
pl. 7, fig. 3

Synonymy

1961 *Trimarginites stenorhynchus* (Oppel) – Christ, p. 288, pl. 16, figs. 4–5, with synonymy
1991 *Trimarginites stenorhynchus* (Oppel) – Schlampp, pl. 34, fig. 1
1994 *Trimarginites stenorhynchus* (Oppel) – Schlegelmilch, p. 46, pl. 14, fig. 4

Material: MNHB J 27372

Locality: section RG 276, Gygi et al. (1979, fig. 3), Chalch quarry, Holderbank AG, bed 34, upper Birmenstorf Member.

Description: Dimensions			
	D	44 mm	
	Wh	20 mm	45 %
	Wt	9 mm	20 %
	U	9 mm	20 %

The carbonate internal mould is septate to the diameter of ca 28 mm. The body chamber is complete and occupies two thirds of the last whorl. The peristome is falcate. The lappets are not preserved. The compressed inner whorls are smooth. Four low, swollen secondary ribs are visible on the body chamber near the peristome. The median keel is only slightly higher than the lateral ones. There is a pronounced egression of the umbilical suture line on the last half whorl.

Age: Luciaeformis Subchron of the Transversarium Chron.

Subfamily Taramelliceratinae Spath 1928
Genus *Taramelliceras* Del Campana 1904
Subgenus *Proscaphites* Rollier 1909

Subgeneric type species: *Ammonites anar* (Oppel 1863)

4.1.5 *Taramelliceras (Proscaphites) anar* (Oppel 1863)
Pl. 7, fig. 2

Synonymy

1955 *Taramelliceras (Proscaphites) anar* (Oppel) – Hölder, p. 81, pl. 16, fig. 3, with synonymy
v 1966 *Taramelliceras (Proscaphites) anar* (Oppel) – Gygi, p. 938, pl. 4, fig. 2
1967 *Proscaphites anar* (Oppel) – Malinowska, p. 78, pl. 2, fig. 6
v 1977 *Taramelliceras anar* (Oppel) – Matyja, tab. 2, pl. 3, fig. 10
1991 *Taramelliceras (Proscaphites) anar* (Oppel) – Schlampp, p. 81, pl. 27, fig. 6
1994 *Taramelliceras (Proscaphites) anar* (Oppel) – Schlegelmilch, p. 32, pl. 7, fig. 13

Material: MNHB J 25960

Locality: section RG 81b, Gygi (1977, pl. 11, fig. 6), excavation below Räckolterenbuck, Gächlingen SH, bed 14b, upper Mumienkalk Bed.

Description: Dimensions			
	D	34.0 mm	
	Wh	16.0 mm	47 %
	Wt	10.6 mm	31 %
	U	5.4 mm	16 %

The glauconitic, carbonate internal mould is septate to the diameter of 24 mm. The body chamber occupies one half of the last whorl. The ribs are fine and nearly radial on the phragmocone. On the body chamber they become falcate. There the primary ribs occur at irregular intervals. At half the whorl height they split into two to six secondary ribs. The secondaries first bend slightly backward, then forward on the siphonal margin. They form a proconvex arc on the siphonal side. On the siphonal margin of the body chamber there are four pairs of elongate clavi. The elongation is along the spiral line. The siphonal side is rounded except at the end of the body chamber. There the siphonal side is somewhat flattened and bears a low, rounded keel. The secondary ribs pass uninterrupted over the keel. An irregularity of the coiling is characteristic for the species: near the aperture the siphonal line bends inward whereas there is a pronounced egression of the umbilical suture line. Therefore the whorl height of the body chamber increases only little from the end of the phragmocone to the aperture.

Remark: The photograph of *Taramellicers (Proscaphites) anar* (Oppel) in Hölder (1955, pl. 16, fig. 3) is at the scale of 2:1. The author did not state this fact in the caption to the plate on p. 146 nor in the description on p. 81 where no dimensions are given. But after the description of the taxon he draws attention to fig. 29 in Beilage 1 and states that this figure is at the scale of

× 2. The size of the drawing corresponds to the size of fig. 3 in pl. 16.

Age: late Antecedens to Luciaeformis Subchron.

Subgenus *Metahaploceras* SPATH 1925

Subgeneric type species: *Ammonites strombecki* OPPEL 1857, designated by HÖLDER (1955, p. 70).

4.1.6 *Taramelliceras (Metahaploceras) wenzeli* (OPPEL 1863)
Pl. 11, figs. 2–3

Synonymy

1983 *Taramelliceras (Metahaploceras) wenzeli* (OPPEL) – SCHAIRER, p. 39, pl. 1, figs. 12–15, with synonymy.
1994 *Taramelliceras (Metahaploceras) wenzeli* (OPPEL) – SCHLEGELMILCH, p. 37, pl. 10, fig. 6

Material: MNHB J 32276

Locality: section RG 78, GYGI (1969, pl. 16), Mülitobel, Wilchingen SH, bed 60, Wangental Member.

Description: Dimensions			
	D	32.0 mm	
	Wh	18.0 mm	56 %
	Wt	–	–
	U	3.5 mm	11 %

The carbonate internal mould is septate to the diameter of ca 15 mm. The last half whorl is formed by the body chamber. The original description by OPPEL (1863, p. 206) agrees very well with the specimen J 32276. The falcate ribs begin at the umbilical suture line. The ribs are first strong, but from the middle of the whorl sides they are attenuated. At the siphonal margin they fade away completely. The rounded siphonal side of the last whorl is smooth. Faint intercalated ribs appear in the middle of the whorl sides. The strong ribs are somewhat approximated near the aperture. This is an indication that the specimen is adult. The *Taramelliceras (Metahaploceras) wenzeli* J 32277 (pl. 11, fig. 3) from the Knollen Bed of Mellikon is more densely ribbed and there are no intercalated ribs.

Age: Latest Bimammatum Chron to early Planula Chron.

Genus *Creniceras* MUNIER-CHALMAS 1892

Type species: *Ammonites renggeri* OPPEL 1863

4.1.7 *Creniceras renggeri* (OPPEL 1863)
Pl. 1, fig. 6, 7

Synonymy

1955 *Creniceras renggeri* (OPPEL) – HAAS, p. 111, pl. 17, fig. 18–37, with synonymy
1956 *Creniceras renggeri* (OPPEL) – ARKELL, pl. 38, fig. 5
1957 *Creniceras renggeri* (OPPEL) – ZIEGLER, p. 567, figs. 13 c-f
1957 *Creniceras renggeri* (OPPEL) – ARKELL *et al.*, p. L282, fig. 334/3
1966 *Creniceras renggeri* (OPPEL) – PALFRAMAN, p. 301, pl. 50, figs. 2–4, pl. 51, figs. 1–12, pl. 52, figs. 1–8
1973 *Creniceras renggeri* (OPPEL) – SAPUNOV, p. 109, pl. 2, fig. 2
1979 *Creniceras renggeri* (OPPEL) – SAPUNOV, p. 60, pl. 13, figs. 5, 6
1982 *Creniceras renggeri* (OPPEL) – DEBRAND-PASSARD, pl. 10, fig. 11
v 1990a *Creniceras renggeri* (OPPEL) – GYGI, pl. 4, figs. 19, 20, 23, 24
v 1991b *Creniceras renggeri* (OPPEL) – GYGI, p. 21, pl. 8, fig. 1, with synonymy
1991 *Creniceras renggeri* (OPPEL) – SCHLAMPP, p. 89, pl. 32, fig. 8

Material: MNHB J 31089, J 31117

Locality: section RG 280, GYGI (1990a, fig. 2), clay pit of Ampthil, Liesberg BL, lower part of bed 7, Renggeri Member.

Description of J 31089: Dimensions			
	D	26.5 mm	
	Wh	9.0 mm	34 %
	Wt	7.0 mm	26 %
	U	8.6 mm	32 %

The internal mould of iron sulfide is septate to the diameter of 18 mm. The body chamber occupies more than half of the last whorl. A constriction before the peristome is visible at the end of the body chamber. The specimen is a complete adult to judge of the strong egression of the umbilical suture line on the last whorl. There are some very fine radial, hardly perceptible ribs at the diameter of 10 mm. These ribs are only visible on the siphonal half of the whorl side. The siphonal teeth begin at the diameter of 14 mm and are prominent from the diameter of 18 mm. The last two teeth before the peristome are attenuated.

Discussion: see GYGI (1991b, p. 14). The nomenclatorial and taxonomic problems relating to this taxon have been dealt with by GYGI (1991a).

Age: The figured, typical specimens are from the Scarburgense Subchron of the Mariae Chron. The vertical range of closely related forms continues into the Cordatum Zone.

Subfamily Streblitinae Spath 1925
Genus *Streblites* Hyatt 1900

Type species: *Ammonites tenuilobatus* Oppel 1858

4.1.8 *Streblites tenuilobatus* (Oppel 1858)
Pl. 14, fig. 4

Synonymy

1964 *Streblites tenuilobatus tenuilobatus* (Oppel) – Höroldt, p. 23, pl. 1, figs. 1–3, with synonymy
1977 *Streblites tenuilobatus* (Oppel) – Ziegler, pl. 3, fig. 6
1991 *Streblites tenuilobatus* (Oppel) – Schlampp, pl. 31, fig. 2
1994 *Streblites tenuilobatus* (Oppel) – Schlegelmilch, p. 43, pl. 12, fig. 13

Material: MNHB J 32269

Locality: section RG 70, Gygi (1969, pl. 17), large quarry, Mellikon AG, bed 124, lower Baden Member.

Description: Dimensions			
	D	42 mm	
	Wh	25 mm	60 %
	Wt	12 mm	29 %
	U ca.	3 mm	ca. 7 %

The glauconitic, carbonate internal mould is wholly septate. There are ten fine, low, slightly prorsiradiate primary ribs on the last half whorl that fade out near the middle of the whorl sides where there is a spiral row of delicate tubercles. One tubercle is associated with every primary rib. The faint secondary ribs begin close to the siphonal margin. There are about seven secondaries per primary rib. The secondary ribs fade away on the siphonal side and do not touch the keel. Only traces of the hollow, sharp keel are preserved.

Age: Hypselocyclum Chron.

Superfamily Stephanocerataceae Neumayr 1875
Family Cardioceratidae Siemiradzki 1891
Subfamily Cardioceratinae Siemiradzki 1891
Genus *Quenstedtoceras* Hyatt 1877

Type species: *Ammonites leachi* Sowerby 1819

4.1.9 *Quenstedtoceras lamberti lamberti* (Sowerby 1819)
Pl. 1, fig. 1

Synonymy

1970 *Quenstedtoceras (L.) lamberti lamberti*, morphotype *lamberti* (Sowerby) – Marchand, p. 63, pl. 7, fig. 1–4, pl. 8, fig. 1–14, with synonymy
v 1982 *Quenstedtoceras lamberti lamberti* (Sowerby) – Marchand, in Gygi & Marchand, pl. 1, fig. 1–3
1986 *Quenstedoceras lamberti* (Sowerby) – Marchand, p. 247, pl. 4, fig. 1–2, 5–6, pl. 5, fig. 1–2, 6, 10, with synonymy
1991 *Quenstedtoceras lamberti* (Sowerby) – Page, p. 113, pl. 17, fig. 7, 8, *non* pl. 18, fig. 8, 9.

Material: MNHB J 31715

Locality: section RG 60, Gygi (1969, pl. 17), Eisengraben, Gansingen AG, bed 3, Schellenbrücke Bed.

Description: Dimensions			
	D	95 mm	
	Wh	38 mm	40 %
	Wt	26 mm	27 %
	U	28 mm	29 %

The iron oolitic, carbonate internal mould is septate to the diameter of about 73 mm. It is a complete adult macroconch with the peristome. The inner whorls are compressed. At the beginning of the body chamber the whorl thickness increases more than proportionally and so does the height of the steep umbilical wall. At the peristome the umbilical wall becomes rounded. The aperture has thus an oval cross-section. The ribbing fades already on the last half whorl of the phragmocone and disappears on the body chamber.

Age: Lamberti Subchron of the Lamberti Chron.

Genus *Cardioceras* Neumayr & Uhlig 1881
Subgenus *Scarburgiceras* Buckman 1924

Subgeneric type species: *Ammonites scarburgensis* Young & Bird 1828

4.1.10 *Cardioceras (Scarburgiceras) paucicostatum* Lange 1973
Pl. 1, fig. 2

Synonymy

1973 *Cardioceras (Scarburgiceras) paucicostatum* sp. n. – Lange, p. 90, pl. 20, figs. 3, 4, 6, 9
1983 *Cardioceras (Scarburgiceras) paucicostatum* Lange – Wright, pl. 18, figs. 2–3
1986 *Cardioceras paucicostatum* Lange – Marchand, p. 287, pl. 7, figs. 1–5, 7, 9, with synonymy
v 1990a *Cardioceras (Scarburgiceras) paucicostatum* Lange – Gygi, p. 179, fig. 2, pl. 3, figs. 12, 14
1991 ? *Quenstedtoceras paucicostatum* (Lange) – Page, p. 114, pl. 17, fig. 9

Material: MNHB J 31219

Locality: section RG 280, Gygi (1990a, fig. 2), clay pit of Ampthil, Liesberg BL, lower part of bed 6, upper Herznach Formation.

Description: The marly, iron oolitic internal mould of this specimen is so incompletely preserved that it cannot be measured. The inner whorls are flattened. At least a part of the body chamber is preserved. There are ca. 21 primary ribs on the last whorl. The secondary ribs begin in the middle of the whorl sides between the primary ribs. There are less than two secondary ribs per primary rib. No keel is visible.

Age: The specimen has been found in the lowermost part of bed 6 in section RG 280 (pl. 30) together with *Quenstedtoceras lamberti lamberti*. The vertical range of *Cardioceras paucicostatum* straddles on the Middle/Late Jurassic boundary, the boundary between the Lamberti and Scarburgense Subzones (MARCHAND & FORTWENGLER (1994, p. 79, fig. 21)).

4.1.11 *Cardioceras (Scarburgiceras) scarburgense* (YOUNG & BIRD 1828)

Pl. 1, figs. 3–5

Synonymy

- 1986 *Cardioceras scarburgense* (YOUNG & BIRD) – MARCHAND, p. 303, pl. 8, fig. 2, with synonymy
- v 1990a *Cardioceras (Scarburgiceras) scarburgense* YOUNG & BIRD – GYGI, pl. 3, figs. 1, 2, 4, pl. 4, figs. 21, 22
- v 1990a *Cardioceras (Scarburgiceras) woodhamense* ARKELL – GYGI, pl. 3, fig. 5
- 1991 *Cardioceras (Scarburgiceras) scarburgense* (YOUNG & BIRD) – SCHLAMPP, p. 94, pl. 34, fig. 6
- 1994 *Cardioceras (Scarburgiceras) scarburgense scarburgense* (YOUNG & BIRD) – SCHLEGELMILCH, p. 23, pl. 3, fig. 2

Material: MNHB J 31103, J 31104, J 31229

Locality of J 31103: section RG 280, GYGI (1990a, fig. 2), clay pit of Ampthil, Liesberg BL, bed 7, Renggeri Member, 1.2 m above the base.

Description of J 31103: Dimensions			
	D	29.0 mm	
	Wh	13.5 mm	47 %
	Wt	9.5 mm	33 %
	U	7.0 mm	24 %

The internal mould of iron sulfide of J 31103 is wholly septate. The primary ribs are radial. There are 11 of them on the last half whorl. The primary ribs either split into two secondaries just below half the whorl height, or they continue undivided and bend forward towards the siphonal side. In the second case there is an intercalated secondary rib, so that there are two secondary ribs per primary rib in all. There is no keel on this specimen, but on the larger specimen J 31229 (pl. 1, fig. 5) the beginning of an indistinct keel can be discerned on the last half whorl.

Age: Scarburgense Subchron of the Mariae Chron.

4.1.12 *Cardioceras (Scarburgiceras) praecordatum* DOUVILLE 1912

Pl. 1, figs. 8–9

Synonymy

- 1986 *Cardioceras praecordatum* DOUVILLE – MARCHAND, p. 323, pl. 9, figs. 7–9, 13, pl. 10, figs. 5, 10-15, with synonymy
- v 1990a *Cardioceras (Scarburgiceras) praecordatum* DOUVILLE – GYGI, pl. 4, fig. 8, pl. 5, fig. 3, pl. 6, fig. 4
- 1994 *Cardioceras (Scarburgiceras) praecordatum* DOUVILLE – SCHLEGELMILCH, p. 24, pl. 3, fig. 4

Material: MNHB J 30949, J 31114

Locality: section RG 280, GYGI (1990a, fig. 2), clay pit of Ampthil, Liesberg BL, bed 7, Renggeri Member, J 31114 3.5 m above the base, J 30949 27 m above the base.

Description of J 31114: Dimensions			
	D	34 mm	
	Wh	14 mm	41 %
	Wt	8 mm	24 %
	U	10 mm	29 %

The internal mould of iron sulfide is septate to the diameter of 30 mm. The radial primary ribs are numerous and fine. There are 35 of them on the last whorl. The majority of the primary ribs split at half the whorl height into two secondary ribs that bend forward. There is a distinct keel.

Age: Praecordatum Subchron of the Mariae Chron.

4.1.13 *Cardioceras (Scarburgiceras) bukowskii* MAIRE 1938

Pl. 1, fig. 11

Synonymy

- 1986 *Cardioceras bukowskii* MAIRE – MARCHAND, p. 339, pl. 11, fig. 1, pl. 12, fig. 2
- v 1990a *Cardioceras (Scarburgiceras) bukowskii* MAIRE – GYGI, pl. 7, figs. 1, 3
- 1994 *Cardioceras (Scarburgiceras) bukowskii* MAIRE – SCHLEGELMILCH, p. 24, pl. 3, fig. 5

Material: MNHB J 30948

Locality: Creekbed northwest of La Cornée, Rebévelier JU, Renggeri Member, not *in situ*. An ill-preserved representative of this species collected from *in situ* has been figured by GYGI (1990a, pl. 6, fig. 1).

Description: Dimensions of J 30948			
	D	32 mm	
	Wh	15 mm	47 %
	Wt	9 mm	28 %
	U	7 mm	22 %

The internal mould of iron sulfide is wholly septate. There are 38 primary ribs on the last whorl. These ribs are radial. Some of them are unsplit, but the majority splits somewhat below half the whorl height into two secondary ribs. The whorl thickness is greatest where the primary ribs split. The keel is well-developed.

Discussion: *Cardioceras bukowskii* is similar to its ancestor *Cardioceras praecordatum*. The principal difference between the two forms is that *Cardioceras bukowskii* has a narrower umbilicus than *Cardioceras praecordatum*.

Age: Bukowskii Subchron of the Cordatum Chron.

Subgenus *Pavloviceras* BUCKMAN 1920

Subgeneric type species: *Quenstedtoceras pavlowi* DOUVILLE 1912

4.1.14 *Cardioceras (Pavloviceras) cf. mariae* (D'ORBIGNY 1848)

Pl. 1, fig. 10

Synonymy

v 1982 *Cardioceras (Pavloviceras)* cf. *mariae* (D'ORBIGNY) – GYGI & MARCHAND, pl. 2, fig. 7

Material: MNHB J 25206

Locality: Section RG 209, GYGI (1977, pl. 11, fig. 1), Herznach iron mine, Herznach AG, not *in situ*.

Description: Dimensions			
	D	46 mm	
	Wh	21 mm	46 %
	Wt	24 mm	52 %
	U	13 mm	28 %

The iron oolitic, carbonate internal mould is septate to the diameter of 32 mm. The body chamber occupies the last half whorl. The whorls are thicker than high, and the siphonal side is rounded. There are 18 primary ribs on the last whorl. Most of them do not bifurcate, because the majority of the secondary ribs is intercalated. The primary ribs are high and sharp. They have their highest elevation in the middle of the whorl sides and become attenuated at the siphonal side.

Discussion: The specimen cannot be assigned to *Cardioceras (Pavloviceras) mariae* (D'ORBIGNY), because the whorls are too thick and the siphonal side is rounded. The ribs form a more distinct chevron on the siphonal side than is indicated by D'ORBIGNY (1847, pl. 179, fig. 6) for his *mariae*.

Age: Scarburgense Subchron of the Mariae Chron.

Subgenus *Cardioceras* NEUMAYR & UHLIG 1881

Subgeneric type species: *Ammonites cordatus* SOWERBY 1813

4.1.15 *Cardioceras (Cardioceras) costicardia vulgare* ARKELL 1946

Pl. 2, fig. 1

Synonymy

v 1995 *Cardioceras (Cardioceras) costicardia vulgare* ARKELL – GYGI, fig. 3/2, with synonymy

Material: MNHB J 31646

Locality: Creek bed northwest of La Cornée, Rebévelier JU, Renggeri Member.

Description: Dimensions			
	D	49 mm	
	Wh	21 mm	42 %
	Wt	17 mm	34 %
	U	14 mm	29 %

The internal mould of iron sulfide is wholly septate. There are 26 primary ribs on the last whorl. The ribs end in a tubercle and split there into two secondary ribs that bend strongly forward on the siphonal margin. Some additional secondary ribs are intercalated.

Discussion: The figured specimen has more primary ribs than the type of the subspecies of ARKELL that has 22 primaries at the corresponding ontogenetic stage. The shoulders have a stronger inclination than those of the holotype of *costicardia* that has been refigured by ARKELL (1945, pl. 69, fig. 17).

Age: Costicardia Subchron of the Cordatum Chron.

4.1.16 *Cardioceras (Cardioceras) cordatum* (SOWERBY 1813)

Pl. 2, fig. 3

Synonymy

1986 *Cardioceras cordatum* (SOWERBY) – MARCHAND, p. 381, pl. 15, figs. 27, 31, pl. 16, figs. 8, 9, pl. 17, fig. 6, with synonymy
v 1989 *Cardioceras (Cardioceras) cordatum* (SOWERBY) – FISCHER & GYGI, figs. 4 H-I
non 1991 *Cardioceras (Cardioceras) cordatum* (SOWERBY) – SCHLAMPP, pl. 34, figs. 3, 4
1994 *Cardioceras (Cardioceras) cordatum* (SOWERBY) – SCHLEGELMILCH, p. 25, pl. 3, fig. 11

Material: MNHB J 23027

Locality: section RG 207, GYGI & MARCHAND (1982, fig. 2), excavation beside water conduit in Churz Tal, Siblingen SH, bed 14a, Glaukonitsandmergel Bed.

Description: Dimensions			
	D	47 mm	
	Wh	19 mm	40 %
	Wt	16 mm	34 %
	U	15 mm	32 %

The glauconitic and ferruginous carbonate internal mould is wholly septate. There are 13 primary ribs on the last whorl. These ribs end in a tubercle in the middle of the whorl sides. Two secondary ribs issue from the tubercles and bend abruptly forward on the siphonal margin, together with a third, intercalated secondary rib. The secondary ribs are attenuated to near-disappearance on the siphonal shoulders and there run almost tangentially. Where they are weakest, they bifurcate into fine tertiary ribs. The tertiaries rise in an angle of about 45° towards the keel and form fine denticles where they cross the keel.

Age: Cordatum Subchron of the Cordatum Chron.

4.1.17 *Cardioceras (Cardioceras) persecans* (BUCKMAN 1925)

Pl. 2, fig. 4

Synonymy

1986 *Cardioceras cordatum* (SOWERBY), morphe mince, variant *persecans* – MARCHAND, p. 397, pl. 15, figs. 10, 22, pl. 16, figs. 2, 3, 11, pl. 17, fig. 7, pl. 18, figs. 3, ?10, with synonymy
v 1993 *Cardioceras (Cardioceras) persecans* (BUCKMAN) – GYGI & MARCHAND, pl. 2, figs. 2, 3, 4

Material: MNHB J 24982

Locality: section RG 208, GYGI (1977, pl. 11, fig. 2), excavation on Brunnrain, Üken AG, bed 9, upper Schellenbrücke Bed.

Description: Dimensions			
	D	50 mm	
	Wh	23 mm	46 %
	Wt	15 mm	30 %
	U	14 mm	28 %

The iron oolitic, carbonate internal mould is septate to the diameter of 44 mm. There are 26 primary ribs on the last whorl. The primaries end in a low tubercle on half the whorl height. One secondary rib may originate from a tubercle, but in most cases the secondaries are intercalated between the primary ribs. There are two and in one case three secondary ribs per primary. The secondary ribs form a tubercle on the siphonal margin. There they bend sharply forward and become weak towards the keel. Some of the secondary ribs bifurcate near the base of the keel to form fine tertiaries. These grow stronger on the keel and form denticles where they cross it.

Age: Cordatum Subchron of the Cordatum Chron.

4.1.18 *Cardioceras (Cardioceras)* cf. *stella* ARKELL 1947

Pl. 2, fig. 5

Synonymy

v 1982 *Cardioceras (Cardioceras)* cf. *stella* ARKELL – GYGI & MARCHAND, pl. 8, fig. 1

Material: MNHB J 25184

Locality: section RG 209, GYGI (1977, pl. 11, fig. 1), Herznach iron mine, Herznach AG, bed 7, lower Schellenbrücke Bed.

Description: Dimensions			
	D	61 mm	
	Wh	29 mm	48 %
	Wt	21 mm	34 %
	U	17 mm	27 %

The iron oolitic, carbonate internal mould is septate to the diameter of 46 mm. The last whorl has 21 sharp primary ribs. These ribs end in tubercles somewhat below half the whorl height. One secondary rib continues from the tubercles, and one or two additional secondary ribs are intercalated. The tubercles of the secondary ribs form the siphonal margin where the secondaries bend abruptly forward. A few secondary ribs vanish on the inclined shoulders. Most secondaries continue over the shoulders to the base of the keel where they are attenuated. Some of them split there and form tertiary ribs. The ribs crossing the keel are enhanced in denticles.

Discussion: The specimen J 25184 cannot be assigned to *Cardioceras (Cardioceras) stella* ARKELL, because it is too small. It is septate only to the diameter of 46 mm, whereas the holotype must have been septate, according to ARKELL (1946, p. 333), to a diameter of at least 125 mm. The umbilicus of the holotype is 24 % as compared with 27 % of J 25184. The specimen from Herznach is also more densely ribbed than the holotype: at a diameter of 61 mm it has 21 primary ribs, yet the holotype has only 16 primary ribs at the diameter 65 mm.

Age: Cordatum Subchron of the Cordatum Chron.

Subgenus *Subvertebriceras* ARKELL 1941

Subgeneric type species: *Cardioceras densiplicatum* BODEN 1911.

4.1.19 *Cardioceras (Subvertebriceras) costellatum* BUCKMAN 1925

Pl. 2, fig. 2

Synonymy

v 1995 *Cardioceras (Subvertebriceras) costellatum* BUCKMAN – GYGI, p. 19, fig. 3/3, with synonymy

Material: MNHB J 31648

Locality: Bollement, St-Brais JU, Renggeri Member.

Description: Dimensions			
	D	35 mm	
	Wh	15 mm	43 %
	Wt	13 mm	37 %
	U	10 mm	29 %

The internal mould of iron sulfide is wholly septate. 32 primary ribs have been counted on the last whorl. Some of the primary ribs end in an elongated, low tubercle in the middle of the whorl sides. There they split up into two secondary ribs. Some of the primaries are undivided. The ribs are enhanced on the siphonal margin and then are attenuated on the shoulders. They grow stronger again on the keel where they form denticles.

Age: Costicardia Subchron of the Cordatum Chron.

4.1.20 *Cardioceras (Subvertebriceras) densiplicatum* BODEN 1911
Pl. 2, fig. 7

Synonymy

1911 *Cardioceras vertebrale* SOW. sp. var. *densiplicata* nov. var. – BODEN, p. 159, pl. 1, fig. 14
1942 *Cardioceras (Subvertebriceras) densiplicatum* BODEN – ARKELL, p. 240, pl. 52, figs. 3–5, pl. 53, figs. 1, 4, 7–12, with synonymy
1977 *Cardioceras (Subvertebriceras) densiplicatum* BODEN – BOURSEAU, p. 92, pl. 8, figs. 5, 10, with synoymy
1979 *Cardioceras (Subvertebriceras) densiplicatum* BODEN – SYKES & CALLOMON, pl. 112, fig. 4
v 1982 *Cardioceras (Vertebriceras) densiplicatum* BODEN – GYGI & MARCHAND, pl. 11, figs. 5–6
1984 *Cardioceras (Subvertebriceras) densiplicatum* BODEN – TARKOWSKI, pl. 11, figs. 1, 6, 7, pl. 12, fig. 6
v 1989 *Cardioceras (Vertebriceras) densiplicatum* BODEN – FISCHER & GYGI, figs. 4 B-C
1994 *Cardioceras (Subvertebriceras) densiplicatum* BODEN – SCHLEGELMILCH, p. 27, pl. 5, fig. 1

Material: MNHB J 23045

Locality: section RG 212, GYGI (1977, pl. 11, fig. 7), excavation above the shooting range in Churz Tal, Siblingen SH, bed 7, Mumienmergel Bed.

Description: Dimensions			
	D	46 mm	
	Wh	20 mm	43 %
	Wt	19 mm	41 %
	U	13 mm	28 %

The glauconitic, carbonate internal mould is wholly septate. There are 20 primary ribs on the last whorl. The ribs end in a high tubercle at half the whorl height. Two and occasionally three secondary ribs may be counted per primary rib. The secondary ribs form tubercles at the siphonal margin. Some of the secondaries split on the almost horizontal shoulders and form fine tertiary ribs. The strong keel is denticulated.

Age: Densiplicatum Subchron of the Transversarium Chron.

Subgenus *Maltoniceras* ARKELL 1941

Subgeneric type species: *Ammonites maltonensis* YOUNG & BIRD 1822

4.1.21 *Cardioceras (Maltoniceras) schellwieni* BODEN 1911
Pl. 2, fig. 12

Synonymy

1911 *Cardioceras Schellwieni* nov. sp. – BODEN, p. 158, pl. 2, fig. 3
1941 *Cardioceras (Maltoniceras) schellwieni* BODEN – ARKELL, p. 234, pl. 51, fig. 11
v 1982 *Cardioceras (Maltoniceras) schellwieni* BODEN – GYGI & MARCHAND, pl. 13, figs. 3, 6, 7
1994 *Cardioceras (Maltoniceras?) schellwieni* BODEN – SCHLEGELMILCH, p. 28, pl. 6, fig. 1

Material: MNHB J 23029

Locality: section RG 207, GYGI & MARCHAND (1982, fig. 2), excavation beside water conduit in Churz Tal, Siblingen SH, bed 16a, lower Mumienkalk Bed.

Description: Dimensions			
	D	85 mm	
	Wh	37 mm	44 %
	Wt	27 mm	32 %
	U	22 mm	26 %

The glauconitic, carbonate internal mould with parts of the shell is septate to the diameter of 58 mm. More than half of the last whorl is occupied by the body chamber. The specimen appears to be a nearly complete adult. The inner whorls have been well described by BODEN (1911, p. 158). On the last whorl of specimen J 23029, at the end of the phragmocone, there are 9 widely-spaced primary ribs. The ribs are straight and radial. They end in a tubercle at half the whorl height. There are two secondaries per primary rib. One secondary begins near a median tubercle, whereas the second is intercalated. The secondary ribs form a tubercle on the siphonal margin. The keel is high and finely denticulated. There are three to four denticles per secondary rib. No tertiary ribs are visible on the inclined shoulders. The ribbing fades away almost completely on the body chamber.

Age: Antecedens Subchron of the Transversarium Chron.

Subgenus *Miticardioceras* BUCKMAN 1923

Subgeneric type species: *Miticardioceras mite* BUCKMAN 1923, pl. 375.

4.1.22 *Cardioceras (Miticardioceras) tenuiserratum* (OPPEL 1863)
Pl. 2, fig. 10

Synonymy

1986 *Cardioceras tenuiserratum* (OPPEL) – MARCHAND, p. 425, pl. 22, figs. 11–12, with synonymy
1991 *Cardioceras (Miticardioceras) tenuiserratum* (OPPEL) – SCHLAMPP, p. 95, pl. 34, fig. 8
1994 *Cardioceras (Cawtoniceras) tenuiserratum* (OPPEL) – SCHLEGELMILCH, p. 27, pl. 5, fig. 3

Material: MNHB J 25158

Locality: section RG 208, GYGI (1977, pl. 11, fig. 2), excavation on Brunnrain, Üken AG, bed 12 or higher up, lower Birmenstorf Member.

Description: Dimensions			
	D	24 mm	
	Wh	10 mm	42 %
	Wt	7 mm	29 %
	U	7 mm	29 %

The carbonate internal mould is septate to the diameter of 16 mm. The last two septa are approximated and indicate that the specimen is adult. The body chamber occupies two thirds of the last whorl. The first primary ribs appear at the diameter of 6 mm. They begin on the rounded umbilical margin and are radial. The ribs end in a low tubercle in the middle of the whorl sides. There are 12 primary ribs per whorl at the diameter of 19 mm. The secondary ribs are reduced to small tubercles on the siphonal margin. Two such tubercles can be counted per primary rib. The strongly inclined shoulders are smooth. The finely denticulated keel is low. There are four denticles per secondary tubercle. The ornamentation fades towards the end of the body chamber.

Age: Late Antecedens to early Luciaeformis Subchron of the Transversarium Chron.

Genus *Amoeboceras* Hyatt 1900

Type species: *Ammonites alternans* von Buch 1832

4.1.23 *Amoeboceras glosense* (Bigot & Brasil 1904)

Pl. 5, fig. 3

Synonymy

1904 *Cardioceras alternans* var. *glosensis* – Bigot & Brasil, p. 17, pl. 1, fig. 17
1916 *Cardioceras alternoides* (Nikitin) – Nikitin, p. 6, pl. 1, fig. 1
1976 *Amoeboceras glosense* (Bigot & Brasil) – Sykes & Surlyk, fig. 5D
1979 *Amoeboceras glosense* (Bigot & Brasil) – Sykes & Callomon, p. 872, pl. 113, figs. 5–7, 9, pl. 115, figs. 1, 9, pl. 116, figs. 1–3, 6–9
v 1993 *Amoeboceras glosense* (Bigot & Brasil) – Atrops et al., pl. 1, figs. 2–4

Material: MNHB J 27679.

Locality: section RG 276, Gygi *et al.* (1979, fig. 3), Chalch quarry, Holderbank AG, probably bed 32, Birmenstorf Member.

Description: Dimensions			
	D	50 mm	
	Wh	21 mm	42 %
	Wt	15 mm	30 %
	U	16 mm	32 %

The carbonate internal mould is septate to the diameter of 39 mm. One fourth of the last whorl is occupied by the body chamber. 25 primary ribs can be counted on the last whorl. They are radial and straight on the phragmocone. Many of them are undivided. On the body chamber the ribbing is modified: the primary ribs end in a tubercle slightly above half the whorl height. There they split up into two secondary ribs. The secondaries are enhanced at the siphonal margin and continue to near the base of the keel where they vanish. The sharp keel is well-preserved only on the phragmocone. It has few and indistinct denticles.

Discussion: The holotype of *Amoeboceras glosense* as refigured by Sykes & Callomon (1979, pl. 155, fig. 9) has a diameter of 86 mm and is wholly septate. The specimen MNHB J 27679 from Holderbank is septate to a diameter of only 39 mm and is therefore much smaller. The modified ribbing on the body chamber of J 27679 suggests that the specimen cannot be assigned without doubt to the taxon *glosense*. However, Sykes & Callomon (1979) assume a certain variability within this taxon: in the specimens 5 and 6 of their pl. 113 there are apparently weak tubercles on the whorl sides. The specimen J 27679 from Holderbank is therefore assigned with reservation to *Amoeboceras glosense*.

Age: Late Luciaeformis Subchron of the Transversarium Chron.

4.1.24 *Amoeboceras* cf. *serratum* (Sowerby 1813)

Pl. 8, fig. 4

Synonymy

v 1993 *Amoeboceras serratum* (Sowerby)-*Amoeboceras ovale* (Quenstedt) intermediate form – Atrops *et al.*, pl. 1, fig. 6

Material: MNHB J 31456

Locality: Quarry 500 m north of Mönthal AG, Gerstenhübel Beds, Effingen Member.

Description: Dimensions			
	D	18.4 mm	
	Wh	7.8 mm	42 %
	Wt	–	–
	U	5.0 mm	27 %

This tiny specimen is only an imprint in lime mudstone. There are 30 primary ribs on the last whorl. They begin on the rounded umbilical wall and swing slightly back until the umbilical margin. Then they bend somewhat forward. In the middle of the whorl sides they swing very little back again and end at the siphonal margin in an elongate tubercle. Short secondary ribs are intercalated between the majority of the primaries. There is a prominent keel with smooth sides and regular, fine denticles.

Discussion: The ribbing of J 31456 compares well with the inner whorls of the neotype of *Amoeboceras serratum* (Sowerby) as figured by Sykes & Callomon (1979, pl. 117, fig. 1c). The neotype has somewhat more primary ribs. It is so much larger than the specimen from Mönthal that J 31456 cannot be assigned to *A. serratum*. Atrops et al. (1993, pl. 1, fig. 6) classified the specimen from Mönthal as an intermediate form between *Amoeboceras serratum* (J. Sowerby) and *Amoeboceras ovale* (Quenstedt).

Age: It is difficult to establish the age of the Gerstenhübel Beds for lack of diagnostic ammonites. According to the mineralostratigraphic correlations by Gygi & Persoz (1986, pl. 1), this prominent limestone unit is somewhat younger than the latest

Perisphinctes (Dichotomoceras) bifurcatus (QUENSTEDT) and considerably older than *Euaspidoceras hypselum* (OPPEL). The age of *Amoeboceras* cf. *serratum* J 31456 is therefore probably the late Bifurcatus Chron.

4.1.25 *Amoeboceras ovale* (QUENSTEDT 1849)
Pl. 10, fig. 2

Synonymy

1915 *Cardioceras ovale* QUENSTEDT, emend. SALFELD – SALFELD, p. 166, pl. 16, figs. 1–2, 5, 8–10, with synonymy
1988 *Amoeboceras ovale* (QUENSTEDT) – MATYJA & WIERZBOWSKI, pl. 1
v 1993 *Amoeboceras ovale* (QUENSTEDT) – ATROPS *et al.*, pl. 1, fig. 9
1994 *Amoeboceras ovale* (QUENSTEDT) – MATYJA & WIERZBOWSKI, pl. 1, figs. 4–7, 11–12
1994 *Amoeboceras (Amoeboceras) ovale* (QUENSTEDT) – SCHLEGELMILCH, p. 30, pl. 7, fig. 3

Material: MNHB J 25608

Locality: section RG 70, GYGI (1969, pl. 17), large quarry, Mellikon AG, bed 6, lower Crenularis Member.

Description: Dimensions			
	D	35 mm	
	Wh	13 mm	37 %
	Wt	–	–
	U	11 mm	31 %

The carbonate internal mould is septate to the diameter of 20 mm. Three quarters of the last whorl are occupied by the body chamber. There are 33 primary ribs on the last whorl. The ribs begin on the rounded umbilical wall and first swing strongly backward. On the internal part of the whorl sides the primary ribs lean forward. In the middle of the whorl sides they bend again slightly backward. The primary ribs end on the body chamber somewhat above half the whorl height. Secondary ribs appear in their place that are intercalated between the primaries. There are 19 primary ribs and 24 secondaries on the last half whorl. The high and narrow keel has smooth walls and fine, sharp denticles.

Age: Grossouvrei Subchron of the Bifurcatus Chron to the Hypselum Subchron of the Bimammatum Chron.

4.1.26 *Amoeboceras tuberculatoalternans* (NIKITIN 1878)
Pl. 10, fig. 3

Synonymy

1915 *Cardioceras tuberculato-alternans* NIKITIN – SALFELD, p. 162, pl. 17, fig. 4, with synonymy
v 1993 *Amoeboceras tuberculatoalternans* (NIKITIN) – ATROPS *et al.*, pl. 1, fig. 14

Material: MNHB J 31462

Locality: section RG 76, GYGI (1969, fig. 2), Hornbuck, Erzingen D, bed 11, Hornbuck Member.

Description: Dimensions			
	D	18 mm	
	Wh	8 mm	44 %
	Wt	7 mm	39 %
	U	5 mm	28 %

The carbonate internal mould is septate to the diameter of 11 mm. The last two septa are approximated and indicate that this small specimen is adult. The primary ribs begin at the rounded umbilical margin and lean slightly forward. In the middle of the whorl sides they become radial and form a distinct tubercle. Beyond this tubercle the primary ribs are strongly attenuated. They are again enhanced forming a tubercle at the siphuncular margin. There the ribs turn sharply forward and vanish completely on the shoulders which are horizontal in cross-section. The secondary ribs are intercalated at irregular intervals. The keel is low and has smooth sides. It bears sharp denticles.

Age: Bimammatum Subchron of the Bimammatum Chron.

Superfamily Perisphinctaceae STEINMANN 1890
Family Perisphinctidae STEINMANN 1890
Subfamily Perisphinctinae STEINMANN 1890
Genus *Perisphinctes* WAAGEN 1869

Type species: *Ammonites variocostatus* BUCKLAND 1836

Subgenus *Neomorphoceras* ARKELL 1953

Subgeneric type species: *Ammonites Chapuisi* OPPEL 1857

4.1.27 *Perisphinctes (Neomorphoceras) chapuisi* (OPPEL 1857)
Pl. 8, fig. 6

Synonymy

1966 *Perisphinctes (Neomorphoceras) chapuisi* (OPPEL) – ENAY, p. 443, with synonymy
1994 *Neomorphoceras chapuisi* (OPPEL) – SCHLEGELMILCH, p. 62, pl. 21, fig. 4

Material: MNHB J 26129

Locality: section RG 207, GYGI & MARCHAND (1982, fig. 2), excavation beside water conduit in Churz Tal, Siblingen SH, bed 16b, upper Mumienkalk Bed.

Description: Dimensions			
	D	18 mm	
	Wh	5 mm	28 %
	Wt	5 mm	28 %
	U	8 mm	44 %

The glauconitic, carbonate internal mould is septate to the diameter of 12 mm. The last two septa are somewhat approximated. The body chamber is complete to the peristome and occupies two thirds of the last whorl. There is a conspicuous constriction before the peristome. A siphuncular furrow is visible on the last quarter whorl of the phragmocone. On the last half whorl of the phragmocone there are distinct, straight primary ribs that are slightly prorsiradiate (inclined forward). They split into two secondary ribs at two thirds the whorl height. The secondaries are interrupted at the siphonal furrow. The umbilicus of the inner whorls is narrow, but it rapidly increases on the last half whorl of the phragmocone. The last whorl covers the preceding one only slightly. The whorl thickness even decreases a little from the end of the phragmocone to the aperture.

Age: late Antecedens Subchron to Luciaeformis Subchron of the Transversarium Chron.

4.1.28 *Perisphinctes (Neomorphoceras) collinii* (Oppel 1863)

Pl. 8, fig. 7

Synonymy

1966 *Perisphinctes (Neomorphoceras) collinii* (Oppel) – Enay, p. 444, with synonymy
1991 *Neomorphoceras collinii* (Oppel) – Schlampp, pl. 1, figs. 1–2
1994 *Neomorphoceras collinii* (Oppel) – Schlegelmilch, p. 63, pl. 21, fig. 10

Material: MNHB J 24170

Locality: section RG 230, Gygi (1977, pl. 11, fig. 3), excavation north of Eisengraben, Gansingen AG, upper Birmenstorf Member.

Description:	Dimensions			
		D	38.0 mm	
		Wh	9.4 mm	25 %
		Wt	9.5 mm	25 %
		U	19,0 mm	50 %

The carbonate internal mould is septate to the diameter of 22 mm. The body chamber occupies almost the entire last whorl. It ends at a constriction near the aperture, but the peristome itself is not preserved. At the end of the phragmocone there is a faint siphonal furrow. The delicate primary ribs are straight and radial. Somewhat above half the whorl height they split into two secondary ribs that continue in the same direction. The secondaries are attenuated along a narrow siphonal band. The innermost whorl has a narrow umbilicus, but on the last whorl of the phragmocone the umbilicus becomes disproportionately wider. The thickness of the last whorl does not vary.

Age: Luciaeformis Subchron of the Transversarium Chron.

Subgenus *Otosphinctes* Buckman 1926

Subgeneric type species: *Otosphinctes ouatius* Buckman 1926

4.1.29 *Perisphinctes (Otosphinctes) paturattensis* de Loriol 1901

Pl. 2, fig. 6

Synonymy

1989 *Perisphinctes (Otosphinctes) paturattensis* de Loriol – Melendez, p. 270, pl. 36, figs. 2–7, with synonymy

Material: MNHB J 23277

Locality: section RG 208, Gygi (1977, pl. 11, fig. 2), excavation on Brunnrain, Üken AG, bed 9, upper Schellenbrücke Bed.

Description:	Dimensions			
		D	40.8 mm	
		Wh	12.5 mm	31 %
		Wt	12.8 mm	31 %
		U	19.0 mm	47 %

The iron oolitic, carbonate internal mould is septate to the diameter of 27 mm. The last two septa are approximated. Two thirds of the last whorl are occupied by the body chamber. The specimen is a complete adult with the peristome and on one side with part of a lappet. The primary ribs are straight and radial. They begin at the umbilical suture line and bifurcate at about two thirds the whorl height. The secondary ribs are faint. They have the same direction as the primaries and are not attenuated at the siphonal side. There are deep and narrow constrictions every half or two thirds a whorl. The last constriction is directly before the peristome. A pair of parabolic nodes is on the body chamber at the diameter of 34 mm. The inner whorls have a depressed section.

Age: Cordatum Subchron of the Cordatum Chron.

4.1.30 *Perisphinctes (Otosphinctes) siemiradzkii* Enay 1966

Pl. 8, fig. 1 – text-fig. 41

Synonymy

1966 *Perisphinctes (Otosphinctes) siemiradzkii* n. sp. – Enay, p. 458, pl. 26, figs. 1–3
1982 *Perisphinctes (Otosphinctes) siemiradzkii* Enay – Debrand-Passard, pl. 14, fig. 4
v 1989 *Perisphinctes (Otosphinctes) siemiradzkii* Enay – Fischer & Gygi, fig. 6 B

Material: MNHB J 23656

Locality: section RG 230, Gygi (1977, pl. 11, fig. 3), excavation north of Eisengraben, Gansingen AG, upper Birmenstorf Member.

Description: Dimensions

D	102 mm	
Wh	28 mm	27 %
Wt	–	–
U	52 mm	51 %

The carbonate internal mould is septate to the diameter of 69 mm. The body chamber occupies seven eights of the last whorl. It is probably complete, because the two last ribs are approximated and lean abnormally forward. The maximum diameter of the specimen must have been 112 mm. The primary ribs are sharp and straight. They begin at the umbilical suture line and are inclined 9–14° forward. Many of them are undivided, but most split into two secondary ribs at two thirds the whorl height. The secondary ribs are not attenuated on the siphonal side. They have the same direction as the primary ribs. The section of the inner whorls is almost circular, but slightly depressed. At the end of the body chamber the whorl height approaches the whorl thickness. The rib curve of the specimen from Gansingen (text-fig. 41) closely resembles the curve of the holotype in ENAY (1966, fig. 131).

Age: Luciaeformis Subchron of the Transversarium Chron.

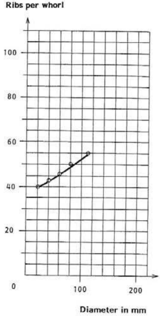


Fig. 41: Rib curve of *Perisphinctes (Otosphinctes) siemiradzkii* ENAY MNHB J 23656.

Subgenus *Arisphinctes* BUCKMAN 1924

Subgeneric type species: *Arisphinctes ariprepes* BUCKMAN 1925

4.1.31 *Perisphinctes (Arisphinctes) plicatilis* (SOWERBY 1817)

Pl. 3, fig. 1 – text-fig. 42

Synonymy

- v 1966 *Perisphinctes (Arisphinctes) plicatilis* (SOWERBY) – ENAY, p. 416, pl. 19, fig. 2, with synonymy
- v 1972a *Perisphinctes (Arisphinctes) plicatilis* (SOWERBY) – MALINOWSKA, p. 184, text-fig. 8, pl. 4, figs. 1–2
- v *non* 1972b *Perisphinctes (Arisphinctes) plicatilis* (SOWERBY) – MALINOWSKA, p. 18, pl. 5, fig. 1
- 1973 *Perisphinctes (Arisphinctes) plicatilis* (SOWERBY) – SAPUNOV, p. 111, pl. 2, fig. 4
- *non* 1974 *Perisphinctes (Arisphinctes) plicatilis* (SOWERBY) – SEQUEIROS, p. 160, pl. 17, fig. 2, pl. 18, fig. 2
- 1979 *Perisphinctes (Arisphinctes) plicatilis* (SOWERBY) – SAPUNOV, p. 76, pl. 17, fig. 3
- ? 1984 *Perisphinctes (Arisphinctes) plicatilis* (SOWERBY) – MELENDEZ, p. 445, pl. 23, fig. 2
- *non* 1984 *Perisphinctes (Arisphinctes) plicatilis* (SOWERBY) – MELENDEZ, pl. 23, fig. 1
- v 1989 *Perisphinctes (Arisphinctes) plicatilis* (SOWERBY) – FISCHER & GYGI, fig. 4 D
- ? 1989 *Perisphinctes (Arisphinctes) plicatilis* (SOWERBY) – MELENDEZ, p. 229, pl. 23, fig. 2
- *non* 1989 *Perisphinctes (Arisphinctes) plicatilis* (SOWERBY) – MELENDEZ, pl. 23, fig. 1
- 1994 *Perisphinctes (Kranaosphinctes) plicatilis* (SOWERBY) – SCHLEGELMILCH, p. 59, pl. 18, fig. 2

Material: MNHB J 24633

Locality: section RG 81b, GYGI (1977, pl. 11, fig. 6), excavation

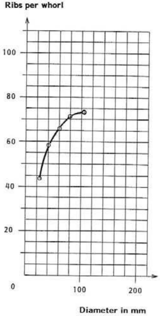


Fig. 42: Rib curve of *Perisphinctes (Arisphinctes) plicatilis* (SOWERBY) MNHB J 24633.

below Räckolterenbuck, Gächlingen SH, bed 13, Mumienmergel Bed.

Description: Dimensions	D	105 mm	
	Wh	35 mm	33 %
	Wt	29 mm	28 %
	U	44 mm	42 %

The glauconitic, carbonate internal mould is wholly septate. The primary ribs are fine, low and blunt. They begin at the umbilical margin. The ribs are straight on the flat, convergent whorl sides and lean about 8° forward. They split on the siphonal margin into two, feeble secondary ribs. Unsplit primaries are not uncommon. The secondary ribs continue in the same direction as the primaries. They almost vanish along a narrow siphonal band. The siphonal side is rounded.

Age: Densiplicatum or early Antecedens Subchron of the Transversarium Chron.

4.1.32 *Perisphinctes (Arisphinctes) helenae* DE RIAZ 1898

Pl. 3, fig. 2 – text-fig. 43

Synonymy

v 1989 *Perisphinctes (Arisphinctes) helenae* DE RIAZ – FISCHER & GYGI, fig. 5 A
? 1989 *Perisphinctes (Arisphinctes) helenae* DE RIAZ – MELENDEZ, p. 233, pl. 24, fig. 1, with synonymy

Material: MNHB J 24575

Locality: section RG 81b, GYGI (1977, pl. 11, fig. 6), excavation below Räckolterenbuck, Gächlingen SH, bed 14a, lower Mumienkalk Bed.

Description: Dimensions	D	92 mm	
	Wh	27 mm	29 %
	Wt	20 mm	22 %
	U	46 mm	50 %

The glauconitic, carbonate internal mould is wholly septate. The section of the last whorl is trapezoidal with flat, slightly convergent whorl sides. There is a pronounced siphonal margin, and the siphonal side is only moderately rounded. The primary ribs are straight, low, but sharp. They lean about 10° forward. The primaries begin on the inner whorls at the umbilical suture line, but on the last whorl there is a smooth band at the base of the rounded umbilical wall. The primary ribs are somewhat drawn backward on the umbilical wall. A few of them are simple. Most of them split into two secondary ribs that have a stronger forward inclination than the primaries. The point of bifurcation is high on the whorl sides, at 83 % of the whorl height. The secondary ribs are strong. They are not attenuated at the siphonal side where they form a forward leaning arc.

Age: Antecedens Subchron of the Transversarium Chron.

Subgenus *Dichotomosphinctes* BUCKMAN 1926

Subgeneric type species: *Perisphinctes* cf. *Wartae* BUKOWSKI mutatio *antecedens* SALFELD 1914.

4.1.33 *Perisphinctes (Dichotomosphinctes) antecedens* SALFELD 1914

Pl. 3, fig. 4 – text-fig. 44

Synonymy

1982 *Perisphinctes (Dichotomosphinctes) antecedens* SALFELD – DEBRAND-PASSARD, pl. 13, fig. 2
1989 *Perisphinctes (Dichotomosphinctes) antecedens* SALFELD – MELENDEZ, p. 292, pl. 41, figs. 1–3, with synonymy
v 1989 *Perisphinctes (Dichotomosphinctes) antecedens* SALFELD – FISCHER & GYGI, fig. 5 D

Material: MNHB J 24701

Locality: section RG 207, GYGI & MARCHAND (1982, fig. 2), excavation beside water conduit in Churz Tal, Siblingen SH, lower Mumienkalk Bed 16a.

Description: Dimensions	D	120.0 mm	
	Wh	32.0 mm	27 %
	Wt	32.5 mm	27 %
	U	62.0 mm	52 %

The glauconitic, carbonate internal mould is septate to the diameter of 107 mm. The body chamber forms one fourth of the

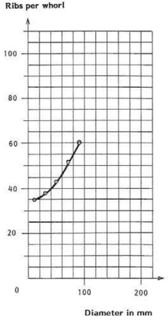


Fig. 43: Rib curve of *Perisphinctes (Arisphinctes) helenae* DE RIAZ MNHB J 24575.

last whorl. The strong primary ribs are straight and sharp. They begin on the umbilical wall and bifurcate regularly at 80 % of the whorl height. They have a mean inclination of 9° forward. The secondary ribs are strong. They bend a little more forward than the primaries and form a forward leaning arc at the siphonal side. There are deep constrictions. The whorl sides are slightly convex and convergent. The siphonal side is rounded.

Age: Antecedens Subchron of the Transversarium Chron.

4.1.34 *Perisphinctes (Dichotomosphinctes) elisabethae* DE RIAZ 1898
Pl. 3, fig. 5 – text-fig. 45

Synonymy

1966 *Perisphinctes (Dichotomosphinctes) elisabethae* DE RIAZ – ENAY, p. 490, pl. 30, figs. 4, 5, pl. 31, figs. 2–6, with synonymy
non 1977 *Perisphinctes (Arisphinctes) elisabethae* (DE RIAZ) – ZIEGLER, pl. 1, fig. 1
1980 *Perisphinctes (Dichotomosphinctes) elisabethae* DE RIAZ – BROCHWICZ-LEWINSKI, p. 210, pl. 1, fig. 1
1981 *Perisphinctes (Dichotomosphinctes) elisabethae* DE RIAZ – ENAY & BOULLIER, pl. 2, fig. 3
non 1987 *Perisphinctes (Arisphinctes) elisabethae* (DE RIAZ) – ZIEGLER, pl. 1, fig. 4
v 1989 *Perisphinctes (Dichotomosphinctes) elisabethae* DE RIAZ – FISCHER & GYGI, fig. 5 E
non 1994 *Perisphinctes (Kranaosphinctes) elisabethae* DE RIAZ – SCHLEGELMILCH, p. 60, pl. 18, fig. 3

Material: MNHB J 24528

Locality: section RG 81b, GYGI (1977, pl. 11, fig. 6), excavation below Räckolterenbuck, Gächlingen SH, bed 14a, lower Mumienkalk Bed.

Description: Dimensions

D	77 mm	
Wh	24 mm	31 %
Wt	21 mm	27 %
U	34 mm	44 %

The glauconitic, carbonate internal mould is septate to the diameter of 80 mm. One eighth of the last whorl is occupied by the body chamber. The fine, but sharp primary ribs are slightly proconvex. On the inner whorls they begin at the umbilical suture line. On the last whorl the base of the umbilical wall is smooth. There the primary ribs begin on the rounded umbilical margin where they first swing somewhat backward. On the whorl sides the ribs have a mean forward inclination of 11°. Some of them are simple, but most of them split on the siphonal margin into two secondary ribs. The secondaries have a stronger forward inclination than the primary ribs and form a proconvex arc at the siphonal side. They may locally be attenuated at a shallow siphonal furrow on the phragmocone. The point of bifurcation is at 80 % of the whorl height. The whorl sides are flat and slightly convergent. The siphonal side is rounded except where there is a furrow. Two shallow constrictions are visible on the last two whorls.

Age: late Antecedens Subchron of the Transversarium Chron.

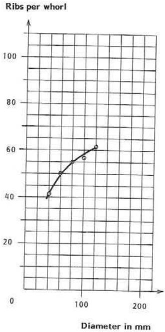


Fig. 44: Rib curve of *Perisphinctes (Dichotomosphinctes) antecedens* SALFELD MNHB J 24701.

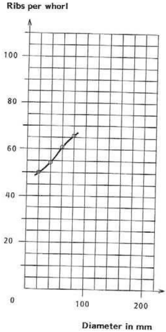


Fig. 45: Rib curve of *Perisphinctes (Dichotomosphinctes) elisabethae* DE RIAZ MNHB J 24528.

4.1.35 *Perisphinctes (Dichotomosphinctes) luciaeformis* ENAY 1966

Pl. 5, fig. 4 – text-fig. 46

Synonymy

1966 *Perisphinctes (Dichotomosphinctes) luciaeformis* n. sp. – ENAY, p. 496, pl. 32, figs. 1–3
1984 *Perisphinctes (Dichotomosphinctes) luciaeformis* ENAY – MELENDEZ, p. 602, pl. 45, figs. 1–2, pl. 46, figs. 1–4, ? pl. 47, figs. 2–4
1989 *Perisphinctes (Dichotomosphinctes) luciaeformis* ENAY – MELENDEZ, p. 301, pl. 45, figs. 1–2, pl. 46, figs. 1–4, ? pl. 47, figs. 2–4
v 1989 *Perisphinctes (Dichotomosphinctes) luciaeformis* ENAY – FISCHER & GYGI, fig. 6 D
1990 *Perisphinctes (Dichotomosphinctes) luciaeformis* ENAY – FONTANA, p. 75, pl. 2, figs. 1–4

Material: MNHB J 23652

Locality: section RG 212, GYGI (1977, pl. 11, fig. 7), excavation above the shooting range in Churz Tal, Siblingen SH, bed 10, glauconitic bed of the lowermost Effingen Member.

Description: Dimensions

D	117 mm	
Wh	36 mm	31 %
Wt	28 mm	24 %
U	55 mm	47 %

The glauconitic, carbonate internal mould is septate to the diameter of 77 mm. The body chamber occupies two thirds of the last whorl. The primary ribs are low, but sharp. They begin on the lower part of the rounded umbilical wall and are straight or almost imperceptibly proconcave. On the last whorl there are eleven unsplit primary ribs. They lean 8° forward. Most of the primaries split at about 72 % of the whorl height into two secondary ribs. The secondaries have a slightly greater forward inclination than the primary ribs. They form a proconvex arc on the siphonal side. At the end of the phragmocone and at the beginning of the body chamber there is a narrow and shallow siphonal furrow that is not deep enough to interrupt the secondary ribs. The last whorl covers the preceding one by only 16 %. The sides of the last whorl are slightly convex and converge very little. The siphonal side is rounded. The constrictions are narrow and not deep. They are commonest on the innermost whorls.

Age: Luciaeformis Subchron of the Transversarium Chron.

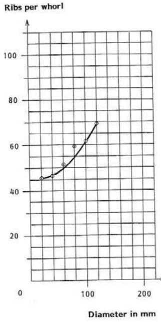


Fig. 46: Rib curve of *Perisphinctes (Dichotomosphinctes) luciaeformis* ENAY MNHB J 23652.

Subgenus *Dichotomoceras* BUCKMAN 1919

Subgeneric type species: *Dichotomoceras dichotomum*. BUCKMAN 1919

4.1.36 *Perisphinctes (Dichotomoceras) rotoides* RONCHADZE 1917

Pl. 9, fig. 1 – text-fig. 47

Synonymy

v 1917 *Perisphinctes rotoides* n. sp. – RONCHADZE, p. 11, pl. 1, fig. 8

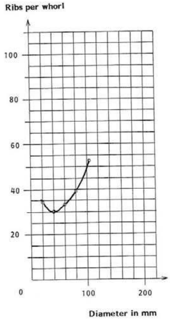


Fig. 47: Rib curve of *Perisphinctes (Dichotomoceras) rotoides* RONCHADZE MNHB J 27971.

non 1937 *Perisphinctes (Dichotomosphinctes) rotoides* RONCHADZE – ARKELL, p. 90, pl. 16, figs. 1–7
non 1952 *Perisphinctes (Dichotomosphinctes) rotoides* RONCHADZE – SIEGFRIED, p. 309, pl. F, fig. 2
1959 *Dichotomosphinctes rotoides* RONCHADZE – COLLIGNON, pl. 64, fig. 287
pars 1966 *Perisphinctes (Dichotomosphinctes) rotoides* RONCHADZE – ENAY, p. 467, figs. 138/1–2, pl. 27, figs. 9, 11, non fig. 10
non 1975b *Perisphinctes (Dichotomosphinctes) rotoides* RONCHADZE – BROCHWICZ-LEWINSKI, pl. 3, fig. 2
non 1976 *Perisphinctes (Dichotomosphinctes) rotoides* RONCHADZE – SAPUNOV, pl. 2, fig. 1
non 1977 *Perisphinctes (Dichotomosphinctes) rotoides* RONCHADZE – BOURSEAU, p. 51, pl. 1, fig. 6, pl. 4, figs. 3, 8
non 1979 *Perisphinctes (Dichotomosphinctes) rotoides* RONCHADZE – SAPUNOV, p. 82, pl. 19, fig. 1
non 1984 *Perisphinctes (Dichotomosphinctes) rotoides* RONCHADZE – TARKOWSKI, pl. 14, fig. 6

Material: MNHB J 27971

Locality: section RG 276, GYGI *et al.* (1979, fig. 3), Chalch quarry, Holderbank AG, bed 46, lower Effingen Member.

Description: Dimensions			
	D	104 mm	
	Wh	32 mm	31 %
	Wt	–	–
	U	49 mm	47 %

The carbonate internal mould is septate to the diameter of ca 68 mm. The exact figure cannot be established, because the inner whorls are compressed in the plane of the spiral axis. Three quarters of the last whorl are occupied by the body chamber. The primary ribs are strong and sharp. They begin at the umbilical suture line and swing somewhat back on the rounded umbilical wall. The primaries are straight on the whorl sides except near the aperture where they are slightly proconvex. They have a forward inclination of about 10°. The primary ribs split up into secondary ribs at 73 % of the whorl height. On the body chamber there are mostly two and sometimes three secondaries per primary rib. The secondary ribs are a little more inclined forward than the primaries. The secondary ribs are interrupted along a short siphonal furrow at the beginning of the body chamber. The specimen seems to be a complete adult, because the last primary ribs are slightly proconvex and approximated.

Discussion: ARKELL (1937, p. 90) assigned the name *rotoides* to small *Dichotomosphinctes* of the Antecedens Subchron in England. He did not measure the innermost whorls of the cast of RONCHADZE's holotype exactly enough to recognize that the rib curve first falls to the diameter of 40 mm and only then begins to ascend (ARKELL, 1937, text-fig. 23, compare with text-fig. 47 of this paper). ENAY (1966, fig. 137) has measured the inner whorls of the holotype in more detail, but the subtle morphological difference in the ribbing as well as the considerable age difference between the French and the English material apparently did not occur to him.

On September 3 in 1980 the upper part of the section RG 276 at Holderbank AG has been re-excavated. Four specimens of *Perisphinctes rotoides* RONCHADZE could be collected from bed 46 (GYGI & PERSOZ 1986, p. 422), this is to say from above bed 42 with *Larcheria schilli* (OPPEL). It became apparent from the rib curves that these specimens were early representatives of *Dichotomoceras*. MNHB J 27971 as described above agrees very well with the holotype of *rotoides* RONCHADZE 1917.

R. Gygi explained this to E. Cariou when he inspected his collection at Basel in 1987. This lead CARIOU & MELENDEZ (1990, p. 144) and CARIOU et al. (1991, p. 704) to introduce a new Rotoides Subzone based on section RG 276 at Holderbank, Switzerland, (see GYGI 1990b), a section near Pamproux, France, and another section at Moscardon, Spain. Therefore *Perisphinctes (Dichotomosphinctes) rotoides* ARKELL, non RONCHADZE has to be given a new name. During the preparation of this manuscript, GLOWNIAK (1997, p.45) named it *arkelli* n. sp.

Age of MNHB J 27971: Rotoides Subchron of the Bifurcatus Chron.

4.1.37 *Perisphinctes (Dichotomoceras) stenocycloides* SIEMIRADZKI 1898

Pl. 9, fig. 3

Synonymy

1989 *Perisphinctes (Dichotomoceras) stenocycloides* SIEMIRADZKI – MELENDEZ, p. 311, pl. 51, figs. 1–5, with synoymy

Material: MNHB J 23728

Locality: section RG 276, GYGI *et al.* (1979, fig. 3), Chalch quarry, Holderbank AG, bed 50, lower Effingen Member. The specimen has been excavated in 1975, at a time, when the section of the Birmenstorf and the lower Effingen Member was only partially visible. The complete section RG 276 became accessible in 1978 and was then measured. The fossil horizons excavated in 1975 could then be easily identified, because the outcrop runs very obliquely through the section.

Description: The specimen is compressed in an axial plane of the spiral. The diameter, the whorl height and the umbilicus have therefore been measured in the axial plane which is at an angle of 45° against the plane of maximum compression.

Dimensions:			
	D	92 mm	
	Wh	28 mm	30 %
	Wt	26 mm	28 %
	U	44 mm	48 %

The carbonate internal mould is septate to the diameter of ca 75 mm. Two thirds of the last whorl are occupied by the body chamber. The primary ribs are strong, sharp and straight on the whorl sides. They begin on the lower part of the rounded umbilical wall. On the wall they are either straight or swing a little backward. At the whorl sides the primary ribs have a forward inclination of 0–5°. They split into two secondary ribs at 75 % of the whorl height. The forward inclination of the secondaries is greater than that of the primaries. The secondary ribs form a proconvex arc on the siphonal side. They are strong and sharp as the primaries. At the end of the phragmocone and at the beginning of the body chamber there is a shallow siphonal furrow that reduces the height of the secondary ribs. The last whorl covers the preceding one by 25 %, so that the point of bifurcation of the primary ribs lies just beneath the umbilical suture line.

Discussion: On the last but one whorl of SIEMIRADZKI's holotype the point of bifurcation of the primary ribs is visible. This is also the case with the specimens figured by DUONG (1974, pl. 7, figs. 1 and 5). This seems to be a minor difference between MNHB J 23728 and the holotype. All other measurable characters agree well with the type.

Age: Stenocycloides Subchron of the Bifurcatus Chron.

4.1.38 *Perisphinctes (Dichotomoceras) bifurcatoides* ENAY 1966

Pl. 9, fig. 2 – text-fig. 48

Synonymy

1989 *Perisphinctes (Dichotomoceras) bifurcatoides* ENAY – MELENDEZ, p. 315, pl. 52, figs. 1–3, pl. 53, figs. 1–3, pl. 54, figs. 1–4, with synonymy

Material: MNHB J 23704

Locality: section RG 276, GYGI et al. (1979, fig. 3), Chalch quarry, Holderbank AG, bed 50, lower Effingen Member.

Description: Dimensions			
	D	101.6 mm	
	Wh	33.0 mm	32 %
	Wt	–	–
	U	45.0 mm	44 %

The carbonate internal mould is septate to the diameter of 58 mm. Three fourths of the last whorl are occupied by the body chamber. The primary ribs begin on the rounded umbilical wall. There they swing backward. On the sides of the inner whorls the primary ribs are straight and have a forward inclination of about 10°. They are strong and sharp. On the body chamber the inclination of the primaries decreases to zero. On the rear part of the body chamber they are proconcave, but they become proconvex near the aperture. At about 75 % of the whorl height the primary ribs split into two secondary ribs. On the body chamber are two unsplit primaries and one intercalated secondary rib. The secondary ribs are strong and high. Their forward inclination is greater than that of the primaries. The last whorl covers the preceding one by ca 25 %.

Age: Stenocycloides Subchron of the Bifurcatus Chron.

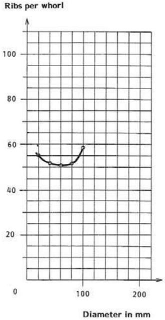


Fig. 48: Rib curve of *Perisphinctes (Dichotomoceras) bifurcatoides* Enay MNHB J 23704.

4.1.39 *Perisphinctes (Dichotomoceras) duongae* MELENDEZ 1984, *emend.* GYGI

Pl. 9, fig. 4 – text-fig. 49

Synonymy

1984 *Perisphinctes (Dichotomoceras) duongi* sp. nov. – MELENDEZ, p. 643, pl. 56, figs. 1–6

1989 *Perisphinctes (Dichotomoceras) duongi* sp. nov. – MELENDEZ, p. 325, pl. 56, figs. 1–6

Emendation: MELENDEZ (1984, p. 643) introduced the name *duongi* in order to honour the late Miss Dara-Moni Duong of Cambodia, author of DUONG (1974). According to the articles 31 and 32c of the INTERNATIONAL CODE OF ZOOLOGICAL NOMENCLATURE (1985), the name must be changed into *duongae* because of the female sex of the person the name relates to.

Material: MNHB J 23533

Locality: section RG 226, R. GYGI (1973, fig. 3), road cut north of Jakobsberg quarry, Auenstein AG, not *in situ*, lower Effingen Member.

Description: Dimensions			
	D	90 mm	
	Wh	29 mm	32 %
	Wt	25 mm	28 %
	U	38 mm	42 %

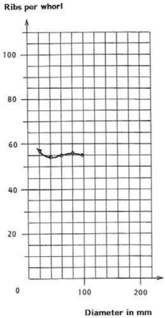


Fig. 49: Rib curve of *Perisphinctes (Dichotomoceras) duongae* MELENDEZ MNHB J 23533.

The carbonate internal mould is septate to the diameter of 62 mm. Three quarters of the last whorl are occupied by the body chamber. The primary ribs begin on the perpendicular umbilical wall where they are inclined backward. The primary ribs are straight on the subparallel, slightly convex whorl sides. They are strong and sharp. Their forward inclination is about 30° on the innermost preserved whorl and decreases to 8° on the body chamber. The primary ribs split at 69 % of the whorl height into two secondaries. The secondary ribs are also strong and sharp. Their forward inclination is only a little greater than that of the primaries. They form a proconvex arc on the siphonal side. There is a short, very shallow siphonal furrow at the end of the phragmocone and at the beginning of the body chamber. The last whorl covers the preceding one by 32 %, so that the points of bifurcation of the primary ribs are only occasionally visible on the inner whorls.

Age: According to MELENDEZ (1989, p. 330), the taxon occurs in the late Stenocycloides Subchron of the Bifurcatus Chron.

4.1.40 *Perisphinctes (Dichotomoceras)* cf. *bifurcatus* (QUENSTEDT 1847)

Pl. 8, fig. 3

Material: MNHB J 23543

Locality: section RG 226, GYGI (1973, fig. 3), road cut north of Jakobsberg quarry, bed 55, 2.3 m above the base, lower Effingen Member.

Description: The specimen is compressed in the equatorial plane as well as slightly in an axial plane. The dimensions of the specimen have therefore been measured in the axial plane which is inclined 45° to the axial plane of maximum compression. The measured dimensions are then only approximate:

D	55 mm	
Wh	18 mm	33 %
Wt	–	–
U	23 mm	42 %

The marly internal mould is septate to the diameter of probably 52 mm. Somewhat less than a fourth of the last whorl is occupied by the body chamber. The primary ribs begin at the umbilical suture line. They swing back very little on the rounded umbilical wall. On the whorl sides the primary ribs are straight. Their forward inclination is 0–5°. The primaries split into two secondary ribs relatively low, this is to say at 63 % of the whorl height. The secondaries are slightly bent forward. The last whorl covers the preceding one by only 17 %, so that the point of division of the primary ribs is well visible on the inner whorls. In a letter dated at 9 December 1996, R. Enay remarked that the ribbing in this specimen is too dense for a typical *bifurcatus*.

Age: later part of Bifurcatus Chron.

Genus *Subdiscosphinctes* MALINOWSKA 1972 a
Subgenus *Subdiscosphinctes* MALINOWSKA 1972 a

Subgeneric type species: *Perisphinctes kreutzi* SIEMIRADZKI 1891

4.1.41 *Subdiscosphinctes (Subdiscosphinctes) lucingae* (FAVRE 1875)

Pl. 5, fig. 1 – text-fig. 50

Synonymy

1966 *Lithacoceras (Discosphinctes) lucingae* (FAVRE) – ENAY, p. 540, figs. 166, 169/10–12, pl. 37, fig. 10, with synonymy
v 1989 *Subdiscosphinctes (Subdiscosphinctes) lucingae* FAVRE – FISCHER & GYGI, fig. 6A

Material: MNHB J 23755

Locality: section RG 60, GYGI (1969, pl. 17), Eisengraben, Gansingen AG, not *in situ*, collected from the upper Birmenstorf Member.

Description: Dimensions

D	99 mm	
Wh	36 mm	36 %
Wt ca	27 mm	27 %
U	37 mm	37 %

The carbonate internal mould is septate to the diameter of 58 mm. The body chamber occupies three quarters of the last whorl. The primary ribs begin in the upper part of the rounded

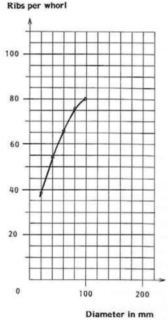


Fig. 50: Rib curve of *Subdiscosphinctes (Subdiscosphinctes) lucingae* (Favre) MNHB J 23755.

umbilical wall. They swing somewhat back on the umbilical margin. On the slightly convex whorl sides of the phragmocone the primary ribs are straight and lean 12° forward. On the body chamber the primaries become increasingly proconcave. Some of them are undivided, but most of them split into two secondary ribs at 67 % of the whorl height. The undivided primary and the secondary ribs bend very little forward on the siphonal margin and so form a proconvex arc on the siphonal side. Constrictions are common on the inner whorls. There are four constrictions on the last whorl.

Age: Luciaeformis Subchron of the Transversarium Chron.

Subgenus *Aureimontanites* Brochwicz-Lewinski 1975 a

Subgeneric type species: *Lithacoceras (Subdiscosphinctes) boreale* Malinowska 1972 a

4.1.42 *Subdiscosphinctes (Aureimontanites) wojciechi n. sp.*

Pl. 8, fig. 5 – text-fig. 51

Synonymy

1972 a *Lithacoceras (Subdiscosphinctes) kreutzi* (Siemiradzki) – Malinowska, p. 221, pl. 27, figs. 1, 2, pl. 28
1972 *Lithacoceras (Lithacoceras) kreutzi* (Siemiradzki) – Brochwicz-Lewinski, pls. 1, 2, 3, 4
1975 a *Lithacoceras (Lithacoceras) kreutzi* (Siemiradzki) – Brochwicz-Lewinski, pl. 21, fig. 2
1975 a *Perisphinctes kreutzi* Siemiradzki – Brochwicz-Lewinski, pl. 22, fig. 1
1975 a *Lithacoceras (Lithacoceras) kreutzi sensu* Brochwicz-Lewinski, 1972 – Brochwicz-Lewinski, pl. 22, fig. 2
? 1975 a *Lithacoceras (Subdiscosphinctes) kreutzi sensu* Malinowska, 1972 – Brochwicz-Lewinski, pl. 22, fig. 3

Holotype: Original to Brochwicz-Lewinski, 1972, pl. 1, Warsaw University, Institute of Geology, Br 02/204.

Type locality: Zawodzie, Poland.

Type horizon: Platy limestones.

Derivation of the name: In honour of Wojciech Brochwicz-Lewinski, author of many papers on Oxfordian perisphinctids in Poland.

Diagnosis: Species of the subgenus *Aureimontanites* with fine biplicate ribbing on the inner whorls and swollen, distant primary ribs on the body chamber. The diameter of the complete adult can be as much as 300 mm.

Material: MNHB J 23659

Locality: section RG 230, Gygi (1977, pl. 11, fig. 3), excavation north of Eisengraben, Gansingen AG, upper Birmenstorf Member.

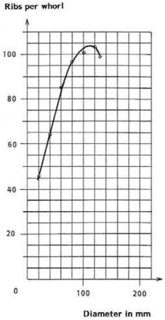


Fig. 51: Rib curve of *Subdiscosphinctes (Aureimontanites) wojciechi* n. sp. MNHB J 23659.

Description: Dimensions			
	D	119 mm	
	Wh	43 mm	36 %
	Wt	29 mm	24 %
	U	44 mm	37 %

The carbonate internal mould is septate to the diameter of 123 mm. One eighth of the last whorl is occupied by the body chamber. The fine primary ribs begin above the smooth umbilical wall, on the rounded umbilical margin where they swing backward. On the slightly convex whorl sides the primary ribs are either straight or somewhat proconcave. There they have a forward inclination of 12–15°. At 79 % of the whorl height the primary ribs generally split into two secondary ribs, but many primaries are undivided. The simple primary ribs and the secondaries bend forward on the siphonal margin and form a proconvex arc on the rounded siphonal side. The ribs are not attenuated near the siphuncle. The rib curve (fig. 51) rises in a straight line from the diameter of 20 mm to 60 mm. The curve reaches a peak before the diameter of 120 mm with 103 ribs per whorl and then begins to descend. The specimen is therefore a macroconch and belongs to the subgenus *Aureimontanites.*

Affinities: The inner whorls of *Subdiscosphinctes (Aureimontanites) wojciechi* n. sp. resemble *Subdiscosphinctes (Subdiscosphinctes) kreutzi* (SIEMIRADZKI) so much that there can be no doubt that the new taxon is the macroconch of *Subdiscosphinctes (Subdiscosphinctes) kreutzi*, as has been assumed by BROCHWICZ-LEWINSKI (1972, p. 478). BROCHWICZ-LEWINSKI & ROZAK (1976a, p. 115) have drawn attention to difficulties in recognizing the dimorphism of certain perisphinctids. It is therefore unadvisable to give the same specific name to the macroconch and the microconch of a dimorphic pair as has been suggested by MAKOWSKI (1963, p. 18). A new specific name is therefore needed as is proposed here.

Age: Luciaeformis Subchron of the Transversarium Chron.

4.1.43 *Subdiscosphinctes (Aureimontanites) cracoviensis* (SIEMIRADZKI 1891)

Pl. 7, fig. 1 – text-fig. 52

Synonymy

- 1891 *Perisphinctes Cracoviensis* n. sp. – SIEMIRADZKI, p. 48, pl. 3, figs. 1, 4
- *non* 1898 *Perisphinctes cracoviensis* SIEMIRADZKI – DE RIAZ, p. 35, pl. 15, fig. 1
- 1972 *Lithacoceras (Discosphinctes) cracoviense* (SIEMIRADZKI) – BROCHWICZ-LEWINSKI, p. 484, pl. 10, 11, 12, fig. 2
- 1976a *Subdiscosphinctes cracoviensis* (SIEMIRADZKI) – BROCHWICZ-LEWINSKI & ROZAK, pl. 30

Material: MNHB J 23655

Locality: section RG 230, GYGI (1977, pl. 11, fig. 3), excavation north of Eisengraben, Gansingen AG, upper Birmenstorf Member.

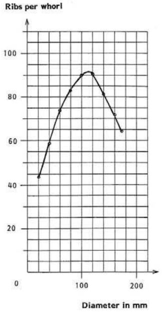


Fig. 52: Rib curve of *Subdiscosphinctes (Aureimontanites) cracoviensis* (SIEMIRADZKI) MNHB J 23655.

Description: Dimensions			
	D	163 mm	
	Wh	56 mm	34 %
	Wt	–	–
	U	64 mm	39 %

The carbonate internal mould is septate to the diameter of 101 mm. More than 80 % of the last whorl are occupied by the body chamber. On the inner whorls the primary ribs begin at the umbilical suture line. From there to the rounded umbilical margin the primaries bend slightly back. On the somewhat convex whorl sides the primary ribs are straight and lean 8–15° forward. The whorl section is oval. The low ribs are fine and blunt. On the body chamber the primaries become proconcave. There they start on the umbilical margin and leave the umbilical wall smooth. Many of the primary ribs are undivided on the phragmocone. The majority of them splits into two secondary ribs at about 60 % of the whorl height. On the body chamber the number of secondary ribs per primary rib increases from two to four towards the aperture, and the point of division becomes more and more diffuse. The forward inclination of the secondary ribs with respect to the primaries is slight on the phragmocone and diminishes to zero at the end of the body chamber. The last whorl covers the preceding one by 42 %. No constrictions are visible on the inner whorls, but on the body chamber there are two of them. The rib curve (fig. 52) rises steeply to the diameter of 115 mm and then descends just as steeply.

Age: Luciaeformis Subchron of the Transversarium Chron.

Genus *Larcheria* Tintant 1961

Type species: *Larcheria larcheri* Tintant 1961

4.1.44 *Larcheria schilli* (Oppel 1863)
Pl. 8, fig. 2 – text-fig. 53

Synonymy

? 1966 *Lithacoceras (Larcheria) schilli* (Oppel) – Enay, p. 529, pl. 36, fig. 3, with synonymy
1982 *Larcheria* aff. *schilli* (Oppel) – Marchand *et al.*, p. 104, pl. 1, fig. 1
1984 *Larcheria schilli* (Oppel) – Melendez *et al.*, pl. 4, fig. 2, pl. 5, fig. 2
1990 *Larcheria schilli* (Oppel) – Fontana, pl. 4, fig. 1

Material: MNHB J 23534

Locality: section RG 226, Gygi (1973, fig. 3), road cut north of Jakobsberg quarry, Auenstein AG, bed 46?, not *in situ*, lower Effingen Member.

Description:	Dimensions			
		D	80.6 mm	
		Wh	30.0 mm	37 %
		Wt	22.0 mm	27 %
		U	30.0 mm	37 %

The carbonate internal mould is septate to the diameter of 62 mm. The body chamber occupies the last half whorl. The primary ribs begin on the rounded umbilical margin. The lower part of the umbilical wall is smooth. The ribs first bend a little backward. On the converging whorl sides the primary ribs lean 8–10° forward. The primaries are straight or slightly proconvex. At half the whorl height the primary ribs are attenuated, so that the point of division into secondary ribs becomes indistinct. The primary ribs split into two or three secondaries at about 60 % of the whorl height. The secondary ribs bend forward. They form a proconvex arc on the rounded siphonal side. The last whorl covers the preceding one by 36 %.

Age: Schilli Subchron of the Bifurcatus Chron.

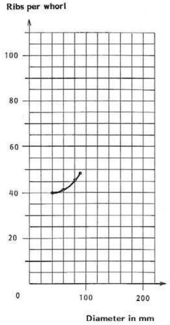


Fig. 53: Rib curve of *Larcheria schilli* (Oppel) MNHB J 23534.

Genus *Passendorferia* Brochwicz-Lewinski 1973
Subgenus *Passendorferia* Brochwicz-Lewinski 1973

Subgeneric type species: *Passendorferia teresiformis* Brochwicz-Lewinski 1973

4.1.45 *Passendorferia (Passendorferia) ziegleri* (Brochwicz-Lewinski 1973)
Pl. 6, fig. 1 – text-fig. 54

Synonymy

v 1973 *Nebrodites (Passendorferia) ziegleri* n. sp. – Brochwicz-Lewinski, p. 311, pls. 15–18, pl. 22, fig. 2
cf. 1974 *Perisphinctes (Arisphinctes) plicatilis* (Sowerby) – Sequeiros, p. 160, pl. 18, fig. 2

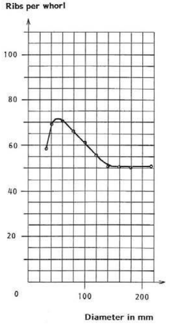


Fig. 54: Rib curve of *Passendorferia (Passendorferia) ziegleri* (Brochwicz-Lewinski) MNHB J 24079.

1976 *Passendorferia ziegleri* (BROCHWICZ-LEWINSKI) – SAPUNOV, pl. 6, fig. 2
cf. 1977 *Passendorferia ziegleri* BROCHWICZ-LEWINSKI – SEQUEIROS, p. 360, pl. 2
non 1977 *Passendorferia ziegleri* BROCHWICZ-LEWINSKI – SEQUEIROS, pl. 3, fig. 3
cf. 1984 *Passendorferia (Passendorferia)* cf. *ziegleri* BROCHWICZ-LEWINSKI) – MELENDEZ, p. 255, pl. 2, fig. 2
cf. 1989 *Passendorferia (Passendorferia)* cf. *ziegleri* (BROCHWICZ-LEWINSKI) – MELENDEZ, p. 138, pl. 2, fig. 2

Material: MNHB J 24079

Locality: section RG 230, GYGI (1977, pl. 11, fig. 3), excavation north of Eisengraben, Gansingen AG, upper Birmenstorf Member.

Description: Dimensions	D	269 mm	
	Wh	57 mm	21 %
	Wt	–	–
	U	168 mm	62 %

The carbonate internal mould is septate to the diameter of 212 mm. The body chamber of the undamaged specimen occupied at least two thirds of the last whorl. The primary ribs are fine and blunt on the inner whorls. On the outer whorls they become stronger and disproportionally widely spaced. The primary ribs are straight and radial. They begin close to the umbilical suture line. At the diameter of 150 mm many primary ribs split into two low, blunt secondary ribs at about 80 % of the whorl height. The last split rib is at the diameter of 180 mm. From there on the ribs are simple and become stronger towards the aperture. They are not attenuated at the siphonal side. The whorl section is nearly circular on the inner whorls. The outer whorls are trapezoidal with rounded umbilical and siphonal margins. The siphonal side is rounded. The coiling is extremely evolute, serpenticone. The last whorl covers the preceding one by only 10 %. Constrictions occur every three fourth of a whorl at small diameters and every two third of a whorl at great diameters.

Age: Luciaeformis Subchron of the Transversarium Chron.

Subgenus *Enayites* BROCHWICZ-LEWINSKI & ROZAK 1976

Subgeneric type species: *Ammonites birmensdorfensis* MOESCH 1867

4.1.46 *Passendorferia (Enayites) birmensdorfensis* (MOESCH 1867)

Pl. 5, fig. 2 – text-fig. 55

Synonymy

1989 *Passendorferia (Enayites) birmensdorfensis* (MOESCH) – MELENDEZ, p. 157, pl. 11, figs. 5–12, with synonymy
? 1990 *Passendorferia (Enayites) birmensdorfensis* (MOESCH) – CLARI et al., pl. 1, fig. 1

Material: MNHB J 31607

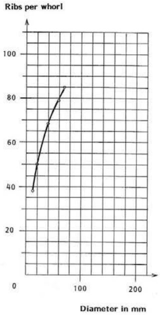


Fig. 55: Rib curve of *Passendorferia (Enayites) birmensdorfensis* (MOESCH) MNHB J 31607.

Locality: section RG 32, GYGI (1969, pl. 17), Schellenbrücke, Küttigen AG, bed 7, lower Birmenstorf Member.

Description: Dimensions	D	69.0 mm	
	Wh	18.3 mm	27 %
	Wt	–	–
	U	37.0 mm	54 %

The carbonate internal mould is septate to the diameter of 38 mm. The entire last whorl is occupied by the body chamber. The last two septa are approximated. The specimen then is an adult microconch. The peristome is broken off. The fine primary ribs begin just above the umbilical suture line and are straight and radial. About half of them are undivided. The others split into two secondary ribs at about 75 % of the whorl height. The last whorl covers the preceding one by only about 10 %. Nevertheless, the points of division of primary ribs are not visible on the inner whorls. The secondary ribs are radial just like the primaries. At the beginning of the body chamber they fade away almost completely along a narrow and shallow furrow along the siphonal line. The whorl section is almost circular to thick-oval. Constrictions appear about every three quarters of a whorl.

Age: Luciaeformis Subchron of the Transversarium Chron.

Genus *Wegelea* nov. gen.

Type species: *Perisphinctes gredingensis* WEGELE 1929, p. 49, pl. 1, fig. 7 (holotype by monotypy).

Diagnosis: Large perisphinctid with a relatively narrow umbilicus. The ribbing is weaker and blunter than in *Larcheria*. The whorls are much higher than thick. The peristome is simple, without lappets.

Derivation of the name: The name refers to L. Wegele, the author of *Perisphinctes gredingensis*.

Temporal range: Late Bimammatum Chron.

4.1.47 *Wegelea gredingensis* (WEGELE 1929)
Pl. 13, fig. 1 – text-fig. 56

Synonymy

1929 *Perisphinctes gredingensis* n. sp. – WEGELE, p. 49, pl. 1, fig. 7

Material: MNHB J 31720

Locality: section RG 85 (detailed section unpublished, for condensed version see GYGI, 1969, pl. 19, upper section), Wisse Rise, Beggingen SH, bed 55, upper Küssaburg Member.

Description: Dimensions			
	D	145 mm	
	Wh	50 mm	34 %
	Wt	23 mm	16 %
	U	55 mm	38 %

The carbonate internal mould is septate to the diameter of about 71 mm. Only traces of septal sutures can be seen. Probably the entire last whorl is occupied by the body chamber. The primary ribs begin on the rounded umbilical margin where they swing back. The primary ribs are straight on the whorl sides. Their forward inclination may be as much as 18° on the inner whorls and diminishes to zero near the aperture. The primary ribs are weak and blunt. They split at about half the whorl height into two or three secondary ribs at the beginning of the body chamber. Further towards the aperture there are regularly three secondaries per primary rib. The primary ribs become so faint in the middle of the whorl height of the body chamber that the point of division into secondaries is indistinct. The secondaries bend slightly forward at the siphonal margin, but they become radial near the aperture. The strength of the secondary ribs increases from the point of division to the siphonal line where the ribs are relatively strong, but blunt. The last whorl covers the preceding one by 33 %. The whorl section is high-oval with the greatest thickness not far above the umbilical margin. A premature peristome is visible close to the end of the last whorl (pl. 13, fig. 1).

Discussion: It is difficult to assign this characteristic perisphinctid with a relatively narrow umbilicus, weak and blunt ribs and an attenuation of the ribbing on the whorl sides to an existing

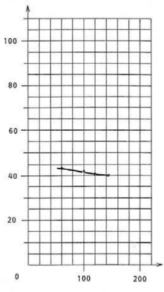


Fig. 56: Rib curve of *Wegelea gredingensis* (WEGELE) MNHB J 31720.

genus. TINTANT (1959, p. 129) thought it was a *Larcheria* and ENAY (1964, p. 493) followed him in this. Indeed, *Wegelea* n. g. is morphologically very close to *Larcheria*, but there is a time gap of three subzones between the two genera without intermediate forms. ENAY (1966, p. 518) classed *Wegelea gredingensis* with *Orthosphinctes* and assumed it was a microconch. This cannot be done, because the umbilicus of *Wegelea gredingensis* is too narrow for *Orthosphinctes*. Moreover, the ribbing of *Wegelea gredingensis* cannot be compared with the ribbing of *Orthosphinctes*. The peristome of *Wegelea* is simple, without lappets. These are the reasons why the new genus has been introduced above.

Age: Hauffianum Subchron of the Bimammatum Chron.

Subfamily Idoceratinae SPATH 1924
Genus *Idoceras* BURCKHARDT 1906

Type species: *Ammonites planula* HEHL in ZIETEN 1830.

4.1.48 *Idoceras balderum* (OPPEL 1863)
Pl. 14, fig. 3

Synonymy

1863 *Ammonites Balderus* Opp. – OPPEL, p. 242, pl. 67, fig. 2
1878 *Ammonites balderus* OPPEL – DE LOLRIOL, p. 94, pl. 15, fig. 7, *non* fig. 8
1929 *Idoceras Balderus* OPPEL – WEGELE, p. 78, pl. 9, fig. 7

1959 *Idoceras balderum* (Oppel) – Ziegler, p. 25, pl. 1, figs. 3, 4
1977 *Idoceras (Idoceras) balderum* (Oppel) – Ziegler, pl. 3, fig. 5
1980 *Idoceras balderum* (Oppel) – Barthel & Schairer, pl. 1, figs. 1, 3, 4
1987 *Idoceras balderum* (Oppel) – Ziegler, pl. 2, fig. 2

Material: MNHB J 31719

Locality: section RG 62, Gygi (1969, pl. 17), cliff west of Besserstein ruin, Villigen AG, bed 124, lower Wettingen Member.

Description: Dimensions			
	D	48.0 mm	
	Wh	18.0 mm	38 %
	Wt	–	–
	U	18.0 mm	38 %

The carbonate internal mould was found lying flat at the upper surface of a limestone bed. It is diagenetically compressed. The inner whorls are totally flattened. The last septum of the phragmocone can be seen only indistinctly on one side. The entire last whorl is occupied by the body chamber. The primary ribs on the rear part of the body chamber either split into two secondary ribs or remain simple. On the last half of the body chamber the primary ribs fade away completely at half the whorl height. Only close to the siphonal margin appear low, blunt secondary ribs that are interrupted along the siphonal line. The secondaries bend strongly forward near the aperture. This and their "flattened" appearance (see Ziegler, 1959, p. 26) indicate that the specimen is adult in spite of its small size.

Age: Divisum Chron.

Genus *Subnebrodites* Spath 1925

Type species: According to a letter by F. Atrops dated 16 September, 1996: *Ammonites planula* Quenstedt (1888, pl. 108, fig. 2).

4.1.49 *Subnebrodites planula* (Quenstedt 1888)
Pl. 11, fig. 5

Synonymy

1888 *Ammonites planula gigas* – Quenstedt, p. 978, pl. 108, fig. 2
pars 1989 *Idoceras (Subnebrodites) planula* (Hehl in Zieten, 1830) – Schairer, p. 99, pl. 1, figs. 1–5, pl. 2, figs. 1–2, pl. 3, figs. 1–2, ? pl. 4, fig. 1, with synonymy

Material: MNHB J 31723

Locality: section RG 84 (detailed section unpublished, for condensed version see Gygi, 1969, pl. 19, upper section), township quarry, Hemmenthal SH, lower Wangental Member.

Description: Dimensions			
	D	77 mm	
	Wh	25 mm	32 %
	Wt	–	–
	U	35 mm	45 %

The carbonate internal mould is septate to the diameter of about 84 mm. The body chamber occupied at least three quarters of the last whorl. The complete specimen must have had a diameter of about 100 mm. The inner whorls are finely ribbed, but on the body chamber the primary ribs are coarse and widely spaced. The secondary ribs bend strongly forward and fade entirely along the siphonal line. The whorl section is elliptic.

Age: early Planula Chron.

4.1.50 *Subnebrodites laxevolutus* (Fontannes 1879)
Pl. 11, fig. 4

Synonymy

1959 *Idoceras laxevolutum* (Fontannes) – Ziegler, p. 28, pl. 1, fig. 6, with synonymy
? 1974 *Idoceras laxevoluta* (Fontannes) – Barbulescu, pl. 41, figs. 5–6
pars 1989 *Idoceras (Subnebrodites) laxevolutum* (Fontannes) *sensu* Ziegler, 1959 – Schairer, p. 101, pl. 4, figs. 2–7, pl. 5, figs. 1–4, with synonymy

Material: MNHB J 32275

Locality: section RG 70, Gygi (1969, pl. 17), large quarry, Mellikon AG, bed 108, upper Letzi Member.

Description: Dimensions			
	D	87 mm	
	Wh	28 mm	32 %
	Wt	–	–
	U	41 mm	47 %

The carbonate internal mould is septate to the diameter of 55 mm. The body chamber occupies seven eighths of the last whorl. The body chamber is diagenetically compressed, whereas the phragmocone is almost completely flattened. The primary ribs begin at the umbilical suture line and lean a little forward on the whorl sides. The majority of them splits into two secondary ribs. The secondary ribs bend forward and are strongly attenuated along the siphonal line. There are 43 primary ribs on the last whorl.

Age: Planula Chron.

4.1.51 *Subnebrodites schroederi* (Wegele 1929)
Pl. 13, fig. 4

Synonymy

pars 1989 *Idoceras (Subnebrodites) schroederi* Wegele – Schairer, p. 104, pl. 7, figs. 1–8, with synonymy

Material: MNHB J 31714

Locality: section RG 82, Gygi (1969, pl. 16), quarry below Steimürlichopf in Churz Tal, Siblingen SH, bed 134, lowermost Wangental Member.

Description: Dimensions			
	D	78 mm	
	Wh	26 mm	33 %
	Wt	17 mm	22 %
	U	33 mm	42 %

The carbonate internal mould is septate to the diameter of 47 mm. Three quarters of the last whorl are occupied by the body chamber. The primary ribs swing somewhat back on the umbilical margin. On the whorl sides the ribs are straight or slightly proconcave and lean about 5° forward. The great majority of them splits into two secondary ribs. Only one primary rib is unsplit on the last whorl. The secondary ribs are interrupted along a relatively wide band along the siphonal side. The last whorl covers the preceding one by 34 %. There are 35 primary ribs on the last whorl.

Age: early Planula Chron.

Family Ataxioceratidae BUCKMAN 1921
Subfamily Ataxioceratinae BUCKMAN 1921
Genus *Orthosphinctes* SCHINDEWOLF 1925
Subgenus *Orthosphinctes* SCHINDEWOLF 1925

Subgeneric type species: *Ammonites tiziani* OPPEL 1863.

4.1.52 *Orthosphinctes (Orthosphinctes) colubrinus* (REINECKE 1818)

Pl. 11, fig. 6, pl. 13, fig. 5 – text-fig. 57

Synonymy

1966 *Orthosphinctes (Orthosphinctes) colubrinus* (REINECKE) – ENAY, p. 515, with synonymy
non 1966 *Perisphinctes (Orthosphinctes) colubrinus* REINECKE – ANDELKOVIC, p. 45, fig. 39, pl. 9, fig. 1
1972 *Nautilus colubrinus* REINECKE in HELLER & ZEISS, p. 27, pl. 4, fig. 72

Material: MNHB J 31712, J 32267

Locality of J 31712: section RG 82, GYGI (1969, pl. 16), quarry below Steimürlichopf in Churz Tal, Siblingen SH, bed 134, lowermost Wangental Member.

Description of J 31712: Dimensions			
	D	68.6 mm	
	Wh	20.0 mm	29 %
	Wt	18.0 mm	26 %
	U	31.0 mm	45 %

The carbonate internal mould is septate to the diameter of 35 mm. The body chamber occupies somewhat more than the last whorl. The last constriction before the peristome is preserved at the end of the body chamber, but the peristome is broken off. The primary ribs begin just above the umbilical suture line and are mostly straight and radial. They are high, but blunt. The primaries split at two thirds of the whorl height into two secondary ribs. Three primary ribs are unsplit on the last whorl. The secondary ribs bend a little forward and form a pro-

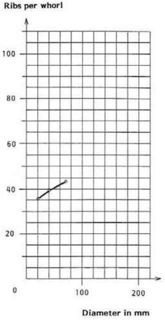


Fig. 57: Rib curve of *Orthosphinctes (Orthosphinctes) colubrinus* (REINECKE) MNHB J 31712.

convex arc at the siphonal side. They are slightly attenuated along the siphonal line. The whorl section is oval with the greatest thickness at about one third of the whorl height.

Discussion: The first tens of ammonites listed in the catalog by SCHAUROTH in the Naturkunde-Museum Coburg, Germany, belong probably all to the collection of J. M. C. Reinecke. The largest of the three specimens from Staffelstein listed under the catalog number 42 compares well with the drawing by REINECKE (1818, pl. 12, fig. 72). Exactly the entire last whorl of the specimen is occupied by the body chamber. In the copy of REINECKE's booklet kept at Coburg the broken surface at the aperture is drawn as being smooth. This may be an indication that the type had at least a part of the body chamber. Nevertheless, in the REINECKE copy kept at Bantz castle near Staffelstein, the corresponding drawing no. 72 indicates that the last whorl of the type ends with a septum. The type would then be a phragmocone and be larger than the largest ammonite no. 42 in the Coburg museum. Judging from the Bantz copy, the type would be lost. Under the circumstances, the matter cannot be decided, and the neotype designated by GEYER (1961, p. 22, pl. 2, fig. 3) without knowledge of Reinecke's collection must be further retained.

Age: Earliest Planula Subchron of the Planula Chron.

Subgenus *Praeataxioceras* ATROPS 1982

Subgeneric type species: *Perisphinctes Laufenensis* SIEMIRADZKI (1898, p.188, pl. 26, fig. 46), designated by ATROPS (1982, p. 50).

4.1.53 *Orthosphinctes (Praeataxioceras)* sp. gr. *laufenensis* (SIEMIRADZKI 1898)

Pl. 11, fig. 1 – text-fig. 58

Material: MNHB J 31722

Locality: section RG 76, GYGI (1969, fig. 2), Hornbuck, Erzingen D, bed 12, Hornbuck Member.

Description: Dimensions			
	D	82 mm	
	Wh	26 mm	32 %
	Wt	16 mm	20 %
	U	39 mm	48 %

The carbonate internal mould is septate to the diameter of 52 mm. Three fourths of the last whorl are occupied by the body chamber. The specimen is a complete adult with the peristome and a lappet preserved on one side (pl. 11, fig. 1b). The primary ribs begin close to the umbilical suture line and are straight and radial. They are low but sharp. At about 60 % of the whorl height they split into two secondary ribs. A third, intercalated secondary rib is added to the majority of the primary ribs. The secondary ribs are radial. The whorl section is elliptic. The last whorl covers the preceding one by less than 20 %. Therefore the points of division of the primary ribs are visible on the last but one whorl. There is a straight and deep constriction before the peristome.

Discussion: The described specimen J 31722 differs from the description and the figures by SIEMIRADZKI in several respects. The whorl sides of the Basel specimen are convex, not flat and converging like in SIEMIRAKZKI's type. The peristome is straight and radial. *Orthosphinctes (Orthosphinctes) polygyratus* (QUENSTEDT, 1849, p. 161, pl. 12, fig. 3) is similar, but it has a narrower umbilicus and prorsiradiate ribs. The type of *Nautilus polygyratus* REINECKE (1818, p. 73, pl. 5, figs. 45–46) could not be found in the Naturkunde-Museum Coburg (Germany) where the Reinecke collection is kept. REINECKE (loc. cit.) stated that his specimens of *N. polygyratus* came from Tremersdorf and Staffelstein. Tremersdorf must be an error, because, according to E. Mönnig, curator at the Naturkunde-Museum Coburg, the village of Tremersdorf is situated on Muschelkalk (late Triassic). A large part of the specimens from the Late Jurassic in the Reinecke collection is from Mt. Staffelberg above the town of Staffelstein. The title of REINECKE's booklet says that these ammonites have been collected from a ploughed field. Marly, fossiliferous strata of the earliest Kimmeridgian form a nearly flat surface on the top of Mt. Staffelberg. The type of *Nautilus polygyratus* REINECKE must then be of early Kimmeridgian age, as GEYER (1961, p. 21) concluded when he designated a neotype.

Age: Bimammatum Subchron of the Bimammatum Chron.

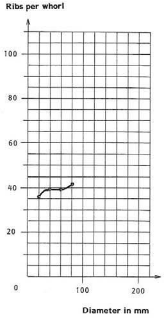


Fig. 58: Rib curve of *Orthosphinctes (Praeataxioceras)* sp. gr. *laufenensis* (SIEMIRADZKI) MNHB J 31722.

Genus *Ataxioceras* FONTANNES 1879
Subgenus *Parataxioceras* SCHINDEWOLF 1925

Subgeneric type species: *Ammonites lothari* OPPEL 1863.

4.1.54 *Ataxioceras (Parataxioceras) lothari huguenini* ATROPS 1982

Pl. 14, fig. 2

Synonymy

1982 *Ataxioceras* (m. *Parataxioceras*) *lothari huguenini* n. ssp. – ATROPS, p. 206, pl. 7, figs. 3–4, pl. 9, fig. 4, pl. 44, figs. 3–5, pl. 45, fig. 3

Material: MNHB J 26388

Locality: section RG 70, GYGI (1969, pl. 17), large quarry, Mellikon AG, bed 124, lower Baden Member.

Description: Dimensions			
	D	72.5 mm	
	Wh	27.0 mm	37 %
	Wt	18.0 mm	25 %
	U	25.0 mm	34 %

The carbonate internal mould is septate to the diameter of 47 mm. More than one half of the last whorl is occupied by the body chamber. The primary ribs begin at the umbilical suture line. On the last whorl they first swing back. They become very strong and sharp at the umbilical margin, then weaker in the middle of the whorl sides. The primary ribs lean about 7° forward on the sides of the last whorl. On the inner whorls the forward inclination of the primaries is stronger. There the primaries split into secondary ribs above the middle of the whorl height. On the body chamber the lowest points of division are below half the whorl height. At the end of the body chamber there are five secondary ribs per primary. The secondary ribs bend forward and form a proconvex arc at the rounded siphonal side. The whorl sides are slightly convex. The umbilical wall is high and vertical on the inner whorls and becomes rounded on the last whorl.

Age: Lothari Subchron of the Hypselocyclum Chron.

4.1.55 *Ataxioceras (Parataxioceras)* cf. *pseudoeffrenatum* WEGELE 1929

Pl. 14, fig. 1 – text-fig. 59

Synonymy

1961 *Ataxioceras (Parataxioceras) pseudoeffrenatum* WEGELE – GEYER, p. 69, pl. 16, fig. 1, with synonymy
1992 *Ataxioceras (Parataxioceras) pseudoeffrenatum* WEGELE – FINKEL, p. 240, *non* fig. 9, figs. 17, 20

Material: MNHB J 31721

Locality: section RG 70, GYGI (1969, pl. 17), large quarry, Mellikon AG, bed 124, lower Baden Member.

Description: Dimensions			
	D	111 mm	
	Wh	37 mm	33 %
	Wt	24 mm	22 %
	U	46 mm	41 %

The carbonate internal mould is septate to a diameter of at least 78 mm. The last half whorl is occupied by the body chamber. The primary ribs of the inner whorls begin at the umbilical suture line. They swing slightly back on the low and rounded umbilical wall. They are strongest at the umbilical margin. Their height and forward inclination varies already on the inner whorls. The forward inclination of the primary ribs is between 5° and 15°. On the inner whorls the primaries split above half the whorl height into secondary ribs. On the last whorl the primary ribs begin to broaden already at the base of the convex whorl sides. The ribs there split irregularly into 6 – 8 secondary ribs. On the phragmocone the secondaries bend slightly forward, but on the body chamber they are radial. The last whorl covers the preceding one by 36 %. The whorl section is high-oval.

Discussion: The figured specimen J 31721 is classed with reservation with the taxon *pseudoeffrenatum* WEGELE, because both the holotype of WEGELE (1929, pl. 8, fig. 5) and the specimen figured by GEYER (1961, pl. 16, fig. 1) are less densely ribbed and have a slightly narrower umbilicus.

Age: Hypselocyclum Chron.

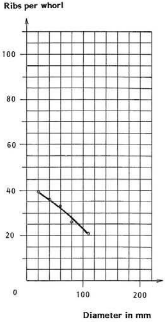


Fig. 59: Rib curve of *Ataxioceras (Parataxioceras)* cf. *pseudoeffrenatum* WEGELE MNHB J 31721.

Family Aulacostephanidae SPATH 1924
Subfamily Pictoniinae SPATH 1924
Genus *Ringsteadia* SALFELD 1913

Type species: *Ammonites pseudocordatus* BLAKE & HUDLESTON 1877

4.1.56 *Ringsteadia suebica n. sp.*

Pl. 12, fig. 1 – text-fig. 60

Holotype: MNHB J 31724, ex collection L. Rollier in the Geological Institute of the Eidgenössische Technische Hochschule (ETH) Zürich (see GYGI, 1969, p. 101). Original to pl. 12, fig. 1.

Type locality: Dreifaltigkeitsberg above Gosheim near Spaichingen, southern Germany (Rollier's handwriting on the specimen).

Type horizon: To judge from the slightly glauconitic material of the internal mold, the specimen is from the Knollen Bed marker bed in the Villigen Formation.

Derivation of the name: from the Latin *Suebia*, a region in southern Germany.

Diagnosis: Large species of the genus *Ringsteadia* with a maximum diameter of the shell of about 400 mm and around 280 mm of the phragmocone. The primary ribs are strong and blunt. The secondary ribs fade away at the diameter of 220 mm.

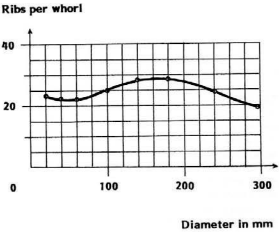


Fig. 60: Rib curve of *Ringsteadia suebica* n. sp. MNHB J 31724.

Description: Dimensions

D	316 mm		
Wh	96 mm	30 %	
Wt	76 mm	24 %	
U	131 mm	41 %	

The slightly glauconitic, carbonate internal mould is septate to the diameter of 282 mm. Half of the last whorl is occupied by the body chamber. The strong, but blunt primary ribs begin at the umbilical suture line. The ribs are straight and have a forward inclination of 15° at the diameter of 110 mm. There are apparently three secondary ribs per primary rib. The secondary ribs disappear at the diameter of 220 mm, from where the siphonal side becomes smooth. The whorl section is oval. The primary ribs are reduced to broad, low waves with striae on the body chamber.

Discussion: It is concluded from the whorl section, the slight inclination of the umbilical wall and the type of ribbing that the specimen J 31724 belongs to the genus *Ringsteadia*. The holotype of the new species may be compared with *Ringsteadia anglica* Salfeld no. 25502 that is kept in the collection of the Geological Survey of Great Britain at Keyworth, Nottingham, England (see Salfeld, 1917, pl. 13). This English specimen is designated here as the lectotype of *Ringsteadia anglica*. The specimen MNHB J 31724 from Gosheim is not conspecific with *R. anglica* for the following reasons: It is somewhat larger, its phragmocone has a diameter of 282 mm as compared with 244 mm in the lectotype of *R. anglica*. *Ringsteadia suebica* has considerably thicker whorls than *R. anglica*. The siphonal side of *R. suebica* is rounded, not angular. The rib curves of the two taxa are similar (fig. 60). *Ringsteadia anglica* Salfeld is the closest relative of *Ringsteadia suebica* n. sp. in northwest-european *Ringsteadiae*.

Age: Latest Hauffianum Subchron of the Bimammatum Chron. This means that the genus *Ringsteadia* probably survived somewhat longer in the submediterranean faunal province than in the northwest-european faunal province (see 5.6, the Oxfordian-Kimmeridgian boundary, below).

Subfamily Aulacostephaninae Spath 1924
Genus *Rasenia* Salfeld 1913
Subgenus *Eurasenia* Geyer 1961

Subgeneric type species: *Ammonites rolandi* Oppel 1863

4.1.57 *Rasenia (Eurasenia) trifurcata* (Reinecke 1818)

Pl. 14, fig. 5

Synonymy

1961 *Rasenia (Eurasenia) trifurcata* (Reinecke) – Geyer, p. 93, pl. 1, fig. 7, pl. 19, fig. 3, pl. 22, fig. 4, with synonymy

Material: MNHB J 26452

Locality: section RG 70, Gygi (1969, pl. 17), large quarry, Mellikon AG, bed 124, lower Baden Member.

Description: Dimensions

D	120 mm		
Wh	43 mm	36 %	
Wt	44 mm	37 %	
U	46 mm	38 %	

The glauconitic, carbonate internal mould is probably wholly septate. The primary ribs begin on the umbilical margin. There are 16 primary ribs at all visible stages. The rib curve is therefore a horizontal straight line. The primary ribs are radial, high and sharp. Their maximum elevation is at one third of the whorl height. There they split into two strong secondary ribs. One, and in one case, two secondaries are intercalated, so that there are generally three secondaries per primary rib. The secondary ribs are somewhat attenuated along the siphonal line. They lean a little forward. The whorl section is thick-oval (see Geyer, 1961, fig. 123 d).

Age: Hypselocyclum Chron.

Genus *Sutneria* Zittel 1884
Subgenus *Sutneria* Zittel 1884

Subgeneric type species: *Nautilus platynotus* Reinecke 1818

4.1.58 *Sutneria (Sutneria) galar galar* (Oppel 1863)

Pl. 13, fig. 3

Synonymy

1961 *Sutneria (Sutneria) galar* (Oppel) – Geyer, p. 132, pl. 4, fig. 7, with synonymy
1974 *Sutneria galar* (Oppel) – Barbulescu, pl. 40, figs. 5–8
1977 *Sutneria galar* (Oppel) – Ziegler, pl. 2, fig. 3

1987 *Sutneria galar* (OPPEL) – ZIEGLER, pl. 1, fig. 2
1991 *Sutneria (Sutneria) galar* (OPPEL) – SCHLAMPP, pl. 19, fig. 1
1994 *Sutneria (Sutneria) galar galar* (OPPEL) – SCHLEGELMILCH, p. 112, pl. 59, fig. 3

Material: MNHB J 23622

Locality: section RG 239, GYGI (1990b, p. 69), excavation at Summerhalde, Schaffhausen, bed 18, base of Schwarzbach Formation.

Description: Dimensions			
	D	26 mm	
	Wh	11 mm	42 %
	Wt	12 mm	46 %
	U	6 mm	23 %

The slightly glauconitic carbonate internal mould is septate to the diameter of 16 mm. The body chamber occupies two thirds of the last whorl. The peristome with lappets is preserved and indicates that the specimen is a complete adult. The primary ribs begin on the umbilical margin above the smooth and vertical umbilical wall. They split at one third of the whorl height into secondary ribs that bend back. The number of secondaries per primary rib increases from two on the phragmocone to four near the peristome. The secondary ribs are strong on the phragmocone and become faint towards the aperture. The body chamber has two abnormal bends so that it diverges from the normal coiling spiral.

Age: Galar Subchron of the Planula Chron.

4.1.59 *Sutneria (Sutneria) platynota* (REINECKE 1818), morphotype A, SCHAIRER 1970

Pl. 13, fig. 2

Synonymy

1970 *Sutneria (Sutneria) platynota* (REINECKE), morphotype A – SCHAIRER, p. 158, pl. 1, figs. 1–9, with synonymy
1977 *Sutneria platynota* (REINECKE) – ZIEGLER, pl. 3, fig. 3
1987 *Sutneria platynota* (REINECKE) – ZIEGLER, pl. 2, fig. 4
1991 *Sutneria (Sutneria) platynota* (REINECKE) – SCHLAMPP, pl. 19, figs. 2–3
1992 *Sutneria platynota* (REINECKE) – FINKEL, fig. 83
1994 *Sutneria (Sutneria) platynota* (REINECKE) – SCHLEGELMILCH, p. 112, pl. 59, fig. 4

Material: MNHB J 23630

Locality: section RG 239, GYGI (1990b, p. 69), excavation at Summerhalde, Schaffhausen, bed 22, lower Schwarzbach Formation.

Description: Dimensions			
	D	20.0 mm	
	Wh	8.0 mm	40 %
	Wt	11.0 mm	55 %
	U	4.7 mm	24 %

The carbonate internal mould is septate to the diameter of 12 mm. Two thirds of the last whorl are occupied by the complete body chamber. The peristome has narrow lappets. The specimen is a complete adult. The primary ribs begin on the umbilical margin and first swing back. On the whorl sides they become radial. On the phragmocone the primary ribs split at half the whorl height into two secondary ribs. The secondary ribs bend back. On the body chamber the primary ribs become coarser and continue to the siphonal margin. There they end in a tubercle. The secondary ribs fade away at the boundary between the phragmocone and the body chamber. The broad and only slightly convex siphonal side of the body chamber is thus smooth. The body chamber has two abnormal bends and diverges from the normal coiling spiral. The ornamentation ceases abruptly at the second abnormal bend.

Age: *"Orthosphinctes"* Subchron of the Platynota Chron.

Family Pachyceratidae BUCKMAN 1918
Genus *Protophites* EBRAY 1860

Type species: *Ammonites Christolii* BEAUDOUIN, 1851, designated by ROMAN (1938, p. 209).

4.1.60 *Protophites christoli* (BEAUDOUIN 1851)

Pl. 2, fig. 8

Synonymy

1851 *Ammonites Christolii* – BEAUDOUIN, p. 587, pl. 10, figs. 1–2
1900 *Oecoptychius christoli* BEAUDOUIN – GEVREY, p. 45, pl. 2, figs. 1–9
1901 *Oecoptychius Christoli* BEAUDOUIN – DE LORIOL, p. 20, pl. 1, fig. 13
1938 *Christolia Christoli* BEAUDOUIN – ROMAN, p. 209, fig. 28
1951 *Christolia Christoli* BEAUDOIN – JEANNET, p. 106, pl. 31, figs. 7–10
1957 *Protophites christoli* (BEAUDOUIN) – ARKELL *et al.*, p. 296, figs. 355/2a-c

Material: MNHB J 24943

Locality: section RG 208, GYGI (1977, pl. 11, fig. 2), excavation on Brunnrain, Ueken AG, bed 9, upper Schellenbrücke Bed.

Description: Dimensions			
	D	21 mm	
	Wh	10 mm	48 %
	Wt	13 mm	62 %
	U	3 mm	14 %

The iron oolitic, carbonate internal mould is a complete adult with rostrum and peristome. The phragmocone has a diameter of about 12 mm. The greatest whorl thickness is at the end of the phragmocone. A sharp bend of the last whorl is located just before the end of the phragmocone. The body chamber occupies two thirds of the last whorl. There is a pronounced egression of the umbilical suture line of the body chamber. The primary ribs begin on the whorl sides near the umbilical margin and are strongest at the siphonal side. Secondary, intercalated ribs begin at about half the whorl height. The peristome is relatively small.

Age: Late Cordatum Subchron of the Cordatum Chron.

Family Aspidoceratidae ZITTEL 1895
Subfamily Peltoceratinae SPATH 1924
Genus *Gregoryceras* SPATH 1924
Subgenus *Pseudogregoryceras* JEANNET 1951

Subgeneric type species: *Pseudogregoryceras iteni* JEANNET, designated by JEANNET (1951, p. 200).

4.1.61 *Gregoryceras (Pseudogregoryceras) iteni* JEANNET 1951
Pl. 2, fig. 11, pl. 4, fig. 5

Synonymy

v 1977 *Gregoryceras (Pseudogregoryceras) iteni* JEANNET – GYGI, p. 466, pl. 1, figs. 1–3, pl. 10, figs. 1–2, with synonymy

Material: MNHB J 23048

Locality: section RG 209, GYGI (1977, pl. 11, section 1), Herznach iron mine, Herznach AG, not *in situ*, collected from a block fallen from the Schellenbrücke Bed.

Description: Dimensions			
	D	67 mm	
	Wh	23 mm	34 %
	Wt	25 mm	37 %
	U	24 mm	36 %

The iron oolitic, carbonate internal mould is septate to the diameter of 45 mm. The body chamber occupies two thirds of the last whorl. The innermost whorls have a circular cross-section. When the umbilicus attains a diameter of 6 mm, the umbilical wall becomes vertical. Shortly afterwards an umbilical edge develops and the whorl sides become flat. There is a sharp edge at the siphonal margin on the last quarter whorl of the phragmocone. This edge is diagnostic for the taxon. On the body chamber the whorl section is again circular (GYGI, 1977, pl. 10, fig. 1). The inner whorls are smooth. The first umbilical ribs appear at a diameter of 39 mm and bend back. Most of them split into two secondary ribs at the siphonal margin. The secondary ribs form a chevron at the rounded siphonal side where the siphonal margin is a sharp edge.

Age: Cordatum Subchron of the Cordatum Chron.

Subgenus *Gregoryceras* SPATH 1924

Subgeneric type species: *Ammonites transversarius* QUENSTEDT 1847.

4.1.62 *Gregoryceras (Gregoryceras) tenuisculptum* GYGI 1977
Pl. 4, fig. 4

Synonymy

v 1977 *Gregoryceras (Gregoryceras) tenuisculptum* n. sp. – GYGI, p. 471, pl. 1, fig. 5, pl. 10, fig. 4
v 1984 *Gregoryceras (Gregoryceras) tenuisculptum* GYGI – TARKOWSKI, p. 43, pl. 22, fig. 3
v 1994 *Gregoryceras tenuisculptum* GYGI – SCHLEGELMILCH, p. 118, pl. 61, fig. 5
non 1995 *Gregoryceras tenuisculptum* GYGI – BESNOSOV & MITTA, p. 106, pl. 26, fig. 6

Material: MNHB J 23064, holotype

Locality: section RG 212, GYGI (1977, pl. 11, fig. 7), excavation above the shooting range in Churz Tal, Siblingen SH, bed 7, Mumienmergel Bed.

Description: Dimensions			
	D	54.0 mm	
	Wh	17.7 mm	33 %
	Wt	21.5 mm	40 %
	U	22.3 mm	41 %

The glauconitic, carbonate internal mould of the holotype is septate to a diameter of at least 68 mm. The last two visible septal sutures are approximated. The specimen might then be the inner whorls of an adult with a diameter of about 85 mm. The sides of the inner whorls are flat. The umbilical margin is an edge to the diameter of 25 mm, then it becomes rounded. The umbilical wall is steep and high. The first umbilical ribs appear at the diameter of 23 mm. This is diagnostic for the taxon. The ribs begin on the umbilical margin, have a strong backward inclination and an S-form curvature. Most of them split into two secondary ribs in the upper half of the whorl height. The secondary ribs are higher than the primaries and form a proconcave arc at the siphonal side.

Age: Densiplicatum Subchron of the Transversarium Chron.

4.1.63 *Gregoryceras (Gregoryceras) transversarium* (QUENSTEDT 1847)
Pl. 4, figs. 1–2

Synonymy

v 1977 *Gregoryceras (Gregoryceras) transversarium* (QUENSTEDT) – GYGI, p. 486, pl. 6, figs. 2–3, pl. 7, figs. 1–3, pl. 8, figs. 1–2, pl. 10, figs. 16–19, with synonymy
1985 *Gregoryceras transversarium* (QUENSTEDT) – SARTI, pl. 2, fig. 1

v 1991 *Gregoryceras transversarium* (QUENSTEDT) – SCHLAMPP, pl. 23, fig. 3
v 1991 *Gregoryceras (Gregoryceras) transversarium* (QUENSTEDT) – GYGI & VON HILLEBRANDT, p. 159, pl. 6, fig. 1, pl. 8, fig. 1
1994 *Gregoryceras (Gregoryceras)* cf. *romani* (DE GROSSOUVRE) – KRAUTTER, p. 329, fig. 4
v 1994 *Gregoryceras transversarium* (QUENSTEDT) – SCHLEGELMILCH, p. 119, pl. 62, fig. 2

Material: MNHB J 23051, J 28141

Locality of J 28141: Siblingen SH, Mumienkalk Bed.

Description of J 28141: Dimensions			
	D	53.5 mm	
	Wh	20.0 mm	37 %
	Wt	22.7 mm	42 %
	U	19.7 mm	37 %

The glauconitic, carbonate internal mould is septate to the diameter of 63 mm. The umbilical wall of the last whorl is high and steep. A pronounced umbilical edge separates the umbilical wall from the converging whorl sides. The primary ribs begin about half way up on the umbilical wall. They form strong tubercles at the umbilical edge. One or two straight ribs issue from the tubercles and lean thoroughly back. On the phragmocone some of these ribs split into secondaries at two thirds the whorl height. The ribs are attenuated in the middle of the whorl sides and again become strong at the siphonal margin. The whorl sides as measured above the ribs are therefore concave. The ribs are strongest at the slightly convex siphonal side.

Age: Antecedens to Luciaeformis Subchrons of the Transversarium Chron.

4.1.64 *Gregoryceras (Gregoryceras) riazi* (DE GROSSOUVRE 1917)
Pl. 4, fig. 3

Synonymy

v 1977 *Gregoryceras (Gregoryceras) riazi* (DE GROSSOUVRE) – GYGI, p. 473, pl. 1, figs. 6–7, pl. 2, figs. 1–5, pl. 3, figs. 1–3, pl. 4, figs. 1–2, pl. 5, figs. 1–2, pl. 10, figs. 5–11, with synonymy
1982 *Gregoryceras riazi* DE GROSSOUVRE – DEBRAND-PASSARD, pl. 12, fig. 3
v 1991 *Gregoryceras (Gregoryceras) riazi* (DE GROSSOUVRE) – GYGI & VON HILLEBRANDT, p. 158, pl. 3, fig. 8
1991 *Gregoryceras riazi* (DE GROSSOUVRE) – SCHLAMPP, pl. 23, fig. 2
v 1994 *Gregoryceras riazi* (DE GROSSOUVRE) – SCHLEGELMILCH, p. 118, pl. 61, fig. 6

Material: MNHB J 23062

Locality: section RG 230, GYGI (1977, pl. 11, fig. 3), excavation north of Eisengraben, Gansingen AG, upper Birmenstorf Member.

Description: Dimensions			
	D	134 mm	
	Wh	42 mm	31 %
	Wt	–	–
	U	61 mm	46 %

The carbonate internal mould is septate to the diameter of 105 mm. One half of the last whorl is occupied by the body chamber. The primary ribs begin in the upper part of the steep umbilical wall. They are enhanced at the umbilical margin in tubercles. On the inner whorls two primary ribs are often connected in a tubercle with an arc or an obtuse angle. The primary ribs bend back on the converging whorl sides. Some of them split into two secondary ribs above half the whorl height. The ribs are attenuated in the middle of the whorl sides and become very strong at the flattened siphonal side.

Age: Antecedens to Luciaeformis Subchrons of the Transversarium Chron.

Subfamily Euaspidoceratinae SPATH 1931
Genus *Euaspidoceras* SPATH 1931

Type species: *Ammonites perarmatus* SOWERBY 1822.

4.1.65 *Euaspidoceras hypselum* (OPPEL 1863)
Pl. 10, fig. 1

Synonymy

1931 *Aspidoceras hypselum* OPPEL – DORN, p. 15, pl. 1, figs. 9–11, pl. 2, figs. 3–4, pl. 3, figs. 1–2, with synonymy
1968 *Clambites (Euaspidoceras) hypselum* (OPPEL) – MILLER, pl. 7/8, fig. 8
1974 *Euaspidoceras hypsellum* (OPPEL) – BARBULESCU, pl. 43, fig. 1
1979 *Euaspidoceras hypselum* (OPPEL) – SAPUNOV, p. 148, pl. 46, fig. 1, *non* pl. 45, fig. 2, with synonymy
1991 *Euaspidoceras (Euaspidoceras) hypselum* (OPPEL) – SCHLAMPP, pl. 24, fig. 3
1994 *Euaspidoceras hypselum* (OPPEL) – SCHLEGELMILCH, p. 120, pl. 63, fig. 1

Material: MNHB J 27259

Locality: section RG 37, GYGI (1969, pl. 17), Jakobsberg quarry, Auenstein AG, not *in situ*, out of the limestone succession 55–80 ca 70 m above the Gerstenhübel Beds, Effingen Member.

Description: The ill-preserved and diagenetically deformed specimen cannot be measured exactly. The diameter of the complete specimen must have been around 190 mm. The last septum is at the diameter of 133 mm. The last half whorl is occupied by the body chamber. The last ribs before the aperture are approximated and modified. The specimen is a near-complete adult. The whorls are thicker than high. The siphonal side seems to be more convex than that of OPPEL's type. The ribs begin on the rounded umbilical wall. On the umbilical margin they form a low tubercle. The ribs are attenuated in the middle of the whorl sides, then form a high, swollen tubercle at the siphonal margin. The tubercles carried thin, hollow spines.

Age: Hypselum Subchron of the Bimammatum Chron.

Genus *Epipeltoceras* SPATH 1924

Type species: *Ammonites bimammatus* QUENSTEDT 1858.

4.1.66 *Epipeltoceras bimammatum* (QUENSTEDT 1858)
Pl. 10, fig. 4

Synonymy

- 1962 *Epipeltoceras bimammatum* (QUENSTEDT) – STEFANOV, p. 103, pl. 2, fig. 3
- 1962 *Epipeltoceras bimammatum* (QUENSTEDT) – SCHMIDT-KALER, p. 31, pl. 3, fig. 1
- 1963 *Epipeltoceras bimammatum* (QUENSTEDT) – ENAY, p. 54, pl. 4, fig. 1, with synonymy
- 1974 *Epipeltoceras bimammatum* (QUENSTEDT) – BARBULESCU, p. 137, pl. 42, figs. 4–8, *non* 10
- 1977 *Epipeltoceras bimammatum* (QUENSTEDT) – ZIEGLER, pl. 1, fig. 6
- 1982 *Epipeltoceras bimammatum* (QUENSTEDT) – DEBRAND-PASSARD, pl. 16, fig. 4
- 1987 *Epipeltoceras bimammatum* (QUENSTEDT) – ZIEGLER, pl. 1, fig. 3
- 1991 *Epipeltoceras bimammatum* (QUENSTEDT) – SCHLAMPP, pl. 1, fig. 5
- 1994 *Epipeltoceras bimammatum* (QUENSTEDT) – SCHLEGELMILCH, p. 68, pl. 23, fig. 10

Material: MNHB J 32268

Locality: section RG 76, GYGI (1969, fig. 2), Hornbuck near Riedern am Sand, Erzingen D, bed 11, Hornbuck Member.

Description: Less than half of the specimen is preserved. There are two thirds of the body chamber that is deformed by compaction of the lime mud of the internal mould. Part of an inner whorl is flattened. The last ribs on the body chamber are approximated. The ammonite thus seems to be an adult. The ribs are very stout and widely spaced. The umbilicus is relatively narrow. The siphonal side is flat near the aperture and concave on the rear part of the body chamber.

Age: Bimammatum Subchron of the Bimammatum Chron.

4.1.67 *Epipeltoceras* cf. *bimammatum* (QUENSTEDT 1858)
Pl. 10, fig. 5

Material: MNHB J 31726 ex collection C. Moesch, ETH Zürich no. Ve. S. 6686.

Locality: section RG 35, detailed section unpublished, see GYGI (1969, pl. 19, upper section), Fahr quarry, Auenstein AG, bed 31, Crenularis Member.

Description: Dimensions

D	49 mm	
Wh	15 mm	31 %
Wt	14 mm	29 %
U	20 mm	41 %

The glauconitic, carbonate internal mould is septate to the diameter of 35 mm. The last three septa are approximated. The body chamber occupies the last half whorl and is complete. Part of the peristome and a lappet are preserved. There is a row of low tubercles along the umbilical margin. One and in two cases two ribs issue from these tubercles. The ribs are lowest in the middle of the almost flat whorl sides. The ribs end in tubercles on the siphonal margin. These tubercles are highest at the end of the phragmocone. At this stage the siphonal side is concave. Near the aperture of this complete adult, the tubercles are low and the siphonal side is almost flat.

Discussion: The specimen described here has a wider umbilicus and more numerous and finer ribs than *Epipeltoceras bimammatum* (QUENSTEDT). In this it resembles *Epipeltoceras berrense* (FAVRE, 1876, pl. 3, fig. 11). This is the lectotype in the Museum of Natural History Bern as designated and refigured by SCHMIDT-KALER (1962, p. 31, pl. 3, fig. 4). However, the high and steep umbilical wall, the almost flat whorl sides and the high tubercles on the siphonal margin at the end of the phragmocone indicate that the specimen J 31726 is an intermediate form between *E. berrense* and *E. bimammatum*, but that it is closer to *Epipeltoceras bimammatum* than to the stratigraphically older taxon.

Age: Early Bimammatum Subchron of the Bimammatum Chron.

Subfamily Aspidoceratinae ZITTEL 1895
Genus *Orthaspidoceras* SPATH 1925

Type species: *Ammonites orthocera* D'ORBIGNY 1847.

4.1.68 *Orthaspidoceras uhlandi* (OPPEL 1863)
Pl. 15, fig. 1

Synonymy

- 1985 *Orthaspidoceras uhlandi* (OPPEL) – CHECA, p. 154, pl. 31, fig. 1, with synonymy
- 1991 *Orthaspidoceras uhlandi* (OPPEL) – SCHLAMPP, pl. 25, fig. 6
- 1994 *Orthaspidoceras uhlandi* (OPPEL) – SCHLEGELMILCH, p. 130, pl. 71, fig. 2

Material: MNHB J 22901.

Locality: section RG 70, GYGI (1969, pl. 17), large quarry, Mellikon AG, beds above no. 126, lower Wettingen Member.

Description: Dimensions approximately

D	209 mm	
Wh	84 mm	40 %
Wt	78 mm	37 %
U	65 mm	31 %

The carbonate internal mould is septate to the diameter of 154 mm. Half of the last whorl is occupied by the complete body chamber. Part of the peristome is preserved. The whorl section is thick-oval. The umbilical wall is well rounded and overhanging at the base. A single row of high tubercles is situated somewhat below half the whorl height. Three low, blunt ribs per tubercle begin at half the whorl height. These faint ribs are attenuated along the siphonal line.

Age: Later part of Divisum Chron.

4.2 The vertical range of the taxa

The vertical range of the stratigraphically significant ammonite taxa is indicated in fig. 61. About 8000 ammonites were available for this representation. Some of the vertical ranges as indicated in this figure do not agree with the ranges given by other authors. This is a consequence partly of the fact that the vertical ranges of taxa given in this paper are based on collecting from *in situ*, and partly because the vertical ranges may indeed vary in different parts of Europe. The distribution of ammonites in the succession is very uneven. Ammonites are abundant in the Herznach Formation and in the lowermost Renggeri Member in northwestern Switzerland. They are increasingly rare in the middle and upper Renggeri Member. In the Schellenbrücke Bed there is a profusion of well-preserved ammonites. The lowermost, condensed bed of the Birmenstorf Member (Densiplicatum and Antecedens Subzones) in Canton Aargau contains very few ammonites, but the coeval Mumienmergel and Mumienkalk Beds of Canton Schaffhausen include an abundant ammonite fauna. Ammonites are fairly abundant in the normal facies of the Birmenstorf Member, but rare in the Effingen Member. The Villigen Formation too contains few ammonites except for the Crenularis and the Hornbuck Members. Ammonites are again abundant in the uppermost Villigen and in the lower Schwarzbach Formation.

Consequently, in many cases only single ammonite specimens of a given taxon were available in lithostratigraphical units with few fossils. Nevertheless, all the ammonite zones and subzones could be documented, but not always by their index as in the Grossouvrei and Hauffianum Subzones and in the Hypselocyclum Zone. Moreover, some ammonites found by private collectors not *in situ* have been used, if their origin could be concluded of the lithology of the internal mould (see captions to the plates).

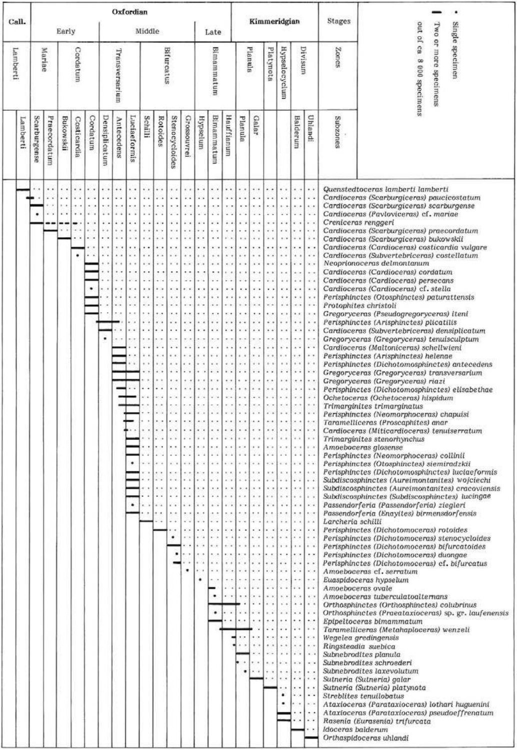


Fig. 61: The vertical range of stratigraphically significant ammonite taxa in northern Switzerland and in adjacent southern Germany.

5. Results and discussion

5.1 The origin of lime mud

The word mud is used here in the sense of Pettijohn (1957, fig. 81) and means a mixture of unconsolidated clay- and silt-sized particles with water. A large amount of lime mud sediment accumulated during the Oxfordian mainly in the basin. Clay- and silt-grade carbonate is a major constituent of the Bärschwil Formation. The greater part of the Effingen Member was originally lime mud (Gygi, 1969, pl. 17, section 37), and the Villigen Formation is an almost pure lime mudstone with only small admixtures of clay minerals (Gygi, 1969. pl. 17, section 62). In the Kimmeridgian very much lime mud has been sedimented both on the platform and in the basin. The main sources of lime mud are discussed in Sections 5.1.1 to 5.1.4.

5.1.1 Bioerosion of hard substrates like reefs and limestone coasts in warm climates

Gygi (1975, fig. 11) found that fish of the genus *Sparisoma* and other reef fishes produce not only sand-size particles, but a large amount of mud. The erosion rate of *Sparisoma viride* (Bonnaterre) was calculated to be 17.4g/m^2/summer month on a reef in agitated water. Assuming a constant grazing activity the year round this amounts to 209g/m^2/year. More than half of this particulate carbonate is mud. Thus modern scarid fish are significant lime mud producers. Their closest functional relatives in the Jurassic are the pycnodontid reef fishes *Mesodon* and *Microdon*. Gygi (1975, p. 356) concluded that these were unimportant producers of reef-derived sediment, because their maxillar dentition did not grow again lifelong as in scarid fish.

According to Hartman (1958), the boring sponge *Cliona* generates fine-grained silt. Tracey *et al.* (1948, p. 876) observed at Bikini in the Pacific that the bulk of boring organisms probably preferred protected environments in the atoll. This would reduce the chance of large-scale export of silt as generated by *Cliona* to the basin.

The surface covered by coral reefs and bioherms in the Late Jurassic of northern Switzerland was relatively small even at the time of their maximum extent in the middle Oxfordian. Coral reefs and bioherms were therefore probably only a minor source of lime mud. The mechanical erosion of Recent reefs by waves is thought to be insignificant (Scoffin et al. 1980, p. 502). Bioerosion of Recent reefs is much more important. It is caused in the tropical West Atlantic to a large extent by the grazing regular sea urchin *Diadema antillarum* Philippi. Ogden (1977, p. 284) estimated an erosion rate of 4.6 kg/m^2/year by this urchin on a patch reef on the northeast coast of St. Croix, U. S. Virgin Islands. The eroded carbonate is excreted in the form of pellets (Scoffin et al. 1980, fig. 6) that may disintegrate with time. Nothing is known of the constituent granulometry of these pellets that have a diameter of less than 1 mm. Regular sea urchins are quite common in the lime-muddy sediment adjacent to lagoon reefs of the upper St-Ursanne Formation near St-Ursanne (Woltersdorf in Pümpin, 1965, p. 867), and they probably have produced carbonate sediment. However, Hunt (1969, p. 39) has found that the rock-boring regular sea urchin *Echinometra lucunter* on coral reefs of Bermuda produces but sand.

5.1.2 Algae

Recent marine calcareous algae like for instance *Penicillus* secrete clay-size aragonite needles within their tissue (Lowenstam 1955, Cloud 1962). After the death of the algae the tissue decays and the aragonite needles are left as mud. Lowenstam & Epstein (1957) and Neumann (1965) thought that such algae are major producers of lime mud.

5.1.3 Nannoplankton

Flügel & Franz (1967, pl. 3, fig. 2, pl. 4, fig. 2) and Gygi (1969, text-fig. 1, pl. 4, fig. 16, pl. 5, fig. 17 and pl. 11, fig. 41) documented that coccoliths of the genus *Watznaueria* are a constituent of Oxfordian lime mudstones in northern Switzerland. Gygi (1969, p. 24) estimated that coccoliths comprise less than 1 % of the rock volume even where they are most abundant in the upper Villigen Formation near Immendingen, southern Germany or in the Letzi Member near Mellikon AG. This may in part be due to recrystallization of the micrite. However, coccoliths and their micellae are well-preserved where they occur. Therefore it is unlikely that they formed primarily a major part of the lime mud in the Oxfordian in the deeper marine facies.

5.1.4 Inorganically precipitated mud

There is growing evidence that much or most of the carbonate, mostly aragonitic, mud sedimented on the Great Bahama Bank is precipitated inorganically as has been concluded by Cloud in a careful study as early as 1962. Kinsman (1969, p. 498) cautioned that there is a difference in the Sr^{+2} content between lagoonal carbonate mud and oolite sand in the Persian Gulf on the one hand and the Sr^{+2} content predicted for "simple inorganic precipitation" from sea water on the other hand. Shinn et al. (1989) found that whitings on the Great Bahama Bank produced great quantities of aragonitic sediment. The authors concluded from carbon and oxygen-isotopic analyses that the suspended sediment in whitings contains chemically precipitated calcium carbonate. Macintyre & Reid (1992, figs. 1 A-F and 2) showed that aragonite needles precipitated in whitings had a different shape than needles secreted by algae. Robbins & Blackwelder (1992, p. 464) gave evidence that cells of picoplankton and degrading organic cellular components trigger the precipitation of clay-size carbonate crystals from supersaturated sea water in whitings on the Bahama platform. On p. 468 they drew attention to the abundant micrite in Proterozoic and lower Paleozoic strata for which formation by the degradation of skeleton-forming invertebrates and macroalgae may be ruled out.

It is concluded from the papers cited above that inorganic precipitation of calcium carbonate initiated by plankton is quantitatively the most important source of lime mud in tropical and subtropical shallow water environments and may well have been the most important source of lime mud during the Oxfordian and Kimmeridgian Ages in northern Switzerland.

5.2 Synsedimentary tectonics

5.2.1 Regional, endogenic subsidence

Northern Switzerland was in the Late Jurassic near the northern margin of the Tethys ocean (fig. 2 and Ziegler 1988, pl. 13) that was undergoing active extension related to sea-floor spreading at the time. The whole area subsided on the average at an equable rate (Büchi *et al.* 1965, p. 33 and fig. 16, see also Wildi *et al.* 1989) that was probably related to the sea-floor spreading of Tethys.

5.2.2 Smaller-scale differential subsidence

It is evident from the paleogeographic maps by Gygi (1990c, mainly figs. 5 and 6) that there must have been block faulting at a smaller regional scale, but no clear fracture pattern is apparent from the maps.

5.2.3 Local tectonism

Minor synsedimentary fractures may be seen in the field. Gygi & Persoz (1986) have figured two examples: on fig. 2 a small subvertical fracture is visible at the lower right hand side of the picture. The amount of displacement dimishes upwards and then finally disappears in the middle of the photograph. Another fracture is in the middle of fig. 8. The thickness of two lime mudstone beds to the right (south) of the fracture increases wedge-like towards the fault. A synsedimentary fault must be present ca. 10 m east of section RG 406 near Vermes JU, adjacent to bed 20 (not shown in pl. 37) judging from the breccia shown in fig. 62 that is interpreted to be a fault breccia.

5.2.4 Exogenic subsidence

Ziegler (1982, p. 106) reported that a thickness of 3000 m of sediments can accumulate in a basin with an initial depth of 1000 m. Gygi (1986, p. 472) confirmed this at the smaller scale of the Rhodano-Swabian epicontinental basin by calculations. The basement then subsided under the load of sediments by two

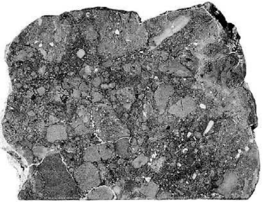


Fig. 62: Presumed fault breccia in the Günsberg Formation, section RG 406, Vermes JU, ravine southeast of La Kohlberg farm, ca 10 m to the east of the creek at an elevation of about 740 m. Sample Gy 4915. Scale x 0.48.

thirds the compacted thickness of the sediments. Gygi (1986) illustrated this effect in his figures 3A, B and C. The differential, exogenic basement subsidence was caused by the shifting of the depocenters of three consecutive shallowing-upward successions during the Oxfordian.

5.3 Eustatic sea-level changes

Several authors (Hallam 1978, fig. 11, Haq *et al.* 1987 and Sahagian & Jones 1993, fig. 3) agree that a net eustatic sea level rise occurred in the Oxfordian Age. Gygi (1986) compared the vertical transition from oolite to carbonate mud with coral bioherms in the middle St-Ursanne Formation near St-Ursanne with other sections in Europe of the same age (Late Antecedens Subchron). He concluded from his calculations of subsidence that there must be an eustatic component in the relative sea-level rise that caused this vertical facies change. He attempted to quantify the eustatic sea-level rise of the Antecedens Subchron by comparing the lagoonal upper St-Ursanne Formation with its coral bioherms with the Recent lagoon of the Bermuda atoll. He arrived at a minimum of 7 m of this individual sea-level rise and at a total of 25–30 m of eustatic sea-level rise for the whole Oxfordian. This is of course only a coarse estimate. Sahagian & Jones (1993, fig. 3) calculated an eustatic sea-level rise above the stable Russian Platform of only a few meters during the Oxfordian Age. Both long and short term variations in relative sea-level are discussed in Gygi *et al.* (1998).

5.4 Depositional sequences

The depositional sequences in the sense of Vail that can be discerned in the Late Jurassic of northern Switzerland are described and discussed in Gygi *et al.* (1998). The sequence boundaries as discerned in that paper are indicated in this work in fig. 40 and in plates 16–44.

5.5 Biochronology: ammonite zones and subzones

A range chart of the figured ammonites is given in fig. 61.

5.5.1 The lower boundary of the Oxfordian Stage

The Colloque du Jurassique Luxembourg 1962 recommended that the Late Jurassic Epoch should begin with the Oxfordian Age. The lower boundary of the Oxfordian Stage has been established by the same international congress to be the base of the *Quenstedtoceras mariae* Zone: Colloque Du Jurassique Luxembourg 1962 (1964, p. 85). The base of this zone is equivalent to the lower boundary of the Scarburgense Subzone (see Arkell 1941, p. 170). No stratigraphically complete section of this boundary with ammonites has been published from Central Europe so far. A thick, probably complete section near Thuoux in the Terres Noires of the Dauphinois basin in southeastern France has been proposed by Fortwengler & Marchand (1994, p. 103) as boundary type section (ca. 100 km southeast of Valence in the Rhône valley).

5.5.2 Mariae and Cordatum Zones

The first two zones of the Oxfordian, the Mariae and the Cordatum Zones, can be documented with all their subzones in northern Switzerland (see this paper, pls. 1–2). They are adopted here according to Callomon (1964, tab. 2).

5.5.3 Transversarium Zone

A Transversarium Zone *sensu lato* has been proposed by Oppel (1863, p. 165). Oppel stated that "the proper region of *Amm. transversarius*" was the Birmenstorf Member that had been defined in the same year by Moesch (1863, p. 160) in Canton Aargau. Oppel wrote in Oppel & Waagen (1866, p. 244) that the type locality of the Transversarium Zone was at Birmensdorf near Baden in Canton Aargau. This village is today spelled Birmenstorf (and should not be confused with Birmensdorf in Canton Zürich). Gygi (1977, fig. 2) has mapped the vineyards of the locality called Nettel northeast of Birmenstorf at the scale of 1:5000 and found no indication that an outcrop of the Birmenstorf Member ever existed there. For this reason, Gygi (1969, p. 64) has proposed the fossiliferous section RG 60 in the Eisengraben cleft near Gansingen AG as type section of the Birmenstorf Member. The excavations RG 210 and RG 225 in the Eisengraben and the excavation RG 230 north of Eisengraben (Gygi, 1977, pl. 11) provide a composite reference section of the Transversarium Zone (Gygi, 1977, p. 517) in the sense of Hedberg (1976, p. 58).

Oppel & Waagen (1866, p. 245) indicated that the Transversarium Zone begins in Canton Aargau above the "iron ore with *Amm. Lamberti* and *cordatus*". Gygi (1977, p. 454) named this characteristic bed Schellenbrücke Bed. Gygi & Marchand (1982) figured a rich fauna of cardioceratid ammonites from this bed and fixed its age to be of the Cordatum Subchron. The lowermost bed of the Birmenstorf Member in Canton Aargau, by definition the lowermost bed of the Transversarium Zone, contains near Herznach *Cardioceras (Plasmatoceras) tenuistriatum* Borissjak and *Cardioceras (Subvertebriceras)* aff. *zenaidae* Ilovaisky in Arkell as figured by Gygi & Marchand (1982, pl. 12, figs. 2 and 3). Both of these taxa are indicative of the Densiplicatum Subzone that was introduced by Gygi (1991, fig. 8). *Perisphinctes (Dichotomosphinctes) antecedens* Salfeld, the index of the following subzone, occurs in the same bed. Ammonites are rare in the lowermost bed of the Birmenstorf Member in Canton Aargau, but the coeval Mumienmergel and Mumienkalk Beds (fig. 40) of the adjacent Klettgau valley and Randen Mts. contain a rich ammonite fauna that has been listed by Gygi (1977, tab. 1). Oppel & Waagen (1866, p. 241) stated that at the (western) slope of Mt. Eichberg near Blumberg in southern Germany these thin beds contain "*Ammonites plicatilis* Sow.". Indeed, Fischer & Gygi (1989, fig. 4D) proved that *Perisphinctes (Arisphinctes) plicatilis* (Sowerby) occurs in the Mumienmergel Bed near Gächlingen SH in the Randen Mts. not far south of Blumberg. This is evidence that "*Ammonites plicatilis* Sow." in Oppel & Waagen (1866, p. 241) is not based on a misidentification. The bases of the Transversarium and of the Plicatilis Zones are then coeval as Arkell (1956, tab. 10) concluded. The Transversarium Zone has been introduced by Oppel in 1863 and has priority on the Plicatilis Zone that was only published in 1878.

The view that the Transversarium Zone and the Plicatilis Zone were about time-equivalent as held by Arkell (1956, tab. 10) has been challenged by Callomon (1964, p. 284 and tab. 2). Callomon included the Parandieri Subzone in the Plicatilis Zone and thought that the Transversarium Zone succeeded his Plicatilis Zone. Enay (1966, p. 263) decided that the Parandieri Subzone of Callomon (1960, p. 197) was the lower part of the Transversarium Zone. Cariou *et al.* in Mouterde *et al.* (1971, p. 93) therefore restricted the Plicatilis Zone in France to the Tenuicostatum (or Vertebrale) Subzone and the Antecedens Subzone which is followed by an amputated Transversarium Zone. All the French authors have agreed with this ever since. But this practice is untenable for the sake of stability in stratigraphic nomenclature, at least in Central Europe, if not worldwide, because *Perisphinctes (Arisphinctes) plicatilis* (Sowerby) has a much smaller geographical range than *Gregoryceras (Gregoryceras) transversarium* (Quenstedt) that has been found not only in Central Europe, but also in the Tethyan realm and as far away as northern Chile in the southern hemisphere (Gygi & von Hillebrandt 1991, pl. 8, fig. 1). The Plicatilis Zone should therefore only be used in southern England, northern France and northern Germany.

5.5.3.1 Densiplicatum Subzone

Chiefly the following names have been proposed for this time interval:

- Tenuicostatum Beds Salfeld (1913, tab. 1)
- Vertebrale Subzone Arkell (1947, p. 98)
- Densiplicatum Subzone Gygi (1991b, p. 12 and fig. 8).

The Tenuicostatum Subzone has never gained wide acceptance. The Vertebrale Subzone is commonly used as for instance by

Cariou *et al.* (1991a). The zonal index occurs probably only in England and in the Baltic and is thus unsuitable for Central Europe. A Densiplicatum Zone has been introduced by Sykes & Callomon (1979, p. 845). The index, *Cardioceras (Subvertebriceras) densiplicatum* Boden, is recorded from the Baltic: Boden (1911, pl. 1, fig. 14), from England: Arkell (1942, pl. 52, fig. 4), from southern France: Bourseau (1977, pl. 8, figs. 5 and 10), and from Switzerland: Gygi & Marchand (1982, pl. 11, figs. 5 and 6). The Densiplicatum Subzone, this is to say the biozone of *Cardioceras (Subvertebriceras) densiplicatum* Boden, appears to be best suited for Central Europe. It is here defined to be restricted to the vertical range of the index and does not include the Maltonense Subzone as was proposed by Sykes & Callomon (1979, p. 848).

5.5.3.2 Antecedens Subzone

The Antecedens Subzone as proposed by Arkell (1947, p. 98) is now widely used and is adopted here in its original sense.

5.5.3.3 Luciaeformis Subzone

The interval between the Antecedens and the Schilli Subzones has been called Parandieri Subzone by Tintant (1958, p. 2505). It is named after *Perisphinctes (Perisphinctes) parandieri* de Loriol. Only a few complete specimens of this very large taxon are known (see Enay 1966). No complete adult of it has ever been found in Switzerland. A substitute must therefore be found. *Perisphinctes (Dichotomosphinctes) luciaeformis* Enay is best suited for this, because its vertical range in northern Switzerland fits exactly into the interval between the Antecedens and the Schilli Subzones. The taxon has already been suggested as a subzonal index by Melendez (1989, fig. 22). It has a medium size with a maximum diameter around 150 mm. Near-complete specimens that can be readily identified are there-fore easier to find than representatives of *Perisphinctes (Perisphinctes) parandieri.* The oldest *Perisphinctes (Dichotomosphinctes) luciaeformis* in the collection of the Museum of Natural History Basel is specimen J 24532 that has been found in the excavation RG 81b, bed 14a, lower Mumienkalk Bed, near Gächlingen SH. Among the youngest representatives is specimen J 24157, complete with peristome and lappets, from the upper Birmenstorf Member in excavation RG 230 north of Eisengraben near Gansingen, Canton Aargau. Another specimen, from the condensed glauconitic marl at the base of the Effingen Member in Canton Schaffhausen, has been figured by Fischer & Gygi (1989, fig. 6D) and is refigured in this paper, pl. 5, fig. 4.

5.5.4 Bifurcatus Zone

The Bifurcatus Zone was originally suggested by Boone *in* Petitclerc (1922, p. 9), but was formally introduced independently by Enay (1964, p. 494). The Schilli Subzone as proposed by Boone *in* Petitclerc (1922, p. 9) and Cariou (1966, p. 49) is taken by Gygi (1991b, fig. 8) as the lowest subzone of the Bifurcatus Zone, because the index, *Larcheria schilli* (Oppel), occurs in Canton Aargau above the Birmenstorf Member, and because *Gregoryceras* s. str. disappear below the base of the Schilli Subzone (Gygi, 1977, tab. 1). Provided that the Luciaeformis Subzone can really be discerned from the Parandieri Subzone in the upper Transversarium Zone, the Transversarium Zone would have four subzones. The Transversarium and the Bifurcatus Zones are then about equal in duration if the Schilli Subzone is included in the Bifurcatus Zone. But this is an arbitrary delineation, because the *Dichotomoceras* taxa typical of the Bifurcatus Zone first occur only in the Rotoides Subzone of Cariou & Melendez (1990, p. 144). The Stenocycloides Subzone of Cariou et al. (1991) is well-documented in northern Switzerland, but the index of the Grossouvrei Subzone has not been found to date.

5.5.5 Bimammatum Zone

The Bimammatum Zone was introduced by Oppel (1863, p. 175). Cariou *et al.* in Mouterde *et al.* (1971) have subdivided it into the Hypselum, the Bimammatum and the Hauffianum Subzones. The Hypselum Subzone of Dorn (1930, p. 115) is documented by the index in northern Switzerland (pl. 10, fig. 1). The index of the Bimammatum Subzone is figured on pl. 10, fig. 4 and has been found in the Hornbuck Member. There are no ammonites diagnostic of a subzone in the Küssaburg Member above. *Subnebrodites* of the Planula Zone first appear at the base of the Wangental Member. The Küssaburg Member is therefore tentatively assigned to the Hauffianum Subzone although Gygi (1969, tab. 8) thought it belonged to the Planula Zone. This was based on the small perisphinctid MNHB J 31717 of the Küssaburg Member from Beggingen SH that had been identified as *Idoceras minutum* Dieterich.

5.5.6 Planula and higher Zones

The Planula to the Divisum Zones are interpreted according to Mouterde et al. (1971).

5.6 The boundary between the Oxfordian and the Kimmeridgian Stages

The Oxfordian-Kimmeridgian boundary is difficult to correlate between the type area in southern England and Central Europe because of a pronounced provincialism in ammonites. Moesch (1867, p. 175) drew the boundary at the base of the Letzi Member in Canton Aargau, this is to say at the base of the Planula Zone. Heim (1919, table opposite p. 506), based on unpublished tables by Rollier, placed the boundary in northern Switzerland within his Reineckianus Beds (the Platynota Zone). In the following decades a consensus developed between French, Swiss, German and Polish authors to fix the boundary at the base of the Platynota Zone: Mouterde *et al.* (1971), Gygi (1969, tab. 1), Zeiss (1965, p. 91), Wierzbowski (1965, tab. 2).

This traditional correlation was questioned for the first time by Ziegler (1964, p. 351). Morris (1968, p. 102) thought that the Oxfordian-Kimmeridgian boundary was in the Jura and in Swabia in the uppermost Bimammatum Zone. Sykes & Cal-

LOMON (1979, p. 894) concluded that most if not all of the Planula Zone must be assigned to the Kimmeridgian. WIERZBOWSKI (1991, tab. 1) was of the same opinion (see also ATROPS *et al.* 1993, fig. 3). SCHWEIGERT (1995, p. 176) has recently collected ammonites from *in situ* at Hundsrücken near Balingen, southern Germany. He confirmed the statements by OPPEL (1863, p. 201, 212) that *Amoeboceras bauhini* (OPPEL) and *Taramelliceras hauffianum* (OPPEL) occur together and introduced the Bauhini faunal horizon. The Bauhini Subzone has been introduced by SYKES & CALLOMON (1979, p. 843) as the uppermost subzone of the boreal Oxfordian.

SCHWEIGERT & CALLOMON (1997, fig. 9, p. 43) are now of the opinion that *Amoeboceras bauhini* (OPPEL) occurs at the base of the Kimmeridgian Stage in Great Britain, the type area of the Kimmeridgian. They indicated (1997, fig. 7 and p. 33) that the Bauhini Horizon was glauconitic at many localities in southern Germany. GYGI (1969, p. 57) stated that his glauconitic marker bed of the Knollen Bed could be followed from northern Switzerland into southern Germany at least as far as the region of Balingen. It is then possible that the Knollen Bed and the Bauhini Horizon are coeval. This cannot be decided until more ammonites will be collected from the Knollen Bed. *Ringsteadia suebica* n. sp. has been found almost certainly in the Knollen Bed. According to a personal information by J. Callomon of 29/8/1996, the vertical range of *Ringsteadia* does not extend into the Kimmeridgian in England. There is the possibility that the genus *Ringsteadia* survived somewhat longer in Central Europe than in England, or that *Ringsteadia suebica* n. sp. is not a true *Ringsteadia*. For the time being it is presumed that the Knollen Bed is the earliest lithostratigraphic unit of the Kimmeridgian in northern Switzerland.

The Knollen Bed marker bed has the disadvantage that it is not mappable at the scale of 1 : 25 000. It can only be recognized in good sections. The Oxfordian-Kimmeridgian boundary as defined as the lower boundary of the Knollen Bed can only be recognized where this marker bed exists. Near Balsthal or Porrentruy the new Oxfordian-Kimmeridgian boundary cannot be indicated for lack of biostratigraphic or lithostratigraphic evidence.

5.7 Radiochronology

A first attempt to date Oxfordian sediments in northern Switzerland radiometrically was made by GYGI & MCDOWELL (1970). A detailed correlation of biostratigraphic subzones as documented by figured ammonites with revised numeric ages was published by FISCHER & GYGI (1989). These numeric ages are based on K-Ar radiometric dates from authigenic glauconites with a relatively low potassium content and consequently a not very well-ordered crystal lattice (GYGI & MCDOWELL , 1970, fig. 3 A and tab. 1). This may have reduced argon retention.

GRADSTEIN *et al.* (1995) recently published the first Mesozoic time scale using an integration of radiometric ages and magnetochronologic data of basalt on the ocean floor with data from sediments on land. Their estimate of 159.4 ± 3.6 m. a. for the Callovian/Oxfordian boundary indicates that the age of 149.2 m. a. for the Cordatum Subchron by FISCHER & GYGI (1989) is too young.

5.8 Magnetochronology

The whole of the Oxfordian in non-condensed mud facies and the lower Kimmeridgian sediments of northern Switzerland have been sampled and analysed in order to establish a magnetochronology by J. G. Ogg in 1987. Unforunately, the magnetic signatures were ambiguous and no results were obtained.

5.9 Correlation

A number of marker beds made precise lithostratigraphic correlations possible. These are: the condensed bed at the base of the Birmenstorf Member and the Mumienmergel/Mumienkalk Beds, the Hauptmumienbank Member, the Crenularis Member, the Knollen Bed, the lower boundary of the Reuchenette Formation, the Banné Member, the Virgula Member and the glauconitic marker bed in the Felsenkalk Formation.

Ammonites proved to be the best means of biostratigraphic correlation although they may be rare even in the basin, for instance in the upper Renggeri Member and in the middle and upper Effingen Member. Ammonites are so rare in the shallow water realm that they are insufficient for detailed biostratigraphic correlations there.

Clay minerals, especially kaolinite, made detailed correlations possible in the shallow water realm, mainly in rocks where ammonites are absent. The vertical variation in the kaolinite content has first been calibrated in the basin with ammonites and then correlated into the shallow water rocks. These correlations could be checked and confirmed by a number of ammonites from shallow water sediments (GYGI, 1995).

Sequence stratigraphic analysis of the Oxfordian and Kimmeridgian strata in northwest Switzerland corroborates the correlations arrived at by the methods mentioned above, and if one assumes that key sequence stratigraphic surfaces are isochronous they improve the correlation further. Preliminary comparison of the Upper Jurassic sequence statigraphic surfaces in England (COE, 1992, 1995) with those in Switzerland shows remarkable similarity (COE & GYGI, 1994).

5.10 Palaeogeography and history of sedimentation

Palaeogeographic maps of the Late Jurassic in northern Switzerland were published by GYGI (1990c).

The sedimentation of the Late Jurassic in northern Switzerland began in an epicontinental sea north of the Tethys. The initial water depth was about 60 m in the northwest and 100 m in the east. The land of the Ardenne and of the Rhenan Massifs to the northwest (figs. 2 and 63) mainly supplied siliciclastic sediment to the epicontinental basin. The sediment supply varied widely as a function of eustatic sea-level fluctuations and of climate. The climate was seasonal and varied between humid and relatively dry. A submarine bank of argillaceous prodelta mud built out southeastward from the landmass in early to middle Oxfordian time (early Transversarium Chron). This is the Bärschwil Formation. The formation thins drastically towards the basin (fig. 39). The time-equivalent sediments in the basin are thin beds of iron oolite and glauconitic marl-clay with carbonate nodules.

The supply of terrigenous sediment ceased almost completely in the later Transversarium Chron, probably because the climate became drier. The carbonate platform of the St-Ursanne Formation evolved on top of the argillacious mud bank of the Bärschwil Formation. This platform was rimmed by oolite shoals. A belt of coral bioherms fringed the platform in somewhat deeper water. In the thin, time equivalent basinal sediments of the Birmenstorf Member grew thickly colonized biostromes of siliceous sponges. These contain a rich ammonite fauna.

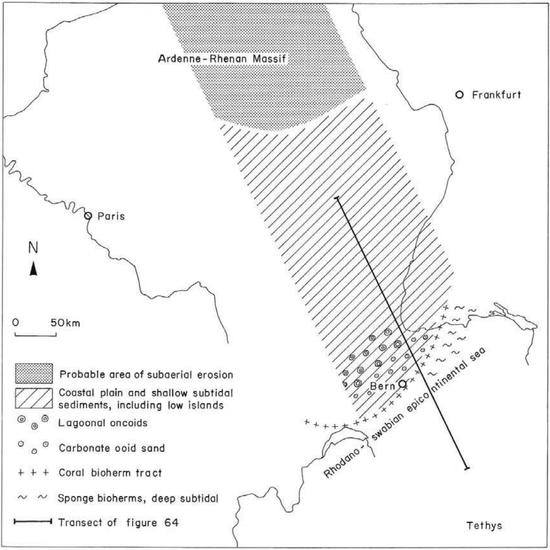


Fig. 63: Palaeogeographical map of Central Europe in the late Oxfordian (early Bimammatum Subchron). The bank of Late Jurassic shallow-water sediments in northwestern Switzerland (late Burgundy platform, now part of the folded Jura Mountains) was probably contiguous to the land of the Ardenne-Rhenan Massif as indicated by the large dinosaur that was found in the lowermost Reuchenette Formation of northern Switzerland near Moutier (GREPPIN 1870). The position of the coastline cannot be indicated because of the erosion of Mesozoic sediments above the Vosges horst. The Tethys *sensu lato* (now: Alps) includes the southern passive margin of Europe from the ultrahelvetic facies belt to the deep penninic basin (STAMPFLI 1993, fig. 11). Refigured from GYGI (1992, fig. 1).

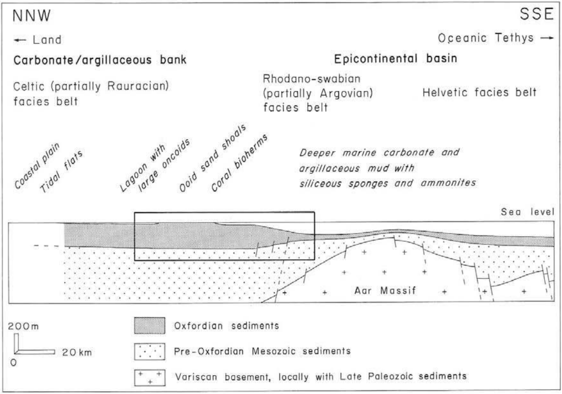


Fig. 64: Schematic cross-section through the epicontinental sea north of the Tethys in the Late Oxfordian (early Bimammatum Subchron). By this time, much of the epicontinental basin was filled up with terrigenous sediment and carbonates that prograded to the south-southeast. Post-Variscan rifts in the igneous and metamorphic basement that are filled with thick Permo-Carboniferous sediments are not shown. Detailed cross-section in inset is shown in fig. 39. Refigured from Gygi (1992, fig. 2).

A strong terrigenous sediment supply from the northwest resumed in the Bifurcatus Chron. The carbonate platform shrank to the narrow band of the Günsberg Formation at that time. Initially, carbonate mud could settle on the inner platform (Vorbourg Member) while large quantities of argillaceous mud passed over the platform. The argillaceous Röschenz Member was then sedimented over the shallow inner bank, and the Effingen Member in the basin. In the early Hypselum Subchron the relative sea-level probably dropped and caused repeated and widespread emersion on the bank (sequence boundary O6). Coastal swamps with peat (now: coaly layers) and freshwater ponds with characean algae and limnic ostracods were formed.

A transgression followed in the later Hypselum Subchron that brought back growth of coral bioherms and oolite shoals to the inner platform. Then the climate grew drier, the terrigenous sediment supply dropped sharply, and another, thin carbonate platform developed. The Hauptmumienbank algal ball sediment was laid down over the inner platform while the oolite shoals of the Steinebach Member and a fringe of coral bioherms were formed at the platform margin.

After another short episode of argillaceous sediment supply (Bure Member) the growth of a widespread carbonate platform resumed (Holzflue and Verena Members). The fringe of coral bioherms reached its maximum progradation at this time. In the earliest Kimmeridgian the coral bioherms beyond the rim of the platform died. Later in the Kimmeridgian the platform shrank somewhat. Coral bioherms reappeared at the platform margin in about the Hypselocyclum Chron near Balsthal.

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Sylvia Gygi, my wife, has found and prepared a great part of the ammonites figured in this paper. The book would not be as well documented without her generous help. K. Müller and A. Heitz prepared the thin sections and the polished slabs. S. Dahint made most of the photographs. The drawing of the sections in ink has been made possible by the funding of B. M. Gygi, my mother. I wish to thank the great number of other persons who have helped me in many ways, especially J. H. Callomon, E. Cariou, E. Mönnig, H. Rieber and A. Wetzel. S. Gygi typed the manuscript and prepared the final version of fig. 61.

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Summary – Résumé – Zusammenfassung

This paper is based on 221 detailed stratigraphical sections that were measured between 1961 and 1995 in a strip between Biel and Boncourt in the west and Möhringen in southern Germany in the east. The bulk of the studied sediments is of Oxfordian age, but many sections continue into the Kimmeridgian. More than 8000 ammonites and a great number of associated macrofossils were collected from *in situ*, almost all of them from measured sections. 2338 thin sections and a large number of polished slabs were prepared in order to describe 29 representative stratigraphical sections in the area between Biel, Boncourt and Balsthal. More than 5000 ammonites have been prepared in order to establish a detailed biostratigraphy. 68 stratigraphically significant ammonite taxa are described and figured. *Subdiscosphinctes wojciechi* and *Ringsteadia suebica* are new species, and *Wegelea* is a new genus. All the ammonite zones and subzones could be documented with ammonites. The majority of the zones and subzones are represented by the index ammonite. The high resolution stratigraphical correlation was constructed using lithostratigraphical marker beds, ammonite biostratigraphy, clay mineral stratigraphy and sequence stratigraphy. Several lithostratigraphical units, the Herznach Formation, Sornetan Member, Grellingen Member, Delémont Member, Buix Member and the Günsberg unit in the rank of a formation are new.

The siliciclastic sediments were supplied from the northwest. An accumulation of argillaceous deposits (Bärschwil Formation) was first laid down in the proximal part of the basin in the central Jura. In the middle Oxfordian a carbonate platform (St-Ursanne Formation) evolved on top of this argillaceous sediment pile. After this the siliciclastic sediment influx from the northwest resumed, the carbonate platform shrank greatly (Günsberg Formation), and the thick Effingen Member was laid down further out in the basin (Wildegg Formation). Another widespread carbonate platform was restored in the late Oxfordian and early Kimmeridgian (Balsthal Formation) and further evolved in the Kimmeridgian (Reuchenette Formation). A summary of the Oxfordian history of sedimentation is given in fig. 39. Fig. 40 is a correlation table.

Etude stratigraphique pluridisciplinaire de l'Oxfordien et du Kimméridgien (Jurassique supérieur) de la Suisse septentrionale et de la zone contiguë en Allemagne méridionale

Résumé

Ce travail a été réalisé par suite de l'étude de 221 coupes stratigraphiques détaillées qui ont été levées entre 1961 et 1995 dans une zone située entre Bienne et Boncourt à l'ouest et Möhringen en Allemagne méridionale à l'est. La plupart des sédiments étudiés est d'âge Oxfordien, mais plusieurs coupes s'étendent jusqu'au Kimméridgien. Plus de 8000 ammonites et la macrofaune accompagnante ont été prélevées d'en place. Presque tous les fossiles proviennent des coupes détaillées. 2338 lames minces et un grand nombre de surfaces polies ont été utilisées pour décrire 29 coupes stratigraphiques représentatives dans la région entre Bienne, Boncourt et Balsthal. La biostratigraphie des ammonites est basée sur plus de 5000 spécimens préparés et 68 descriptions et figurations d'espèces d'ammonites importantes pour la biostratigraphie. *Subdiscosphinctes wojciechi* et *Ringsteadia suebica* sont des espèces nouvelles, et *Wegelea* est un nouveau genre. Toutes les zones et les sous-zones d'ammonites sont représentées par des ammonites. La plupart des zones et des sous-zones d'ammonites a pu être documentée par le taxon index. Les corrélations stratigraphiques à haute résolution sont faites par des niveaux repères lithostratigraphiques, la biostratigraphie des ammonites, la minéralostratigraphie et la stratigraphie séquentielle. Les suivantes unités lithostratigraphiques sont nouvelles: Formation d'Herznach, Membres de Sornetan, Grellingen, Delémont et Buix, et l'unité de Günsberg, élevée au rang de formation.

Les sédiments siliciclastiques proviennent du nord-ouest. Un amas de sédiments argileux (Formation de Bärschwil) a été d'abord déposé dans la partie proximale du bassin au Jura central. A l'Oxfordien moyen, une plateforme carbonatée (Formation de St-Ursanne) s'est formée au-dessus de la pile de sédiments argileux. Ensuite, l'apport de sediments siliciclastiques du nord-ouest a recommencé et la plateforme carbonatée s'est beaucoup contractée (Formation de Günsberg). L'épais Membre d'Effingen s'est sédimenté plus distalement dans le bassin (Formation de Wildegg). Une nouvelle et large plateforme carbonatée (Formation de Balsthal) s'est établie au cours de l'Oxfordien terminal et du Kimméridgien précoce qui a continué d'évoluer pendant le Kimméridgien (Formation de Reuchenette). Une vue d'ensemble de l'histoire de la sédimentation durant l'Oxfordien est représentée sur la fig. 39. La fig. 40 est un tableau de corrélation.

Integrierte Stratigraphie des Oxfordian und Kimmeridgian (Später Jura) in der Nordschweiz und im angrenzenden Süddeutschland

Zusammenfassung

Die vorliegende Arbeit stützt sich auf 221 stratigraphische Detailprofile, welche zwischen 1961 und 1995 auf einem Streifen zwischen Biel und Boncourt im Westen und Möhringen in Süddeutschland im Osten aufgenommen worden sind. Der grösste Teil der untersuchten Sedimente hat Oxford-Alter, aber manche Profile erstrecken sich weit bis ins Kimmeridgian. Mehr

als 8000 Ammoniten samt der begleitenden Makrofauna sind aus dem Anstehenden entnommen worden. Fast alle diese Fossilien stammen aus den Detailprofilen. 2338 Dünnschliffe und eine grosse Anzahl von polierten Anschliffen dienten dazu, 29 repräsentative stratigraphische Profile zwischen Biel, Boncourt und Balsthal zu beschreiben. Die detaillierte Ammoniten-Biostratigraphie beruht auf mehr als 5000 präparierten Ammoniten. 68 stratigraphisch wichtige Ammoniten-Taxa sind hier beschrieben und abgebildet. Neue Arten sind *Subdiscosphinctes wojciechi* und *Ringsteadia suebica*, während *Wegelea* eine neue Gattung ist. Alle Ammonitenzonen und -Subzonen sind durch Ammoniten vertreten. Der grössere Teil der Zonen und Subzonen ist durch das Index-Taxon belegt. Die hochauflösende stratigraphische Korrelation wurde mithilfe von lithostratigraphischen Leithorizonten, der Ammoniten-Biostratigraphie, der Mineralstratigraphie und der Sequenzstratigraphie durchgeführt. Mehrere neue lithostratigraphische Einheiten sind vorgeschlagen worden: Die Herznach-Formation, die Sornetan-, Grellingen-, Delémont- und die Buix-Schichten (Members) sowie die Günsberg-Einheit im Rang einer Formation.

Die siliziklastischen Sedimente stammen aus dem Nordwesten. Eine tonige Schlammbank (Bärschwil-Formation) wurde zuerst im proximalen Bereich des Beckens im zentralen Jura abgelagert. Im mittleren Oxfordian entwickelte sich dann eine ausgedehnte Karbonatplattform (St-Ursanne-Formation) im seichten Wasser über der Schlammbank. Danach setzte erneut siliziklastische Sedimentation aus Nordwesten ein, wodurch die Karbonatplattform auf den schmalen Streifen der Günsberg-Formation zusammenschrumpfte. Gleichzeitig wurden weiter draussen im Becken die mächtigen Effinger Schichten der Wildegg-Formation abgelagert. Eine neue, ausgedehnte Karbonatplattform bildete sich im späten Oxfordian (Balsthal-Formation) und entwickelte sich weiter im Kimmeridgian (Reuchenette-Formation). Eine Gesamtschau der Sedimentationsgeschichte im Oxfordian ist in Fig. 39 dargestellt. Fig. 40 ist eine Korrelationstabelle.

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Plate 1

Fig. 1 – *Quenstedtoceras lamberti lamberti* (SOWERBY), Lamberti Zone, Lamberti Subzone, Schellenbrücke Bed, section RG 60, bed 3, Eisengraben, Gansingen AG. Complete adult with peristome. J 31715, leg. R. Enay, × 1.

Fig. 2 – *Cardioceras (Scarburgiceras) paucicostatum* LANGE, Lamberti Zone, uppermost Lamberti Subzone, iron oolitic marly clay of the upper Herznach Formation, section RG 280, lower part of bed 6, clay pit of Ampthil, Liesberg BL. J 31219, leg. R. Gygi, × 1.

Fig. 3 – *Cardioceras (Scarburgiceras) scarburgense* (YOUNG & BIRD), Mariae Zone, Scarburgense Subzone, lower Renggeri Member, 1.2 m above the base, section RG 280, bed 7, clay pit of Ampthil, Liesberg BL. J 31103, leg. R. & S. Gygi, × 1.

Fig. 4 – *Cardioceras (Scarburgiceras) scarburgense* (YOUNG & BIRD), Mariae Zone, Scarburgense Subzone, lower Renggeri Member, 1.5 m above the base, section RG 280, bed 7, clay pit of Ampthil, Liesberg BL. J 31104, leg. R. & S. Gygi, × 1.

Fig. 5 – *Cardioceras (Scarburgiceras) scarburgense* (YOUNG & BIRD), Mariae Zone, Scarburgense Subzone, lower Renggeri Member, clay pit of Ampthil, Liesberg BL. J 31229, leg. K. Lüdin, × 1.

Fig. 6 – *Creniceras renggeri* (OPPEL), Mariae Zone, Scarburgense Subzone, lower Renggeri Member, clay pit of Ampthil, Liesberg BL. J 31089, leg. H. Zbinden, × 1.

Fig. 7 – *Creniceras renggeri* (OPPEL), Mariae Zone, Scarburgense Subzone, lower Renggeri Member, section RG 280, bed 7, 2 m above the base, clay pit of Ampthil, Liesberg BL. J 31117, leg. R. & S. Gygi, × 2.

Fig. 8 – *Cardioceras (Scarburgiceras) praecordatum* DOUVILLE, Mariae Zone, Praecordatum Subzone, lower Renggeri Member, section RG 280, bed 7, 3.5 m above the base, clay pit of Ampthil, Liesberg BL. J 31114, leg. R. & S. Gygi, × 1.

Fig. 9 – *Cardioceras (Scarburgiceras) praecordatum* DOUVILLE, Mariae Zone, Praecordatum Subzone, Renggeri Member, section RG 280, bed 7, 27 m above the base, clay pit of Ampthil, Liesberg BL. J 30949, leg. R. Himmler, × 1.

Fig. 10 – *Cardioceras (Pavloviceras)* cf. *mariae* (D'ORBIGNY), Mariae Zone, Scarburgense Subzone, not *in situ*, Herznach Formation, iron mine of Herznach AG. J 25206, leg. R. Eichin, × 1.

Fig. 11 – *Cardioceras (Scarburgiceras) bukowskii* MAIRE, Cordatum Zone, Bukowskii Subzone, not *in situ*, Renggeri Member in a creek northwest of La Cornée, Rebévelier JU. J 30948, leg. B. Lange, × 1.

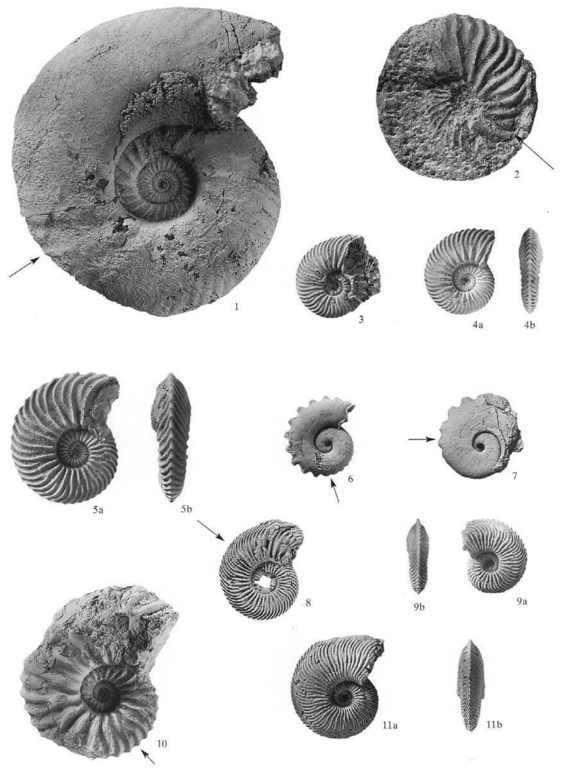
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Plate 2

Fig. 1 – *Cardioceras (Cardioceras) costicardia vulgare* ARKELL, Cordatum Zone, Costicardia Subzone, upper Renggeri Member, out of a creek northwest of La Cornée, Rebévelier JU. J 31646, leg. B. Hostettler, × 1.

Fig. 2 – *Cardioceras (Subvertebriceras) costellatum* BUCKMAN, Cordatum Zone, Costicardia Subzone, upper Renggeri Member, Bollement, St-Brais JU. J 31648, leg. B. Hostettler, × 1.

Fig. 3 – *Cardioceras (Cardioceras) cordatum* (SOWERBY), Cordatum Zone, Cordatum Subzone, Glaukonitsandmergel Bed, section RG 207, bed 14a, excavation near water conduit in Churz Tal, Siblingen SH. J 23027, leg. R. & S. Gygi, × 1.

Fig. 4 – *Cardioceras (Cardioceras) persecans* (BUCKMAN), Cordatum Zone, Cordatum Subzone, Schellenbrücke Bed, upper Herznach Formation, section RG 208, bed 9, excavation on Brunnrain, Ueken AG. J 24982, leg. R. & S. Gygi, × 1.

Fig. 5 – *Cardioceras (Cardioceras)* cf. *stella* ARKELL, Cordatum Zone, Cordatum Subzone, Schellenbrücke Bed, upper Herznach Formation, section RG 209, bed 7, iron mine, Strecke III under Hübstel hill, Herznach AG. J 25184, leg. R. Gygi, × 1.

Fig. 6 – *Perisphinctes (Otosphinctes) paturattensis* DE LORIOL, Cordatum Zone, Cordatum Subzone, Schellenbrücke Bed, upper Herznach Formation, section RG 208, bed 9, excavation on Brunnrain, Ueken AG. J 23277, leg. R. & S. Gygi, × 1.

Fig. 7 – *Cardioceras (Subvertebriceras) densiplicatum* BODEN, Transversarium Zone, Densiplicatum Subzone, Mumienmergel Bed, section RG 212, bed 7, excavation above shooting range in Churz Tal, Siblingen SH. J 23045, leg. R. & S. Gygi, × 1.

Fig. 8 – *Protophites christoli* (BEAUDOUIN), Cordatum Zone, Cordatum Subzone, Schellenbrücke Bed, upper Herznach Formation, section RG 208, bed 9, excavation on Brunnrain, Ueken AG. J 24943, leg. R. & S. Gygi, × 1.

Fig. 9 – *Neoprionoceras delmontanum* (OPPEL), Cordatum Zone, Cordatum Subzone, Schellenbrücke Bed, Herznach Formation, section RG 208, bed 9, excavation on Brunnrain, Ueken AG. J 25052, leg. R. & S. Gygi, × 1.

Fig. 10 – *Cardioceras (Miticardioceras) tenuiserratum* (OPPEL), Transversarium Zone, upper Antecedens or lower Luciaeformis Subzone, lower Birmenstorf Member, section RG 208, bed 12 or further above, excavation on Brunnrain, Ueken AG. J 25158, leg. R. & S. Gygi, × 2.

Fig. 11 – *Gregoryceras (Pseudogregoryceras) iteni* JEANNET, Cordatum Zone, Cordatum Subzone, not *in situ*, Herznach Formation, section RG 209, iron mine of Herznach AG. J 23048, leg. R. Eichin, × 1.

Fig. 12 – *Cardioceras (Maltoniceras) schellwieni* BODEN, Transversarium Zone, Antecedens Subzone, lower Mumienkalk Bed, section RG 207, bed 16a, excavation near water conduit in Churz Tal, Siblingen SH. J 23029, leg. R. & S. Gygi, × 1.

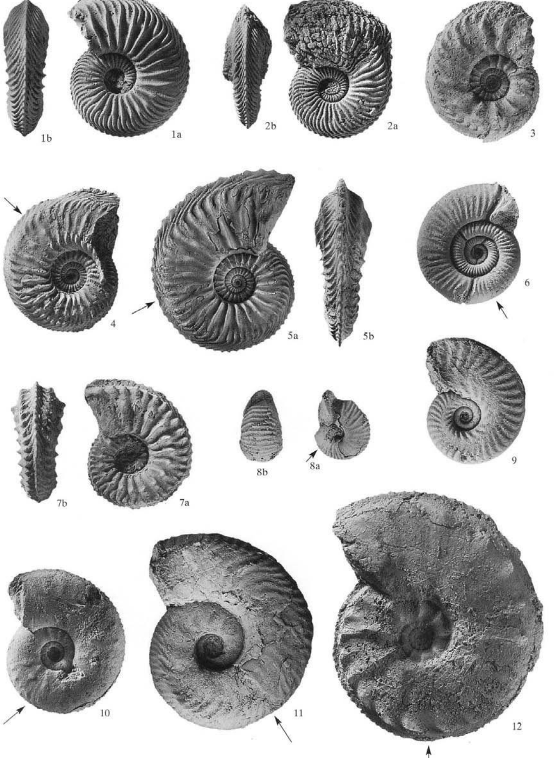
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Plate 3

Fig. 1 – *Perisphinctes (Arisphinctes) plicatilis* (SOWERBY), Transversarium Zone, Densiplicatum Subzone, Mumienmergel Bed, section RG 81b, bed 13, excavation below Räckolterenbuck, Gächlingen SH. J 24633, leg. R. & S. Gygi, × 1.

Fig. 2 – *Perisphinctes (Arisphinctes) helenae* DE RIAZ, Transversarium Zone, Antecedens Subzone, lower Mumienkalk Bed, section RG 81b, bed 14a, excavation below Räckolterenbuck, Gächlingen SH. J 24575, leg. R. & S. Gygi, × 1.

Fig. 3 – *Ochetoceras (Ochetoceras) hispidum* (OPPEL), Transversarium Zone, Antecedens Subzone, upper Mumienkalk Bed, section RG 81b, bed 14b, excavation below Räckolterenbuck, Gächlingen SH. J 25901, leg. R. & S. Gygi, × 1.

Fig. 4 – *Perisphinctes (Dichotomosphinctes) antecedens* SALFELD, Transversarium Zone, Antecedens Subzone, lower Mumienkalk Bed, section RG 207, bed 16a, excavation near water conduit in Churz Tal, Siblingen SH. J 24701, leg. R. & S. Gygi, × 1.

Fig. 5 – *Perisphinctes (Dichotomosphinctes) elisabethae* DE RIAZ, Transversarium Zone, Antecedens Subzone, lower Mumienkalk Bed, section RG 81b, bed 14a, excavation below Räckolterenbuck, Gächlingen SH. J 24528, leg. R. & S. Gygi, × 1.

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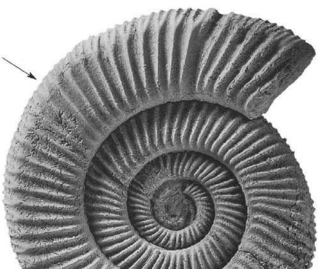

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Plate 4

Fig. 1 – *Gregoryceras (Gregoryceras) transversarium* (QUENSTEDT), Transversarium Zone, Antecedens Subzone, Mumienkalk Bed, Siblingen SH. J 28141, leg. P. Choffat, × 1.

Fig. 2 – *Gregoryceras (Gregoryceras) transversarium* (QUENSTEDT), Transversarium Zone, Luciaeformis Subzone, upper Birmenstorf Member, section RG 230, excavation north of Eisengraben, Gansingen AG. J 23051, leg. R. & S. Gygi, × 1.

Fig. 3 – *Gregoryceras (Gregoryceras) riazi* (DE GROSSOUVRE), Transversarium Zone, Luciaeformis Subzone, upper Birmenstorf Member, section RG 230, excavation north of Eisengraben, Gansingen AG. J 23062, leg. R. & S. Gygi, × 1.

Fig. 4 – *Gregoryceras (Gregoryceras) tenuisculptum* GYGI, refigured holotype, Transversarium Zone, Densiplicatum Subzone, Mumienmergel Bed, section RG 212, bed 7, excavation above the shooting range in Churz Tal, Siblingen SH. J 23064, leg. R. & S. Gygi, × 1.

Fig. 5 – *Gregoryceras (Pseudogregoryceras) iteni* JEANNET, Cordatum Zone, Cordatum Subzone, not *in situ*, Herznach Formation, section RG 209, iron mine of Herznach, Herznach AG. J 23048, leg. R. Eichin, × 1.

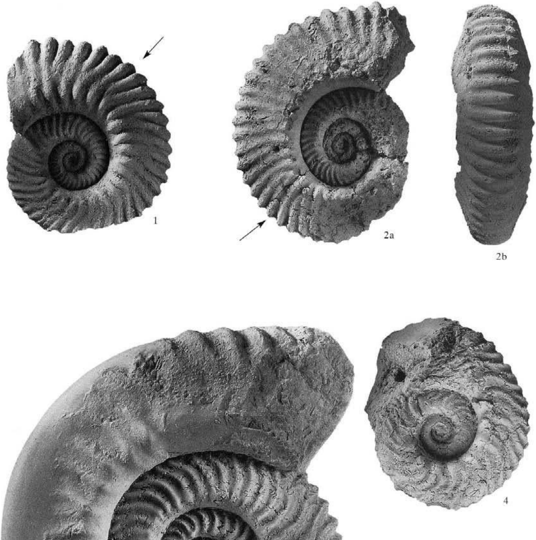
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Plate 5

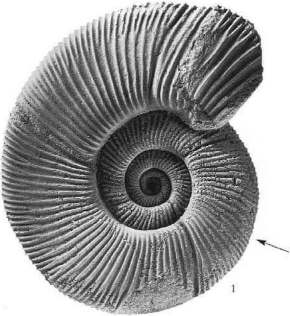
Fig. 1 – *Subdiscosphinctes (Subdiscosphinctes) lucingae* (Favre), Transversarium Zone, Luciaeformis Subzone, not *in situ*, from a block fallen from the upper Birmenstorf Member, section RG 60, Eisengraben, Gansingen AG. J 23755, leg. J. Kaufmann, × 1.

Fig. 2 – *Passendorferia (Enayites) birmensdorfensis* (Moesch), Transversarium Zone, Luciaeformis Subzone, Birmenstorf Member, section RG 32, bed 7, Schellenbrücke, Küttigen AG. J 31607, leg. F. J. Gsell, × 1.

Fig. 3 – *Amoeboceras glosense* (Bigot & Brasil), Transversarium Zone, Luciaeformis Subzone, Birmenstorf Member, section RG 276, probably bed 32, Chalch quarry , Holderbank AG. J 27679, leg. D. Krüger, × 1.

Fig. 4 – *Perisphinctes (Dichotomosphinctes) luciaeformis* Enay, Transversarium Zone, Luciaeformis Subzone, lowermost glauconitic Effingen Member, section RG 212, bed 10, excavation above shooting range in Churz Tal, Siblingen SH. J 23652, leg. R. & S. Gygi, × 1.

Fig. 5 – *Larcheria* cf. *schilli* (Oppel), Bifurcatus Zone, Schilli Subzone, lower Effingen Member, section RG 226, bed 47, road cut north of Jakobsberg quary, Veltheim AG. J 23539, leg. R. & S. Gygi, × 1.



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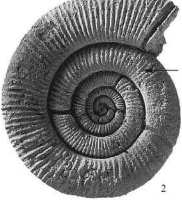

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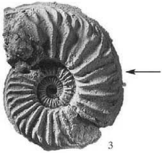

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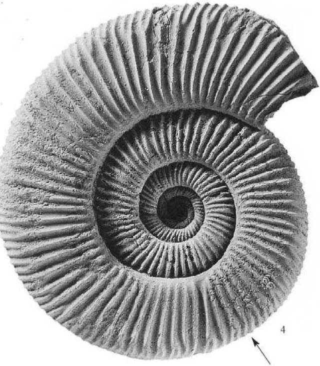

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Plate 6

Fig. 1 – *Passendorferia (Passendorferia) ziegleri* (Brochwicz-Lewinski), Transversarium Zone, Luciaeformis Subzone, upper Birmenstorf Member, section RG 230, excavation north of Eisengraben, Gansingen AG. J 24079, leg. R. & S. Gygi, × 0.9.

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Plate 7

Fig. 1 – *Subdiscosphinctes (Aureimontanites) cracoviensis* (SIEMIRADZKI), Transversarium Zone, Luciaeformis Subzone, upper Birmenstorf Member, section RG 230, excavation north of Eisengraben, Gansingen AG. J 23655, leg. R. & S. Gygi, × 1.

Fig. 2 – *Taramelliceras (Proscaphites) anar* (OPPEL), Transversarium Zone, Antecedens Subzone, upper Mumienkalk Bed, section RG 81b, bed 14b, excavation below Räckolterenbuck, Gächlingen SH. J 25960, leg. R. & S. Gygi, × 2.

Fig. 3 – *Trimarginites stenorhynchus* (OPPEL), Transversarium Zone, Luciaeformis Subzone, upper Birmenstorf Member, section RG 276, bed 34, Chalch quarry, Holderbank AG. Complete adult with peristome. J 27372, leg. R. Gygi, × 1.

Fig. 4 – *Trimarginites trimarginatus* (OPPEL), Transversarium Zone, Antecedens Subzone, upper Mumienkalk Bed, section RG 81b, bed 14b, excavation below Räckolterenbuck, Gächlingen SH. Wholly septate. J 25924, leg. R. & S. Gygi, × 1.


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Plate 8

Fig. 1 – *Perisphinctes (Otosphinctes) siemiradzkii* Enay, Transversarium Zone, Luciaeformis Subzone, upper Birmenstorf Member, section RG 230, excavation north of Eisengraben, Gansingen AG. J 23656, leg. R. & S. Gygi, × 1.

Fig. 2 – *Larcheria schilli* (Oppel), Bifurcatus Zone, Schilli Subzone, lowermost Effingen Member, section RG 226, not *in situ*, probably from bed 46, road cut north of Jakobsberg quarry, Veltheim AG. J 23534, leg. W. Ryf, × 1.

Fig. 3 – *Perisphinctes (Dichotomoceras)* cf. *bifurcatus* (Quenstedt), Bifurcatus Zone, Stenocycloides Subzone, lower Effingen Member, section RG 226, bed 55, 2.3 m above the base of the bed, road cut north of Jakobsberg quarry, Veltheim AG. J 23543, leg. W. Suter, × 1.

Fig. 4 – *Amoeboceras* cf. *serratum* (Sowerby), Bifurcatus Zone, probably Grossouvrei Subzone, Gerstenhübelkalk Beds, Effingen Member, quarry 500 m north of Mönthal AG. J 31456, leg. J. Haller & R. Trümpy, × 2.

Fig. 5 – *Subdiscosphinctes (Aureimontanites) wojciechi* n. sp., Transversarium Zone, Luciaeformis Subzone, upper Birmenstorf Member, section RG 230, excavation north of Eisengraben, Gansingen AG. J 23659, leg. R. & S. Gygi, × 1.

Fig. 6 – *Perisphinctes (Neomorphoceras) chapuisi* (Oppel), Transversarium Zone, Antecedens Subzone, upper Mumienkalk Bed, section RG 207, bed 16b, excavation near water conduit in Churz Tal, Siblingen SH. J 26129, leg. R. & S. Gygi, × 2.

Fig. 7 – *Perisphinctes (Neomorphoceras) collinii* (Oppel), Transversarium Zone, Luciaeformis Subzone, upper Birmenstorf Member, section RG 230, excavation north of Eisengraben, Gansingen AG. J 24170, leg. R. & S. Gygi, × 1.

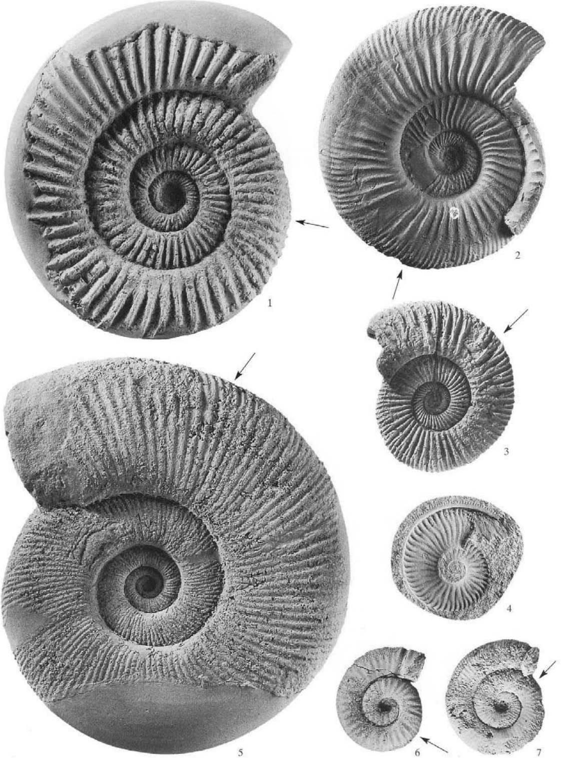
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Plate 9

Fig. 1 – *Perisphinctes (Dichotomoceras) rotoides* RONCHADZE, Bifurcatus Zone, Rotoides Subzone, lower Effingen Member, section RG 276, bed 46, Chalch quarry, Holderbank AG. J 27971, leg. R. Gygi, × 1.

Fig. 2 – *Perisphinctes (Dichotomoceras) bifurcatoides* ENAY, Bifurcatus Zone, Stenocycloides Subzone, lower Effingen Member, section RG 276, bed 50, Chalch quarry, Holderbank AG. J 23704, leg. R. & S. Gygi, × 1.

Fig. 3 – *Perisphinctes (Dichotomoceras) stenocycloides* SIEMIRADZKI, Bifurcatus Zone, Stenocycloides Subzone, lower Effingen Member, section RG 276, bed 50, Chalch quarry, Holderbank AG. J 23728, leg. R. & S. Gygi, × 1.

Fig. 4 – *Perisphinctes (Dichotomoceras) duongae* MELENDEZ, *emend.* GYGI, Bifurcatus Zone, Stenocycloides Subzone, lower Effingen Member, section RG 226, not *in situ*, road cut north of Jakobsberg quarry, Veltheim AG. J 23533, leg. H. Hess, × 1.

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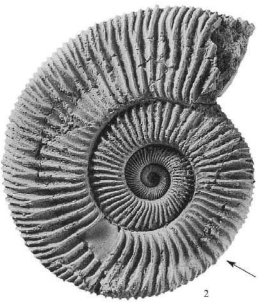

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Plate 10

Fig. 1 – *Euaspidoceras hypselum* (Oppel), Bimammatum Zone, Hypselum Subzone, Effingen Member, section RG 37, not *in situ*, fallen from the limestone succession 55–80 (see Gygi 1969, pl. 17), Jakobsberg quarry, Auenstein AG. J 27259, leg. D. Krüger, × 1.

Fig. 2 – *Amoeboceras ovale* (Quenstedt), Bimammatum Zone, Bimammatum Subzone, lower Crenularis Member, section RG 70, bed 6, large quarry, Mellikon AG. J 25608, leg. W. Bühler, × 1.

Fig. 3 – *Amoeboceras tuberculatoalternans* (Nikitin), Bimammatum Zone, Bimammatum Subzone, Hornbuck Member, section RG 76, bed 11, Hornbuck near Riedern am Sand, Erzingen D (Unterklettgau). J 31462, leg. R. Gygi, × 2.

Fig. 4 – *Epipeltoceras bimammatum* (Quenstedt), Bimammatum Zone, Bimammatum Subzone, Hornbuck Member, section RG 76, bed 11, Hornbuck near Riedern am Sand, Erzingen D (Unterklettgau). J 32268, leg. R. Gygi, × 1.

Fig. 5 – *Epipeltoceras* cf. *bimammatum* (Quenstedt), Bimammatum Zone, Bimammatum Subzone, Crenularis Member, section RG 36 (unpublished), bed 31, Fahr quarry, Auenstein AG. J 31726, leg. C. Moesch, unlimited loan from ETHZ, Ve. S. 6686, × 1.

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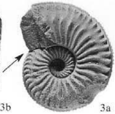

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Plate 11

Fig. 1 – *Orthosphinctes (Praeataxioceras)* sp. gr. *laufenensis* (Siemiradzki), Bimammatum Zone, Bimammatum Subzone, Hornbuck Member, section RG 76, bed 12, Hornbuck near Riedern am Sand, Erzingen D (Unterklettgau). Complete adult with lappet. J 31722, leg. R. Gygi, × 1.

Fig. 2 – *Taramelliceras (Metahaploceras) wenzeli* (Oppel), Planula Zone, Planula Subzone, Wangental Member, section RG 78, bed 60, Mülitobel, Wilchingen SH (see Gygi 1969, pl. 16). J 32276, leg. R. Gygi, × 1.

Fig. 3 – *Taramelliceras (Metahaploceras) wenzeli* (Oppel), top of Bimammatum Zone, uppermost Hauffianum Subzone, Knollen Bed, section RG 70, bed 57, large quarry, Mellikon AG. J 32277, leg. R. Gygi, × 1.

Fig. 4 – *Subnebrodites laxevolutus* (Fontannes), Planula Zone, Planula Subzone, upper Letzi Member, section RG 70, bed 108, large quarry, Mellikon AG. J 32275, leg. R. Gygi, × 1.

Fig. 5 – *Subnebrodites planula* (Quenstedt), Planula Zone, Planula Subzone, Wangental Member, section RG 84, bed 14 (unpublished), township quarry, Hemmenthal SH. J 31723, leg. J. Dosza, × 1.

Fig. 6 – *Orthosphinctes (Orthosphinctes) colubrinus* (Reinecke), Bimammatum Zone, Bimammatum Subzone, Hornbuck Member, section RG 76, bed 5, Hornbuck near Riedern am Sand, Erzingen D (Unterklettgau). Adult with part of lappet. J 32267, leg. R. Gygi, × 1.

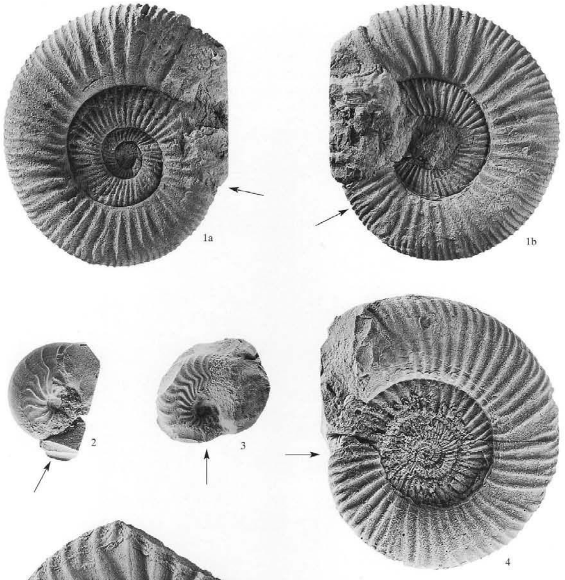
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Plate 12

Fig. 1 – *Ringsteadia suebica* n. sp., Bimammatum Zone, Hauffianum Subzone, Knollen Bed, Dreifaltigkeitsberg near Spaichingen D. J 31724, leg. L. Rollier, unlimited loan from ETHZ, × 0.6.

Fig. 2 – *Glochiceras (Lingulaticeras) lingulatum* (Quenstedt), J 31725, × 0.6.


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Fig. 1 – *Wegelea gredingensis* (Wegele), Bimammatum Zone, Hauffianum Subzone, upper Küssaburg Member, section RG 85, bed 55 (unpublished), Im wisse Rise, Beggingen SH. Near-complete adult with premature peristome. J 31720, leg. R. Gygi, × 1.

Fig. 2 – *Sutneria (Sutneria) platynota* (Reinecke), morphotype A Schairer, Platynota Zone, lower Schwarzbach Formation, section RG 239, bed 22, southernmost quarry at Summerhalde, Schaffhausen. J 23630, leg. R. & S. Gygi, × 2.

Fig. 3 – *Sutneria (Sutneria) galar galar* (Oppel), Planula Zone, Galar Subzone, base of Schwarzbach Formation, section RG 239, bed 18, southernmost quarry at Summerhalde, Schaffhausen. J 23622, leg. R. & S. Gygi, × 2.

Fig. 4 – *Subnebrodites schroederi* (Wegele), Planula Zone, Planula Subzone, lower Wangental Member, section RG 82, bed 134, Steimürlichopf quarry in Churz Tal, Siblingen SH. J 31714, leg. R. Gygi, × 1.

Fig. 5 – *Orthosphinctes (Orthosphinctes) colubrinus* (Reinecke), Planula Zone, Planula Subzone, lower Wangental Member, section RG 82, bed 134, Steimürlichopf quarry in Churz Tal, Siblingen SH. J 31712, leg. R. Gygi, × 1.

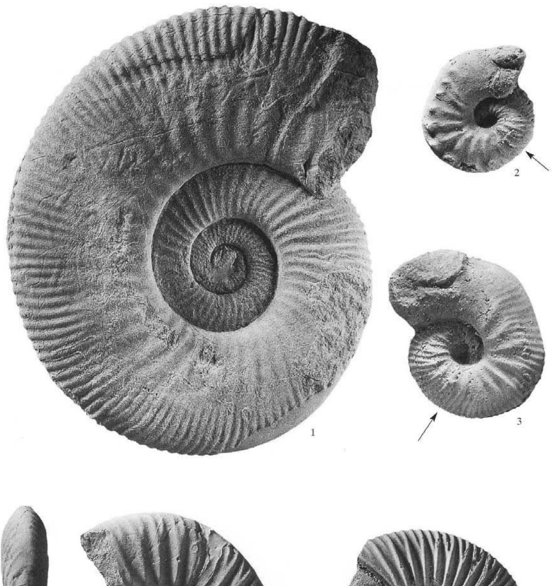
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Plate 14

Fig. 1 – *Ataxioceras (Parataxioceras)* cf. *pseudoeffrenatum* WEGELE, Hypselocyclum Zone, lower Baden Member, section RG 70, bed 124, large quarry, Mellikon AG. J 31721, leg. R. Gygi, × 1.

Fig. 2 – *Ataxioceras (Parataxioceras) lothari huguenini* ATROPS, Hypselocyclum Zone, lower Baden Member, section RG 70, bed 124, large quarry, Mellikon AG. J 26388, leg. R. & S. Gygi, × 1.

Fig. 3 – *Idoceras balderum* (OPPEL), Divisum Zone, lowermost Wettingen Member, section RG 62, bed 124, cliff east of Schrannechopf, Villiger Geissberg, Villigen AG. J 31719, leg. R. Gygi, × 1.

Fig. 4 – *Streblites tenuilobatus* (OPPEL), Hypselocyclum Zone, lower Baden Member, section RG 70, bed 124, large quarry, Mellikon AG. J 32269, leg. R. Gygi, × 1.

Fig. 5 – *Rasenia (Eurasenia) trifurcata* (REINECKE), Hypselocyclum Zone, lower Baden Member, section RG 70, bed 124, large quarry, Mellikon AG. J 26452, leg. R. & S. Gygi, × 1.

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Plate 15

Fig. 1 – *Orthaspidoceras uhlandi* (Oppel), Divisum Zone, lower Wettingen Member, section RG 70, large quarry, Mellikon AG. J 22901, *don.* Schweizerische Sodafabrik, × 1.

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