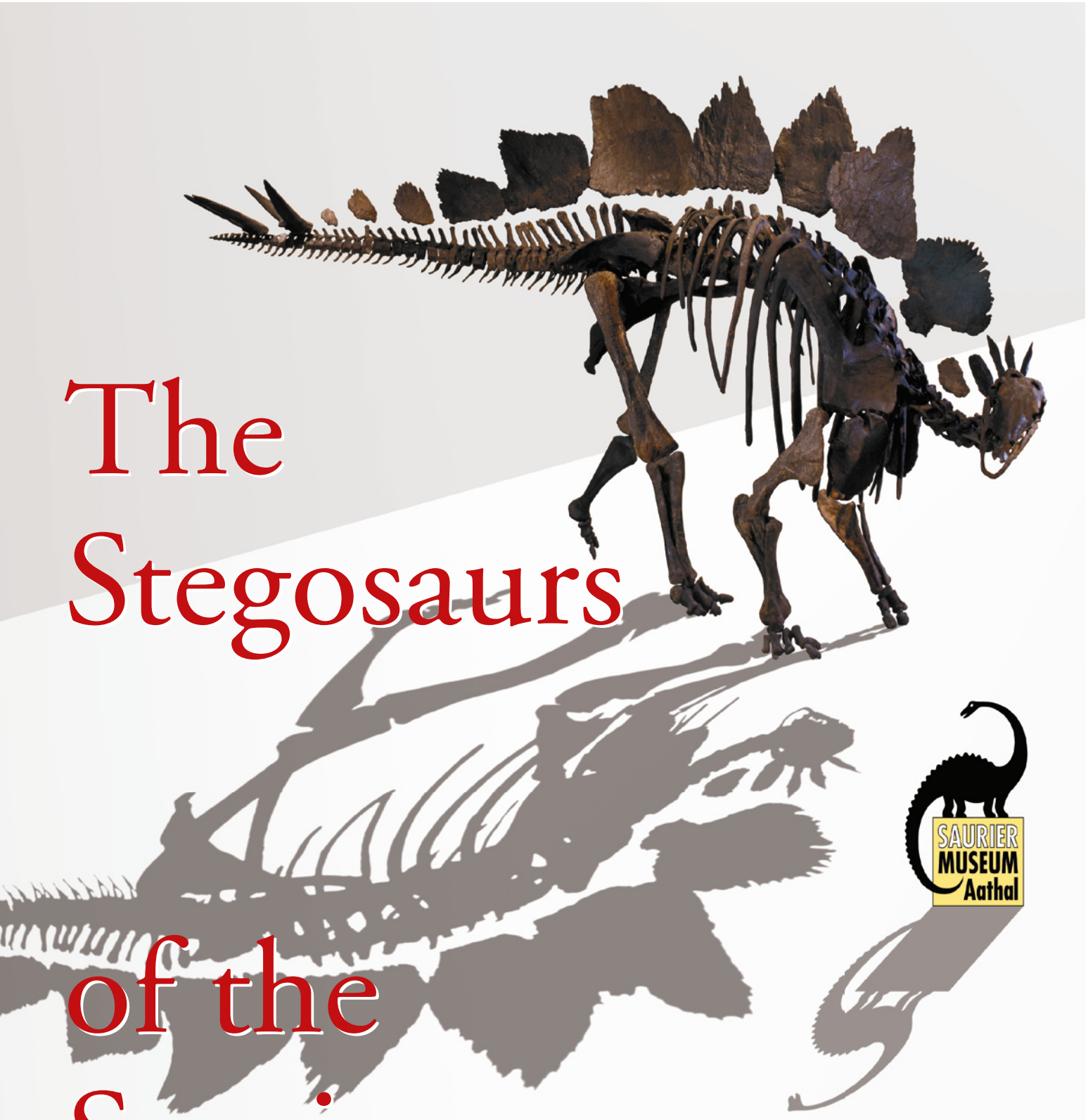


The Stegosaurs of the Sauriermuseum Aathal

by Hans Jakob Siber and Urs Möckli | Sauriermuseum Aathal


Stegosaur stamps from around the world

"Stegosaurs are some of the most visually interesting and unique dinosaurs. Any animal that can be up to 7.5 m (25 ft.) long and weigh up to 5000 kg (11,000 lb) and yet still be bristling with long, sharp spikes and huge, fan-shaped plates has got to be on anyone's list of favorites".

Quotation from John Foster, Jurassic West, 2007



The Stegosaurs of the Sauriermuseum Aathal

Contents

Introduction

We present here the story of how we discovered and dug out four stegosaurs named Moritz, Victoria, Lilly and Sarah from the Morrison Formation in northcentral Wyoming, USA.
All four were excavated and prepared by the Siber team of the Sauriermuseum Aathal in Switzerland. We could have said much more about each find, but due to space limitations, we have to limit ourselves to the essential details and the defining elements of each discovery.
This story also illustrates the ups and downs during our field campaigns, which is par for the course when doing field work. This enterprise definitely had its high and its low points, and it ended, fortunately in greater success than in failure.
This booklet is meant to address professional paleontologists, as well as the general public interested in dinosaurs.
When the Siber team initially started with excavation activities in the field of dinosaur paleontology, we would have been perfectly satisfied in adding one or several "classic" Jurassic dinosaurs to our budding collection at the Sauriermuseum Aathal. However, as it turned out in the course of the 15 years the Siber team has been doing this, the details of many "classic" dinosaurs are not as well known as one might think, considering that *Stegosaurus, Allosaurus, Diplodocus* and *Camarasaurus* are familiar names to millions of people, children and adults around the world. Often what seems to be precisely known in the academic world about a particular dinosaur turns out to be surprisingly "sketchy".
Due to their completeness, the diligence with which they were documented during the excavation, and the special skills that were applied during the preparation phase, our finds have much to offer for dinosaur researchers. With this booklet, the Siber team hopes to contribute to the general knowledge of dinosaur research and to stimulate in particular the research of one of the most fascinating animals the world has ever seen: the stegosaurs of the Upper Jurassic Morrison Formation.

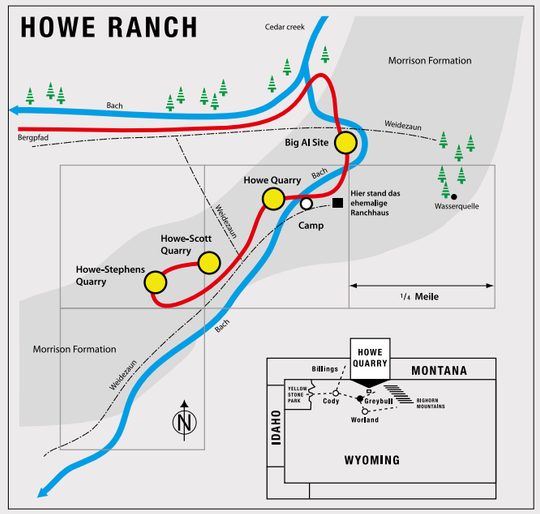
H. J. Kirby Siber, Director Sauriermuseum Aathal, June 2009

A modern representation of stegosaurs grazing in a fern field. How close comes this picture to reality? In truth we don't know. (Life size model created by Wolter Design, Germany)

A Short History of the Howe Ranch as a Dinosaur Locality

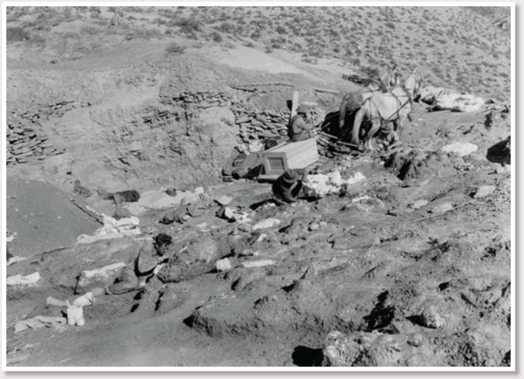
The Siber team's main dig site, the Howe-Stephens Quarry, as it looked at an early stage in 1996, with the Big Horn Mountains on the horizon reaching over 10,000 feet in altitude.

The Howe Ranch first became known as a dinosaur locality in 1934 when Barnum Brown of the American Museum of Natural History, together with a group of ten helpers opened a large pit in the Jurassic Morrison Formation only a stone's throw away from Barker Howe's cabin on the western slopes of the Big Horn Mountains in Wyoming. In the course of a summer, Brown's team excavated a large number of dinosaur tails, necks and bodies, all intermingled and belonging to at least 25 sauropod individuals. This extraordinary site became known as the Howe Dinosaur Quarry and created quite a media stir. Thousands of people came to see the "dinosaur graveyard". One team member, R. T. Bird, was appointed by Brown to draw a map of all bones as they occurred in the ground. It is this map that made it into many publications. It contributed in a large part to the fame of this now classic site, even though very little of the actual bone material survived, due to a fire at the American Museum's storage area and for other reasons. Interestingly, not one stegosaur bone is known from Brown's dig site.



The quarry sites at or near the Howe Ranch. Yellow dots mark sites of major discoveries.

The Howe dinosaur quarry was first opened in 1934 by Barnum Brown (white shirt), a stone's throw away from the pioneer house of rancher Barker Howe (in darker shirt).



One hundred forty-four crates filled with dinosaur bones from the Howe Dinosaur Quarry were shipped from the Howe Ranch to the American Museum of Natural History in New York City.

The Howe Ranch was never really a ranch. The Howe family grew vegetables and helped the many sheep ranchers in the area to tend their herds. In the 1940s the ranch became defunct. It was not productive enough to support a family and was subsequently sold several times.

In 1990 H. J."**Kirby**" **Siber** and his team from the Sauriermuseum Aathal in Switzerland reopened the old Howe Dinosaur Quarry. At that time, the land was owned by Press Stephens who lived a mile away at the Hudson Falls Ranch. Siber found Brown's old site and continued to excavating where Brown's group had left off. During the second field season, the bone deposit suddenly gave out. This is when the team searched for a new possible site on the Howe Ranch and found the locality that became known as the Big Al Site.

Unfortunately for the Siber team, the Big Al Site, although well within the fence posts turned out to be on public land (Bureau of Land Management land). What was until then the most complete skeleton of an allosaur became the property of the US government. This is the reason why the allosaur Big Al One went to the Museum of the Rockies in Bozeman, Montana instead of the Sauriermuseum Aathal in Switzerland.
The now correctly known extent of the land opened up new areas for the Siber team to prospect and dig. At a new site about 500 yards to the south of the classic Howe Dinosaur Quarry, Siber opened a new pit. He named this quarry Howe-Stephens Quarry after the original owner Barker Howe and the present landowner Press Stephens. This quarry became Siber's main dig site for almost ten years and yielded an astonishing assemblage of dinosaur bones, partial skeletons and nearly complete skeletons.

The first stegosaur bones at the Howe Ranch

In the beginning a lot of bones of *Diplodocus* bones, surfaced, the kind Barnum Brown's team had had found at the old site. Then came an excellently preserved skeleton of a camarasaur with a skull. It was called E. T. After digging out E. T. , Siber's team moved to several new sites. An area just north of the Howe-Stephens Quarry seemed the most promising spot. First it produced parts of an apatosaur, with an excellent neck and skull and almost simultaneously the first stegosaur bones from the Howe Ranch. It was, as far as we know, also the first report of a stegosaur from the entire Shell Valley area. This specimen became known as "Moritz".

The first stegosaur bones of the Howe Ranch were discovered in 1995 when the Siber team opened a new dig site 400 yards south of the classic Howe Quarry.

Kirby Siber is taking an aerial photograph of the stegosaur Sarah at the Red Canyon Ranch in 2004.

The Siber team with the stegosaur Sarah at the Red Canyon Ranch in 2004.

Kirby Siber is putting a plaster cast on Victoria's bones in 1996

The stegosaur Lilly's skull when it first surfaced at the Howe-Scott Quarry in 2003.

The 2001 field crew poses for a picture with freshly uncovered bones at the Howe-Stephens Quarry. The bones are a mixed group of disarticulated bones of sauropods and at least one bone of a stegosaur.

Stegosaur «Moritz» cf. *Hesperosaurus mjosi*

Sauriermuseum Support Society (VFSMA) specimen

Location:	Howe-Scott Quarry, Howe Ranch, Shell, Wyoming, USA
Rock Formation:	Upper Jurassic, Morrison Formation
Total length:	4.80 m
Preparation:	Sauriermuseum Aathal, (VFSMA), CH
Mount:	Ben Pabst, Sauriermuseum Aathal, CH

Significance Of the four stegosaurs excavated and prepared by the Siber team, Moritz is, judged by the number of bones missing, the least important specimen. Only about one third of the complete skeleton was recovered and only about one fourth was used for the mount of the original.

First stegosaur of the area The real significance of the Moritz sceleton rests in the fact that Moritz is the first stegosaur from the Howe Ranch to come to light, as well as the first one from the Shell Valley area. It dramatically altered the image of the dinosaur fauna at the Howe Ranch, since before Moritz, this place was thought of as a place where sauropods lived and were occasionally attacked by one or several allosaurs. After Moritz was found stegosaurs had to be integrated into the picture of the ancient landscape. Stegosaurs became part of the scene.

Name The name Moritz was based on a character in the famous German children's book «*Max and Moritz*» by Wilhelm Busch (1832 - 1908). Since Siber had already named a sauropod Max that was found next to the stegosaur, it seemed logical that there should also be a Moritz. Max and Moritz are famous rascals, mean and good-for-nothing-kids. Their fossil counterparts, on the contrary, have proven to be valuable assets to the Sauriermuseum, at least if they are judged not too harshly.

Transport and preparation It was left to the third group of the digging season of 1995 to make sure that all bones exposed at all dig sites were collected before bad weather set in, and that they were packed and made ready for shipping. Nearly ten tons of material, cast bones and blocks of matrix containing partial skeletons, were loaded onto a 40-foot sea freight container. When the freight reached Aathal, Switzerland, the question came up on where to start with the preparation of the various finds: Which dinosaur specimen would be the first to be made ready for display?

Nearly 10,000 pounds of casts and packages from the 1995 dig arrive at the Sauriermuseum's doorstep.

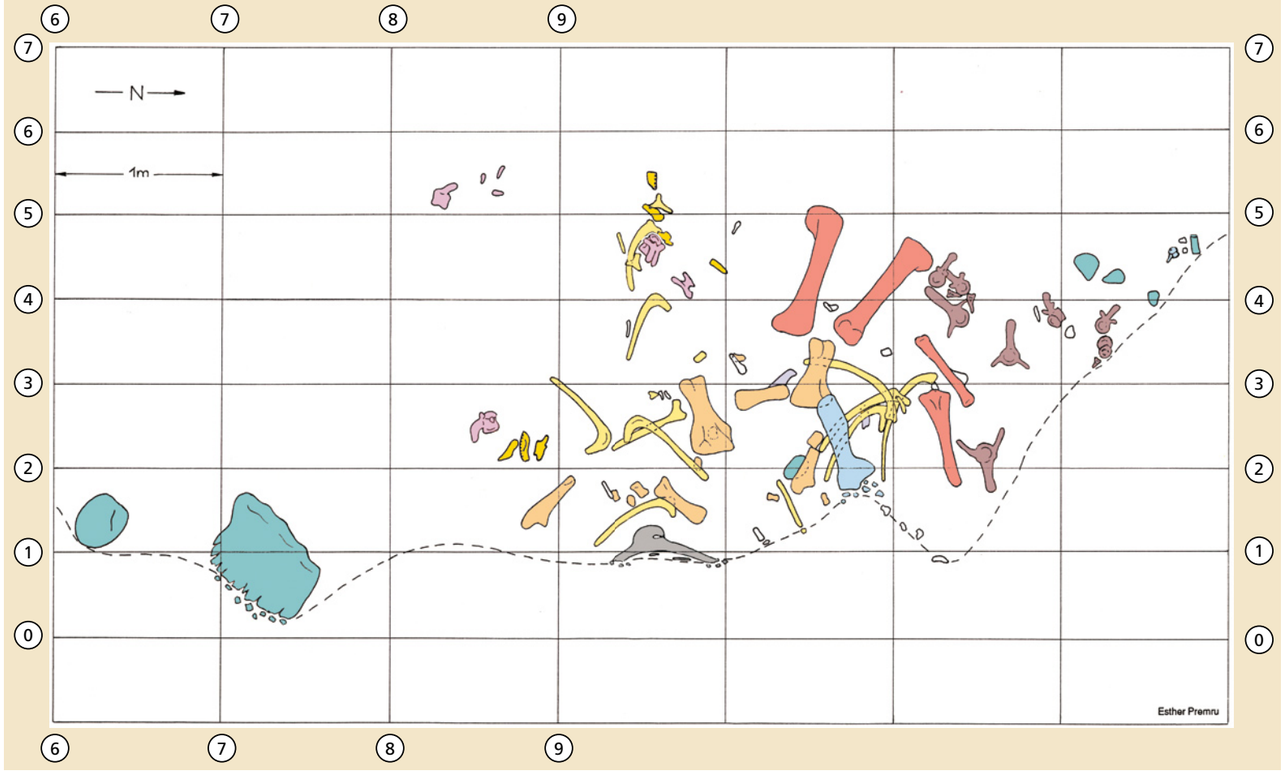
Stegosaur «Moritz» Howe-Scott Quarry 1995

A picturesque view of the pristine landscape looking south from the Howe Ranch toward the Big Horn Mountains.

An aerial view of the quarry area. The quarries are located in the desert next to a large irrigated field.

A backhoe was used to expand the dig site saving hundred of hours of exhausting work with shovel and pick.

Discovery Moritz was found in the tumultuous year of 1995 when the Siber team experimented with an extra large crew of over 20 participants. The digging season was organized in three shifts, an early group, a middle and a late group. Each group was in the field for three to four weeks with an overlapping period of a few days. The first group initiated the digging season at the Howe-Stephens Quarry, where the Siber team had been digging the previous four years but soon abandoned it for a new site which first came to be known as the M-Quarry and whose name was later changed (at the request of the landowner Meredith Scott) to the Howe-Scott Quarry. Here, a partial sauropod was excavated (Max). A third site was opened on the Spring Hill near the northwestern end of the ranch, where another partial sauropod named Aurora was unearthed. Moritz was discovered when the Howe-Scott Quarry expanded and a ditch needed to be built to drain away rainwater. This is when the first stegosaur bones surfaced, among them the characteristically shaped elbow of the ulna.

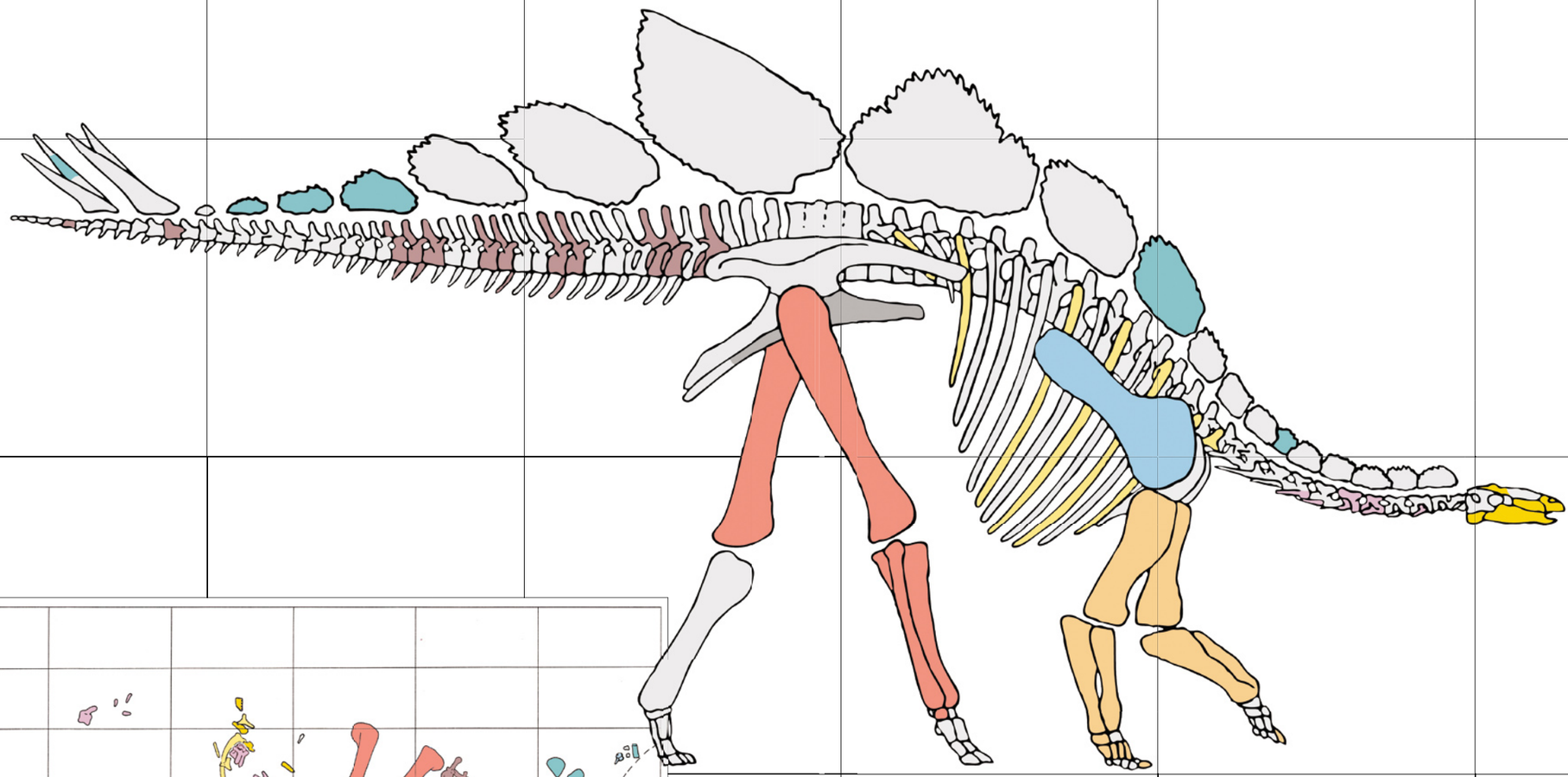


Moritz was found near the surface. Centuries of erosion had eaten away more then half of the skeleton. What was left, rock matrix and bone, were softened and fragile.

The Moritz find includes elements of almost all parts of the skeleton, from the skull bones to one part of a tail spike.

Stegosaur «Moritz» Bone Chart

Revised idealized bone chart, Jan. 2008 / © Sauriermuseum Aathal



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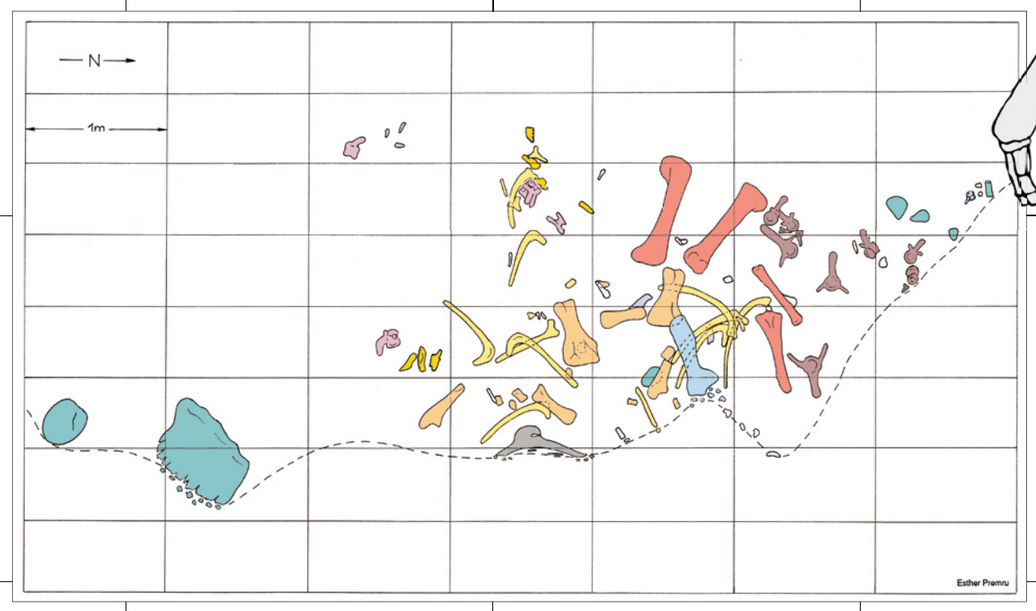


- Plates and spikes
- Pelvis
- Caudals
- Dorsals
- Cervicals
- Skull
- Scapula and coracoids
- Hind legs
- Ribs
- Fore legs
- Missing bones

Stegosaur «Moritz» Bone Inventory

	bones found and prepared	in lab	in exhibition
skull	cranium: right: maxillary, supraorbital, nasal, premaxillary, quadrate, left: maxillary, supraorbital, jugal lower jaw: right: dentary, angular, surangular, articular, prearticular left: dentary, angular, surangular, articular, prearticular one tooth	 X	X
linguale	-		
cervical vertebrae	2		X
cervical ribs right	?2		X
cervical ribs left	2		X
pectoral girdle right	-		
pectoral girdle left	scapula		X
sternal plate	-		
fore leg right	humerus radius, ulna		X
manus right	1 metacarpal 1 phalanx	X	
fore leg left	humerus radius, ulna		X
manus left	1 metacarpal 1 phalanx	X	
dorsal vertebrae	-		
dorsal ribs right	?4		1
dorsal ribs left	5		2
sacrum			
pelvis right	parts of the right pubis	X	
pelvis left	-		
hind leg right	femur tibia + fibula (coossified)		X
pes right	calcaneum ? 1 metatarsal ? 1 phalanx	X	X
hind leg left	femur		X
pes left			
caudal vertebrae	12		X
haemapophses	3		3
caudal spikes	one partial tail spike		X
dorsal plates	6		X
total	65 to 73 bones		

Miscellaneous bones of stegosaur Moritz during the prep phase.

Condition of the bones

It soon became obvious that there were quite a few bones of a stegosaur buried at this place. As a glance at the bone map now illustrates, all bones were found disarticulated, that is, they were somewhat scattered. A second look shows, however, there is a certain logic to the scattering. Skull and neck parts are found at one end of the bone field, tail vertebrae and tail plates at the other end, with the rest in the middle. Eventually about 35% of the skeleton was recovered. Erosion must have destroyed the other 65%. The near-surface position of the find made the weathered matrix really easy to dig. However, the crushed condition of the bones, and the encrustation of the bone ends with iron concretions made the extraction difficult. This type of bone was “thirsty”, a description used by bone diggers for rotten and poorly permineralisezet and deteriorated bones. Thirsty bones need a lot of water-soluble acrylic for stabilization. The acrylic solution seeps into the bone and the water evaporates, leaving the acrylic to bind the bone together. To make matters worse, plant roots had gotten into the fossils; plants love fossil bones because of the minerals in them. If someone foolishly were to try to pull a root out of the bone, the bone would be destroyed because the roots would pull the bone to pieces. All in all, the first stegosaur was initially considered exciting but not a very significant find.

Stegosaur «Moritz» Preparation

Funding of prep work The money needed to prepare all the finds from 1991 to 1995 could not be found in the Sauriermuseum’s own budget. Until then, Siber+Siber AG, the Sauriermuseum’s parent company, had put up the necessary funds, but now some external source had to be found. A request was made to the Swiss Lottery Fund, which sponsors cultural activities. Probably for the first time in their entire history, this fund sponsored the preparation of a dinosaur skeleton, with a grant of 80,000 Swiss Francs (about US $ 50,000 at that time). This sum was most welcome but it was not enough to finance the preparation of a large sauropod. It sufficed, however, for the preparation of Moritz. In the end, the preparation of Moritz still needed some extra help from Siber+Siber AG, and some sacrifice on the part of the preparator Ben Pabst’s salary.

Preparation and mount Once the money was granted, Pabst immediately went about the task of stabilizing and cleaning the bones of stegosaur Moritz. In this task he was helped by Esther Premru, another long- time preparator at the Sauriermuseum Aathal. Slowly, but surely, they got one bone after another done. As a surprise during the preparation more bones appeared than were originally observed in the field. Some bones were hidden in the plaster casts, which contained more than one bone. The preparators also learned to deal with the special problem of weathered and unstable bones, sometimes covered with “nasty” iron concretions.
In the meantime, Kirby Siber located a company in Utah (USA), Western Paleontological Laboratories, Inc., and requested casts or replicas of the bones missing in Moritz. Western Paleo had just excavated and mounted a stegosaur from the Bone Cabin Quarry area in southcentral Wyoming. This specimen turned out to have the parts that Moritz was missing. Siber ordered casts to complement the Moritz find from the Howe Ranch. These casts arrived just in time, right after Pabst had finished the preparation of the bones. The size of the casts turned out to be a pretty good match with bones of Moritz, and the mounting of the skeleton was soon started.

How to mount a stegosaur Valuable insight into the task of mounting a stegosaur was given to Siber by dinosaur artist Steven Czerkas. In the fall of 1997, Siber went to see Czerkas at his studio near Monticello, Utah (USA). In the course of about a day and a half, Siber was broken into the “secrets of stegosaurology” by one who had years earlier made passionate research into this subject. It was Czerkas who made Siber aware of the historic controversy over plate arrangement. Czerkas concluded that the plates were essentially arranged in a single line along the midline of the back of the animal with an alternating shift to the right and the left. Pabst and Siber followed Czerkas’ concept. Today, after having worked with three more, much better preserved stegosaur finds, it seems clear that Czerkas was right with his concept of the plate arrangement. None

Visitors watch ongoing bone preparation at Sauriermuseum’s prep lab.

A field jacket is opened and its contents are carefully cleaned, hardened and made ready for mounting.

Moritz’s original bones (black) are combined with cast bones (white) from a find from the Como Bluff area of southern Wyoming.

Stegosaur «Moritz» Mounting

of the new finds contradict his theory. Therefore, 17 plates were used in the Moritz mount (4 original plates and 13 cast plates). The largest, although preserved, could not be used for the mount, considering its enormous size, weight and weak condition. Seventeen was the number that Czerkas suggested, and this was the largest number of plates known to occur in one individual up to this time. In regard to posture Pabst choose a position suggesting the animal is looking up from grazing. Some carnivore in the distance is catching the stegosaur's attention and the animal is deliberating whether to run or make a stand and fight with its fearsome tail spikes.

Species determination What species does stegosaur Moritz belong to? Up to now we have not been able to clearly relate this specimen to any of the known species. Toni Fürst, who looked at the bones in detail in 1998, referred Moritz to *Stegosaurus armatus*. At that time, *Stegosaurus mjosi* was not known. Species determination is made difficult because only about one third of the skeleton is preserved and also because the existing literature on stegosaurs is sometimes difficult to interpret. Susannah Maidment, who looked at Moritz in 2005, thought it might be related to *Hesperosaurus mjosi*. Understandably, however, she was not willing to commit to this. What further obscures the species identification is the fact is that the mount is a composite. What is clearly needed is better material for comparison. To a large degree, the next three specimens described here, Victoria, Lilly and Sarah, provide a much clearer base for comparison with Moritz, however, species determination remains a problem since the new finds do not fit neatly into one or two types.

Exhibitions worldwide In 1997, Moritz was put on display for the first time at the Sauriermuseum Aathal in conjunction with a general exhibition on stegosaurs. This exhibition had one center piece (Moritz) and explained in words and pictures what was known until then about the stegosaurs from North America and from other continents. Moritz became an instant darling of the museum public and later went on tour. The skeleton was set up at various places in Switzerland, including Davos, Neuchâtel and Basel. It also made appearances in temporary displays in Munich (Germany), Brussels (Belgium) and Tokyo (Japan).

Since Moritz was finished and put on display, it was seen by more than 2.5 million people. It became the mascot dinosaur of the Sauriermuseum Aathal, even though the Siber team had excavated more than a dozen sauropod skeletons and only one stegosaur. Moritz was the undisputed star, at least until allosaur Big Al Two was put on display.

Mounting the original bones is a particular challenge to preparators Ben Pabst and Esther Premru.

Stegosaur «Moritz» Skull

The skull Here is an epilogue about Moritz: Ten years after Moritz was first prepared and mounted (with a cast skull from the Western Paleontological Laboratories, Inc.) preparators from the Sauriermuseum went through the box of bones left over from the first preparation back in 1996. They found a series of skull bones, a total of 14 elements. These elements were then cleaned and hardened, and proved to be parts of the missing skull of Moritz!. The task of assembling the skull was given to Dutch preparator Aart Walen. Walen used a cast of the back of the skull (the occiput) from another of our stegosaurs (Sarah), then combined it with the original skull bones of Moritz, which were mostly from the front. The remaining missing bones were carved in order to reconstruct the skull of Moritz.
The Sauriermuseum's list of original dinosaur skulls from the Howe Ranch now totals eight: one each of *Diplodocus, Apatosaurus, Camarasaurus, Allosaurus* and *Othnielosaurus* and three skulls of stegosaurs.

In the end, 14 skull bones of Moritz were saved. Above: a set of unmounted elements and below: the fully mounted skull.

Stegosaur «Victoria» *Stegosaurus* sp.

Sauriermuseum Aathal specimen

Location:	Howe-Stephens Quarry, Howe Ranch, Shell, Wyoming, USA
Rock Formation:	Upper Jurassic, Morrison Formation
Total length:	6.50 m
Preparation:	Ben Pabst and Esther Premru, Sauriermuseum Aathal, CH
Mount:	Ben Pabst, Sauriermuseum Aathal, CH

Near the end of the preparation phase, Victoria's bones were laid for the first time out as a test for the next phase when the bones were mounted as a free-standing skeleton.

Special features With a length of 6.50 meters from head to tail, Victoria is the largest stegosaur from the Shell Valley area. Its tail spikes are really massive with strong elliptical bases. The large plate above the pelvis seems huge (97 by 65 cm) in comparison with the overall size of the animal. Unfortunately, only a small number of the plates are preserved (6 of possibly 18). Whatever happened to the rest is not known. Did this stegosaur have a reduced number of plates even before it died, or where they lost in burial? Some of the plates are badly cracked in the middle. Whether this is an effect of weathering or disease cannot be determinated at this point.

Species identification Victoria seems to be neither identical to Moritz nor Lilly, and seems even less related to Sarah. For species identification, a detailed study is needed.

Oddities On or near the rib cage, several unidentified, mysterious, rod-like bones were found. They are about 10 to 15 cm long and have a triangular diameter. It is unclear whether they are belly ribs (gastralia) or ossified tendons, or perhaps served some other unidentified function (body armor?).

Stegosaur «Victoria» Howe-Stephens Quarry 1996 | 97

Discovery On the last day of the digging season of 1995, when Kirby Siber and his daughter Maya were the only ones left in camp for the clean-up, Siber collected a bone at the Howe-Stephens Quarry that was left in the ground half-dug out by a volunteer. After two hours of increasingly exciting work this bone turned out to be part of an articulated skeleton. But that year's excavation had already come to a close, and the continuation of this most exciting find had to be postponed to the following year. The site was closed up and the bone was buried under piles of loose dirt. Ben Pabst, as the leader of the first group of diggers in the following digging season reopened the spot where the bones were found. A few days into the dig he excitedly called up Siber at the museum in Aathal, Switzerland. The bones that were found last year turned out to be from a large stegosaur and - surprise - there was a second skeleton, that of a meat eating allosaur right next to the stegosaur. In fact the tail of the allosaur ran over the leg of the stegosaur. It looked like both skeletons would be surprisingly complete. This was, after the turbulent first five years, when moderate success was mixed with the calamitous loss of our first allosaur find Big Al, a moment of triumph. The Siber team's efforts had finally paid off. The new allosaur, which became known as Big Al Two, was the compensation for the first allosaur lost and the stegosaur was the reward for not giving up. That's why it was called Victoria. It was a true victory for the entire team, who had put into this so much work, risk, and perseverance.

Stegosaurs in granite? Rock formations in the nearby Big Horn Mountains are reminiscent of large stegosaur plates.

This casual look at the dig site does not reveal that this site contains two important dinosaur finds, stegosaur Victoria and allosaur Big Al Two.

Stegosaur «Victoria» Howe-Stephens Quarry 1996 | 97

Theory of deposition After the 1997 digging season it looked more and more like a new theory of deposition would have to be formulated, one that took into account the bone richness at the Howe-Stephens Quarry: the fact that one layer contained mostly scattered bones, the one directly underneath contained fully or nearly fully articulated skeletons, and the lowest layer contained two large fossil trees. It became more and more important that the microstratigraphy should be studied in detail, that is, each layer needed to be carefully studied in detail. Furthermore, this very special bone deposit should be described by a trained scientist for the scientific community. A young and very energetic geologist from the French speaking part of Switzerland, Jacques Ayer, seemed to be the right person. In 1998, 1999 and 2001 he accompanied the Siber team to the excavations. His special task was to study the sediments of the Howe-Stephens Quarry and of the surrounding areas. Ayer intended to write his doctorate thesis about this topic. Then Siber's work unfortunately came to a halt in the summer of the year 2003 when the landowner, Dr. Meredith Scott, prohibited further excavations until the legal question concerning ownership of the fossils at the Howe Ranch was cleared up. Ayer has not since been possible to continue his work.

Interpretation of the site These new finds caused the Siber team to rethink the taphonomy of the bone deposit. "Taphonomy" is the study of what happens to an animal (or plant) from the time it dies, eventually gets buried and is later found as a fossil. Instead of thinking of a vast flood that had caused the ancient river to deposit numerous dinosaur remains randomly into the river bed, Siber now started to think about repeated flood events that deposited dinosaur bones in specific places. More than one flood must have been the cause for the "stacked-up" occurrence of the dinosaur bones they were finding at the Howe-Stephens Quarry. The team had already dug through more than four meters of sediment and was still finding more as they went down.

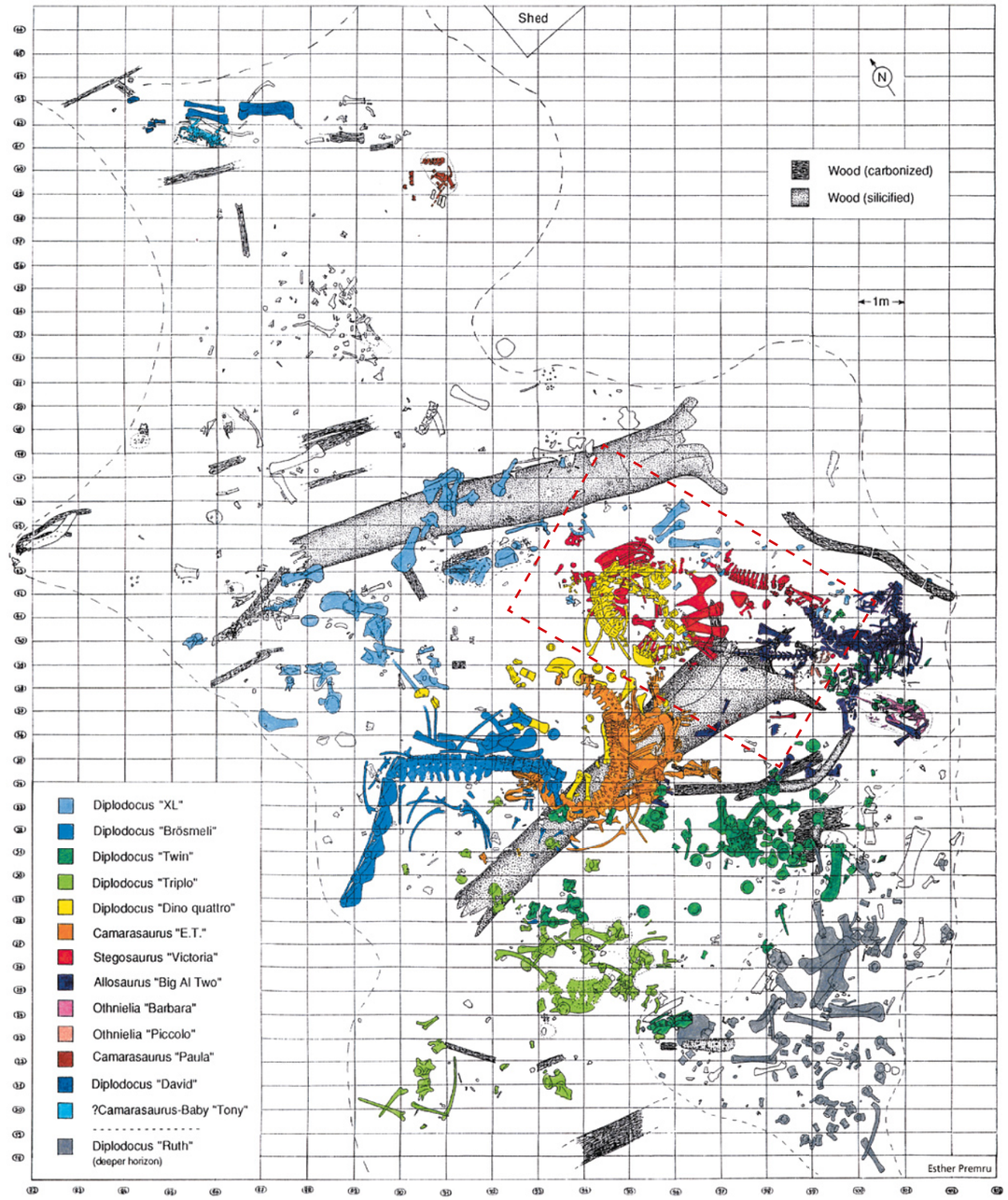
This bone from Victoria's pubis, now safely resting in a plaster jacket, was the first bone to surface from a nearly complete skeleton.

Kirby Siber is puts a plaster jacket on Victoria's bones.

Barbara von Arb and Chris Keilmann are about to break a plaster cast loose from its pedestal.

Stegosaur «Victoria» General Map Howe-Stephens Quarry

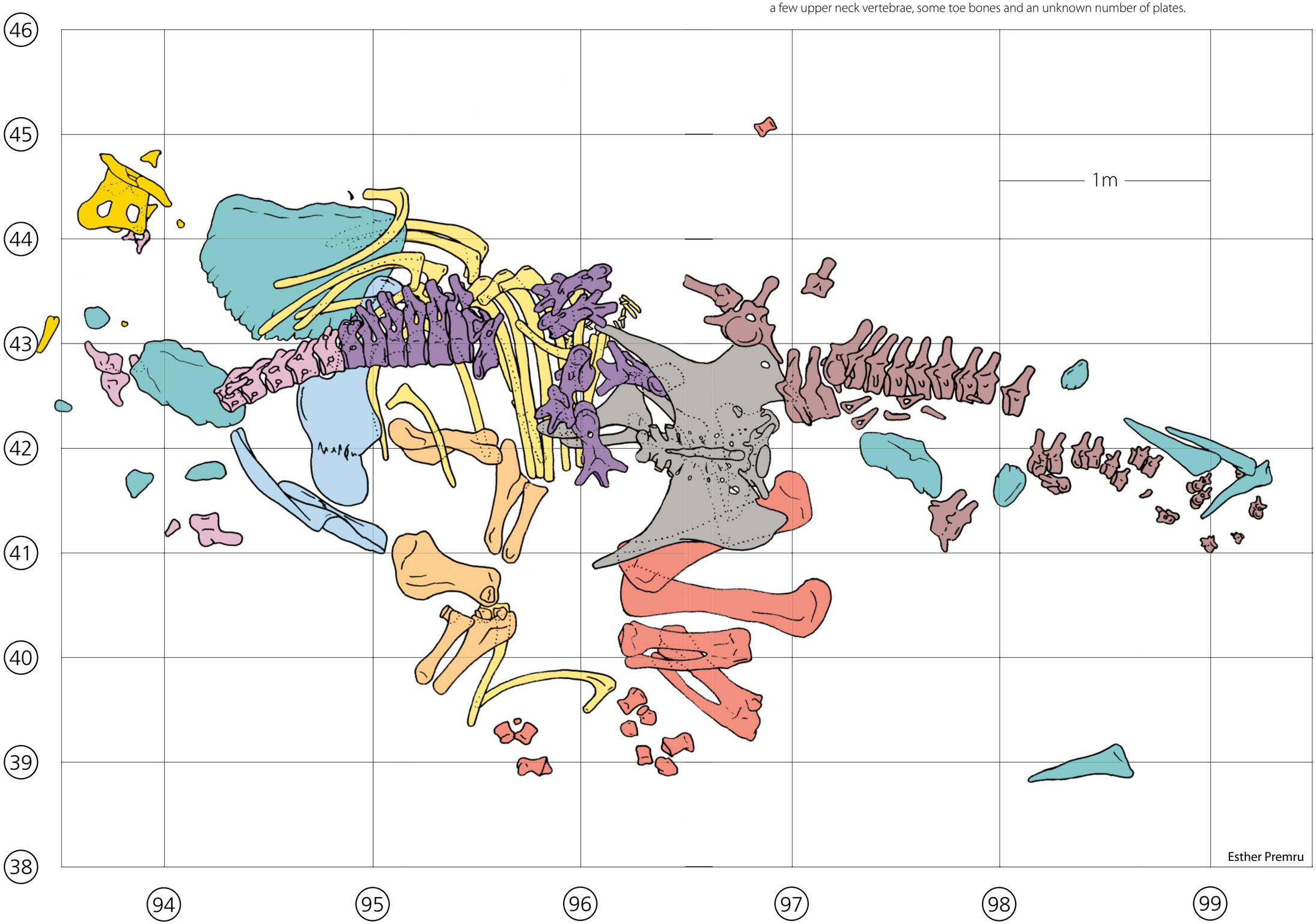
General Quarry Map 1992 - 2001 — Howe-Stephens Quarry | Shell, Wyoming, USA



After ten years of annual digging campaigns the Howe-Stephens Quarry has yielded the remains of at least 13 different dinosaurs, among them stegosaur Victoria (see red square), allosaur Big Al Two, sauropod Baby Toni and *Othnielosaurus* Barbara.

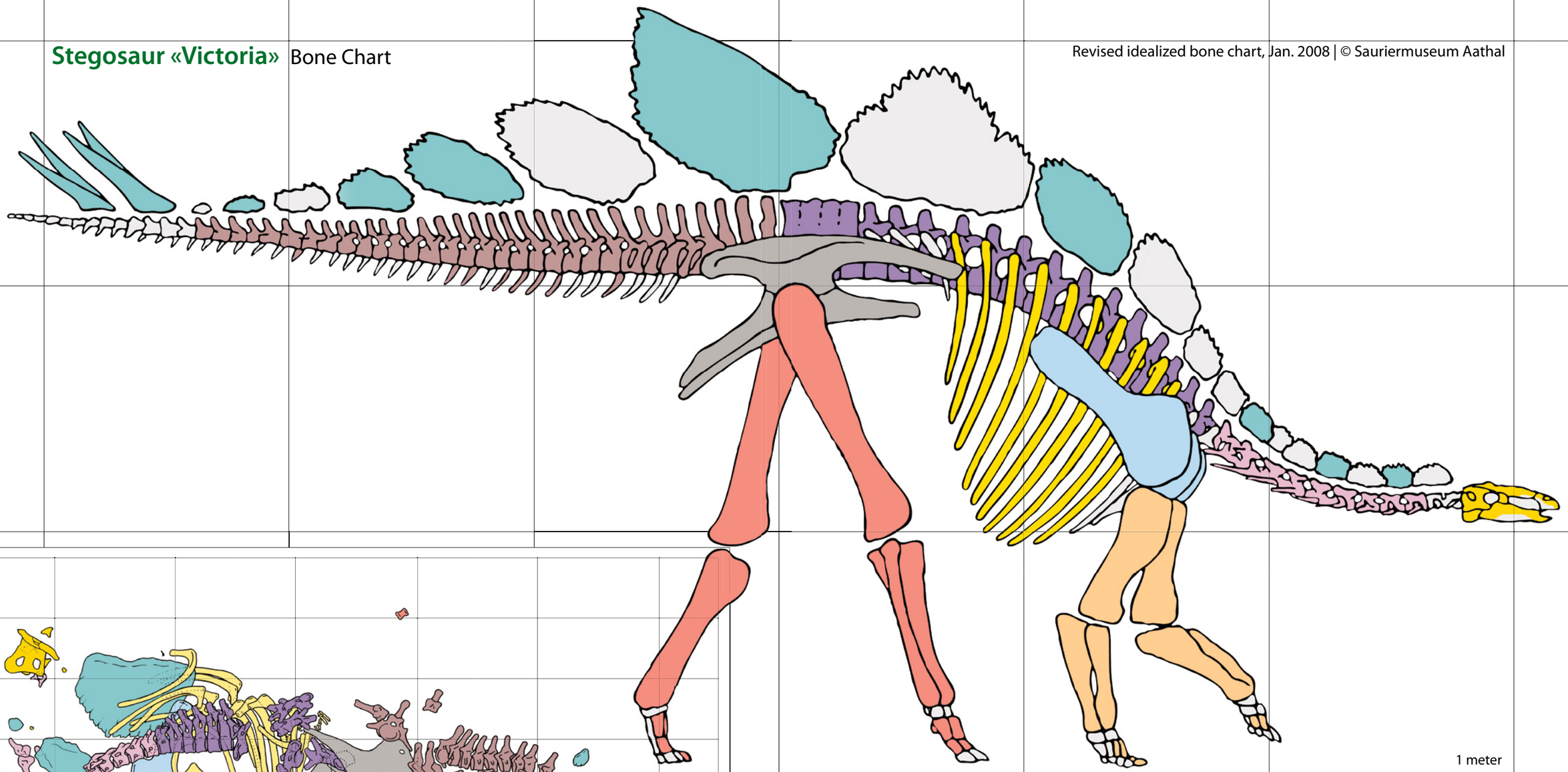
Stegosaur «Victoria» Howe-Stephens Quarry 1996 | 97

After her death Victoria's her body was transported to its final resting place nearly intact. The carcass suffered minor damage as is illustrated by the low number of missing bones, among them some tail vertebrae, a few upper neck vertebrae, some toe bones and an unknown number of plates.



Stegosaur «Victoria» Bone Chart

Revised idealized bone chart, Jan. 2008 | © Sauriermuseum Aathal



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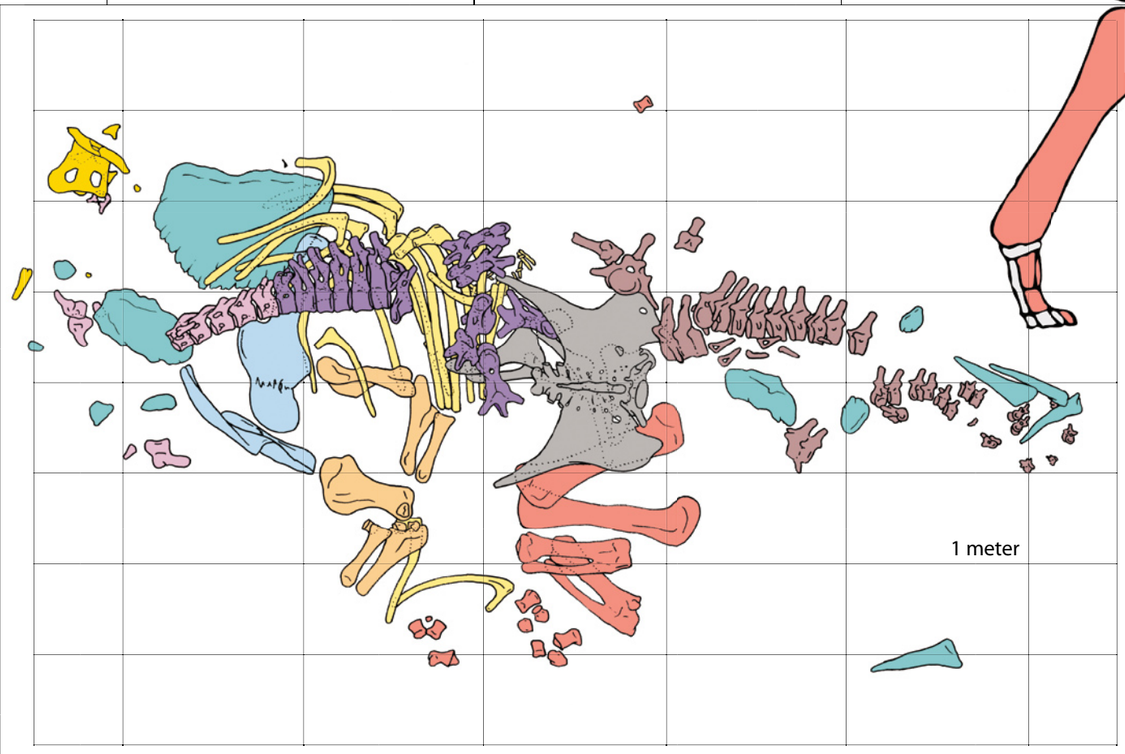


1 meter

- Plates and spikes
- Pelvis
- Caudals
- Dorsals
- Cervicals
- Skull
- Scapula and coracoids
- Hind legs
- Ribs
- Fore legs
- Missing bones

Stegosaur «Victoria» Bone Inventory

	bones found and prepared	in lab	in exhibition
skull	complete		X
linguale	-		
cervical vertebrae	atlas, axis + 7		9
cervical ribs right	7-8		X
cervical ribs left	4-5	X	
pectoral girdle right	scapula, coracoid		X
pectoral girdle left	scapula, coracoid	X	
sternal plate	-		
fore leg right	humerus radius, ulna		X
manus right	ulnare, radiale 4 metacarpals 1 phalanges 2 unguals		X
fore leg left	humerus radius, ulna		X
manus left	1 ?phalanx 1 ?ungual	X	
dorsal vertebrae	14		X
dorsal ribs right	14	4	10 (partly visible)
dorsal ribs left	9 + many rib fragments	X	
sacrum	5 vertebrae		X
pelvis right	pubis, ischium, ilium		X
pelvis left	pubis, ischium, ilium	X	
hind leg right	femur tibia, fibula		X
pes right	astragalus, calcaneus 3 metatarsals 2 phalanges 1 ungual		X
hind leg left	femur tibia, fibula	½	½ X
pes left	2 bones	X	
caudal vertebrae	31		X
haemapophyses	9 + ?2	?2	9
caudal spikes	4		X
dorsal plates	7		X
total	210 to 214 bones		

Condition of the skeletons Excavations for both stegosaur Victoria and allosaur Big Al Two took place during two digging seasons in 1996 and 1997. Major parts of the skeletons were found in full articulation. Some bones, but not many, had moved out of place and drifted away before burial, but were still recovered. The digging turned out to be slow and difficult. A third dinosaur specimen was found entangled in the same pile of bones, a two-meter-sized *Othnielosaurus* named Barbara. The condition of the bones made digging a nerve-wracking test of patience. The brown sandstone covering the bones was "glued" to the bone surface. The bone ends were especially causing endless frustration because rock and bone could not be easily distinguished from one another. It was often virtually impossible to see were the bone was going unless the bone was broken. Visitors who came to look at the site – and there were many – stared at a huge elongated pile of rock. Skeptics were probably thinking that the Siber team was fooling themselves, trying to convince themselves and the visitors that this pile of dirt contained anything valuable. It took two full digging seasons (1996 and 1997) to collect these finds. Then came the even bigger task of cleaning and hardening the bones at the museum's lab. Much money was needed to pay for the time consuming preparation. But where to find the funds became the big question.

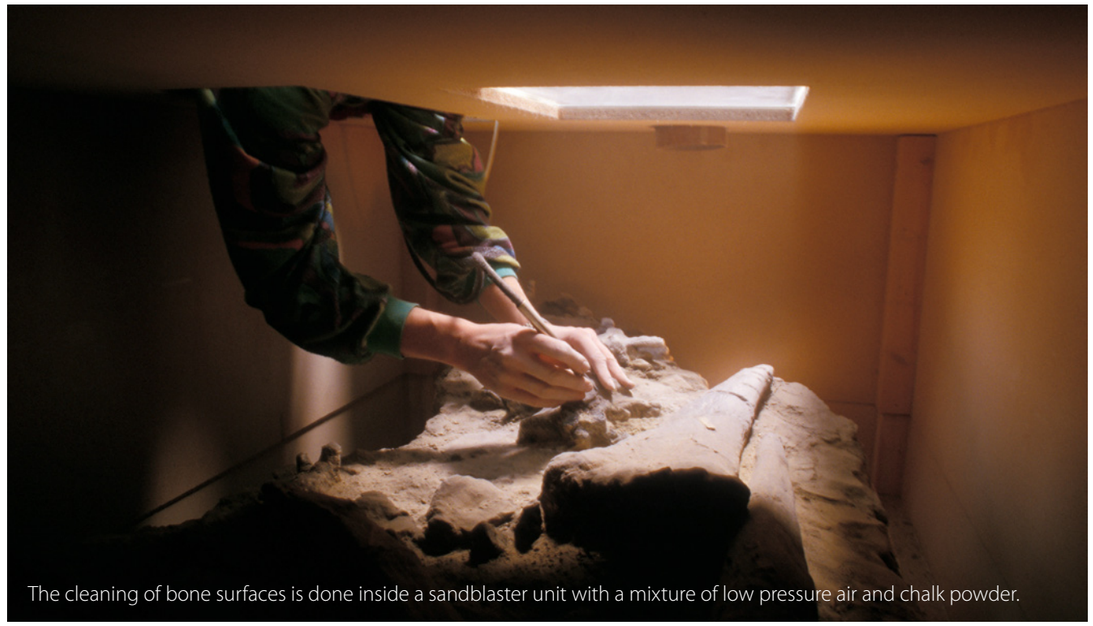
Kirby Siber and Esther Premru discuss procedures at the museum's summer preb lab after fossil skin was first found near one of Victoria's large plates.

Stegosaur «Victoria» Preparation

Money found Fortunately the Sauriermuseum Aathal was able to find a sponsor, at least for one of the special finds. The Muséeum d'Histoire Naturelle in Neuchâtel in the French part of Switzerland planned a dinosaur exhibition and opted to display *Allosaurus* Big Al Two as their main feature and as a world premiere. This museum essentially paid for Big Al Two's preparation. The prep work for the *Othnielosaurus* Barbara was paid for by the organizers of the "World's Largest Dino Expo" that took place in Tokyo in 2001. The stegosaur Victoria project, however, was put on hold. The Sauriermuseum had Moritz and so Victoria had to wait unfinished and unprepared until 2006. Ten years after it was found, preparation was finally undertaken and finished two years later. This time, Siber+Siber Ltd, the Sauriermuseum's parent company, had to jump in again by putting up the funds. Some parts of Victoria, like the skull and the tail with all four large tail spikes, had already been on display for quite a while, but the major part of the skeleton needed work, lots of work, since the bone preservation was poor and only the best and most skilled preparators could cope with this daunting task.

Esther Premru exposes stegosaur spikes and several semi-articulated tail vertebrae.

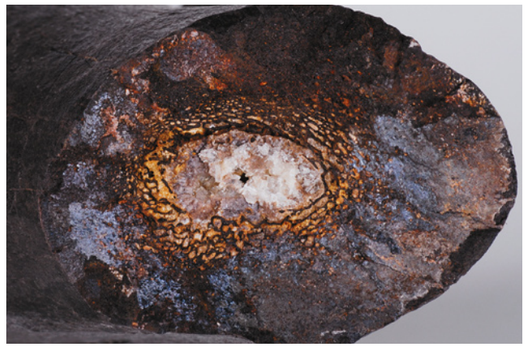
Esther Premru uses an air tool at the museum's prep lab.



The cleaning of bone surfaces is done inside a sandblaster unit with a mixture of low pressure air and chalk powder.

Stegosaur «Victoria» Preparation

Prep work The prep work of Victoria was undertaken to a large part by Esther Premru. Esther, who has 25 years of experience and is generally recognized as a master preparator, nearly gave up in frustration. Often the bone's substance was hard to distinguish from the matrix. To make matters worse, cracks filled with a mineral called gypsum crisscrossed bone and matrix. It borders on a miracle that some of the bones could be saved. In the end, preparation took two years longer than expected, but the bone count grew by the month (see list). And an extraordinary thing happened during the prep phase: stegosaur skin was discovered!

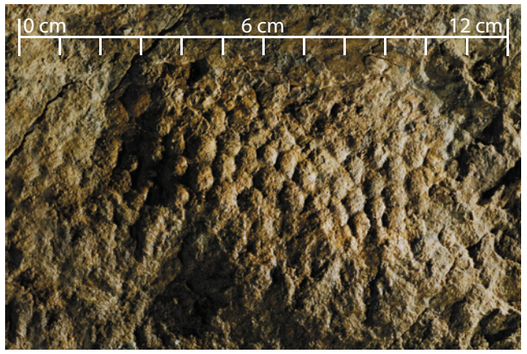


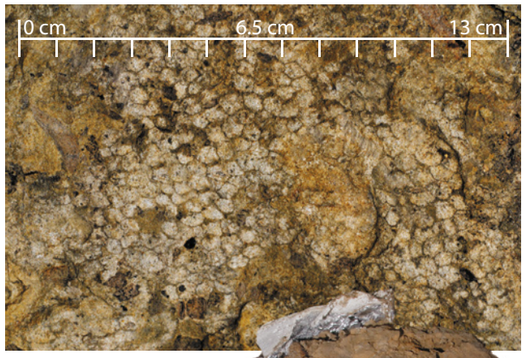
A natural break offers a rare view into the bone cell structure of a tail spike.

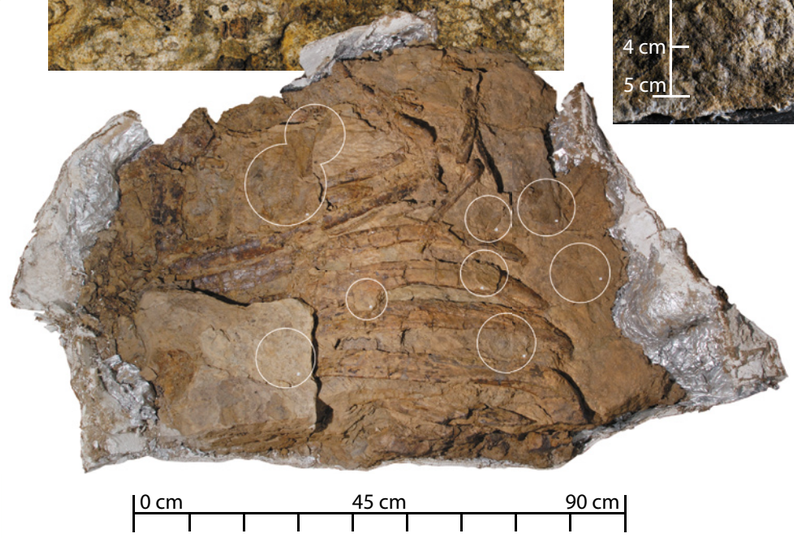
Preparator Ben Pabst assembles Victoria's skull from its components.

Stegosaur «Victoria» Preserved Skin

Skin The first small patch of "skin" was discovered under the large plate, which in the living animal sat above the pelvis, that was found folded under Victoria's left side. The "skin" is actually an impression of the scales and black material, which is probably organic carbon of the orginal skin. More "skin" was found when the rib cage was prepared. In the end there were six fist-sized patches with honeycomb-scale pattern typical of dinosaurs. Never before had skin been found on a North American stegosaur. This was thus quite a significant find. The problem with the discovery of fossil skin is that the preparator must decide whether to save the skin or go after the bones and in the process sacrifice the skin. The Sauriermuseum team decided to save both the skin was left attached to the ribs, and ribs and skin were mounted in the original position on the outer side of the right rib cage. As a result the ribs are still partially covered with original matrix and some visible skin structure.



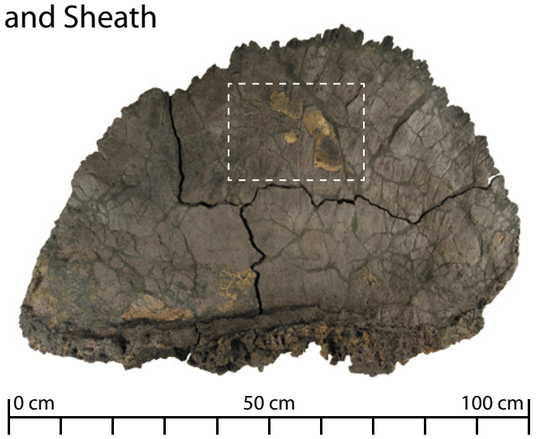




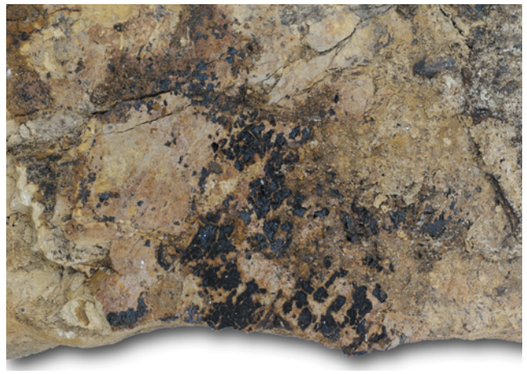
Several hand-sized patches of skin impression have been found along the the rib cage of Victoria's right side, the side on which Victoria came to rest. The "honeycomb" pattern of the skin shows polygons of approximately 1cm diameter. In one instance the polygons seem to be arranged around a larger, 3 cm element.

Stegosaur «Victoria» Preserved Skin and Sheath

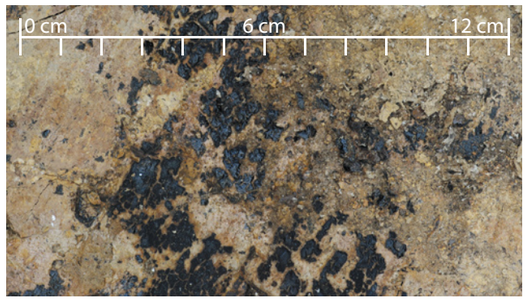
A piece of fossil skin is attached to the plate. The view is from the skin's underside.



Victoria's largest plate, measuring 95 x 65 cm, shows on its left side a small piece of skin.



A one millimeter thick carbon film, apparently representing the horney sheath, was found on the underside of Victoria's biggest plate.

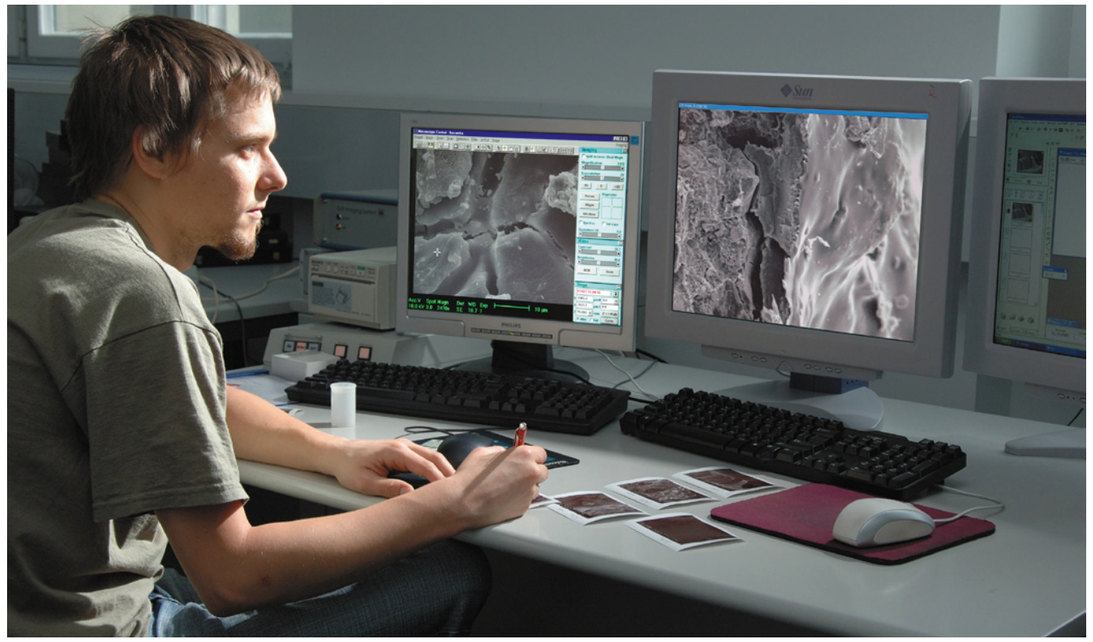


Injuries Poor old Victoria was full of injuries which can be seen in the pathological bones of her skeleton. The joints on both legs were diseased with arthrosis. Ribs were broken and rehealed. One rib particularly stands out with a weird growth (see photo below). The tail shows several fused or incomplete vertebrae most likely stemming from old, poorly healed injuries.

Victoria shows several pathologies, among them diseased tail vertebrae and toe bones, as well as pathological neural extentions in the pelvis region.

Mount Victoria was mounted for the 2008 special exhibition, more than 10 years after it was discovered. A suitable mounting method had to be found. It was anticipated that scientists, particularly stegosaur researchers, would need to be able to look at each bone from all sides. So Pabst, who did the mounting, came up with a solution whereby the most of the bones sit in slots and have clamps that hold them in place. Any bone can be removed from the mount with ease for scientific study. The mount is entirely made of the original bones. In the case of Victoria, missing bones have not been restored as is often done when skeletons are mounted.

Stegosaur «Victoria» Preserved Skin



Researcher Emanuel Tschopp looks at the scanning electron mikroscope image of fossil skin taken from stegosaur Victoria at a specialized lab in the geological Institute of the Swiss Federal Institute of Technology (ETH) in Zurich.

The mounted skeleton of Victoria has been displayed at the Sauriermuseum Aathal since April 2007.
Note the patches of skin on the matrix surrounding the rib cage.

Stegosaur «Lilly» cf. *Hesperosaurus mjosi*

Sauriermuseum Aathal specimen

Location:	Howe-Scott Quarry, Howe Ranch, Shell, Wyoming, USA
Rock Formation:	Upper Jurassic, Morrison Formation
Total length:	4.50 m
Preparation:	Sauriermuseum Aathal, CH
Mount:	Toni Fürst, Sauriermuseum Aathal, CH

The skeleton of stegosaur Lilly has been on exhibit at the Sauriermuseum Aathal since April 2008. The central part of the body was left in original matrix. The rest of the skeleton was mounted on artificial rock.

Reopening of the Howe-Scott Quarry In January, 2002, a 10-year extension to the lease for the fossil rights of the Howe Ranch was granted to Siber. When the digging season started, Siber decided to reopen the Howe-Scott Quarry. If Siber's hypothesis about the taphonomy of the site was correct, then there was a good chance that there would be more finds waiting right below where the 1995 finds were made.
Within hours after the reopening of the Howe-Scottt Quarry, the first bones appeared about 70 to 80 centimeters below the layer where Max and Moritz were found seven years earlier. This time the bones turned out to be a fully articulated tail of an apatosaur attached to a pelvis and a leg and, directly under this, a new stegosaur. This stegosaur specimen, which became known as Lilly, looked really good from the beginning. The fossil bones came out of fresh rock. Weathering had not affected into them as was the case with earlier finds. There was definitely an advantage to using heavy equipment when digging into dinosaur bearing layers. If care was taken with the powerful hydraulic shovel, this method would prove to be less destructive than erosion was to the near-surface finds. At any rate, in the case of the reopening of the Howe-Scott Quarry, only a pelvic bone was slightly damaged by the backhoe. The rest of the bones were left as intact as they had been during the last 150 million years.

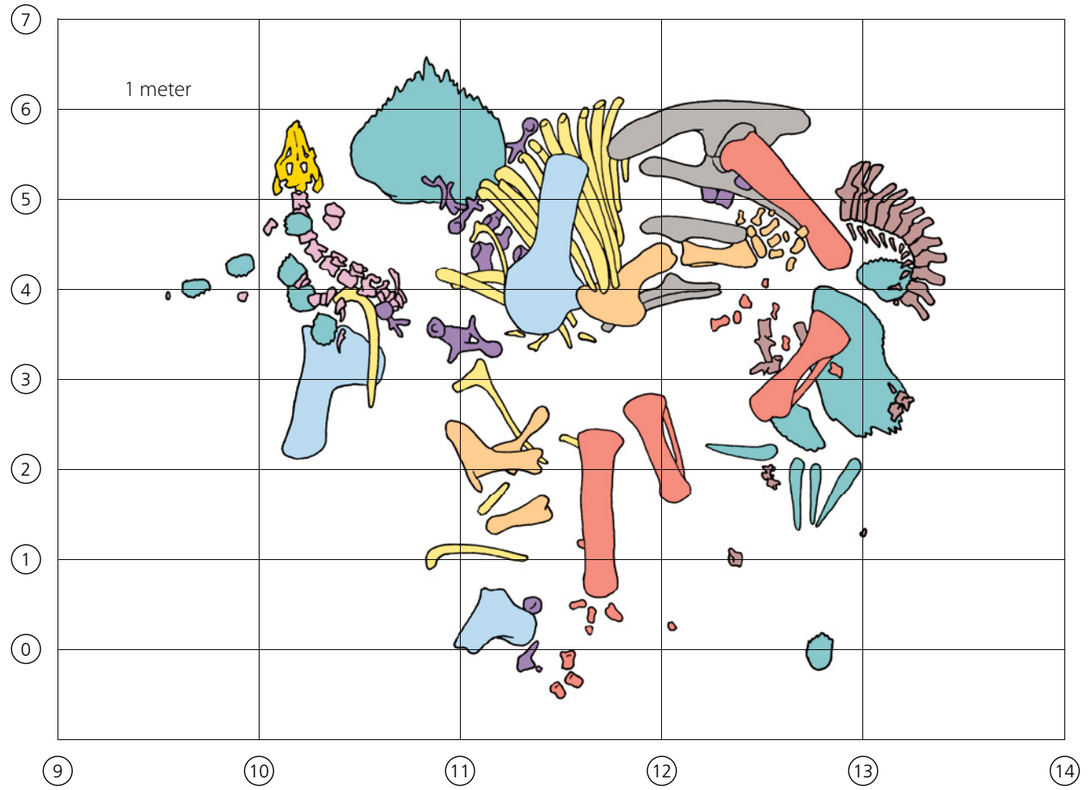
Stegosaur «Lilly»

Howe-Scott Quarry 2002 | 03

Lilly's name Lilly's name originates from twin sisters Nicola and Rabea Lillich, two German paleontologists, who joined the dig as volunteers. They were the ones who first ran into "strange looking" toe bones and later found the stegosaur's tail with the four spikes that made it clear what kind of dinosaur it was. While one part of the 2002 crew was busy excavating the stegosaur tail, the other followed up on the newly discovered apatosaur named Chris. Soon it became apparent that the two skeletons overlapped like two skeletons on one heap. Progress became agonizingly slow. To make matters worse, there was a layer of scrappy bones just 10 centimeters above Lilly. Hundreds of small pieces of broken bones covered Lilly like a blanket. Each object had to be dug up carefully. Theoretically at least, it could be an important part of the skeleton. A large number of such fossil objects were dug up, only later to be discarged. Much energy was spent with not much progress. A second digging season was needed to collect both finds.

Maya Siber marks the crate especially taylored made for Lilly's well preserved skull and neck.

Lilly's skull, as found in the field, is a real paleontologist's dream.

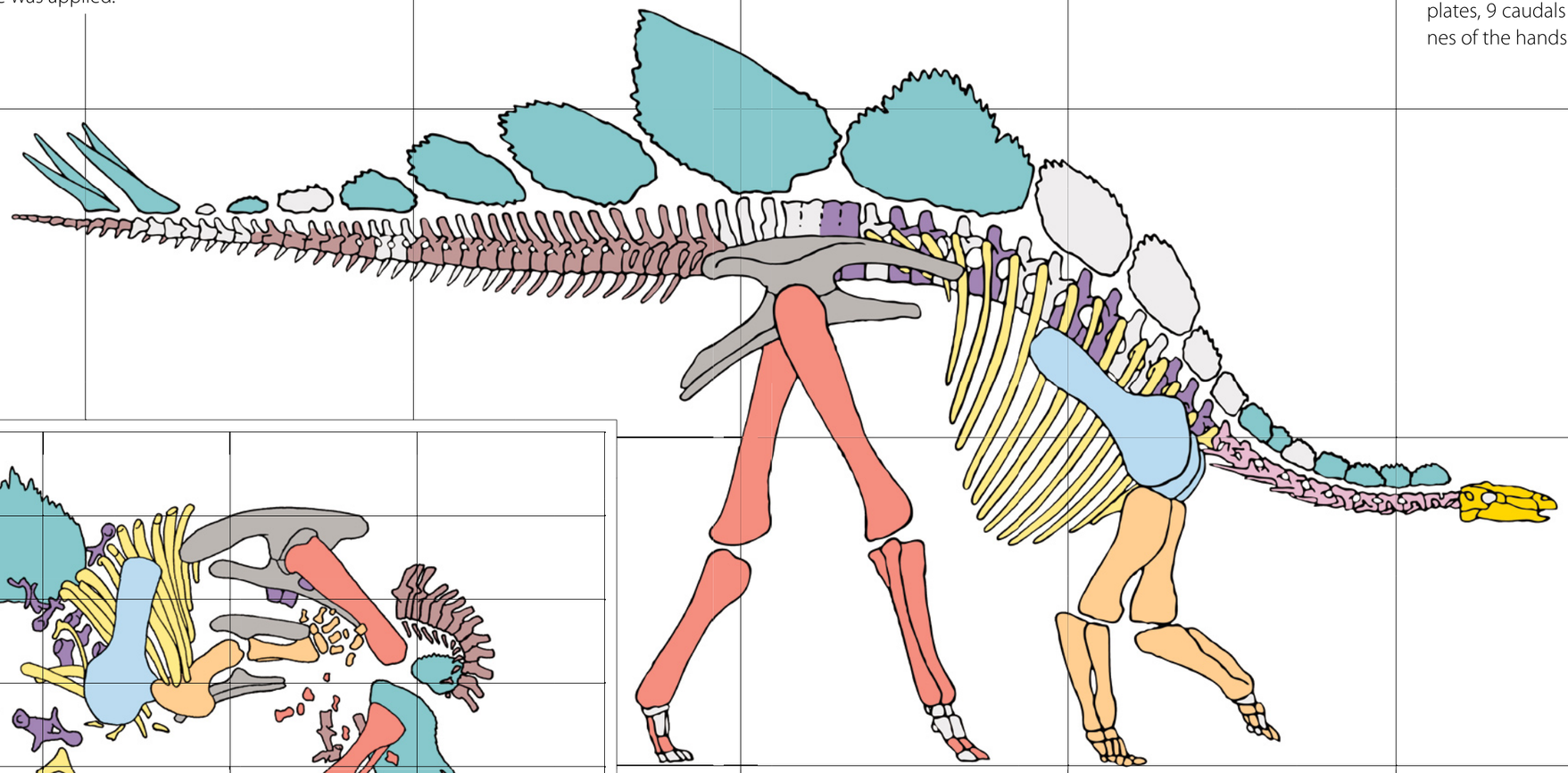


Stegosaur «Lilly» Bone Chart

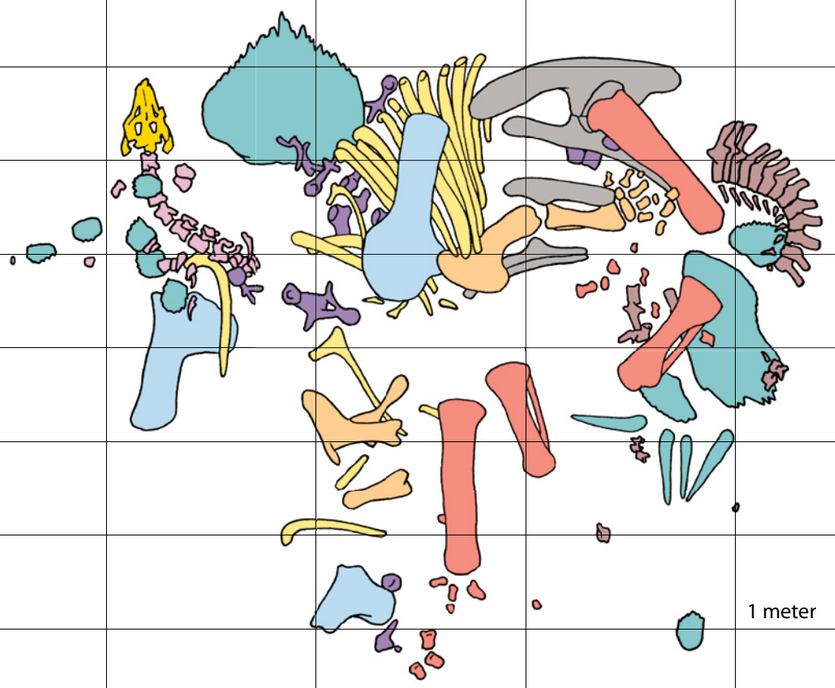
Revised idealized bone chart, Jan. 2008 / © Sauriermuseum Aathal

The skull The following year (2003) brought a surprise, one that all participants will never forget, a real paleontologist's dream. When work on apatosaur Chris continued, skull bones appeared next to the femur. It was Lilly's skull. It really looked like an animal stretching out its head from a mud pool and breathing air after being buried for so long. It was a moving sight. Skulls, especially of Jurassic dinosaurs, are rare. And even rarer are those that are not crushed and still attached to the neck. Difficult work still remained ahead since the huge and heavy sauropod pelvis had to be removed, which stretched over the neck of stegosaur Lilly with only a few centimeters of sandstone separating them. It was a task that required "a delicate touch" since neither the bone nor the matrix in its untreated form was stable, and – it was feared – the bones might crumble whenever too much force was applied.

Stegosaur Lilly's body was deposited in a stream bed. Before reaching its final resting place, some parts of the skeleton were moved slightly.
The missing bones include an unknown number of dorsal plates, 9 caudals and some bones of the hands and feet.



1 meter



1 meter

- Plates and spikes
- Pelvis
- Caudals
- Dorsals
- Cervicals
- Skull
- Scapula and coracoids
- Hind legs
- Ribs
- Fore legs
- Missing bones

Stegosaur «Lilly» Bone Inventory

	bones found and prepared	in lab	in exhibition
skull	complete		X
linguale	found	X	
cervical vertebrae	atlas, axis + 8		X
cervical ribs right	10	1	9
cervical ribs left	7	X	
pectoral girdle right	scapula, coracoid		X
pectoral girdle left	scapula, coracoid	X	
sternal plate	-		
fore leg right	humerus radius, ulna		X
manus right	ulnare, radiale 5 metacarpals 4 phalanges 2 unguals complete articulated hand!		X
fore leg left	humerus radius, ulna		X
manus left	ulnare, radiale 3 metacarpals 1 phalanx 2 unguals		X
dorsal vertebrae	17 (6 + 11 ?*)		6
dorsal ribs right	13		X
dorsal ribs left	16 (10 + 6 ?*)	6	4
sacrum	* 3 to 5 sacral vertebrae		
pelvis right	pubis, ischium, ilium		X
pelvis left	pubis *ischium, *ilium		X
hind leg right	femur tibia, fibula	½	½ X
pes right	astragalus, calcaneum 2 phalanges 1 ungual		X
hind leg left	femur tibia, fibula		X
pes left	astragalus, calcaneum 2 phalanges		X
caudal vertebrae	36		X
haemapophyses	30		X
caudal spikes	4		X
dorsal plates	14		X
total	248 to 269 bones		

Preparator Toni Fürst discusses the work in progress at the Sauriermuseum's prep lab.

Prep work Despite the difficulties in the field, once back in the lab, it became clear that Lilly was a shining star. Chief preparator Toni Fürst discovered that nearly all ribs were in their original position and that the right arm, including shoulderblade and hand, were fully articulated. This also meant that every bone of the stegosaur's hand was present, and that these bones pretty much occupied the position they had when the animal was still alive, a condition rarely seen in large fossil vertebrates. Lilly is, to our knowledge, the only stegosaur with a complete set of hand bones known to science. This was certainly exciting news.

Species identification Are the "apple-shaped" neck plates possibly a feature particular of the stegosaur *Hesperosaurus mjosi*, or is Lilly a new species? Can stegosaur plates be used for species identification or do they vary from individual to individual in number and shape in such a way that they are of no taxonomic value? Such questions can only be solved when more good finds are available for comparison.

Ontogenetic age Judging from the skeleton, Lilly seems to be a young adult. The scapula (shoulder bone) and coracoid (chest bone) are fused, as are the two lower leg bones, the tibia and fibula. Such fusions are a clear sign that Lilly was past the juvenile and the adolescent stage. With its 4.50m size, it is however, small for an adult. Perhaps it can be considered a small adult.

Stegosaur «Lilly» Preparation

The central part of Lilly's body was found in full articulation. The bones of the right arm and the right hand were found to be completely preserved.

No pathologies Lilly shows – this is remarkable for an adult dinosaur skeleton – no visible pathologies. As a rule, life in the Jurassic was rough. Other finds like allosaur Big Al Two, camarasaur E. T. , stegosaur Victoria, all show major pathologies either from disease or injury, or both. Is this an indication that Lilly may have died as a result of drowning in a flood?
What else can be learned from looking at the skeleton? A glance at the close position between the pelvic bone and the scapula (both are in their original positions) illustrates an interesting feature in the living animal: these bones almost touch one another! This means that the shape of the body of this stegosaur must have been very short. Combined with the enormously massive and broad pelvis, this gives the animal a curious triangular shape, somewhat reminiscent of an ankylosaur body. This stegosaur must have been able to swing rapidly on its axis of the hind legs in order to deliver a forceful blow with its tail spikes (an observation made by Ben Pabst).

Mounting Lilly Lilly had few missing bones and was found in the field as a nearly fully articulated skeleton. Therefore, an idealized "in situ" pose was selected for display. For this purpose the main block of matrix containing the rib cage, as well as the arm and hand and the pelvis, was left as found. Around this block the preparators created a field of artificial matrix on which all other bones would be mounted. Only Lilly's real bones were used and missing bones were not added. The bones rest in a negative impression so that each bone would perfectly sit in its place. This technique now allows for the easy removal of any bone if a scientist or researcher needs to look at a particular bone from all sides.

The encasing sandstone often seems to be "glued" to the bone and must be carefully removed with a airscribe, millimeter by millimeter.

Stegosaur «Lilly» Preparation

Tail spikes Lilly's tail spikes are present as a complete set. The two end spikes show a round diameter at the base, and the front pair have oval bases, as could be expected. The surface of the tail spike is pot-marked or pitted, possibly due to insect feeding, a sign that this part of the body was exposed before burial, at least for a little longer than the rest of the skeleton.

The plates Lilly has 14 preserved plates. The original number of plates was likely higher. Plates, particularly from the tail and the dorsal (back) series, seem to be missing. One plate is known to have been left in the field. It was found on the second to last day of the 2003 dig. It was supposed to be collected during the following field season, but this has not happened so far due to problems in Wyoming.

Neck plates The neck also revealed exciting features. Yolanda, Siber's oldest daughter, who was in charge of preparing the neck and the skull, found eight (8) small plates along the neck. The interesting part is not only the high number, but also their shape. These plates are not "pear-shaped" as in *Stegosaurus armatus*, they are rectangular or "apple-shaped".

Lilly's skeleton was taken apart in 5 major blocks and and numerous small parcels for transport.

A movable ventilation system keeps the air clean in the lab.

No armored neck No signs of an armored throat have been detected in Lilly, as has been reported from other discoveries, by the digging crew or the group of preparators, even though they had been looking for signs of the armor, particularly in a specimen as complete as Lilly. Remarkably, none of the other stegosaurs from the Shell Valley area have ever been found with any indication of an armored throat. Perhaps stegosaurs from Colorado and southern Wyoming, where armored throats have been reported, had them as a special adaptation. The stegosaurs from northcentral Wyoming, however, seem to have done without.

The pride and joy of two months of prep work: Lilly's completely articulated arm and hand.

Stegosaur «Lilly» Skull

The neck ribs The neck was found fully articulated. Even the cervical ribs are in their original positions. In a somewhat counter-intuitive fashion, these cervical ribs point upwards and backwards, not down as might be expected.

The skull Lilly features a complete skull. Only the nozzle is slightly displaced. Apparently the skull suffered a heavy blow, most likely as a result of special circumstances shortly before or during burial. The skull has been CT-scanned at the Zürich hospital. Researcher Nicolai Christiansen hoped to be able to look inside skull. However, the results were disappointing. The fact that sediments still fill the skull cavities seemed to obscure clear pictures of the interior.

Yolanda Schicker-Siber working on Lilly's skull.

Lilly's skull illustrates that she got punched in the nose and, as a result, some of the teeth are positioned crooked in her jaw.

Stegosaur «Sarah» cf. *Stegosaurus armatus*

Dinosaur Safari Inc. specimen

Location:	Red Canyon Ranch, Shell, Wyoming, USA
Rock Formation:	Upper Jurassic, Morrison Formation
Total length:	5.60 m
Preparation:	Sauriermuseum Aathal, CH
Casting and mounting:	Black Hills Institute of Geological Research, South Dakota, USA

Principal preparators: Yolanda Schicker-Siber, Esther Premru and Christina Egli with Sauriermuseum owner H. J. Siber.

Unusual circumstances Unusual circumstances led to the Siber team's involvement into the excavation of stegosaur Sarah from the Red Canyon Ranch. In the spring of 2003, Siber's intention was to continue digging at the Howe Ranch, when unexpected difficulties prevented the digging team to enter the Howe Ranch. The team's travel plans were already fixed and could not be changed. As a consequence, a team of nine people arrived in the Shell Valley area late in July ready to dig, but without a dig site in sight. At about this time, Bob Simon from Dinosaur Safari Inc. , who runs a dinosaur quarry on the neighboring Red Canyon Ranch (aerial distance about three miles southeast of the Howe Ranch), was looking for help in the excavation of his first significant find, a nearly fully articulated stegosaur. Bob Simon found this skeleton buried in the top of a hill while expanding his quarry. The condition of the bones was extremely fragile. The first attempts at collecting the specimen left some bones destroyed. An experienced team was needed to cope with the particular difficulties of this find. So Simon invited Siber's experienced team to have a look at the spot.

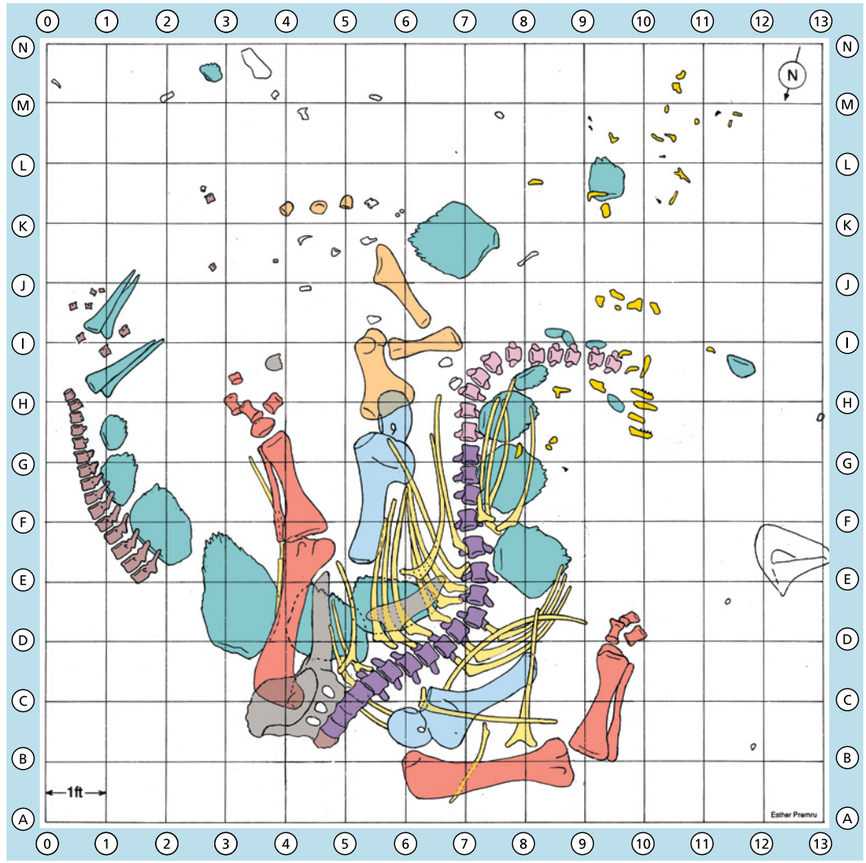
A first inspection revealed that the find was indeed significant. What was exposed up to this time was the central part of a stegosaur's body in full articulation, with a chance of the tail and the neck still hidden under a sandstone layer. Siber decided at the spur of the moment to put his crew to work right there. Siber's team started carefully to clean the already exposed bones. The trouble was that they had weathered to the point of being merely dust. A hardening agent was needed that would deeply penetrate the bones' structure. The problem Simon encountered was that the bones, once cast with plaster on the top side, would simply run out of the cast from the bottom like loose sand when the cast was picked up. The Siber team had occasionally

Stegosaur «Sarah»
Red Canyon Ranch 2004

Stegosaur Sarah as she looked in the field after all her bones were exposed, with Maya Siber pointing to the tail spikes.

encountered such nasty bones at the Howe Ranch and was familiar with a technique that would save such bones. It still required many hours of carefully exposing the bone surfaces, centimeter by centimeter, and treating them with glues and hardening agents, a task that needed an extraordinary amount of skill and patience. However, within the following three weeks, the specimen, which came to be known as "Sarah" was fully brought to light. It was hardened and ready to take apart for the trip to the lab. The name Sarah was chosen by Bob Simon to honor the daughter of the landowner, John Ed Anderson.

Photo opportunity There was a moment when nearly all the bones were exposed in the field. This was the occasion when Sarah was made ready for a photo shooting session. With a backhoe shovel, the photographer was lifted to a height of five meters above the specimen. This bird's eye view offered the best angle to take pictures of the entire skeleton as it laid in the ground. This was a rare case of a Jurassic Morrison dinosaur being exposed in the field as a nearly fully articulated specimen. Most of the Morrison dig sites produce assemblages of various loose bones and partial skeletons as is the case, for instance, at the Dinosaur National Monument, near Vernal, Utah.

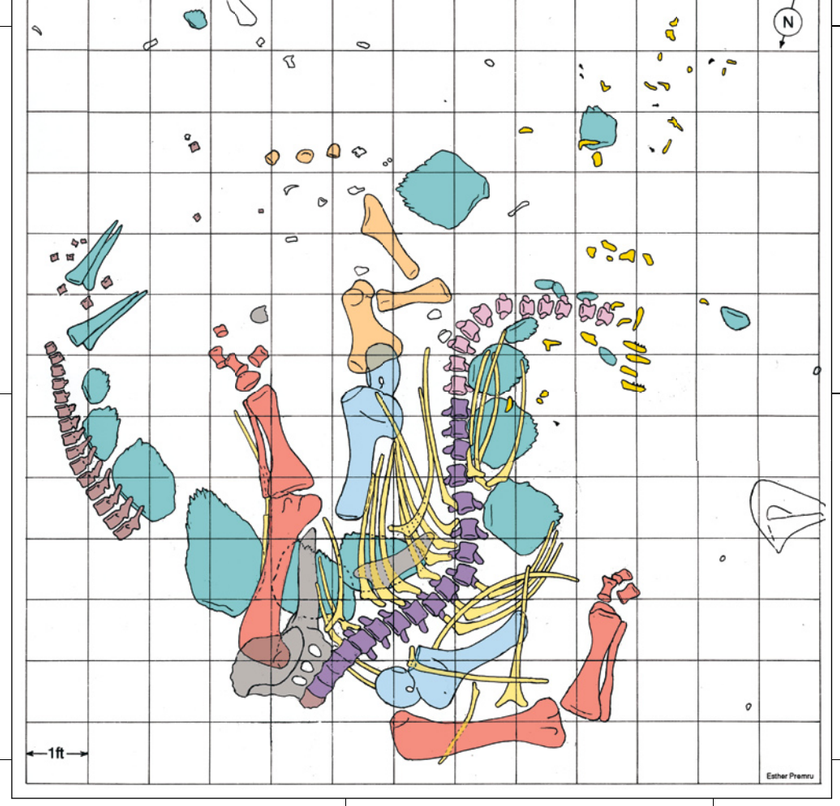


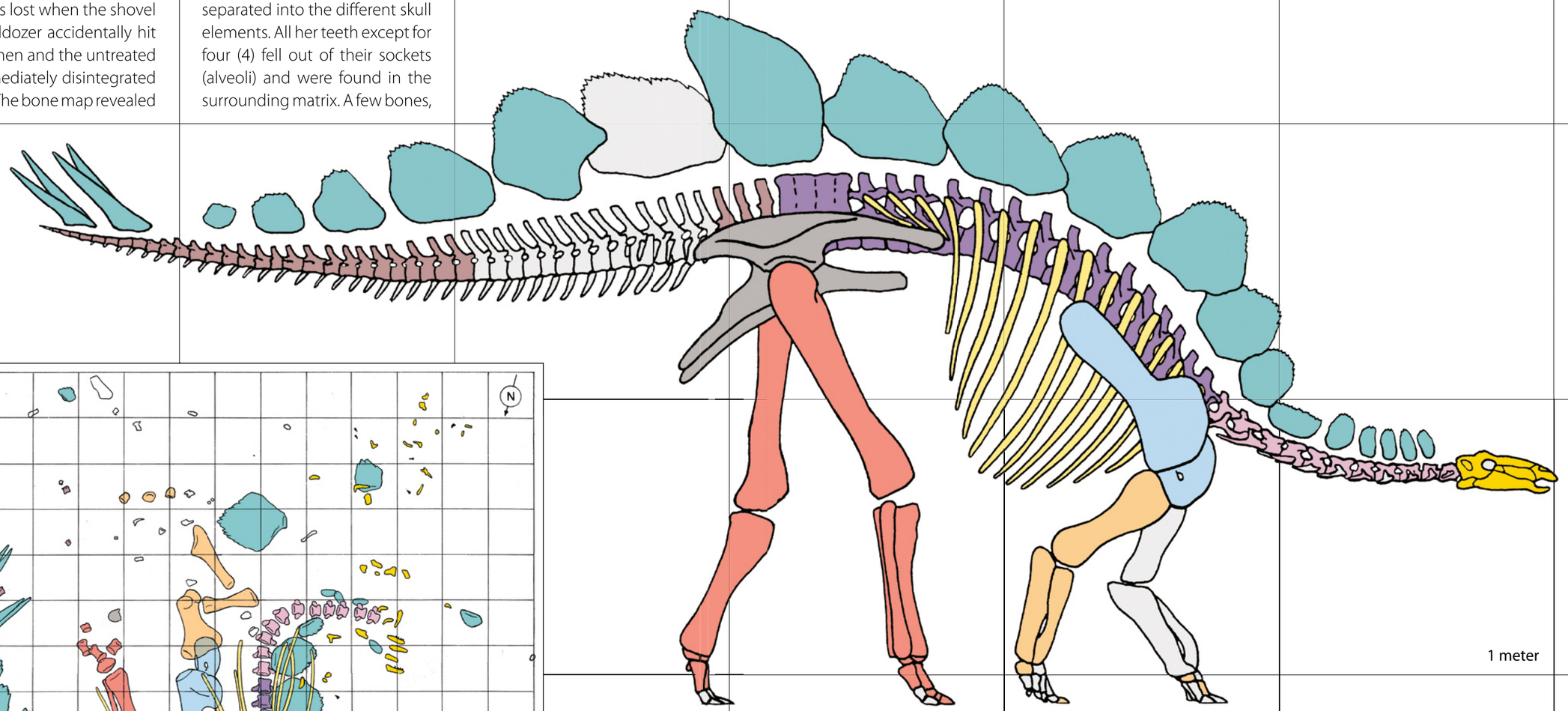
Sarah's body came to rest on its back. As her carcass rotted, Sara's arms and legs fell on either side of the rib cage.
A few toe bones were washed away. The skull separated into its parts. Sediments then rapidly buried the skeleton and preserved it until today.

Stegosaur «Sarah» Bone Chart

Revised idealized bone chart, Jan. 2008 / © Sauriermuseum Aathal

Taphonomy Sarah's skeleton was found virtually complete. Only the left arm and the upper part of the tail were missing. While the left arm was probably lost due to erosion, the upper part of the tail was lost when the shovel of the bulldozer accidentally hit the specimen and the untreated bone immediately disintegrated into dust. The bone map revealed that the dead animal had come to rest on its back. When the body was decaying, the rib cage must have opened up and the arms and legs fell on either side of the vertebral column. The skull separated into the different skull elements. All her teeth except for four (4) fell out of their sockets (alveoli) and were found in the surrounding matrix. A few bones, for instance, small toe bones and smaller plates, drifted slightly to the south. Miraculously, 18 plates were preserved. This is the largest amount of plates found with any North American stegosaur so far. There is a chance that one plate got lost when the bulldozer hit the specimen. So the total series could have been composed of 19 plates. Susannah Maidment suggested that an even number would be more likely, which means 20 plates as a total for Sarah. There is – of course – no definitive proof for the existence of an 19th or 20th plate, however.





1 meter

- Plates and spikes
- Pelvis
- Caudals
- Dorsals
- Cervicals
- Skull
- Scapula and coracoids
- Hind legs
- Ribs
- Fore legs
- Missing bones

Stegosaur «Sarah» Bone Inventory

Preparation Simon and Siber agreed that stegosaur Sarah should be sent to the Sauriermuseum Aathal for preparation. The Siber team already had two stegosaurs from the Howe Ranch (Victoria and Lilly) to prepare. It definitely made sense that the same people should also work on Sarah. Experience gained on one specimen could be used to improve the preparation of the other two specimens. Thus it came that fate played four stegosaur finds into the hands of the Siber team (Moritz, Victoria, Lilly and Sarah), of which the three last ones were of exceptional quality, especially when compared with other stegosaur finds from North America and elsewhere in the world. Good stegosaurs are even rarer than good *Tyrannosaurus rex* finds. The task of preparing the stegosaurs was given to three principal preparators. Victoria went to Esther Premru, Lilly to Toni Fürst from Vienna, and Sarah to Yolanda Schicker-Siber, Kirby's oldest daughter. Each preparator could count on a small group of auxiliary preparators. The preparation of Sarah lasted 18 months. Slowly, but surely, one by one, the unstable and problematic bones were hardened and cleaned so they could be used for casting and molding and would later be strong enough to withstand the strain of making a free mount. Preparation was finished in January 2007. The original skeleton has not jet been mounted, but a mount can be made as soon as a permanent home has been found for Sarah.

Sarah The Stegosaurus

Sarah the Stegosaurus

	Bone Number	Bone Identification	Bone Dimensions (inches)
√	1	Tail Spike	15
√	2	Tail Spike	15
√	3	Tail Spike	15
√	4	Tail Vertebra	2
√	5	Tail Vertebra	1-3/4
√	6	Tail Vertebra	1-1/2
√	7	Tail Vertebra	1
√	8	Tail Vertebra	1-1/2
√	9	Plate	8 x 6
√	10	Plate	9 x 5
√	11	Plate	13 x 12
√	12	Plate	20 x 16
√	13	Femur	34
√	14	Tibia	
√	15	Fibula	
√	16	Ankle Bone?	
√	17	Humerus	15
√	18	Toes or Metatarsals	
√	19	Metatarsal ?	
√	20	Pubis ?	
√	21	Scapula	22" or 31"
√	22	Femur	
	23	Rib	
√	24	Rib	
√	25	Rib (measured straight)	28
√	26	Tibia/Fibula or ~~Ulna/Radius~~ with	
√	27	toes or fingers in jacket	
√	28	Scapula	22" or 31"
√	29	Rib	
√	30	Rib (measured straight)	26
√	31	Rib (measured straight)	23 ??? Plus 33?
	32	Rib	
√	33	Pubis ?	
√	34	Rib	

Sarah The Stegosaurus

	35	Rib	
√	36	Rib	
√	37	Rib	
√	38	Rib	
	39	Rib	
	40	Sacrum	
√	41	Dorsal Vertebra	
√	42	Dorsal Vertebra	
√	43	Dorsal Vertebra	
√	44	Dorsal Vertebra	
√	45	Dorsal Vertebra	
√	46	Dorsal Vertebra	
√	47	Dorsal Vertebra	
√	48	Dorsal Vertebra	
√	49	Dorsal Vertebra	
√	50	Dorsal Vertebra	
√	51	Dorsal Vertebra	
√	52	Dorsal Vertebra	
√	53	Dorsal Vertebra	
√	54	Dorsal Vertebra	
√	55	Dorsal Vertebra	
√	56	Dorsal Vertebra	
√	57	Dorsal Vertebra	
√	58	Dorsal Vertebra	
√	59	Dorsal Vertebra	
√	60	Dorsal Vertebra	
√	61	Dorsal Vertebra	
√	62	Rib	
√	63	Rib	
√	64	Rib	
	65	Rib?	
√	66	Rib	
√	67	Rib	
√	68	Plate	
√	69	Plate	
√	70	Plate	
√	71	Plate ???→ sieht aber aus wie Radius !	
	72	Tail Vertebra	
√	73	Small Vertebra	

Here are the original positions of three of Sarah's tail plates as they were found in the quarry. These plates seem to be arranged with their bases in one straight line, while alternatively tilting to the right or to the left.

After 18 months of prep work, Sarah's bones are assembled at the Sauriermuseum exhibition hall for the first time.

Sarah The Stegosaurus

√	74	Tail Vertebra	
√	75	Ornithopod Claw	
√	76		
√	77		
√	78	Unknown Bone	
√	79	Unknown Bone	
√	80	Unknown small bone in bad condition	
	81	Toe Bone (phalange)	
	82	Unknown (arm or leg)?	
√	83	Ulna	
√	84	Cervical Vertebra	
√	85	Cervical Vertebra	
√	86	Cervical Vertebra	
√	87	Cervical Vertebra	
√	88	Cervical Vertebra	
√	89	Cervical Vertebra	
√	90	Cervical Plate	
√	91	Skull part?	
√	92	Cervical Plate	
√	93	Skull bone (in 2 parts).	12 cm
√	94	Upper Cervical Rib	
√	95 2×	Skull Bone	
√	96 2×	Skull Bone	
√	97	Skull Bone	
√	98	Claw?	
√	99	Skull Bone?	
	100	Skull Parts	
	101	Plate Fragment?	
√	102	Distal Tail Vertebra	
√	103	Rib	
√	104	Rib	
	105	Rib	
	106	Toe Bone (phalange)	7 cm or 3"
	107	Distal Tail Vertebra	7 cm or 3"
√	108	Flat Round Bone	
√	109	Small Vertebra	6 x 6 cm or 2-1/2"
√	110	Skull Bone	
√	111	Skull Bone	
√	112	Skull Bone	

Sarah The Stegosaurus

√	113	Skull Bone	
√	114	Skull Bone	
√	115	Skull Bone	
√	116	Skull Bone	
√	117	Skull Bone ?	
√	118	Big Plate	
√	119	Small Vertebra or Rib?	
	120	Cervical Rib	
	121	Small Tail Vertebra	3/4" x 1/2"
√	122	Toe Bone (phalange)	
√	123	Tail Plate	
	124	Small Plate ?	
√	125 2×	Small Skull Part ?	
√	126	Small Skull Part ?	
√	127	Possible Skull Part	
√	128	Rib or Skull Piece	
√	129	Flat Skull Piece ?	
√	130	Small unknown bone (dermal palte?)	
√	131	Small Unknown bone	
√	132	Small Bone Splinter	
√	133	Unknown Small Bone	
√	134	Small Skull Part ?	
√	135	Skull Bone ?	
	136	Toe Bone (phalange)	
√	137	Possible Dermal Plate	
√	138	Unknown Bone	
√	139	Tooth	
√	140	Tooth	
√	141	Unknown Small Thin Bone	
	142		
	143		
√	144	Unknown Flat rectangular Bone	
√	145	2 Ossicles (dermal)	
√	146	Hoof / Ungual	
√	147	Distal Tail Vertebra	
√	148	Plate	
√	149	Small Bone	
	150	Small Bone (plate)	
	151	Unknown Bone	

Sarah The Stegosaurus

√	152	Stegosaurus tooth	
√	153	Stegosaurus tooth	
√	154	Cervical Rib	
√	155 2×	Caudal Vertebrae in jacket (in VA)	
√	156	Caudal Vertebrae in jacket (in VA)	
√	157	Caudal Vertebrae in jacket (in VA)	
√	158	Caudal Vertebrae in jacket (in VA)	
√	159 2×	Caudal Vertebrae in jacket (in VA)	
√	160	Caudal Vertebrae in jacket (in VA)	
√	161	Caudal Vertebrae in jacket (in VA)	
√	162	Caudal Vertebrae in jacket (in VA)	
√	163	Caudal Vertebrae in jacket (in VA)	
√	164	Caudal Vertebrae in jacket (in VA)	
√	165	Caudal Vertebrae in jacket (in VA)	
√	166	Caudal Vertebrae in jacket (in VA)	
√	167	Caudal Vertebrae in jacket (in VA)	
√	168	Small Bone ?	60 mm x 45 mm
√	169	Cervical Rib	70 mm x 50 mm
√	170	Small Bones (Dryosaurus Plates?)	
√	171	Tail Spike	
	172	Rib	
	173	Plate	
	174	Plate	
	175	Rib	
	176	Rib	

A puzzle of a special kind: Sarah's skull bones and teeth with some other small bones mixed in that are not related to Sarah's skeleton.

Stegosaur «Sarah» Plates and Spikes

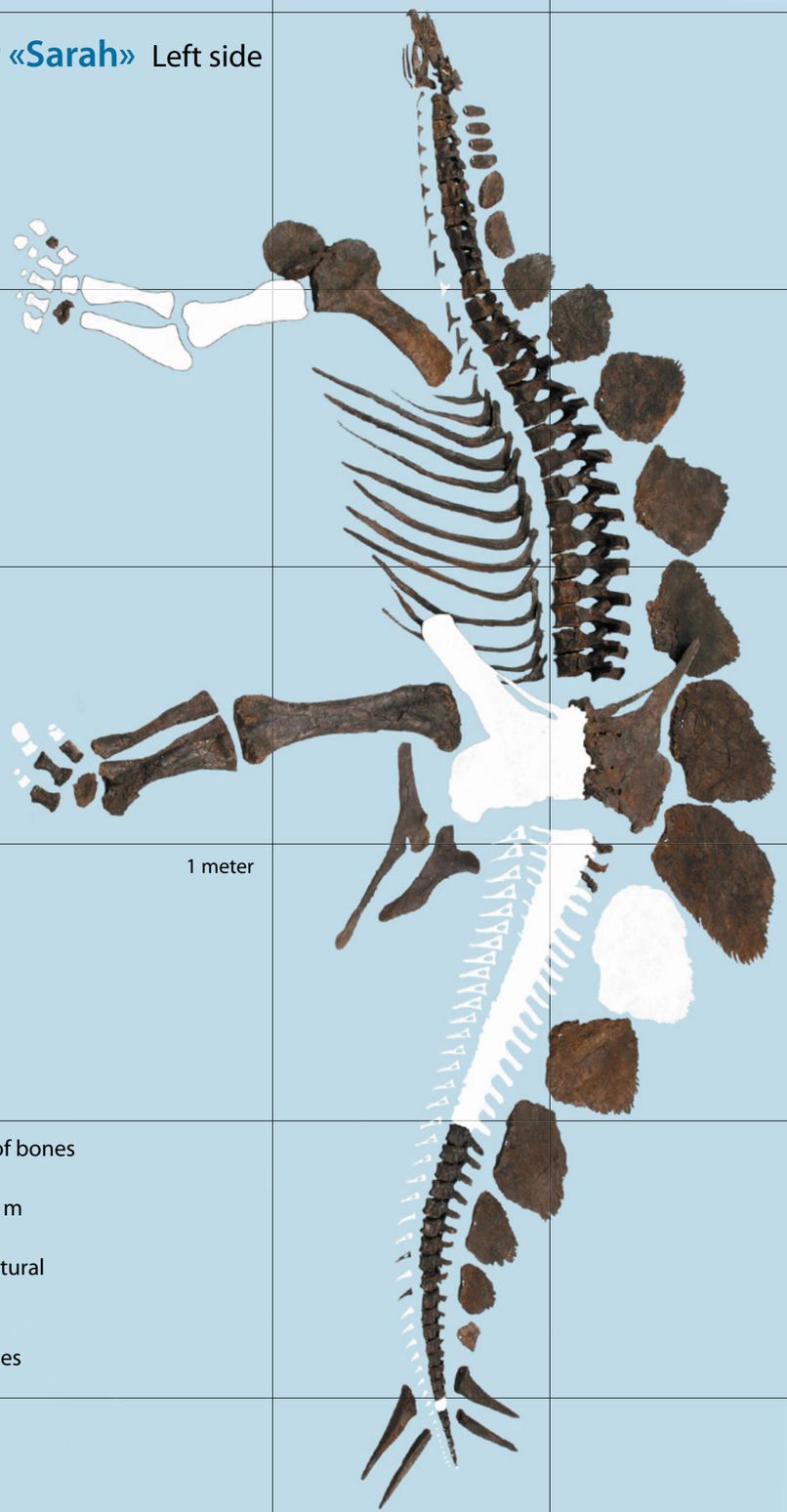
The left and the right sides of the osteoderms of stegosaur Sarah. There is a total of 18 plates and 4 spikes.
The plates are arranged in sequence from neck to tail.

Left side

Note:
There seems to be two plates missing, one just after the largest one and one at the end of the tail.
Also: plate number 13, the largest, should be rotated and oriented horizontally, rather than vertically.

Right side

Stegosaur «Sarah» Left side



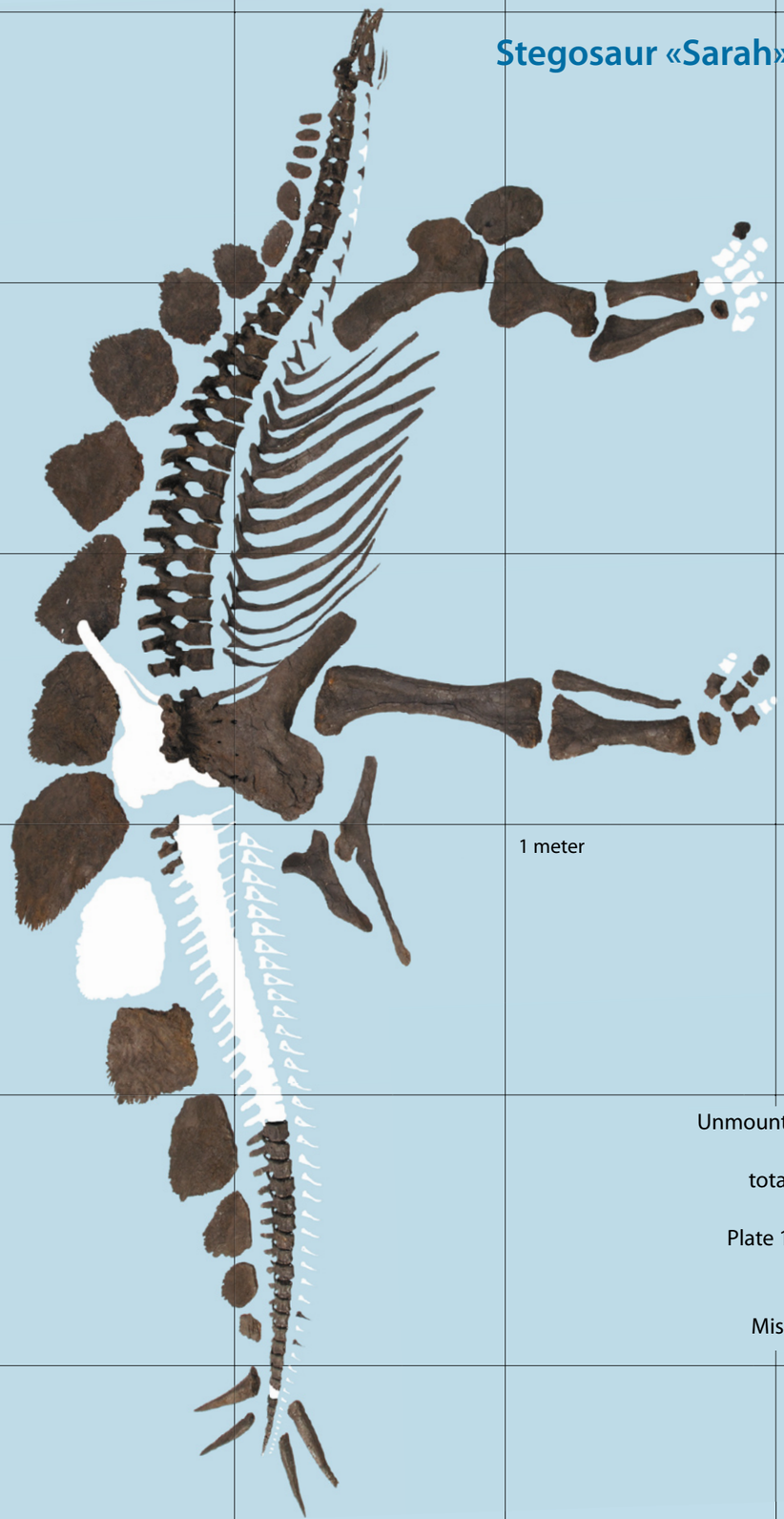
1 meter

Unmounted set of bones
(left side),
total length: 5.60 m

Plate 14 is conjectural

Missing bones

Stegosaur «Sarah» Right side



1 meter

Unmounted set of bones
(right side),
total length: 5.60 m

Plate 14 is conjectural

Missing bones

Stegosaur «Sarah» Skull

10 centimeters

Sarah's skull bones are left here unassembled. This set includes 19 skull elements and 46 teeth, 42 of these are loose teeth and 4 are still embedded in the mandibles.

Stegosaur «Sarah»

Tail spikes The tail spikes have been found – as expected – in groups of two pairs. The very last pair have an almost round diameter at their base, while the first pair in front position shows a more elliptical basel cross-section.

Species identification Stegosaur Sarah differs from the other three stegosaurs found at the Howe Ranch. Its neural arches are extended longer along the dorsal vertebrae. This feature is a characteristic of *Stegosaurus armatus*. The pear-shaped neck plates also seem to point to a *Stegosaurus armatus* affinity for Sarah. Sarah has therefore been temporarily assigned to this genus and species, at least until more is known on how to distinguish the different stegosaurs from the Shell Valley area and the Big Horn Mountains of northcentral Wyoming.

Special features As with the Howe Ranch stegosaurs, no indication of an armored throat has been found.

Mount of cast In February 2007, Sarah's prepared bones were shipped to the Black Hills Institute of Geological Research in Hill City, South Dakota, for casting and molding. A first mounted cast was delivered to the Sauriermuseum in the spring of 2008, just in time for the opening of the new stegosaur exhibit called "Punk im Dinoland" in April. This is – as far as we know – the first mount of a stegosaur skeleton from parts that are from one individual and not a composite from several individuals. It reveals much about the true look of stegosaurs: First and foremost, there is a tremendously wide body at the height of the hips, combined with a relatively short body measured between the arms and legs. This gives the animal a wedge-shaped look. The neck is slightly longer than expected. Very striking is the sequence of plates on the back of the animal. There is a certain "flow" in the series. Each plate seems to have its characteristic shape with respect to the position it occupies within the sequence of plates from head to tail. Once this becomes obvious noted, it is easy to spot erroneous mounts, located in various museum collections around the world, whose plate series are made up of randomly selected plates of unmatched sets.

Emanuel Tschopp and Dr. Thomas Frauenfelder from the Institute of Diagnostic Radiology are examining Sarah's skull in a CT-scan at Zurich's University Hospital.

The cast of stegosaur Sarah as mounted by the Black Hills Institute of Geological Research.

Stegosaur «Moritz»

Sauriermuseum Support Society (VFSMA) specimen

Species identification:	cf. *Hesperosaurus mjosi*
Field name:	«Moritz»
Size:	Length 4.80 m, height 2.90 m
Age of the individual:	Young adult
Geological Formation:	Morrison Formation, Upper Jurassic, 150 million years ago
Locality:	Howe-Scott Quarry, Howe Ranch near Shell, Big Horn County, Wyoming, USA
Excavation team:	The Siber team 1995, consisting of H. J. Kirby Siber, Esther Premru, Markus Hebeisen, Martin Riedi, Illona Kühner, Maya Bosshard, Willi Weber, Esther Wolfensberger, Maya Siber, Sheila Tomlinson and Betty Shem.
Taphomony:	Completely disarticulated skeleton with not much scattering of the bones, clearly pertaining to one individual.
Bone preservation:	Near-surface find, missing bones lost by erosion. Bones slightly crushed and deformed, some iron concretions penetrating bone surface.
Preparators:	Ben Pabst, Esther Premru and Barbara Kuhn. The original skull bones were preparated by Christina Egli and mounted by Aart Walen.
Bone count:	The find consists of 74 bones representing different parts of the skeleton, including 19 skull bones, arms and legs, 7 dermal plates and one spike fragment.
Mount:	Made by Ben Pabst using steel support for a quadrupedal free mount. Missing parts were added from casts of Western Paleo find near Como Bluff.
Special features:	Moritz is the first stegosaur find reported from the Howe Ranch and from the Shell Valley area of the Big Horn County.
First exhibited:	Sauriermuseum Aathal in1997. Moritz has since traveled to many exhibitions around the world and has been seen by 2.5 million people.
Sponsors:	Moritz was excavated with the financial support of Siber + Siber Ltd. The find was later purchased by the Sauriermuseum Suport Society (VFSMA) who paid for the preparation.

Stegosaur «Victoria»

Sauriermuseum Aathal specimen

Species identification:	*Stegosaurus* sp.
Field name:	«Victoria»
Size:	Length 6.50 m, height 3.50 m
Age of the individual:	Very old adult
Geological Formation:	Morrison Formation, Upper Jurassic, 150 million years ago
Locality:	Howe-Stephens Quarry, Howe Ranch near Shell, Big Horn County, Wyoming, USA
Discovery date:	September 1995
Excavation team:	The Siber team of 1996 consisting of H. J. Kirby Siber, Ben Pabst, Barbara von Arb, Jannis Michelis, Chris Keilmann and Ueli Wüthrich. In 1997: H. J. Kirby Siber, Ben Pabst, Jannis Michelis, Esther Wolfensberger, Maya Siber, Chris Keilmann, Jacques Ayer and Bernard Claude.
Taphonomy:	Essentially complete, but skeleton is partially disarticulated. Missing parts: some ribs, caudal vertebrae, foot bones, some plates.
Bone preservation:	Bones slightly crushed, often not permineralized. Some cracks filled with gypsum, some limonite concretion formation particularly covering the ends of the bones.
Preparators:	Principal preparator: Esther Premru
Bone count:	The find consists of 210 to 214 bones, representing all parts of the skeleton including an excellent skull.
Mount:	Free mount with detachable bones made by Ben Pabst.
Special features:	Victoria shows several pathologies, i. e. diseased tail vertebrae, diseased spines on sacrum, broken and rehealed ribs, deteriorated plates. Some skin patches preserved!
First exhibited:	Sauriermuseum Aathal in April 2008.
Sponsors:	Work on Victoria was financed by Siber Collections Ltd.

Stegosaur «Lilly»

Sauriermuseum Aathal specimen

Species identification:	cf. *Hesperosaurus mjosi*
Field name:	«Lilly» (after twin paleontologists Nicola and Rabea Lillich)
Size:	Length 4.50 m, height 2.90 m
Age of the individual:	Young adult
Geological Formation:	Morrison Formation, Upper Jurassic, 150 million years ago
Locality:	Howe-Scott Quarry, Howe Ranch near Shell, Big Horn County, Wyoming, USA.
Discoverer:	Nicola and Rabea Lillich as part of the Siber team in 2002.
Excavation team:	The Siber team of 2002, consisting of H. J. Kirby Siber, Chris Keilmann, Barbara von Arb, Oliver Bichsel, Nicola and Rabea Lillich, Richard Butler, Richie Meyer, James Laatsch and Meagen Verdeyen. In 2003: H. J. Kirby Siber, Yolanda Siber, Maya Siber, Rabea and Nicola Lillich, Toni Fürst, Jean-Claude Delaloye, Katrin Zimmermann, Tomi Schicker, Melanie Martel, Heinrich Malllison, Dimitri Brosens and Emanuel Tschopp.
Taphomony:	Nearly complete, slightly disarticulated individual, some bones missing.
Bone preservation:	Bones often slightly crushed, some with iron concretions on bone ends, bone marrow often not filled with sediment.
Preparators:	Toni Fürst, with Esther Premru, Yolanda Schicker-Siber, and Christina Egli.
Bone count:	242 to 245 identified bones. Missing bones are mostly from the hands and feet. Some bone still buried in matrix.
Mount:	Death pose mount. Some bones "in situ" in original matrix, most bones detachable. Mount made by Toni Fürst and matrix made by Reto Melchior.
Special features:	Right arrm and hand fully articulated with all manus elements in position.
First exhibited:	Sauriermuseum Aathal in April 2008.
Sponsors:	Lilly was excavated with funds from the Siber Collections Ltd. Preparation was partially funded by the Board of the Swiss Federal Institute of Technology (ETH).

Stegosaur «Sarah»

Dinosaur Safari Inc. specimen

Species identification:	cf. *Stegosaurus armatus*
Field name:	«Sarah» (after rancher daughter Sarah)
Size:	Length 5.60 m, height 2.90 m
Age of the individual:	Young adult
Geological Formation:	Morrison Formation, Upper Jurassic, 150 million years ago
Locality:	Red Canyon Ranch, near Shell, Big Horn County, Wyoming, USA.
Discoverer:	Bob Simon of Dinosaur Safari Inc. 2003
Excavation team:	Bob Simon and the Siber team of 2004, including H. J. Kirby Siber, Maya Siber, Chris Keilmann, Esther Wolfensberger, Thomas Böttcher, Dimitri Brosens, Jeroen Venderickx, Beat von Arx, Ruedi and Priska Abbühl.
Taphonomy:	Nearly completely articulated skeleton in dorsal position, upper portion of the tail missing and left arm.
Bone preservation:	Slightly crushed bone, often heavily deteriorated and powdery due to near-surface position. Needed extensive use of hardening agents before removal from matrix.
Preparators:	Toni Fürst, Yolanda Schicker-Siber, Esther Premru, Jean-Claude Delaloye, Manuel Speck and Christina Egli.
Bone count:	Disarticulated but nearly complete skull with loose teeth. Nearly fully articulated post-cranial skeleton with vertebrae column missing upper part of tail, left part of ilium missing, as well as some metapodia. 18 dermal plates and 4 spikes present. Total of 187 bones.
Mount of cast:	Black Hills Institute of Geological Research Inc. staff.
Special features:	Sarah is the stegosaur with the most complete set of dermal plates.
First exhibited:	Sauriermuseum in April 2008.
Sponsors:	Sarah was excavated and prepared witih funds from the Siber Collection Ltd.

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The Stegosaurs of the Sauriermuseum Aathal

by Hans Jakob Siber and Urs Möckli

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Artwork by Mike Kopriva, 2006

"The Morrison Formation, as a window to the Late Jurassic world, is (therefore) a look back to time in the history of today's fauna. It is a snapshot of where we came from, one of the few that is available out of many, many times and places that have changed through vertebrate history. It is a part of our story in a direct sense, and because of that, we can feel a certain connection to the Morrison fauna. We're part of it too".

Quotation from John Foster, Jurassic West, 2007

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