April 25, 2022

New and views

Before going on to a discussion of terrestrial animals in the Triassic Period, let's look at some news items that I thought were interesting.

Geopolitics

I wish that it weren't so, but the Ukraine War continues. Remembering that all wars involve deception, here are a few sites to observe changes in the war:

- Daily updates at the Institute for the Study of War.
- Live Map; regular updates to the changes in the on ground situation.
- Oryx: Assessments of battlefield losses.

Research

- Phys.org: Earliest geochemical evidence of plate tectonics found in 3.8-billion-year-old crystal; research article here, includes a plain language summary.
- From the Woods Hole Oceanographic Institution: Deepest sediment core collected in the Atlantic Ocean.
- When did plate tectonics start? Archean eclogite-facies oceanic crust indicates modern-style plate tectonics; Phys.org report here.
- Erosion and plate tectonics: Middle-lower continental crust exhumed at the distal edges of volcanic passive margins.
- Deep lake cores of ancient Lake Cahuilla could help define Southern San Andreas history; from the American Association for the Advancement of Science (AAAS).
- For those keeping score: Geology's Most-Cited Papers, from Geology, the journal of the Geological Society of America.
- From the Mineralogical Association of Canada, new crystal structure research: Malhmoodite Fe_2+Zr(PO_4)2·4H^2O, Tengchongite CaO·6UO_2·2MO_3·12H_2O, and Shkatulkalite, $Na_2Nb_2Na_3Ti(Si_2O_7)_2O_2(FO)(H_2O)_4(H_2O)_3$.

Paleontology Research

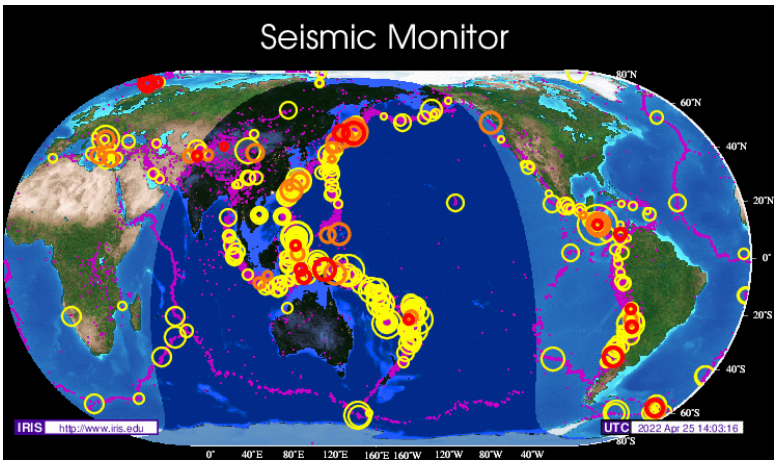
- Linyi Lagerstätte: A new window on Cambrian fauna evolution, a lagerstätte is a deposit of exceptionally well preserved fossils.
- From another lagerstätte: A new marrellomorph arthropod from southern Ontario: a rare case of soft-tissue preservation on a Late Ordovician open marine shelf.
- Soft tissue preservation: Mineralized belemnoid cephalic cartilage from the late Triassic Polzberg Konservat-Lagerstätte (Austria).

- From the University of Kansas: Glowing Spider Fossils Prompt Breakthrough Study of How They Were Preserved at Aix-En-Provence.

Climate Change Research

- Surface warming–induced global acceleration of upper ocean currents; climate modeling.
- Weather isn't climate, but it is often conflated: Researchers predict active hurricane season; from North Carolina State University.
- Historical climate change: Vegetation change across the Drake Passage region linked to late Eocene cooling and glacial disturbance after the Eocene–Oligocene transition.
- More on historical climate change: Human forager response to abrupt climate change at 8.2 ka on the Atlantic coast of Europe.
- Climate change and evolution: Plio-Pleistocene environmental variability in Africa and its implications for mammalian evolution.

Volcanoes, Earthquakes and Geohazards



Link

- Scientists find evidence of largest earthquake in human history 3,800 years ago; 3,800 years ago in Northern Chile.
- It really was an earth-shattering kaboom: Seismic Algorithm Reveals Tonga Islands Eruption Was the Largest Explosive Eruption of the 21st Century; research paper here, with plain language summary.
- Volcanoes at fault if the Earth slips: An Ancient >200 m Cumulative Normal Faulting Displacement Along the Futagawa Fault Dextrally Ruptured During the 2016 Kumamoto, Japan, Earthquake Identified by a Multiborehole Drilling Program, includes plain language summary. Phys.org report here.
- New method for detecting pre-eruption warning signals at Whakaari White Island and other active volcanoes.

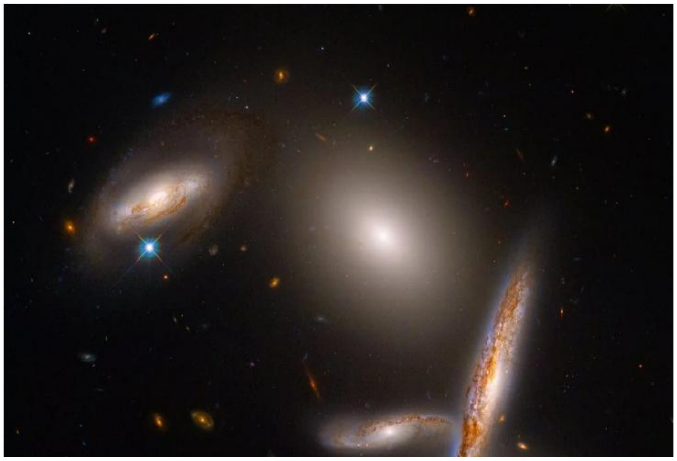
- Studying Volcanoes through Myths, Legends, & Other Unconventional Data.
- Ground Deformation Near Mount Edgecumbe Volcano, Alaska; related: earthquake activity at Mount Edgecumbe.
- Worldwide Volcano News and Updates.
- How geology put a South African city at risk of landslides.
- Scientists scour 'Mexico's Galapagos' for quake, volcano clues.

Mining and Energy

- I wonder how that happened? Fire Breaks Out At Russian Oil Depot Close To Ukrainian Border.
- "Clean coal": Four miners dead, six trapped after tremor in Polish coal mine.
- Why the price of gold is heading for a 'modest new all-time high': Morning Brief.
- From the United States Energy Information Administration (USEIA): Nearly all new U.S. crude oil and natural gas wells are horizontal or directional.
- Ancient mining to make stone tools: Mechanical properties of lithic raw materials from Kazakhstan: Comparing chert, shale, and porphyry.

From Out of This World

- Hubble Space Telescope's 35th Anniversary Photo Features Dramatic Galaxy Cluster.



The Hickson Compact Group NASA, ESA, STScI, Alyssa Pagan

- Exploring planet geology through force-feedback telemanipulation from orbit.
- Discussion on Widespread glasses generated by cometary fireballs during the late Pleistocene in the Atacama Desert, Chile: original article, comment and reply.

April 25, 2022

Terrestrial Animals of the Triassic

Figure 1 - Triassic Animals
Credit: Masato Hattori, United States Geological Survey, public domain

After the destruction of the End Permian Mass Extinction, the surviving terrestrial life during the Triassic Period flourished and diversified. Among vertebrates, the fossil record shows amphibians, reptiles and the earliest mammals. PBS Eons calls the Triassic Period as "Just the Weirdest"

The dominant land vertebrates during the Triassic were archosaur reptiles which largely replaced the therapsids that were dominant during the Permian Period. The archosaurs included:

- Pseudosuchians, ancestors of modern crocodilians were the most common reptile during the Triassic;
- Avemetatarsalia, which includes the first dinosaurs that first appeared during the Triassic and really flourished during the Jurassic and Cretaceous Periods; and
- Pterosaurs that also first appeared during the Triassic and also took off in the following periods of the Mesozoic.

Other reptiles that from the Triassic included :

- The earliest turtles, such as *Proganochelys* and *Proterochersis*, which appeared during the Late Triassic Period,
- Lizard-like allokotosaurs, and
- Lepidosauromorpha, which includes the ancestors of lizards, snakes and the tuatara.

Other survivors of the End Permian Mass Extinction included the cynodonts, ancestors of mammals, and amphibians. Triassic cynodonts included the predator *Cynognathus*. Amphibians

in the Triassic included the Temnospondyli and the first Lissamphibia, the ancestors of all modern amphibians including frogs, salamanders and caecilians.

Terrestrial invertebrates, especially insects, also flourished and diversified during the Triassic. One report on insect fossils from China describes an "an explosion in bug diversity 237 million years ago", so the Triassic, especially the Middle and Late Triassic, was important for the evolution of insects.

Let's look at some examples of terrestrial animals from the Triassic.

Pseudosuchians - *Postosuchus*

Figure 2 - *Postosuchus*
Credit: Dallas Krentzel, Creative Commons Attribution 2.0 Generic license

A rauisuchid reptile that lived in the Late Triassic of what is now North America, fossils of *Postosuchus* were first found in 1980 in the Post Quarry near Post, Texas. (*Postosuchus* means "Crocodile from Post"). Two species of *Postosuchus* are currently identified: *P. kirkpatricki* and *P. alisonae*. The Museum of Texas Tech University, near Post, Texas, has the skeleton shown in Figure 2.

Postosuchus was a big brute, possibly one of the largest carnivorous reptiles during the late Triassic. Fossils of the reptile indicate that adult *Postosuchus* were about 1.2 m in height and 4 m in length from snout to tail tip. In weight, they were probably about 250 to 300 kg. It has a massive skull and dagger-like teeth as well as heavy scales called osteoderms on its back, neck, and possibly above or under the tail. Any of our cynodont ancestors would have given this fearsome predator a wide berth.

When first discovered in 1980, the paleontologists thought that *Postosuchus* walked on all four legs. However, a study published in 2013 indicated that the reptile may have been an obligate biped based on the anatomy of the digits, vertebrae, and pelvis.

The fossils of *Postosuchus* were found in sediments associated with a tropical environment. Herbivores that lived in the same environment included other creatures such as the Pseudosuchians *Desmatosuchus* and *Typothorax,* as well as the lizard-like allokotosaur *Trilophosaurus*.

Pseudosuchians - *Desmatosuchus*

Figure 3 - *Desmatosuchus*
Credit: Frank Kovalchek, Creative Commons Attribution 2.0 Generic license

Another pseudosuchian reptile from the Late Triassic, *Desmatosuchus* was a herbivore whose blunt, bulbous, slightly recurved teeth suggests that it fed by digging up soft vegetation. Some studies suggest that it could have been omnivorous feeding on insects like a modern armadillo

Desmatosuchus was about 4.5 meters in length and had armor and spikes to protect itself from predators, such as *Postosuchus,* with which it shared a tropical environment. The skeleton in Figure 3 was found in Petrified Forest National Park, Arizona.

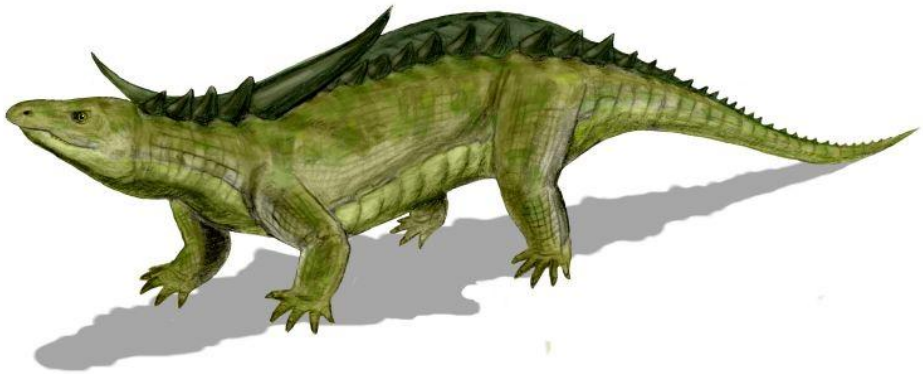


Figure 4 - Reconstruction of *Desmatosuchus*
Credit: Nobu Tamura, Creative Commons Attribution-Share Alike 3.0 Unported license

Edward Drinker Cope first found fossils of *Desmatosuchus* in the late 19th century. *Desmatosuchus* fossils are widespread in Late Triassic sediments such as those in the Dockum Formation and the Post Quarry in Texas as well as in the Chinle Formation of Nevada, Utah, northern Arizona, western New Mexico, and western Colorado. This suggests that *Desmatosuchus* was both common and widespread; and thus a successful creature for its time.

Pseudosuchians - *Typothorax*

Figure 5 - *Typothorax coccinarum* fossil
Credit: Kumiko, Creative Commons Attribution 2.0 Generic license

An aetosaur pseudosuchian, *Typothorax* lived during the Late Triassic in the same environment as *Desmatosuchus* and *Postosuchus*. It was an herbivore with small, leaf like teeth. Typothorax was about 2.5 m long and weighed 100 kg. It had an upturned snout suitable for rooting about for food.

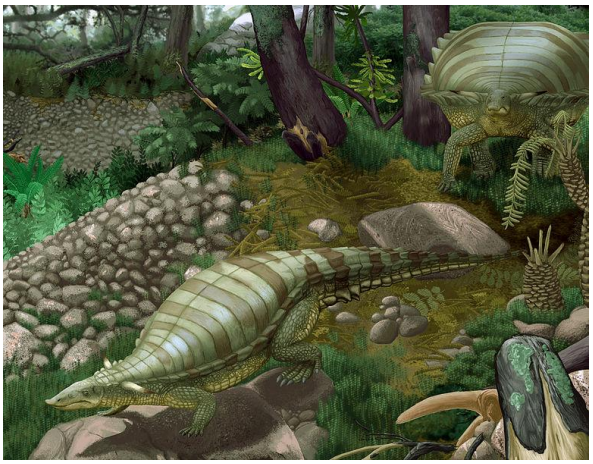


Figure 6 - *Typothorax coccinarum* reconstruction
Credit: Smokeybjb, Creative Commons Attribution-Share Alike 3.0 Unported license

Typothorax is another one of the fossils first found by Edward Drinker Cope, who described it in

1875. *Typothorax* has two known species: *T. coccinarum* and *T. antiquum*. Fossils of *Typothorax* have been found in the Chinle Formation of Arizona, and the Bull Canyon Formation of the Dockum Group in New Mexico and Texas.

Avemetatarsalia, Dinosaurs - *Plateosaurus*

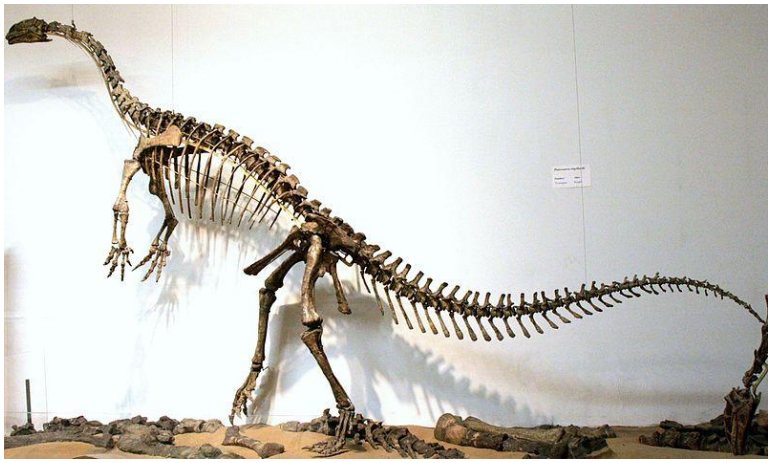


Figure 7 - *Plateosaurus* Skeleton
Credit: FunkMonk, Creative Commons Attribution-Share Alike 3.0 Unported license

One of the earliest dinosaurs, *Plateosaurus*, lived during the Late Triassic in what is now western Europe. *Plateosaurus* had a long, flexible neck and sharp with plump teeth in its skull, indicating that it was an herbivore. It was also apparently bipedal, a feature of many dinosaurs.

Figure 8 - *Plateosaurus engelhardti* reconstruction
Credit: DataBase Center for Life Science (DBCLS), Creative Commons Attribution 4.0 International license

There are three identified species of *Plateosaurus*: *P. trossingensis, P. gracilis* and *P. longiceps*. Fossils of the dinosaur have been found in the Löwenstein Formation and Trossingen Formation of Germany and Switzerland. A fossil identified as *Plateosaurus* was found in Late Triassic

sediments beneath the North Sea during oil exploration off the shore of Norway. Although originally identified as *Plateosaurus*, fossils found in the Fleming Fjord Formation of Greenland have since been assigned to a related genus, *Issi*.

Plateosaurus was first discovered in 1834 by the physician Johann Friedrich Engelhardt and described by Hermann von Meyer in 1837.

Pterosaurs - *Austriadactylus*

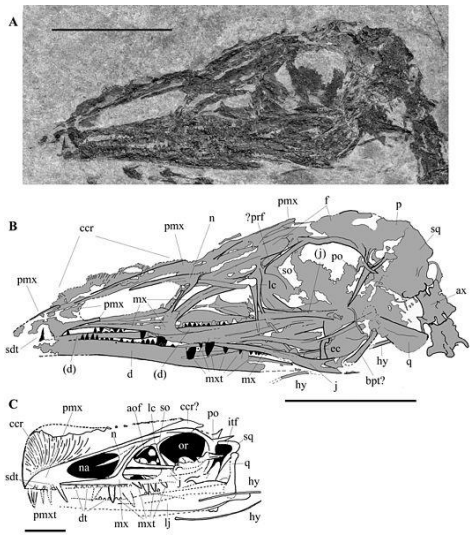


Figure 9 - *Austriadactylus cristatus* skull and lower jaw
Credit: F.M. Dalla Vecchia, Creative Commons Attribution-Share Alike 3.0 Unported license

One of the earliest pterosaurs, *Austriadactylus* ("Austrian finger") was first found in 2002 by Fabio Marco Dalla Vecchia in Late Triassic rocks from the Seefelder Schichten of Tyrol Austria. In 2009, Dalla Vecchia reported a specimen from Italy in the Dolomia di Forni Formation. So far, there is only one species in the genus: *A. cristatus*.

Figure 10 - 3D Model of Austriadactylus cristatus
Credit: Петр Меньшиков, Creative Commons Attribution 4.0 International license

With an estimated wingspan of 1.2 m, *Austriadactylus* had teeth designed to catch prey, such as small fish terrestrial lizards and amphibians.

Turtles - *Proganochelys*

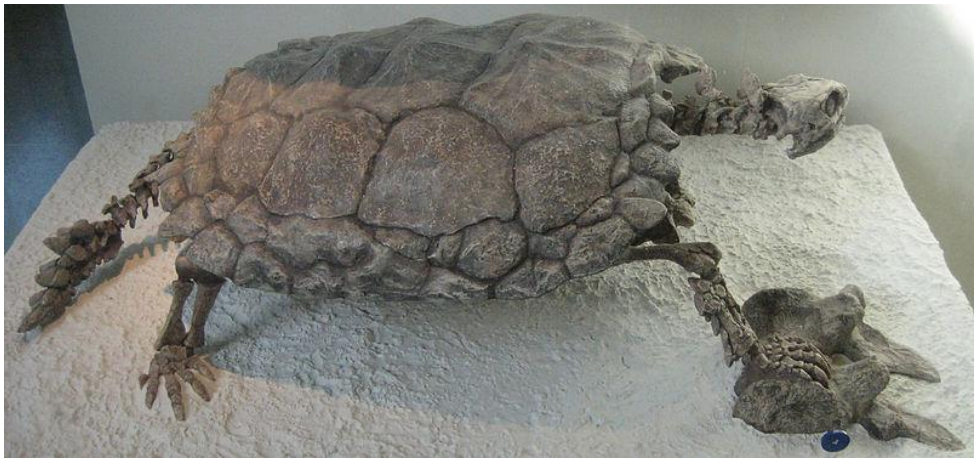


Figure 11 - *Proganochelys quenstedti*
Credit: Claire Houck, Creative Commons Attribution 2.0 Generic license

Proganochelys is one of the oldest turtles found in the fossil record and lived during the Late Triassic. With a shell about one metre in diameter, the fossils suggest that it was a herbivore. Like many modern turtles, *Proganochelys* appears to have lived in small water bodies and the locations of the fossils suggest that it was common throughout Laurasia during the Late Triassic.

Figure 12 - Model of *Proganochelys*
Credit: Ghedoghedo, Creative Commons Attribution 4.0 International licence

Only two species of *Proganochelys* has been identified: *P. quenstedti* and *P. ruchae*. *Proganochelys* was named by Georg Baur in 1887. Fossils of *Proganochelys* were first found in shales, sandstones and limestones near the towns of Halberstadt, Tübingen, and Trossingen,

Germany. Since then, fossils of *Proganochelys* have been found in China, Thailand and Greenland.

Fossils of *Proganochelys* are often found in association with another ancient Triassic turtle *Proterochersis*.

Allokotosaurs - *Trilophosaurus*

Figure 13 - *Trilophosaurus buettneri* skeleton
Credit: Claire Houck, Creative Commons Attribution 2.0 Generic license

A lizard-like allokotosaur, fossils of *Trilophosaurus* ("lizard with three ridges") have been found in the Late Triassic of North America. It had a short, heavily built skull with large, flat teeth having sharp shearing surfaces in the cheeks. It may also have been equipped with a horny beak since there are no teeth at the front of the lower jaw. This set up indicates that was built to eat tough plant material.

Figure 14 - *Trilophosaurus* reconstruction
Credit: ArthurWeasley, Creative Commons Attribution-Share Alike 3.0 Unported license

The fossils of *Trilophosaurus* indicate that in life it was about 2.5 m long. There are currently four recognised in the genus: *T. buettneri, T. dornorum, T. jacobsi*, and *T. phasmalophos.* E. C. Case first described *Trilophosaurus* in 1928.

Fossils of *Trilophosaurus* have been found in the Chinle Formation of Arizona, Bluewater Creek Formation of New Mexico as well as the Colorado City Formation, Cooper Canyon Formation, Tecovas Formation, and Trujillo Formation of Texas.

Lepidosauromorpha - *Taytalura*

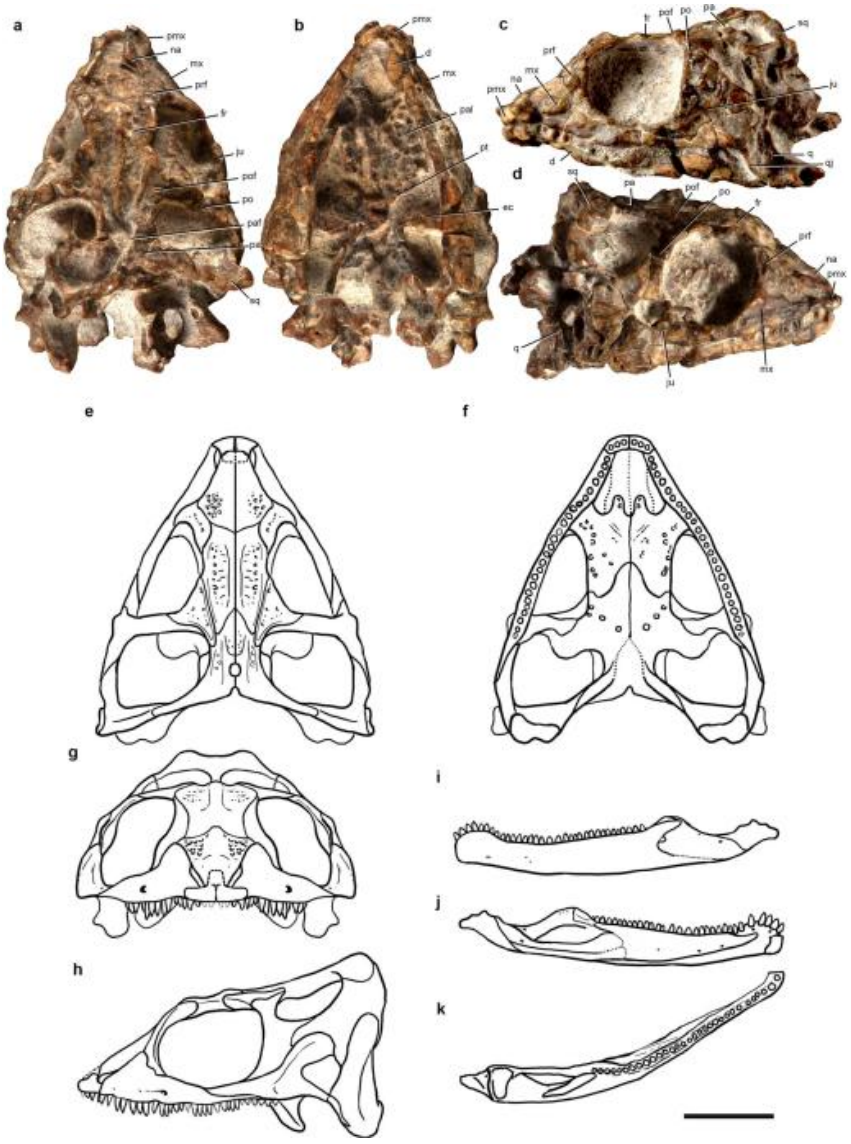


Figure 15 - *Taytalura alcoberi* skull
Credit: Richard Martinez, Martinez et al 2021

First described by Richard Martinez in 2021, *Taytalura* was a small lepidosaur related to the ancestors of modern lizards, snake and tuataras. The genus has one species, *Taytalura alcoberi*,

that was found in the Ischigualasto Formation of Argentina. *Taytalura* is considered the earliest example of a lepidosaur in the fossil record, so far.

Figure 16 - Illustration of *Taytalura alcoberi*
Credit: Jorge Blanco, CC BY Licence

Cynodonts - *Cynognathus*

Figure 17 - *Cynognathus crateronotus*
Credit: Daderot, public domain

Cynodonts were therapsids that can be considered the transition between reptiles or mammals. *Cynognathus* was a 1.2 m long predatory cynodont that lived in the Middle Triassic.

There is only one identified one species of *Cynognathus* - *C. crateronotus*. The first fossil of *Cynognathus* was a skull found in the Karoo region of southern Africa by the British paleontologist Harry Govier Seeley in 1889. Seeley found the fossil at a location where Alfred Brown had earlier had discovered a tooth.

Geologists have also found fossils of *Cynognathus* in the *Cynognathus* Assemblage Zone of the Beaufort Group, Karoo Supergroup, found in South Africa and Lesotho; the Fremouw Formation

of Antarctica, and the Puesto Viejo Group of Argentina.

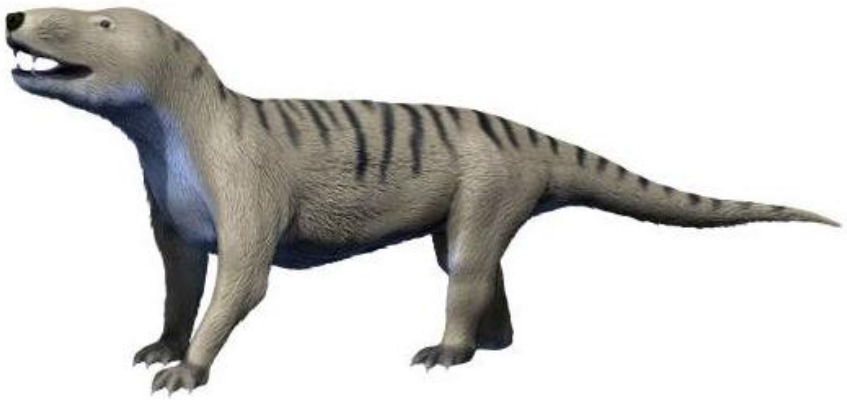


Figure 18 - Reconstruction of *Cynognathus*
Credit: Nobu Tamura, Creative Commons Attribution 4.0 International licence

Temnospondyli Amphibians - *Mastodonsaurus*

Figure 19 - *Mastodonsaurus giganteus*
Credit: Ghedoghedo, Creative Commons Attribution-Share Alike 3.0 Unported license

Although its name means "breast tooth lizard" *Mastodonsaurus* was actually a temnospondyl amphibian. Fossils of *Mastodonsaurus* were first described in fossils found in Middle Triassic formations of Germany by George Jaeger in 1828.

Full grown *Mastodonsaurus* were five to six m in length and probably weighed around 2000 kg; this is comparable in size to modern salt water crocodiles. *Mastodonsaurus* had a huge head with conical shaped teeth; i.e. the teeth of a carnivore, and it seems to have been a denizen of swamps and wetlands. It wasn't safe to go swimming the Middle Triassic with *Mastodonsaurus* around, especially if you were a fish that was probably its favourite prey.

Figure 20 - *Mastodonsaurus* reconstruction
Credit: ДиБгд at Russian Wikipedia, public domain

There are four recognised species of *Mastodonsaurus: M. jaegeri, M. cappelensis, M. giganteus* and *M. torvus*. Locations where it can be found include the Kupferzell bonebed in Baden-Württemberg, Germany.

Insects - *Gigatitan*

Gigatitan was a big mantis-like titanopteran insect that lived during the Early Triassic Period. Fossils of *Gigatitan* were found in the Madygen Formation in Kyrgyzstan.

Aleksandr Grigorevich Sharov originally described *Gigatitan* in 1968. Sharov also described all four recognised species of *Gigatitan*: *G. vulgaris, G. extensus, G. magnificus,* and *G. vulgaris*.

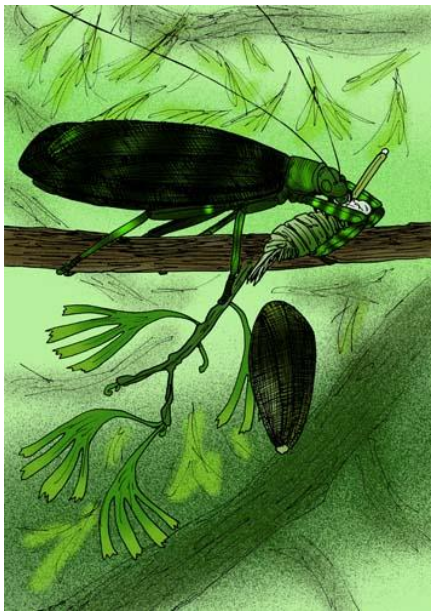


Figure 21 - *Gigatitan* reconstruction
Credit: Apokryltaros, Creative Commons Attribution 4.0 International licence

An interesting thing that I found when looking for sites on *Gigatitan* is that some of these prehistoric creatures are used in role playing games. The entry on *Gigatitan* at Additional Creatures Wiki has some interesting entries; apparently, if you are caught by a *Gigatitan,* you can expect "nothing more than a quick and violent death in manner of a brutal throat slit!"

Insects - *Mesochorista proavita*

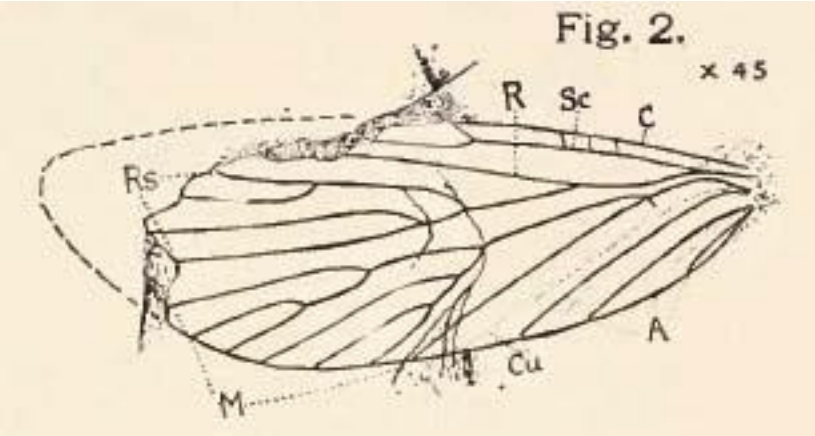


Figure 22 - Wing of *Mesochorista proavita*
Credit: R. J. Tillyard, 1916, public domain

Insects can be delicate creatures and it's amazing that any of them fossilize; either in whole or in part. Such is the case with *Mesochorista proavita*, a Triassic aged species of scorpionfly that is only known from fossils of its wings.

Robert John Tillyard originally described the fossils of in 1916. Tillyard found the fossils in the Denmark Hill Insect Bed of Queensland, Australia. The Denmark Hill Insect Bed is part of the Blackstone Formation (Ipswich Coal Measures Group) and is dated to the Carnian age, the lowest stage of the Late Triassic. Blackstone Formation sediments of are lacustrine in origin.

Standard Caveat

The purpose of my weblog postings is to spark people's curiosity in geology. Don't entirely believe me until you've done your own research and checked the evidence. If I have sparked your curiosity in the subject of this posting, follow up with some of the links provided here. If you want to, go out into the field and examine some rocks on your own with the help of a good field guide. Follow the evidence and make up your own mind.

In science, the only authority is the evidence.