Amazing Reptile Fossils from the Marine Triassic of China

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Known as the "true terrestrial tetrapod," reptiles mainly live on land. However, some reptile groups made a secondary adaptation to their life in water. Generally called "marine reptiles," they are mostly extinct, and their fossils are found in Mesozoic marine deposits around the world. Ichthyosaurs and Plesiosaurs are the most famous marine reptiles that lived in the "dinosaur age," namely the Jurassic and Cretaceous. Many more "sea monsters" were ruling the ocean in the Triassic period, when dinosaurs had just arisen from its archosaur ancestors.

In the Triassic, marine reptiles were inhabitants of a near-shore environment and shallow epicontinental seas. So far their fossils are found in three major faunal provinces, *i.e* the Western Tethyan Province (nowaday Europe and the Middle East), the Eastern Tethyan Province (or by some authors, the Western Pacific Province, nowaday southern China) and the Eastern Pacific Province (North America). The collecting and the study of marine reptile fossils in Europe have a long history of nearly 200 years, while in China, the first specimen, named as *Keichousaurus hui*, was not published until 1956. By 1999, only a few genera and species had been known. All these specimens, mainly ichthyosaurs and nothosaurs, are incomplete and poorly preserved. Furthermore, some of these taxa were proved to be the nomen dubium (invalid name), such as *Shingyisaurus*, which is now referred to as *Nothosaurus*. sp. Great changes happened during the following decades. Since 1999, hundreds of complete skeletons have been excavated from Guizhou and Yunnan provinces, southwestern China with the discovery of at least 24 new genera. Among these new collections are some important reptile groups never reported before from the Eastern Tethyan Province, such as the placodont, the thalattosaur, and the protorosaur. Besides, some more amazing taxa came to light, including the first marine "thecodonts" and the most primitive turtle.

Suction in the sea

By the Middle Triassic time, a number of reptile lineages had diversified in shallow epicontinental seas and intraplatform basins along the margins of parts of Pangea, including the giraffe-necked protorosaurid reptile *Dinocephalosaurus*, collected from middle Triassic marine deposits about 230 Million years old in southwestern China. This taxon represents the first unambiguous

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evidence for a fully aquatic protorosaur. Further, its extremely elongated neck is explained as an adaptation to aquatic life, for example, to increase the feeding efficiency in water. The adaptive significance of neck elongation in *Tanystropheus* has generated many speculations, but in *Dinocephalosaurus*, it presumably served a functional role. Extending the head vertically in order to gulp air at the surface would have been impossible; the hydrostatic pressure would have simply prevented the lung inflation. To breathe, this animal would have had to move with the neck held nearly horizontal on the air-water interface, the head emerging from the water. Such a posture could increase its "hull length" to reduce the wave-induced resistance to locomotion. The slender neck would also position the head well in front of the sturdy body, such that *Dinocephalosaurus* could closely approach potential preys before its profile became apparent in dimly lit water. Given the length and slenderness of the cervical ribs, moderate lateral flexion of the neck must have been possible. Contraction of muscles originating from cervical ribs and bridging the intervertebral joints would rapidly straighten the neck while the ribs simultaneously splayed outward. The consequent increase of the esophageal volume could create suction, thereby the animal could essentially swallow the pressure waves created by its head lunging forward. This would have resulted in an almost perfect strike at a prey in water.

Fig.1 *Dinocephalosaurus orientalis* Li 2003, a marine protorosaur with an extremely long neck.

An early near-shore archosaur

The Archosauria originated in the Late Permian (about 250 million years ago) and later gave rise to dinosaurs (including birds), pterosaurs, and crocodylomorphs (including extant crocodylians). Its early members, traditionally called "thecodonts," flourished worldwide during the Triassic, from 250 to 205 million years ago, and have long been considered terrestrial. Archosaurian remains had been reported from Triassic marine strata before, but none showed aquatic adaptation and were believed to be the remains of terrestrial animals washed out to sea. In 2006, we reported a new Triassic archosaurian named *Qianosuchus mixtus*, which has several specializations normally associated with aquatic reptiles. Together with fishes, nothosaurs, protorosaurs and ichthyosaurs, it was collected from the Middle Triassic marine limestone in west Guizhou, China. The new archosaurian is well represented by articulated skeletons, indicating a mosaic anatomy of both aquatic and terrestrial adaptation. This, combined with the specimen taphonomy, suggests that *Qianosuchus* may have lived in a coastal–island environment, a situation similar to some recent saltwater crocodiles. *Qianosuchus* probably used the strong hind limbs to walk on land or in shallow water and the long and laterally compressed tail to swim in deeper water. With dagger-like teeth and a large size, *Qianosuchus* may have dominated the fauna and preyed on whatever it could reach, such as near-shore nothosaurian sauropterygians and protorosaurs, and even mixosaurid ichthyosaurs and fishes, most of which commonly occur in the same beds of the new archosaurian.

Fig. 2 As an early kin of the dinosaur, *Qianosuchus mixtus* Li *et al* 2006 is the only known "thecodonts" to have invaded into the sea.

How did the turtle get its shell

The origin of the turtle body plan remains one of the great mysteries of reptile evolution. The anatomy of turtles is highly derived, which renders it difficult to establish their relationships with other groups of reptiles. The oldest turtle in textbook, *Proganochelys* from the Late Triassic period in Germany has a fully formed shell and offers no clue as to its origin. While in 2008, we described a new 220-million-year-old turtle from Guizhou Province, southwestern China, somewhat older than *Proganochelys*. This documents an intermediate step in the evolution of the turtle shell and associated structures, and is thus seen as a "missing link" for turtle origin, just as the *Archaeopteryx* seen for bird evolution. We named it "*Odontochelys semitestacea*," which means "turtle with teeth and a half-shell." *Odontochelys* is of great importance to the origin of the special body plan of the turtle. Briefly speaking, a ventral plastron is fully developed in this species, but the dorsal carapace consists of neural (central) plates only. The dorsal ribs are expanded, and osteoderms absent. The new species shows that the plastron might have evolved before the carapace and that the first step of carapace formation might be the ossification of the neural plates coupled with broadening of the ribs. This corresponds to early embryonic stages of carapace formation in extant turtles, and shows that the turtle shell is not derived from a fusion of osteoderms. Phylogenetic analysis places the new species basal to all known turtles, fossil or extant. The marine deposits that yielded the fossils indicate that this primitive turtle inhabited marginal areas of the sea or river deltas.

Fig. 3 *Odontochelys semitestacea* Li *et al* 2008, the most primitive turtle serves as a "missing link" for turtle origin.

References

Li Chun, Wu Xiaochun, Rieppel O,Wang Liting & Zhao Lijun, 2008. An ancestral turtle from the Late Triassic of Southwestern China. *Nature,* 456: 497−501.

Li Chun, Zhao Lijun & Wang Liting, 2007. A new species of *Macrocnemus* (Reptilia: Protorosauria) from the Middle Triassic of southwestern China and its palaeogeographical implication. *Science in China Series D: Earth Sciences*, 50(11): 1601−1605.

Li Chun, Wu Xiaochun, Cheng Yannian & Sato T, 2006. An unusual archosaurian from the marine Triassic of China. *Naturwissenschaften,* 93: 200−206.

Li Chun, Rieppel O *et al*, 2004. A Triassic protorosaur with an extremely long neck. *Science*, 305: 1931.

Li Chun, Rieppel O, 2002. A new cyamodontoid placodont from Triassic of Guizhou, China. *Chinese Science Bulletin*, 47(2): 156−159.

Li Chun, 2000. Placodont (Reptilia, Placodontia) from Upper Triassic of Guizhou, southwest China. *Vertebrata PalAsiatica*, 38(4): 314−317.

Zhao Lijun, Wang Liting & Li Chun, 2008. A review of advances in Triassic Marine Reptile research in China. *Acta Palaeontologica Sinica*, 2008, 47(2): 99−106. (In Chinese)