

Biostratigraphy of Triassic Marine Reptiles in Southwest Guizhou and Its Adjacent Area

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Abstract This paper briefly reviews the Triassic marine reptile fossils in Guizhou Province, especially the fossils that have been recently found in the Guanling area. Based on three sections at Guanling and Xingyi, Guizhou Province and Luoping, Yunnan Province, four horizons with vertebrate fossils are recognized in the Middle and Upper Triassic of this area; They are from bottom to top: Member I and Member II of the Guanling Formation, and the Zhuganpo Member and the Wayao Member of the Falang Formation.

Key words: Southwest Guizhou, Middle and Upper Triassic, marine reptiles, Guanling Formation, Falang Formation

1 Introduction

Study of ancient marine reptiles of Guizhou Province began with the description of *Keichousaurus hui* (Pachypleurosauridae, Sauropterygia) by C. C. Young in 1958. Thereafter more marine reptile fossils were excavated; and 4 genera of Ichthyosauria and Sauropterygia were reported (Young, 1965a, b). Although the knowledge of Chinese Triassic marine reptiles had been greatly improved, there was still no comprehensive understanding of these creatures.

Many more perfectly preserved Triassic marine reptile fossils have been recently discovered in Guanling, Xingyi and Anlong, Panxian of Guizhou Province, and Luoping of Yunnan Province (Fig. 1). There are not only new genera of ichthyosaurs and sauropterygians, but also thalattosaurs and placodonts, which were first reported in China. Supported by the National Natural Science Foundation of China and Innovation Funds of the Chinese Academy of Sciences, we initially investigated more than 20 localities and measured 3 sections. As indicated by fieldwork data, these fossils were found in 4 vertebrate-bearing horizons of Middle to Upper Triassic age.

2 Stratigraphical Sections with Fossils

Section 1: Stratigraphical section of the lower part of the Wayao Member and the upper part of the Zhuganpo Member of the Falang Formation in Guanling, Guizhou (at Nanguashan in Maowa Village, 25°53'46"N, 105°24'40" E) (Fig. 2)

Wayao Member of the Falang Formation

Thickness > 29.13 m

5. Greyish black, thin-bedded micrite with horizontal bedding, flaky after weathering.

13.6 m

4. Greyish black, thin-bedded muddy micrite with wavelite-like laminations, rich in encrinites, and brown marl with horizontal bedding about 1 m thick on top, containing fossil marine reptiles.

8.54 m

3. Dark grey, medium-thick-bedded (25 cm) micrite, interbedded with dark grey marl with horizontal bedding. The marl appears flaky after weathering. There are abundant bivalves on bedding planes of the marl. Contains fossil marine reptiles.

6.99 m

Zhuganpo Member

Thickness > 22.9 m

2. Grey to dark grey, medium-thick-bedded (15–20 cm) micrite, with 4 layers of thick-bedded (about 50 cm) micrite (something



Fig. 1. Locality map of fossils and section in Guizhou and Yunnan, China.

missing here) near the bottom. Marl intercalated between the layers.

10.33 m

- 1. Yellowish grey, medium-thick-bedded micrite, with thick-bedded micrite, intercalated with greyish yellow marl about 2–3 cm thick.

12.57 m

(underlying strata not measured)

Section 2: Stratigraphical section of the Zhuganpo Member of the Falang Formation in Xingyi, Guizhou (from 25°8'49" N, 105°1'3" E to 25°8'47" N, 105°1'17" E) (Fig. 3)

Zhuganpo Member of the Falang Formation

Thickness > 64.62 m

(overlying strata not measured)

- 5. Dark grey, thin-bedded micrite interbedded with greyish black, thin-bedded muddy micrite with fine horizontal bedding,

4.64 m

containing *Keichousaurus*.

3.57 m

- 4. Dark grey, thin-bedded micrite, intercalated with some medium-thick-bedded micrite, each individual bed being 29 cm thick.

7.60 m

- 3. Dark grey, medium-thick-bedded micrite intercalated with some thin-bedded (6–7 cm) micrite.

1.9 m

- 2. Dark grey, medium-thick-bedded micrite, each individual bed being 20–25 cm thick and thinning upwards.

27.37 m

- 1. Dark grey, thick-bedded micrite.

10.85 m

conformity

Guanling Formation: greyish yellow, micrograined to fine-grained dolostone

Section 3: Stratigraphical section of the Zhuganpo Member of the Falang Formation in Luoping County, Hunan Province (from 25°01'16" N, 104°27'41" E to 25°01'12" N, 104°27'49" E) (Fig. 4)

Overlying strata: Wayao Member of the Falang Formation

- 11. Black, thin-bedded micrite intercalated with a few layers of thick-bedded limestone. The upper part is composed mainly of mudstone, with abundant fossil invertebrates: the ammonites *Trachyceras* sp. and *T. multiterlatum*; the conodonts *Paragondolella polygnathiformis*, *P. folita folita* and *P. maantangensis*; the bivalves, *Halobia kui*, and *H. sp.*; the crinoid, *Traumatocrinus hsui*.

Thickness > 7.74 m

- 10. Thick-bedded micrite containing mud gravel, intercalated with medium-thick-bedded micrite.

20.18 m

- 9. Grey, thin-bedded to medium-thick-bedded micrite, without siliceous nodules.

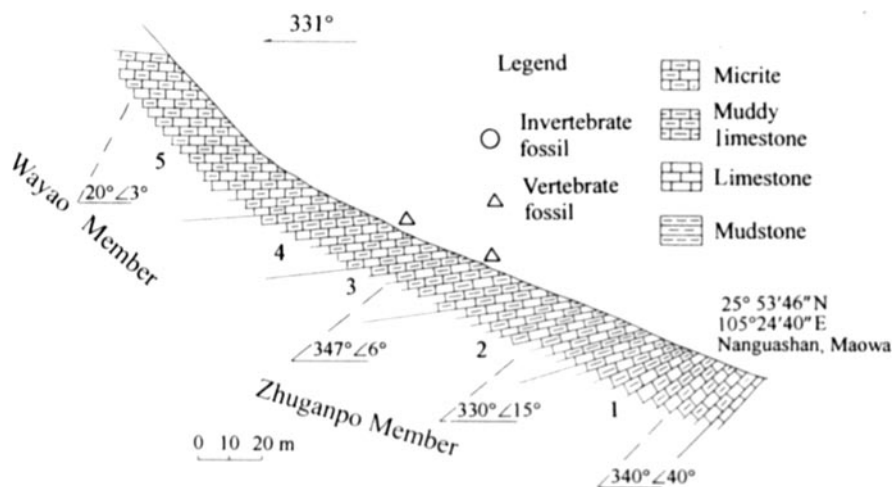


Fig. 2. Stratigraphical section in Guanling, Guizhou.

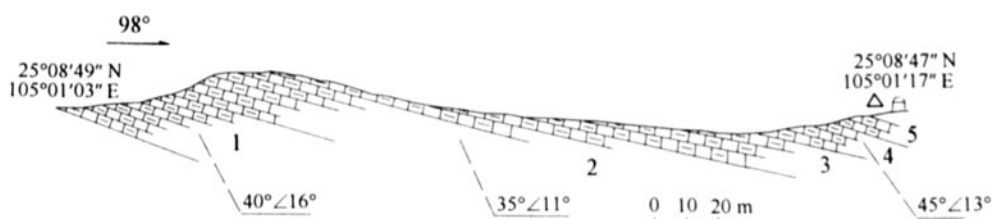


Fig. 3. Stratigraphical section in Xingyi, Guizhou (legend as in Fig. 2).

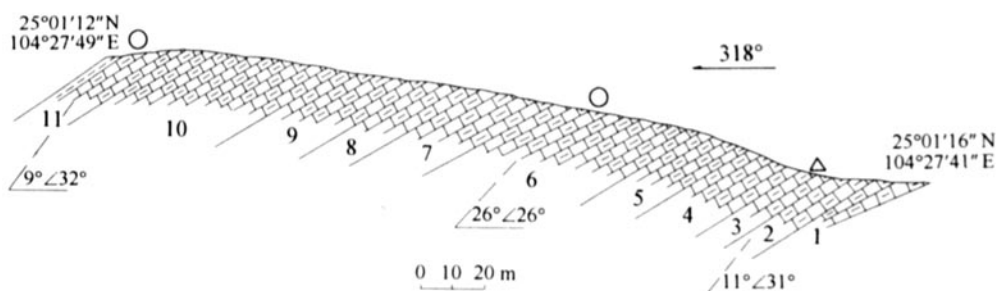


Fig. 4. Stratigraphical section in Luoping, Yunnan (legend as in Fig. 2).

8. Grey, thick-bedded micrite with a few siliceous nodules, intercalated with medium-bedded micrite. 6.28 m
7. (Outcrops discontinuous, description based on sporadic outcrops) lithology same as the sixth layer, but thinner. 5.45 m
6. Grey, medium-bedded micrite with thick-bedded micrite, siliceous lumps intermittent along the bedding plane, with a 3–4 cm-thick layer abundant in ammonites near the bottom (gen. et sp. undetermined). 11.88 m
5. Grey, medium-thick-bedded micrite with thin-bedded micrite. 8.12 m
4. (covered by the Quaternary) 5.46 m
3. Grey, thin-bedded to medium-thick-bedded (bed is about 15 cm thick) micrite, intercalated with yellow, thin-bedded muddy micrite (the thickness of an individual bed is 2 cm). Yields *Keichousaurus* and fossil fishes, and perhaps also contains ichthyosaurs. 3.63 m
2. Grey, medium-thick-bedded micrite intercalated with thin-bedded micrite with horizontal bedding. Thickness of bed is about 12–17 cm and increases upwards. 17.78 m
1. Grey, thin-bedded to medium-thick-bedded micrite, with horizontal bedding. The thickness of thin bed is 4–5 cm, that of medium thick bed is 12 cm. 6 m
0. Grey, thick-bedded limestone with laminations composed of mud. The bottom is cut by a fault.

3 Horizons and Age of the Fossiliferous Strata

All the specimens of Triassic marine reptiles in Guizhou

Province, reported from 1958 to 1965, were published with exact localities but ambiguous horizons. The ages of *Shingyisaurus unexpectus*, *Chinchenia sungi*, *Sanchiaosaurus dengi* and *Mixosaurus maotaiensis* were considered to be Middle Triassic by Young and Dong (1972). Based on the stratigraphic classification in use (Dong, 1997), we verified many localities, including some old ones. This was a basic work for understanding the geohistorical distribution, evolution, and migration of these ancient monsters.

Chinchenia sungi was discovered in dolostone breccia near Cangxi Bridge, Shangpu, 7 km east of Qingzhen, Guizhou Province. *Sanchiaosaurus dengi* came from muddy dolostone near Jinzhong Bridge in the suburbs of Guiyang City. Both localities belong to Member I of the Guanling Formation, which is believed to be Anisian in age. *Chinchenia sungi* and *Sanchiaosaurus dengi* are marine reptiles in the lowest horizon known in Guizhou Province so far.

During the field survey in 2000, we found a new vertebrate fossil locality in Xinmin, Panxian, where thick limestone has a worm-like structure on its surface. The strata consist of Member II of the Guanling Formation (late Anisian). No systematical collection and study of the fossils from this locality have been carried out yet.

The holotypes of *Keichousaurus hui* and *Nothosaurus* sp. (= "*Shingyisaurus unexpectus*", Young, 1965a; Rieppel, 1998) were collected from Dingy, Guizhou

Province. The deposits bearing vertebrate fossils were believed to be the Middle-Upper Triassic (Young, 1958), or the lower Middle Triassic Guanling Formation (Young, 1965a). The strata were considered as the Zhuganpo Formation by Chen (1985) after his field measurement of the section in Dingxiao, Xingyi. Our fieldwork confirmed Chen's conclusion, except for the demarcation of the bottom of the Zhuganpo Member. Recently, many fossil marine reptiles including *Keichousaurus hui* were found in some new localities such as Wusha, Longguang of Guizhou Province, and Luoping of Hunan Province. The fossils are contained in dark grey limestone of the Zhuganpo Member, Falang Formation, as the case with the fossils of Xingyi. The age of the Zhuganpo Member is Ladinian of the Middle Triassic (Dong, 1997) or early Carnian of the Late Triassic as suggested by the study of conodonts (Yang et al., 1995; Wang et al., 1998). The study of palaeogeography indicates that this area experienced transgression at that time, marked by a broad, gentle limestone slope dipping from northwest to southeast (Wang, 1996).

So far, 11 genera and 13 species of Triassic marine reptiles have been reported from the Guanling area (Li, 1999, 2000; Liu, 1999; Yin et al., 2000). All the fossils are from the lower beds of the Wayao Member, Falang Formation (Carnian), which are mainly grey to dark grey, thin or medium-thick limestone, muddy limestone and bioclastic limestone. This is the uppermost bed with marine reptile fossils in the southwest of Guizhou Province.

4 Faunal Components and Characters

As mentioned above, all the fossil marine reptiles in the southwest of Guizhou Province and adjacent areas are distributed in 4 horizons. The lowest one is Member I of the Guanling Formation, which yields *Chinchenia sungi* and *Sanchiaosaurus dengi*. These two genera were put into Nothosauridae by Young (1965a), but the former was later assigned to Pistosauridae because of the special characters of lower jaw symphysis, amphicoelous vertebrae and the expanded distal end of the transverse process (Rieppel, 1999). Several pairs of terrestrial vertebrate tracks were reported from the muddy dolostone of the lower Guanling Formation, about 40 m above the bottom (Wang and Ma, 1989). These footprints are quite similar to those of

Chirotherium of Germany (Zhen, 1996). So, the early Middle Triassic fauna in Guizhou Province comprises the members of Nothosauridae and Pistosauridae, as well as a terrestrial archosauriform reptile that lived an amphibious life.

Although the fossils recently found in Member II of the Guanling Formation have not been studied, the presence of ichthyosaurs and abundant fossil fishes is unquestionable. This is the lowest horizon of ichthyosaurs in Guizhou, later than the earliest ichthyosaurs in China (Young, 1972), which was found from the Lower Triassic in Chaoxian, Anhui Province.

Besides countless *Keichousaurus hui* of Pachypleurosauridae and *Shingyisaurus unexpectus*, which was initially assigned to Simosauridae (Young, 1965a) and later to Nothosauridae (*Nothosaurus* sp., Rieppel, 1998), ichthyosaurs and thalattosaurs also have been found from the Zhuganpo Member of the Falang Formation. This is the lowest horizon of thalattosaurs in China. The marine reptile fauna of the Falang Formation shows a greater abundance than that of the Guanling Formation in both the number of species and individuals.

Marine reptiles from the Wayao Member of the Falang Formation include *Qianichthyosaurus zhoui* (Li, 1999), *Sinocyamodus xinpuensis* (Li, 2000) and *Anshunsaurus huangguoshuensis* (Liu, 1999), as well as other ichthyosaurs and thalattosaurs (Yin et al., 2000). *Anshunsaurus* was identified as sauropterygian when it was named, and later was assigned to Askeptosauridae (Order Thalattosauria) for its elongated and tapering premaxillary rostrum, retracted nares, contact of the premaxilla with the frontal, reduced upper temporal fossa (Rieppel et al., 2000). *Anshunsaurus* is the first undoubted thalattosaur in China, although it has appeared in the Zhuganpo Member, which is below the *Anshunsaurus* bed. *Sinocyamodus xinpuensis* is the first placodont discovered in China and indicates the presence of placodonts in the eastern Tethyan Province. The appearance of *Sinocyamodus* in Guizhou makes it possible to draw a comprehensive parallel between the western Tethyan Province and southwestern China. Although the presence of Pachypleurosauridae in the Wayao Member (Yin et al., 2000) is questionable, it is clear that the reptiles in the Wayao Member are more abundant and varied than those in the Zhuganpo Member, Falang Formation.

5 Conclusions

(1) Marine reptile fossils are distributed in 4 beds of the Middle and Upper Triassic in southwest Guizhou Province and its adjacent area; they are from bottom to top: Member I and Member II of the Guanling Formation and the Zhuganpo Member and Wayao Member of the Falang Formation.

(2) There were less diversity and limited individuals in the reptile fauna before the Ladinian, and afterwards both species and individuals increased rapidly, especially in the Carnian.

(3) The range of the Triassic marine reptiles appearing in the deposits of southwest Guizhou Province is generalized as follows:

Eusauroptrygia: from Member I of the Guanling Formation (early Anisian) to the Zhuganpo Member of the Falang Formation (Ladinian)

Ichthyosauria: from Member II of the Guanling Formation (late Anisian) to the Wayao Member of the Falang Formation (Carnian)

Thalattosauria: from the Zhuganpo Member of the Falang Formation (Ladinian) to the Wayao Member of the Falang Formation (Carnian)

Placodontia: Wayao Member of the Falang Formation (Carnian)

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