HORIZONS AND ASSEMBLAGES OF MIDDLE TRIASSIC MARINE REPTILES FROM PANXIAN, GUIZHOU, CHINA

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The Triassic marine reptiles from Guizhou Province, China, have attracted much attention during the past decade. The Triassic of Guizhou has traditionally yielded marine reptile fossils (Young 1958, 1960, 1965), including the Ladinian (Middle Triassic) locality in Dingxiao (Xingyi) that is famous for the pachypleurosaur Keichousaurus. However, the recent boom was fueled by the discovery of two new localities yielding well-articulated specimens of various marine reptile groups (Wang et al., 2001; Jiang, Motani, Li, et al., 2005). The first to be reported was the locality near Xinpu in Guanling County (Li, 1999; Liu, 1999), where the Wayao Member of the Falang Formation is exposed. The Wayao Member, which yields articulated marine reptile fossils, is now correlated to the early Carnian (Upper Triassic) based on conodonts, cephalopods, and ichthyoliths. However, some workers maintain that it corresponds to the late Ladinian (Middle Triassic) based on bivalves (see Jiang, Motani, Li, et al. 2005 and references therein).

The second locality, near Yangjuan Village, Xinmin District, Panxian County (Fig. 1), appeared in publication slightly later (Wang et al., 2001). This locality yields fossils that are much older than those from Guanling or Dingxiao: a study of conodont biostratigraphy by Sun et al. (2006) established that the Upper Member of the Guanling Formation that is exposed in the area corresponded to the Anisian (Bithinian to Illyrian). They also indicated that reptile beds were found in their Cy 12 and 13, where the conodonts Nicoraella kockeli and N. germanicus co-existed. The horizon corresponds to the lower part of the Kockeli Zone, and therefore represents the early Pelsonian (Sun et al., 2006). Accordingly, the vertebrate assemblage(s) from the Yangjuan area is the oldest well preserved fauna from the Middle Triassic, including the Monte San Giorgio area where reptile-bearing strata span the late Anisian to the latest Ladinian (Sun et al., 2006).

The Yangjuan locality has yielded a remarkable assemblage of marine reptiles, including unique lineages such as the protorosaur Dinocephalosaurus (Li, 2003; Li et al., 2004), and the archosauroid Qianosuchus (Li et al., 2006). However, some important specimens were collected by amateurs, without a precise stratigraphic record beyond ‘Guanling Formation near Xinmin’. Therefore, it is unclear whether all of these marine reptiles were found in Cy 12 and 13, and if so, whether in a single or multiple horizons. This lack of provenance is problematic because what has so far been considered a single assemblage may indeed represent multiple assemblages depending on the stratigraphic horizon of each species. It is important to clarify the vertical distribution of all vertebrate remains, as well as their taphonomic state, to better understand the ecosystem(s) recorded in the Yangjuan area.

A joint excavation by the University of California, Davis, Peking University, and Università degli Studi di Milano was held during June–July, 2006 in the Yangjuan area. Many local amateur collectors participated in our excavation, which provided us with an invaluable opportunity to confirm and scrutinize the horizons of some published specimens through interviewing the original collectors. Some of the specimens occurred in sites other than our main excavation site. We therefore measured four stratigraphic sections located throughout the area where marine reptile fossils have been collected. The purpose of the present note is to report the detailed stratigraphy of published marine reptile

FIGURE 1. Locality map for Yangjuan sections. A, position of Guizhou (black) within China. B, position of Xinmin within Guizhou. C, positions of the four stratigraphic sections relative to Xinmin and Yangjuan. Section names and coordinates are: S1, Chupiwa South (N25°31′46″, E104°54′48″); S2, River Northwest (N25°31′43″, E104°54′33″); S3, Dry Well (N25°31′25″, E104°53′55″) and S4, Hill South (N25°31′08″, E104°54′20″).

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fossils based on a stratigraphic correlation that we established, and to give preliminary taphonomic observations on the whole fossiliferous content of the horizon.

SECTIONS AND CORRELATION

The Anisian is very widely exposed near Yangjuan Village as marine carbonates. We measured four representative sections along the fossiliferous level, which are referred to as Chupiwa South, River Northwest, Dry Well, and Hill South from north to south (Fig. 1, S1 to S4 in this order). The four sections barely fit inside a 1 km² quadrant. The uppermost bed, which can be used as a clear marker bed because of thickness and a slumped structure, was numbered 100. The correlation among the four sites is corroborated by a characteristic sequence (Fig. 2), which starts from a thin bentonite layer (bed 86; b3 in Fig. 2) to thick laminated marl (87), thick bentonite (88; b4), thinner laminated marl (89) and hard carbonate beds with some visible crystals and cavities (90 and 91). These last beds often become reddish after weathering, making their identification easy. The two upper laminated marl beds that are known to yield articulated marine reptiles are referred to by local collectors as Big and Small Flower Beds (beds 87 and 89, respectively).

Three other bentonite layers are known in the area. Layer b1 is thin, yet known in both Hill South and Dry Well—the relevant level is unexposed in Chupiwa South or River Northwest at this point. Layer b2 is seen in the northern two sections (Chupiwa South and River Northwest), whereas very thin layers may be seen in parts of the southern two (Hill South and Dry Well). Layer b5 is so far known only in River Northwest.

VERTEBRATE FOSSILS

We searched for vertebrate remains in the beds between 77 and 89 at Hill South by removing several square meters of barren limestone beds from the cliff and breaking carbonate layers thus obtained into small pieces by hand. In doing so, we kept rocks from different beds separated from each other. This labor inten-

FIGURE 2. Stratigraphic sections. Numbers 77 to 89 refer to field bed numbers that are used in text. Cartoons on the right represent fish and reptile remains from left to right. Half a reptile symbol indicates occurrence of fragmentary reptilian fossils only, and a complete symbol articulated skeletal remains. Symbols b1 to b5 represent bentonite layers discussed in text, with real lines connecting existing layers and dotted line representing extrapolation (b5 only exists in S2). Textures are explained in the legend in the figure.
sive operation was performed by up to 30 workers simultane-ously processing rocks on site. Representative specimens were collected and deposited in the collection of the Geological Mu-seum, Peking University.

Fish and reptilian remains were not uncommon in the beds that we examined. When including isolated bones, all beds in the range contained both fish and reptile fossils except for very thin beds (Fig. 2). The number of reptilian fossils that we collected from one corner of the quarry, where the most detailed sampling was performed, was about 25 from the rock volume of about $3 \times 3 \times 2$ meters. None of them was articulated. From the same corner, we collected about 100 fish specimens, although the collection was less exhaustive than for reptilians. Note that most of these specimens were fragments, and the numbers given are approximations. Well-articulated marine reptile remains occurred only in a limited number of beds. We confirmed the occurrence of such fossils in beds 79, 85 and 87, but local collectors reported that beds 77 and 89 also yielded well-articulated skeletons. In addition, there are reports of very rare occurrences of articulated specimens from other beds, namely beds 90–91. A high abundance of articulated fish remains is known in bed 84, which is referred to as “Fish Bed” by the local collectors. It is not the purpose of the present contribution to discuss the fish fauna further, because much preparation is necessary before a preliminary conclusion can be drawn.

Three major sets of beds yield well-articulated reptile fossils: a lower set that starts from bed 77 and ends at bed 79, a middle set that comprises bed 85, and an upper set that contains beds 87 to 89. We refer to them as the Lower, Middle, and Upper Reptile Horizons (LRH, MRH and URH, respectively) hereafter. We refrain from naming those beds that do not yield articulated specimens frequently (beds 90 and 91). We do not include bed 85 in URH despite of its proximity to the latter (Fig. 2) because of a substantial difference in lithology; beds 87 and 89 are laminated marls whereas bed 85 is made of massive limestones, indicating different depositional environments. Also, there is a bentonite layer between the two, indicating that volcanic activity could have resulted in the inferred difference in living environment. Indeed, these two beds yield different assemblages of marine reptiles, as described below. The newly designated reptile horizons overlap the previously set Cy boundaries by Sun et al. (2006). Thus, beds 89–91 are in Cy 10 of Sun et al. (2006), 79–87 in Cy 12, and 77 in Cy 13.

Most specimens in the collection of the Peking University, namely the sauropeterygian Lariosaurus (Jiang, Hao, et al., 2005), the ichthyopterygian Phalarodon cf. P. fraasi (Jiang et al., 2007), an undescribed sauropeterygian Placodus (Jiang, Hao, et al., 2006), and undescribed ichthyopterygians (Jiang, Motani, Schmitz, et al., 2005), were all collected from bed 79 near Dry Well. One exception is the sauropeterygian Nothosaurus (Jiang, Maisch, et al., 2005), which is from MRH. Local collectors reported that specimens of the archosaur Qianosuchus also occurred in MRH. Its occurrence in MRH agrees with our field observation: Qianosuchus is the largest marine reptile from this area, reaching up to 3 m (Li et al., 2006), and we found reptilian vertebrae from bed 85 that are too large for any other species known so far. Of the marine reptile fossils that have been described by previous authors, the ichthyopterygian Mixosaurus panxianensis (Jiang, Schmitz, et al., 2006) is the only one to have occurred in URH (Table 1). This is the most common species in the area, and is found throughout the beds that we examined. There are undescribed reptile groups from URH that will be described once the specimens are prepared, including a pachypleurosaur from bed 87. None of these undescribed species are found in LRH or MRH. Dinoccephalosaurus (Li, et al., 2004) is unique in its stratigraphy. Local amateurs collected the published specimens of this genus from bed 90 or 91 near Chupiwa, in which no other reptiles have been found. This report is confirmed by the red color of the matrix of the referred specimen described by Li et al. (2004). The stratigraphic information above was obtained from selected key collectors, and does not reflect ‘rumors’ among local farmers that are often self-contradictory. See Table 1 for the summary of marine reptile occurrences.

The faunal difference between MRH and LRH is mostly based on marine reptile membership: there is no overlap between the two except for Mixosaurus panxianensis that is commonly found throughout the section. Given the small sample size of large vertebrates, it is possible that the membership difference may decrease as more specimens are collected. However, the physical gap between the two horizons is large (Fig. 2), with two bentonite layers that indicate repeated volcanic activity. We therefore feel that the recognition of two different marine reptile horizons, MRH and LRH, is appropriate.

URH, on the other hand, is distinct from the other two marine reptile horizons in general body size of the reptilian species. Thus, species from URH tend to be small, rarely exceeding 1 m in total length, and are usually much smaller. MRH and LRH yield larger species than URH, with the total length reaching 2 m, and sometimes more (as in Qianosuchus). The smallest species in LRH and MRH, Mixosaurus panxianensis, is one of the largest in URH. The size difference could reflect average water depths, which we infer to have been deeper in LRH and MRH than in URH based on the presence of pachypleurosaur. In URH, however, further sedimentological and stratigraphic studies are needed to test this inference.

In conclusion, three different marine reptile assemblages are recognized in the Anisian exposure of the Yangjuan area, with M. panxianensis being the only species shared among the three. Larger species, sometimes exceeding 2 m in total length, occur in LRH and MRH, whereas URH typically yields small marine reptiles rarely reaching 1 m. Isolated occurrences of articulated marine reptiles are known outside of these three assemblages, namely Dinoccephalosaurus from beds above LRH as well as fragmentary specimens throughout the sections examined (Fig. 2).

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<tr>
<th>Bed Locality</th>
<th>Lariosaurus</th>
<th>Placodus</th>
<th>Phalarodon</th>
<th>Undescribed ichthyos</th>
<th>Mixosaurus</th>
<th>Nothosaurus</th>
<th>Qianosuchus</th>
<th>Undescribed pachypleurosaur</th>
<th>Other undescribed</th>
<th>Dinoccephalosaurus</th>
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<td>Beds 90–91</td>
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<td>URH (beds 87–89)</td>
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<td>MRH (bed 85)</td>
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<td>LRH (beds 77–79)</td>
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* Denote occurrences of a particular taxon. See text for each case.
SUMMARY

Previously published marine reptile fossils from Yangjuan Village, Xinmin District, Panxian County, Guizhou Province, China suffered from uncertainty in their stratigraphic occurrence. Through fieldworks and interviews with the original collectors, it has become clear that most of these fossils occurred in three different levels within the early Pelsonian of the Anisian (Middle Triassic). The fossils represent at least three different assemblages, one of which possibly occupied shallower water depth than the other two.

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LITERATURE CITED


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