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GASTROLITHS IN THE TRIASSIC ICHTHYOSAUR *PANJIANGSAURUS* FROM CHINA

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INTRODUCTION

GASTROLITHS (stomach stones) are frequently reported in association with plesiosaur remains, especially elasmosaurids (e.g., Brown, 1904; Williston, 1904; Welles and Bump, 1949; Darby and Ojakangas, 1980; Everhart, 2000; Cicimurri and Everhart, 2001). Stones are also known from several other fossil and modern aquatic vertebrates, including fishes (Dapples, 1938; Thomson, 1966; Trewin, 1986), penguins (Emery, 1963; Stonehouse, 1967; Boswall and MacIver, 1975), crocodilians (Cott, 1961; Neill, 1971; Keller and Schaal, 1992), and pinnipeds (Fleming, 1951; Mohr, 1963; Bryden, 1999).

However, gastroliths are very rarely reported in ichthyosaurs, despite the fact that a large number of articulated skeletons are known from this clade. Some ichthyosaurs show preserved gut contents (e.g., Pollard, 1968; Keller, 1976; Kear et al., 2003), and sand is occasionally found in the gastric area of ichthyosaurs (R. Wild, personal commun., 2000; Wings, personal obs.). Gastroliths with grain sizes >2 mm are only known from two specimens: the one described in detail here and a complete but undescribed skeleton from the famous Upper Jurassic Solnhofen Limestone of Germany (Taylor, 1993; Wings, personal observation). The German specimen is probably referable to the genus *Nannopterygius* Huene, 1922, so far only known from England. The specimen is preserved as a slab, which is on exhibit at the Jura-Museum, Eichstätt, Germany, and a counterslab, which is accessioned to the collections of the Staatliches Museum für Naturkunde, Karlsruhe, Germany.

A description of the stones found in the perfect holotype specimen (Museum of the Yichang Institute of Geology and Mineral Resources # TR00001) of *Panjiangsaurus epicharis* described by Chen and Cheng (2003) (Fig. 1) is important not only because of the scarcity of ichthyosaurian gastroliths, the find is also relevant for the interpretation of gastrolith function. *Panjiangsaurus epicharis* is possibly a junior synonym of *Guizhouichthyosaurus tangae* (Yin et al., 2000) from the same region and horizon. Likewise, *Cymbospondylus asiaticus*, which was described from two skulls by Li and You (2002), probably also represents the same species. However, these taxonomic questions are not the focus of the current paper. There are at least eight sufficiently prepared skeletons of *Panjiangsaurus* and *Guizhouichthyosaurus* Yin, Zhou, Cao, Yu, and Luo, 2000 combined, including the missing holotype of *Guizhouichthyosaurus*, two specimens on display at the Museum of the Yichang Institute of Geology, Yichang, Hubei Province, two in situ specimens at the Woo Long Gong National Geological Park, Guanling County, two in the collections of the City of Guanling, and one more at the museum of the Dragon Palace Cave, Anshun County, Guizhou Province, China. All except the holotype of *Guizhouichthyosaurus* were personally examined and none except the specimen described here show any evidence of stones in their gut region.

METHODS

Because most of the gastroliths are still in situ in the rib cage of the specimen, a special approach was taken to document the physical characteristics of all the preserved gastroliths as precisely as possible. More than 100 stones were prepared out from the main in situ clusters A and B (Fig. 1) of the skeleton, of which 84 stones were completely isolated and the others were retained in small groups held together by matrix. Except for one stone, which was prepared mechanically, acid was used to free the stones from the matrix. The isolated stones were weighed, as were the detached groups of stones. To estimate the mass of the in situ pebbles, their volumes were estimated using data for length, width, and height. The estimated volumes were multiplied with respective densities of the in situ pebbles to gain mass data. To crosscheck the results, the same amount of pebbles from modern environments with a similar shape, size, and rock type were weighed. For the final estimate of in situ pebble mass, we used the mean value of both results. Finally, the estimate of total gastrolith mass was obtained by adding the in situ mass estimate to the measured mass of the isolated stones and stone groups.

Length, width, and height of the isolated pebbles were also measured to calculate sphericity, using the method described by Dobkins and Folk (1970). Pebbles still embedded in the specimen were measured in all available dimensions.

Three isolated gastroliths (one from cluster A and two from cluster B) were chosen for SEM examinations. The samples were sputtercoated with gold and examined with a Camscan MV 2300 SEM. Pictures were taken at a different magnification and compared to the results of Whittle and Onorato (2000).

DESCRIPTION OF THE GASTROLITH CLUSTERS AND THE GASTROLITHS

Panjiangsaurus epicharis was a large ichthyosaur: the total length of the holotype is 5.4 m. The specimen is exposed in right lateral view with the skull embedded in ventrolateral view (Fig. 1). The rib cage is preserved in articulation. Two clusters of gastroliths (cluster A and cluster B) are associated with the posterior region of the rib cage. Ventrally to the rib cage, the specimen shows numerous gastralia, representing the disarticulated gastral basket (Fig. 1). The specimen is embedded in a dark gray micrite. Through weathering, the dark gray micrite has become light gray. The gastrolith clusters have a matrix that differs from the surrounding rock and consists of crystalline calcite.

The gastroliths in cluster A (Fig. 2.1), located approximately 23.5 cm anterior to the pelvic girdle, cover the distal parts of some ribs, thus lying outside of the body cavity; those in cluster B are situated near the middle of the dorsal vertebral column, between some right and left ribs (Fig. 2.2). Between the two clusters, there are several isolated stones in gaps between ribs. Cluster A covers approximately 175 cm^2, while cluster B covers approximately 113 cm^2. The preserved thickness of cluster A is about 3.5 cm, whereas the preserved thickness of cluster B is 2.4 cm. Consequently, the volume of stones in cluster A is higher than the volume in cluster B. One hundred and sixty-nine gastroliths can be counted in the clusters in situ. However, because many additional stones remain hidden in the clusters, the total number of stones is probably as high as several hundred. There is no