Discovery of Ordovician vertebrate fossil from Inner Mongolia, China

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THE material under study was found from the Zhuozishan Formation (lower Middle Ordovi-

cian)[1] of Zhuozishan, Wuhai, Inner Mongolia. This specimen was quite suggestive of the exoskeleton fragment of vertebrates by its ornaments, i.e. tiny and densely set tubercles on the surface. However, the gross morphology of the preserved part cannot exclude the possibility of being arthropods. Recent histological study shows that this specimen is mainly composed of spongy acellular bone, similar to the Heterostraci[2] and some Ordovician vertebrates[3]. Therefore, this fragment represents the earliest record of vertebrate fossils in China, and China is the fourth locality of Ordovician vertebrates after North America[4, 5], Australia[6], and Bolivia[7—9] in the world.

1 Description

Material: A fragment of exoskeleton, IVPP. V11246.

Locality and horizon: Zhuozishan, Wuhai, Inner Mongolia; Zhuozishan Formation, lower Middle Ordovician.

Description: Since we cannot determine to which part of the exoskeleton this specimen belongs, its orientation in this work (fig. 1) is temporary. This is a small specimen with a preserved length of about 1.5 cm and a maximum height of 1 cm. Its posterior and lower margins are probably natural. The specimen twists downwards anteriorly and anteroventrally, and forms a cone near the center. The rest of the specimen is fairly flat, or gently arched. Its surface is ornamented with tiny and dense tubercles, which are rounded or oval in shape. There are about 16—20 tubercles in 1 mm^2. The surface of tubercle is smooth, and deficient of any ridges.

Fig. 1. A fragment of vertebrate exoskeleton from Middle Ordovician of Inner Mongolia. ×4.

The exoskeleton is very thin with a thickness of about 0.13 mm. Histologically, the exoskeleton is subdivided into two layers (fig. 2). The upper layer forms the main portion of the exoskeleton, with a thickness of about 0.11 mm. It has many cavities and canals, and is the same as the spongy middle layer of the Heterostraci and some Ordovician vertebrates[2, 3, 5, 9]. This spongy hard tissue is a kind of acellular bone, which is unique to some early vertebrates. The Chinese specimen lacks the external layer generally seen in some early vertebrates[2, 3], such as Herterostraci. Among them the tubercles are usually formed of dentinous tissue covered with a thin enamel or enameloid layer in some cases. The hard tissue in the tubercles of our specimen is still the acellular bone. The lower layer is about one eighth of the total thickness. The hard tissue is relatively dense, and deficient of the cavities seen in the upper layer. It corresponds to the lamellar basal layer of the Herterostraci, *Astraspis* and *Eriptychius*[2, 3, 5, 9].

2 Discussion

By now, the earliest and unequivocal vertebrates have been found from the Ordovician sediments. Among them, the earliest are *Arandaspis* and *Porophoraspis* from the early Llanvirn rocks of the Amadeus Basin, Australia[6]. Two other horizons of Ordovician vertebrates are slightly younger, and of Caradoc in age. The Harding Sandstone of North America yielded

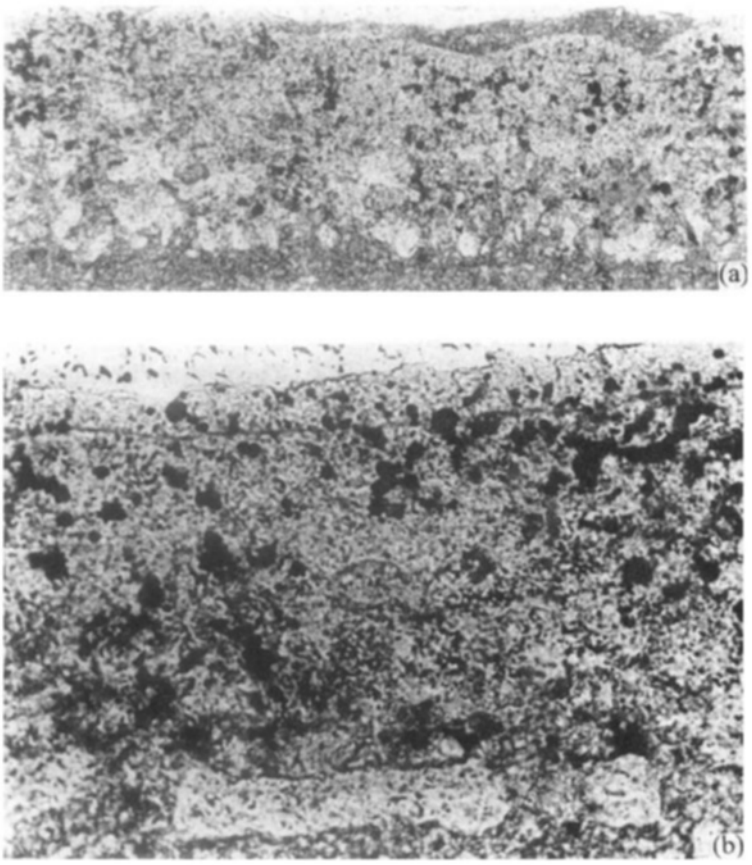

Fig. 2. Thin sections of vertebrate exoskeleton from Middle Ordovician of Inner Mongolia. (a) ×180; (b) ×450.

Astraspis, *Eriptychius*, *Pycnaspis*, and an unnamed vertebrate whose hard tissue has bone cell lacunae[5]. The Anzaldo Formation of Bolivia yielded *Sacabambaspis* and *Andinaspis*[7, 8]. Despite of the incomplete nature, the specimen of Inner Mongolia can be referred to vertebrates by its histological structure. Its age is the early Middle Ordovician (Llanvirn), the same as that of *Arandaspis* and *Porophoraspis*. Therefore, China is the fourth locality of Ordovician vertebrates, and our specimen is one of the two earliest vertebrate records in the world.

These Ordovician vertebrates also have some significance in the paleobiogeographic interpretation. According to Scotese's paleogeographic reconstruction[10], in Ordovician, Australia and South America as parts of Gandwana, were supposed to be separated from North America which was a part of Laurentia. With the evidence of Ordovician vertebrates, Gagnier[8] suggested a more compact reconstruction of Pangea type, with a closed paleo-Pacific Ocean, to explain the paleogeographic distribution of the Ordovician vertebrates. The discovery of Inner Mongolia may suggest the proximity of China to Gandwana (specifically Australia) in Ordovician times, and China was not an isolated continent at that time. In addition, our discovery confirms a phenomenon that all Ordovician vertebrate records fall within the warm Ordovician zones, near the paleoequator, if we follow Scotese's reconstruction of paleolatitudes.

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