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The First Record of a Pterosaur from the Early Cretaceous Strata of Öösh (Övörkhangai; Mongolia)

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ABSTRACT

Although dinosaur fossils are common in the Early Cretaceous strata of Öösh, remains of other vertebrates are rare. Here we describe the first pterosaur fossil known from this locality. The specimen consists of a single vertebra that exhibits sufficient morphology to identify it as a nonazhdarchid tapejaroid pterosaur. Remains of such animals have been found in similarly aged rocks (some with accompanying similar faunas) throughout central Asia.

INTRODUCTION

During the 2000 field season of the Mongolian Academy–American Museum of Natural History Expedition to Mongolia, an isolated pterosaur cervical vertebra was collected from the Öösh locality in Övörkhangai Aimag. This vertebra represents the first record of pterosaurs at Öösh and the first pterosaur specimen collected by the Mongolian Academy of Sciences–American Museum of Natural History joint paleontological expeditions. Pterosaurs were previously known from only three localities in Mongolia (Unwin and Bakhurina, 2000). Tatal, in western Mongolia, has yielded the Early Cretaceous (Berriasian–Valanginian) remains of the dsungaripterid ‘‘*Phobetor*’’ *parvus* (genus name preoccupied), Hüren Dukh, in eastern Mongolia, has yielded a large Early Cretaceous (Aptian–Albian) ornithocheirid, and Bakhar in central Mongolia has yielded a small, Middle Jurassic nonpterodactyloid, possibly anurognathid, pterosaur (Unwin and Bakhurina, 2000).

The Öösh locality was discovered in 1922 by Walter Granger of the AMNH Central

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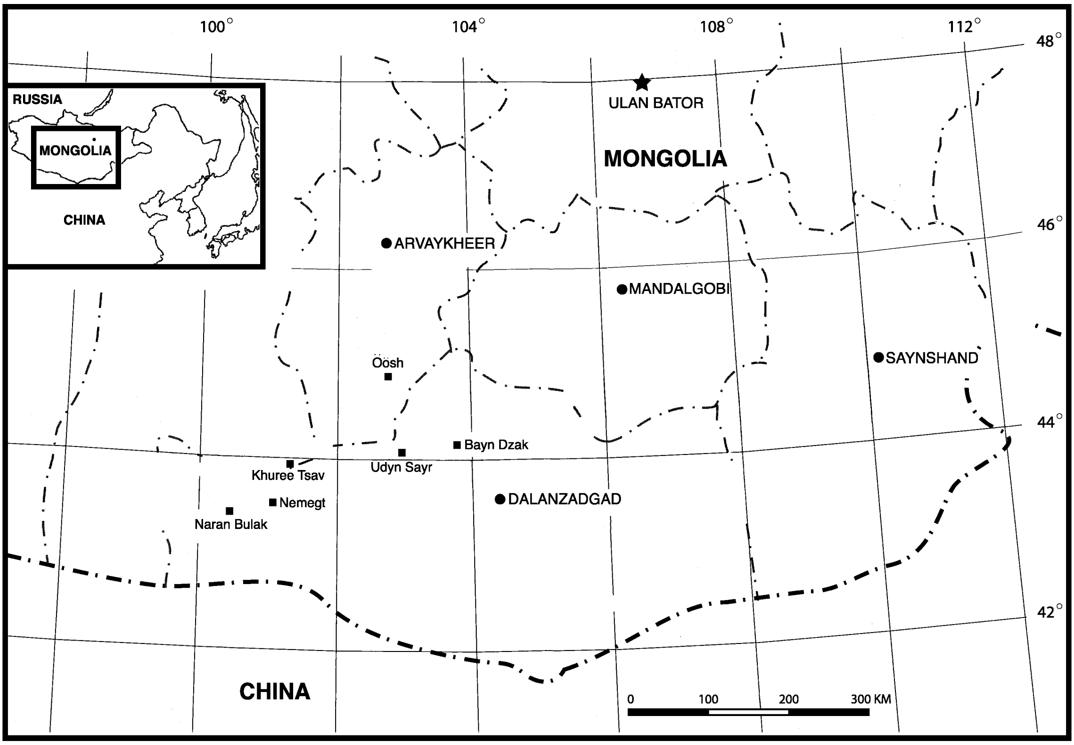

Fig. 1. Map of Mongolia showing the geographical relationship of the Öösh locality to other Gobi fossil localities (modified from Watabe and Suzuki, 2000).

Asiatic Expeditions (Andrews, 1932; see Watabe and Suzuki, 2000: fig. 1) (see fig. 1 herein). It consists of a desert hollow that lies about 40 km north of the Artsa Bogdo Range and 64 km west of the type section of the Djadokhta Formation at Bayn Dzak (“The Flaming Cliffs”), in the Altai region of central Mongolia (Berkey and Morris, 1927). Exposures stretch about 13 km from north to south, at least 24 km from east to west, and are dominated by a 3-km-long red mesa capped by basalt (Berkey and Morris, 1927). In 1922, the badlands of this area produced the holotype specimens of *Psittacosaurus mongoliensis*, the sauropod *Asiatosaurus mongoliensis*, and the theropod *Prodeinodon mongoliense* (Andrews, 1932). Gobiconodontids have subsequently been recovered from this locality (Rougier et al., 2001) as well as several other undescribed types of dinosaurs (Norell, personal commun.).

INSTITUTIONAL ABBREVIATIONS: AMNH, American Museum of Natural History; IGM, Institute of Geology Mongolia.

ANATOMICAL ABBREVIATIONS: mh, median hypapophysis; nc, neural canal; ns, neural spine; pe, postexapophysis; pf, pneumatic foramen; po, postzygaphophysis; pr, postzygapophysis.

GEOLOGICAL CONTEXT

Öösh contains the type section and only locality of the Öösh Formation, an approximately 600-m-thick Early Cretaceous succession of red claystones, red sandstones, and black paper-shales (Berkey and Morris, 1927). The claystones and sandstones were interpreted as the sediments of a large alluvial fan deposited at the foot of an ancient mountain range, and the dark paper-shales as shallow lake sediments deposited at the foot of the developing fan system (Berkey and Morris, 1927). These strata lie uncomformably on top of the folded and partially metamorphosed rock floor of the Gobi region (Berkey and Morris, 1927). The rock units are slightly tilted and cut by numerous north-

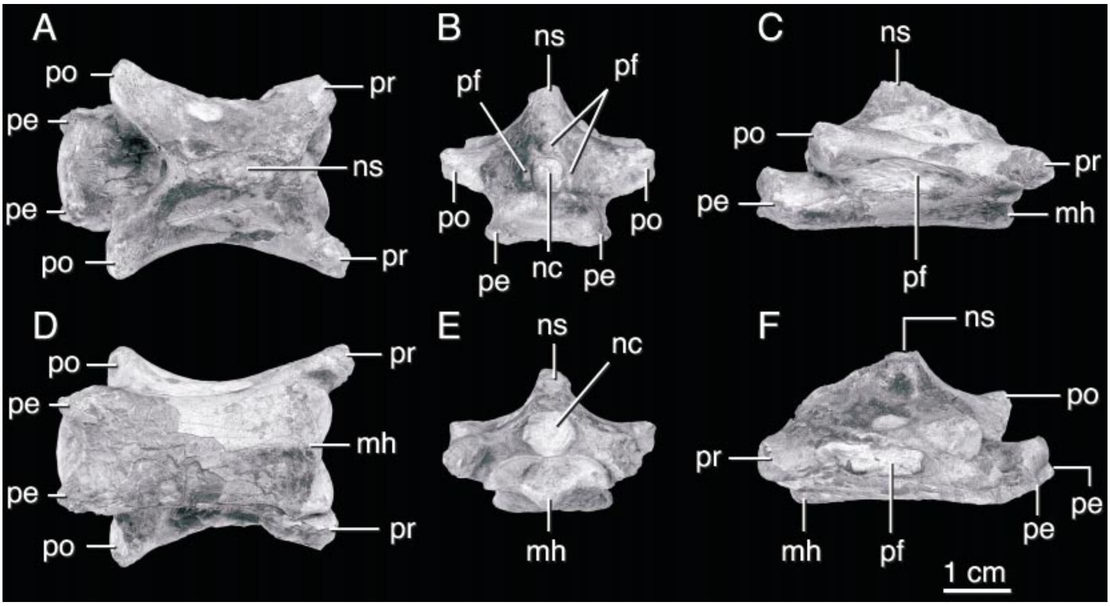

Fig. 2. Photograph of IGM 100/1321 in **A,** dorsal; **B,** posterior; **C,** right lateral; **D,** ventral; **E,** anterior; and **F,** left posterolateral view. See text for a list of abbreviations. Scale equals 1 cm.

ward-striking normal faults (Berkey and Morris, 1927). In the Russian literature, the Öösh Formation is called the Tevsh Formation (see Jerzykiewicz, 2000). The Öösh Formation has most often been assigned to the Hüteeg Svita, Hüteeg Gorizont (Aptian–Albian), but, more recently authors have assigned it to the Öndörukhaa Svita, Tsagaantsav Gorizont (Berriasian-Valanginian) (Maryanska, 2000; Shuvalov, 2000).

The pterosaur vertebra comes from the ‘‘cannonball’’ beds (as defined in Berkey and Morris, 1927), a concretionary zone which forms the lowest part of the Öösh Formation. These beds are nearly 60 m thick and are composed of greenish-gray sandstones and siltstones that alternate with red siliceous clays and red concretionary sandstones (Berkey and Morris, 1927). These beds yielded the holotype of *Psittacosaurus mongoliensis*. The vertebra was found as surface float in the green siltstones.

The occurrence of Psittacosaurus is indicative of a *Psittacosaurus* bochron (Lucas, 2001). As Psittacosaurus is a ubiquitous fossil in radiometrically aged Early Cretaceous rocks throughout Asia, its established range is ‘‘Barremian to Aptian or possibly too as young as early Albian’’ (Lucas, 2001: 170).

SYSTEMATIC PALEONTOLOGY

PTEROSAURIA KAUP, 1834

PTERODACTYLOIDEA PLIENINGER, 1901

DSUNGARIPTEROIDEA YOUNG, 1964

ORNITHOCHEIROIDEA SEELEY, 1870

Tapejaroidea Kellner, 1989 incertae sedis
Figure 2

DESCRIBED MATERIAL: IGM 100/1321 middle-series cervical vertebra with the dorsal portion of the neural spine missing.

LOCALITY AND HORIZON: ‘‘Cannonball’’ beds of the Öösh Formation (type area). Altai region, Övörkhangai Aimag, central Mongolia fig. 1).

AGE: Early Cretaceous (Berriasian–Valanginian or Aptian–Albian).

DESCRIPTION: IGM 100/1321 measures 41.3 mm long, 20.1 mm at its middle width, and has a preserved height of 20.4 mm. As in all pterosaurs, this vertebra is procoelous, and as in all pterodactyloids, it lacks cervical rib facets. The body of the centrum is dor-

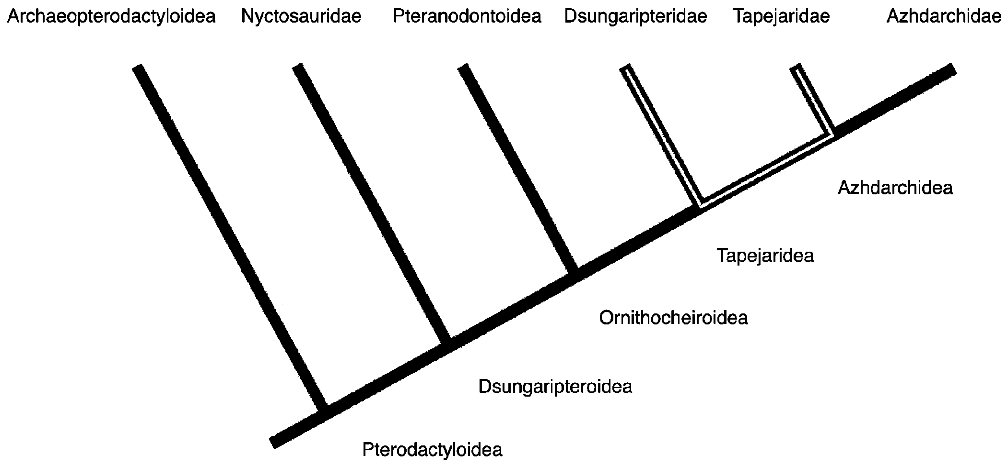

Fig. 3. Cladogram illustrating the phylogenetic relationships of the Pterodactyloidea as presented by Kellner (1996). The possible placement of the midcervical vertebrae, IGM 100/1321, is represented by the solid white lines. These lines mark the distribution of midcervical vertebrae with tall and bladelike neural spines, lateral pneumatic foramina, and postexapophyses within the Pterodactyloidea.

soventrally compressed and constricted in its midsection. The lateral sides of the centrum are laterally excavated to house elliptical, presumably pneumatic, foramina. The concave anterior cotyle does not extend beyond the level of the anterior margin of the prezygapophyses, is separated from the prezygapophyses by a pair of troughs, and has a median hypapophysis projecting from its ventral margin. The convex posterior condyle, however, does extend beyond the level of the posterior margin of the postzygapophyses and has a pair of blunt postexapophyses projecting from its ventral margin. The neural arch is completely fused to the centrum.

The transverse process is constricted in midsection and is inclined anteroventrally with respect to the centrum. The articular facets of the postzygapophyses are steeply oriented lateroventrally, while the articular facets of the prezygapophyses are not preserved. Anteriorly, the neural canal is circular and lacks adjacent lateral pneumatic foramina. Posteriorly, the canal is subrectangular, laterally flanked by a small pair of dorsoventrally oriented fossae containing even smaller pneumatic foramina, and bordered dorsally by a small circular pneumatic foramen.

The dorsalmost part of the neural spine is missing. From the preserved portion, it is possible to determine that the spine ran the entire length of the neural arch, was relatively wide, and had a constant width along its length. Among existing pterosaur middle-series cervical neural spine morphologies, the preserved neural spine best corresponds with a tall and bladelike neural spine. The width of the neural spine at its break suggests that it extended to a much greater height than the low, or extremely low, neural spines of some pterosaurs. The constant width of the preserved neural spine in IGM 100/1321 corresponds more to the bladelike morphology found in most pterosaurs, rather than to the spike-shaped spines that decrease in width anteriorly, or the ridgelike spines that decrease in width toward their midsections found in other pterosaurs.

DISCUSSION

In the context of the phylogenetic analysis of Kellner (1996), an examination of the character states that can be determined in IGM 100/1321 identifies it as a nonazhdarchid tapejaroid (see fig. 3). This placement includes only taxa that are contained in the family Dsungaripteridae or the family Tapejaridae. A relatively short vertebral body and the presence of lateral pneumatic foramina identify this vertebra as belonging to a nonazhdarchid dsungaripteroid pterosaur, and the presence of postexapophyses identifies this vertebra as belonging to an ornithocheiroid pterosaur. Bennett (1994) reported that the pneumatic foramina lateral to the neural canal found in this specimen is also an ornithocheiroid synapomorphy. The only ornithocheiroids with tall and bladelike neural spines, as suggested by the preserved portion of the spine, belong to either the Dsungaripteridae or the Tapejaridae. Tall and bladelike neural spines are absent in the other two taxa within the Ornithocheiroidea, the Pteranodontoidea and the Azhdarchidae. Within the Pteranodontoidea the neural spines are spikelike, and within the Azhdarchidae the neural spines form extremely low ridges. If the characters of the neural spine are not considered, this vertebra would be placed as a nonazhdarchid ornithocheiroid.

To date, the tapejarids are known from the Early Cretaceous Santana Formation of Brazil (Kellner and Tomida, 2000) and the Early Cretaceous Jiufotang Formation of Liaoning Province of northeast China (Wang and Zhou, 2002). The dsungaripterid ''*Phobetor*'' *parvus* from Tatal in western Mongolia and *Dsungaripterus weii* and *Noripterus complicidens* from the Junggar Basin of Xinjiang of northwest China have also been reported from the Early Cretaceous of central Asia (Unwin et al., 2000). Like the Öösh vertebra, the dsungaripterid ''*Phobetor*'' *parvus* from Tatal, Mongolia, was found in the same sediments as *Psittacosaurus*, sauropod, and theropod remains (Bakhurina, 2001). Based on the morphology of the Öösh vertebra and its occurrence in Early Cretaceous sediments of central Asia, it is likely that it represents a dsungaripterid pterosaur.

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