First Record of a Basal Neoceratopsian Dinosaur from the Late Cretaceous of Kazakhstan

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First record of a basal neoceratopsian dinosaur from the Late Cretaceous of Kazakhstan

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The oldest known ceratopsians come from the Late Jurassic of China (Zhao et al. 1999; Xu et al. 2006). During the Early Cretaceous, the basal ceratopsian *Psittacosaurus* was among the most common dinosaurs in Asia but more derived basal neoceratopsians were quite rare on that continent (Xu et al. 2002; Makovicky and Norell 2006). Basal neoceratopsians became more abundant in the Late Cretaceous of Mongolia and China, although they are not known in this region from the latest Cretaceous (You and Dodson 2004; Alifanov 2008). In contrast, basal neoceratopsians are rare during the Early Cretaceous in North America but became common and diverse during the Campanian and Maastrichtian (You and Dodson 2004; Chinnery and Horner 2007). Little is known about the evolutionary history of this group in more inland regions of what are now Kazakhstan and adjoining countries. *Asiaceratops* documents the presence of basal neoceratopsians in the Cenomanian of Uzbekistan (Nessov et al. 1989). Here we report on the first record of a basal neoceratopsian in the Late Cretaceous of Kazakhstan, based on two cranial bones from the Turonian Zhirkindek Formation in the northeastern Aral Sea region.

Introduction

In the northeastern Aral Sea region of Kazakhstan, two major stratigraphic units have yielded remains of Late Cretaceous vertebrates: the Turonian Zhirkindek Formation and the Santonian–?Campanian Bostobe Formation (Nessov 1995, 1997; Kordikova et al. 2001; Dyke and Malakhov 2004; Averianov 2007). Strata of the Bostobe Formation are more widely distributed than those of the Zhirkindek Formation, exposures of which are confined to the area around the Tyul'kili hill. Lev Nessov prospected this locality in 1982 and found, along with skeletal remains of other dinosaurs and crocodylians, two bones of a neoceratopsian dinosaur, which have remained unrecognized for 26 years and are here reported for the first time.

Institutional abbreviation.—ZIN PH, Paleoherpetological collection, Zoological Institute, Russian Academy of Sciences, Saint Petersburg, Russia.

Systematic paleontology

Dinosauria Owen, 1842

Ornithischia Seeley, 1887

Ceratopsia Marsh, 1890

Neoceratopsia Sereno, 1986

Neoceratopsia indet.

Figs. 1, 2.

Material.—ZIN PH 1/111, incomplete right frontal (locality TUL-4, 1982; Fig. 1). ZIN PH 2/111, incomplete right postorbital (locality TUL-72, 1982; Fig. 2). The bones were found at two different sites (TUL-4 and TUL-72) and most likely do not represent a single individual.

Locality and horizon.—Tyul'kili (= Kankazgan; localities bear the prefix TUL, as above). An isolated hill about 80 km north of Dzhusaly (also known as Zhosaly or Jhosaly) station, northeastern Aral Sea region, Kazakhstan. Grey clays and sands of the Zhirkindek Formation, Late Cretaceous (Turonian).

Frontal.—The frontal is flat, thick, and narrow, with facets or borders for the nasal and prefrontal anteriorly, the left frontal medially, the parietal posteriorly, the supratemporal fenestra posterolaterally, the postorbital laterally, and forming the dorsal margin of the orbit anterolaterally. In ZIN PH 1/111, the sides that form the margin of the supratemporal fenestra and contact the postorbital are broken off. The sutural contact with the left frontal is chipped off from the anterior and middle portions of the bone but is complete posteriorly. The medial margin of the bone is straight. The anterior end of the frontal is triangular, and most of its dorsal surface bears a deep notch for the nasal. The facet for the prefrontal occupies a much smaller area on the bone compared with that for the nasal, but its width is similar to that of the nasal facet. A short, thin portion on the lateral side between the facet for the prefrontal and the thicker area for contact with the postorbital apparently forms the free orbital margin. The short posteromedial margin of the frontal is oblique, indicating that an anteromedian process of the parietals was wedged between the frontals. The suture for contact with the parietal is complete and sharply decreases in depth posteriorly. The dorsal surface of the frontal along the missing margin of the supratemporal fenestra is depressed, indicating the presence of a short frontal depression in this region. The frontal is thickest in the region above the rather low crista cranii. Only a small portion of the orbital roof is preserved. The ventral impression for the cerebral hemisphere is small.

Postorbital.—The postorbital (ZIN PH 2/111) is a flat bone, with contacts for the frontal medially, the laterosphenoid ventro-

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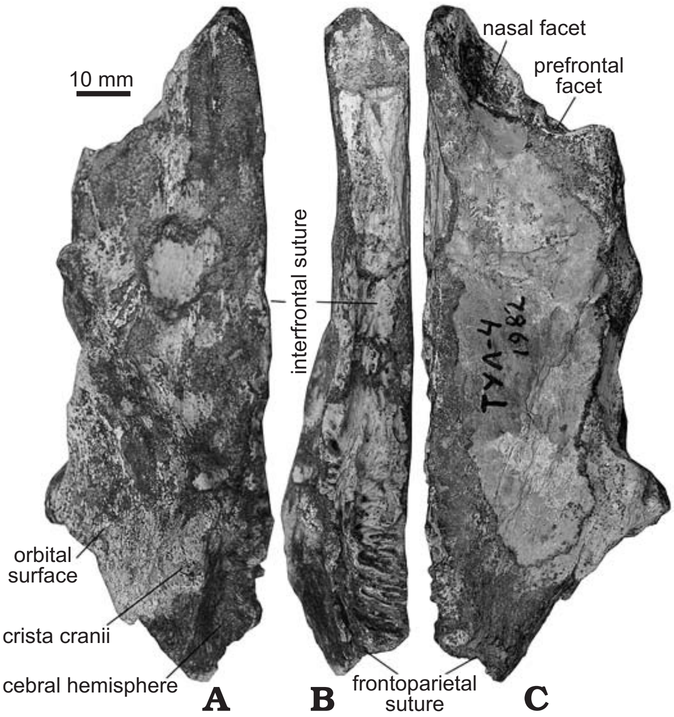

Fig. 1. Neoceratopsia indet., from the Zhirkindek Formation (Late Cretaceous: Turonian), Tyul'kili hill, northeastern Aral Sea region, Kazakhstan. ZIN PH 1/111, right frontal in ventral (**A**), medial (**B**), and dorsal (**C**) views.

medially, and the jugal ventrally. It forms the posterodorsal margin of the orbit and the anterolateral margin of the supratemporal fenestra. The bone lacks most of the ventral process for contact with the jugal. The short suture for the postorbital is completely preserved; a deep recess near the posterior margin indicates the presence of a spine-like articular process on the frontal. Posterior to this recess, a medially facing, L-shaped, and concave facet contacted the laterosphenoid. The anterior side of the postorbital is formed by the deeply concave orbital surface. The anterior end of the bone is elevated above the level of the supratemporal fenestra. There is no trace of a supraorbital horn. The lateral surface of the postorbital is rugose, as in *Protoceratops* (Brown and Schlaikjer 1940: figs. 11–13) and *Leptoceratops* (Brown and Schlaikjer 1942: fig. 1). The posterior and ventral portions of the bone form a flat, nearly vertical plate. The dorsal rim of the postorbital, which forms the lateral margin of the supratemporal fenestra, is thicker than the ventral plate. On the dorsal surface of the postorbital, a shallow, anteriorly tapering groove is probably the facet for the anterior process of squamosal.

Discussion

The structure of the frontal ZIN PH 1/111 is plesiomorphic for neoceratopsians: it is paired, narrow, and exhibits a weakly delimited frontal depression, which surrounds the margin of the supratemporal fenestra, much as in *Yinlong* and *Liaoceratops* (Xu et al. 2002, 2006). In more derived basal neoceratopsians, the frontal is shorter and wider, with a more extensive frontal depression, and the ridge delimiting this depression extends transversely (Chinnery 2004: fig. 3A; You and Dodson 2004). In its overall proportions, ZIN PH 1/111 most closely resembles the frontal of *Bagaceratops* (Fig. 3). In *Bagaceratops rozhdestvenskyi*, the frontals are fused in the holotype but are paired in a larger referred specimen (Maryańska and Osmólska 1975: figs. 6A, 9A).

Previously identified synapomorphies permit the plate-like postorbital to be confidently identified as that of a neocerato-

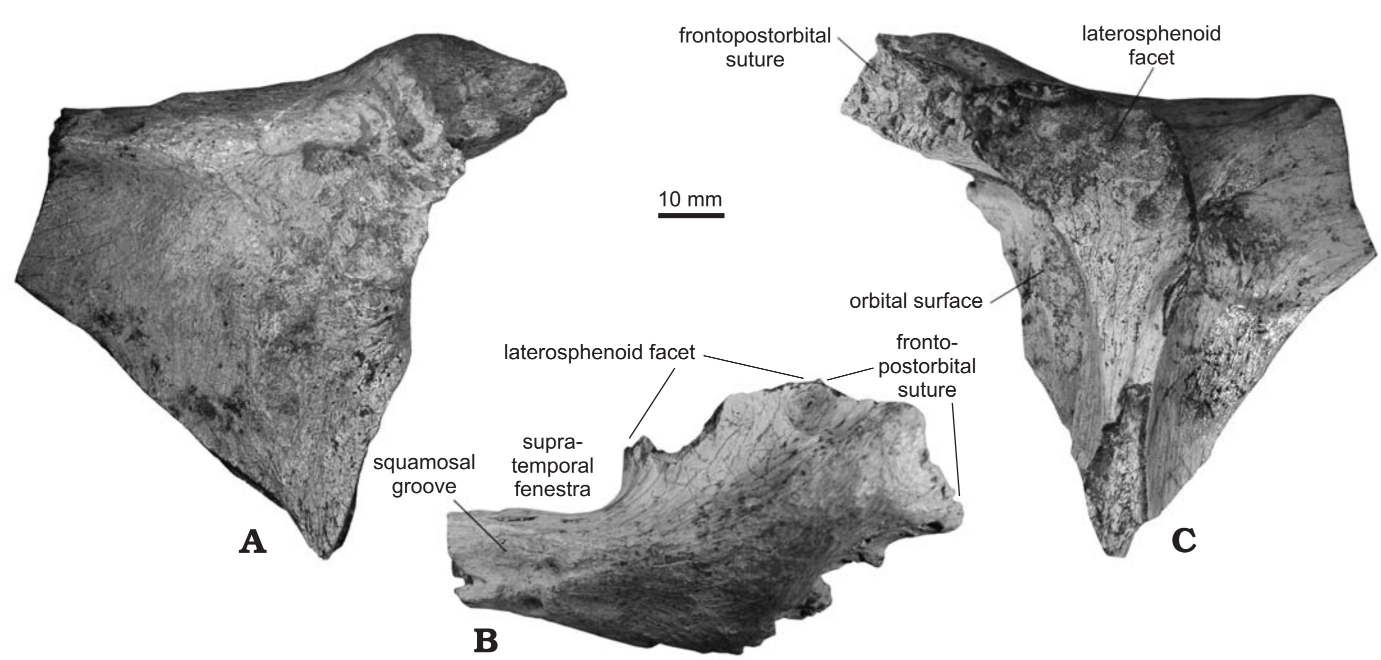

Fig. 2. Neoceratopsia indet., from the Zhirkindek Formation (Late Cretaceous: Turonian), Tyul'kili hill, northeastern Aral Sea region, Kazakhstan. ZIN PH 2/111, right postorbital in lateral (**A**,) dorsal (**B**), and medial (**C**) views.

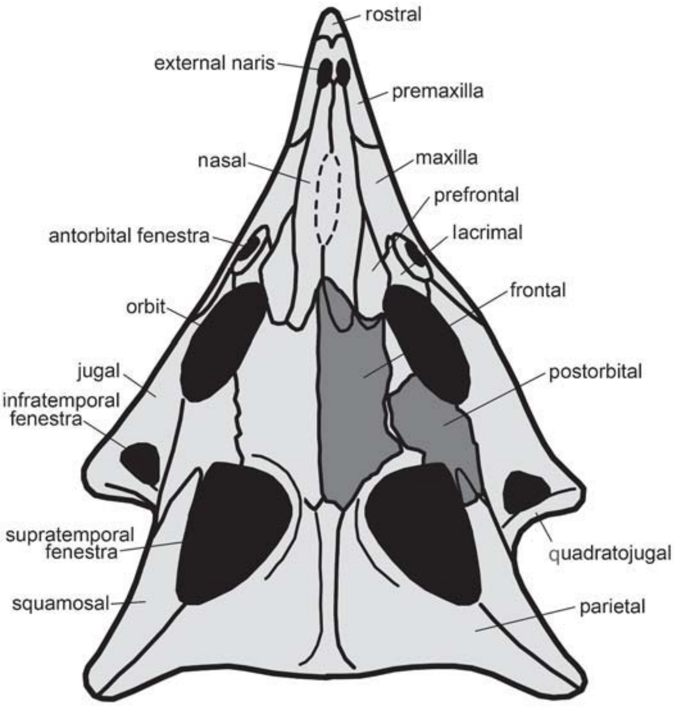

Fig. 3. Outlines of the frontal and postorbital ZIN PH 1/111 and 2/111 (shown in dark grey) superimposed on the skull of *Bagaceratops rozhdestvenskyi* in dorsal view (after Maryańska and Osmólska 1975: fig. 6A).

psian (Xu et al. 2002: character 24; Makovicky and Norell 2006: character 32). It is plate-like, unlike the inverted L-shaped postorbital of more basal ceratopsians. Particularly, ZIN PH 2/111 closely resembles the isolated postorbital of *Prenoceratops* from the Campanian Two Medicine Formation of Montana, USA, described and figured by Chinnery (2004: fig. 4A–C), differing mainly in the larger facet for the laterosphenoid. A plesiomorphic feature of ZIN PH 2/111 is the anterior extension of the squamosal onto the postorbital, which more closely resembles the condition of *Psittacosaurus* (e.g., Averianov et al. 2006) than that in basal neoceratopsians. The absence of the supraorbital horn excludes the Tyul'kili neoceratopsian from the clade *Zuniceratops* + Ceratopsidae (Xu et al. 2002; Makovicky and Norell 2006).

The cranial bones from Tyul'kili cannot be assigned to any known taxon of basal Neoceratopsia. They most likely do not belong to a single individual, and it cannot even be established that they represent the same taxon. Both bones come from to a rather large form, comparable in size to *Udanoceratops* from the Campanian Djadokhta Formation of Mongolia (Kurzanov 1992). The preserved length of the frontal ZIN PH 1/111 is 128 mm and that of the postorbital ZIN PH 2/111 is 71 mm. Unfortunately, the frontal and the postorbital are still unknown for *Udanoceratops*.

The bones reported here document for the first time the presence of a basal neoceratopsian in the Zhirkindek Formation and represent the first record for this group from the territory of Kazakhstan. The previously known dinosaurian record from this stratigraphic unit included indeterminate remains of Tyrannosauridae, Ornithomimidae, Therizinosauroidea, Dromaeosauridae, Sauropoda, and Hadrosauridae (Nessov 1995; Averianov 2007). The age of the Zhirkindek Formation is considered Turonian (Nessov 1995, 1997; Kordikova et al. 2001; Averianov 2007). To the south, in the Kyzylkum Desert of Uzbekistan, basal neoceratopsians were abundant during the Cenomanian, but rare during the Turonian when they may have been replaced ecologically by the basal ceratopsid *Turanoceratops* (Nessov et al. 1989; Nessov 1995; Sues and Averianov 2009). Additional discoveries are needed to reconstruct the evolutionary history of neoceratopsian dinosaurs in Middle Asia and Kazakhstan.

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