Protoceratopsian embryos from Inner Mongolia, People's Republic of China

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New protoceratopsid fossils from Bayan Mandahu include the smallest specimens of *Protoceratops* and *Bagaceratops* recovered to date. None of these specimens were found associated with dinosaur eggshells, but all are small enough to fit within any of the eggs that have been attributed to protoceratopsians. It is concluded that they represent embryonic dinosaurs. No specimens are complete, but together they allow a better understanding of the cranial anatomy of the embryos.

The absence of embryos in the thousands of eggs collected from Cretaceous sediments of China and Mongolia may represent a taphonomic condition whereby embryos were destroyed by the decomposing contents of the eggs. If this is correct, embryonic dinosaurs from central Asia may only have been preserved when the eggs were broken so that the liquid contents drained.

Les nouveaux fossiles de Protocératopsidiens trouvés à Bayan Mandahu incluent les plus petits spécimens de *Protoceratops* et de *Bagaceratops* découverts jusqu'à nos jours. Aucun de ces spécimens n'a été trouvé associé à des coquilles d'oeuf de dinosaures, mais ils sont tous suffisamment petits pour être contenu à l'intérieur de n'importe lequel des oeufs qui ont été reconnus comme appartenant aux Protocératopsidiens. Nous concluons qu'ils représentent des dinosaures embryonnaires. Aucun des spécimens n'est complet, cependant leur ensemble permet une meilleure compréhension de l'anatomie crâniale des embryons.

L'absence d'embryons à l'intérieur des milliers d'oeufs livrés par les sédiments crétacés de la Chine et de la Mongolie reflète vraisemblablement des conditions taphoniques qui favorisaient la destruction des embryons par les produits de la décomposition des substances que contenaient les oeufs. Si cette interprétation est exacte, les dinosaures embryonnaires de l'Asie centrale ont pu être préservés, seulement, parce que leurs oeufs furent brisés et que leurs substances liquides furent drainées.

[Traduit par la rédaction]

在巴彦满达呼发现的原角龙类化石包括了迄今为止最小的 Protoceratops 和 Bagaceratops 标本。所有这些标本都没有与恐龙蛋壳共生的现象，但是它们的个体之小都足以容纳人任何一个目前归属于原角龙类的蛋化石中。因此可以肯定，这些标本代表了恐龙的胚胎。尽管这些标本都不完全，但它们在总体上使我们对胚胎的脑颅构造解剖有了一个更好的了解。

在中国和蒙古白垩纪地层中发现的数千个恐龙蛋都不包含化石胚胎。这可能是因为当时的埋藏条件导致蛋中成分的分解，从而破坏了胚胎的保存。倘若如此，恐龙胚胎在中亚地区得以保存的唯一条件是恐龙蛋破裂而使其中的液体流出。

[译文由杂志社提供]

Новые ископаемые остатки protoceratopsid из отложений Баян Мандаху включают самые маленькие экземпляры Protoceratops и Bagaceratops, обнаруженные к настоящему времени. Ни один из этих экземпляров не был найден в ассоциации со скорлупой яиц динозавров, но все они довольно небольшого размера, чтобы вмещаться в любое из яиц, отнесенных к protoceratopsians. Сделано заключение, что они представляют собой эмбрионы динозавров. Нет ни одного полного экземпляра, но их совокупность позволяет лучше понять анатомию черепа эмбрионов.

Отсутствие эмбрионов в тысячах яиц, собранных в меловых осадках Китая и Монголии может характеризовать таксономические условия, обусловившие разрушение эмбрионов

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при разложении содержимого яиц. Если это верно, эмбрионы динозавров центральной части Азии могли сохраняться только в случае разбитых яиц при высыхании их жидкого содержимого.

[Перевод выполнен для редакции Научно-Исследовательские Журналы]

Introduction

The first protoceratopsian was described by Brown (1914) from the Scollard Formation of Alberta, Canada. *Leptoceratops gracilis* remained poorly known until subsequent descriptions by Sternberg (1951) and Russell (1970). A second species, from the St. Mary River Formation of Montana, was referred to this genus by Brown and Schlaikjer (1942), but Sternberg (1951) used this specimen to establish *Montanoceratops*.

Between 1922 and 1925 (Andrews 1932), the Central Asiatic Expeditions of the American Museum of Natural History recovered numerous skeletons of *Protoceratops andrewsi* at the Flaming Cliffs (Bayn Dzak) of Mongolia, a source that has proven to be rich for other expeditions (Efremov 1954; Gradzinski and Jerzykiewicz 1972; Maryańska and Osmólska 1975). In 1930, a Sino-Swedish expedition recovered *P. andrewsi* remains from a site in northern China that they referred to as Ulan Tsonchi (Bohlin 1953).

A second species of *Protoceratops* was described by Maryańska and Osmólska (1975) from the Barun Goyot Formation of Mongolia, but has been designated as a distinct genus by Kurzanov (1990). *Breviceratops kozlowskii*, as the name suggests, has a shorter face than similar sized specimens of *Protoceratops*.

Bohlin (1953) described two species of *Microceratops* from northern China, although only *Microceratops gobiensis* is presently considered to be valid (Dodson and Currie 1990). Additional specimens from Mongolia were described by Maryańska and Osmólska (1975), who also established *Bagaceratops rozhdestvenskyi* from the Barun Goyot at Khermeen Tsav in Mongolia.

Nessov et al. (1989) established a new form of protoceratopsian, *Asiaceratops salsopaludalis*, from Cenomanian or Early Turonian beds of the southwestern Kyzyl Kum desert of Uzbekestan.

Udanoceratops tschizhovi is the most recently described, and the largest, protoceratopsian. It came from Djadokhta redbeds of southernmost Mongolia (Kurzanov 1992).

During the summer of 1988 and 1990, members of a Sino-Canadian expedition collected large numbers of protoceratopsians at Bayan Mandahu, Inner Mongolia, 25 km west of the Sino-Swedish site of Ulan Tsonchi (near the modern village of Bayan Tu). Protoceratopsian embryos, juveniles, and adults are represented by 29 skulls, which range in size from 2 cm to almost 1 m. Additional specimens from this site are in the collections of the Inner Mongolia Museum in Hohhot. Most Bayan Mandahu protoceratopsians seem to be referable to *Protoceratops*, but some represent *Bagaceratops* and the giant *Udanoceratops*. The presence of several protoceratopsians at the same site might mean that some of these taxa are synonymous, or it might show that the strata at Bayan Mandahu represent more than one time or ecosystem.

Ontogenetic series of protoceratopsians, including many immature specimens, have been described (Brown and Schlaikjer 1940; Kurzanov 1972; Maryańska and Osmólska 1975; Dodson 1976). An immature specimen has also been figured, but not described, by Barsbold and Perle (1983). In this paper we will describe even younger specimens. The descriptive section of this paper is restricted to features used to establish the identity of the juveniles from Bayan Mandahu.

Dinosaur eggs from Central Asia were first identified in 1923 from the Flaming Cliffs of Bayn Dzak (Andrews 1932), although one had actually been discovered at the same locality the previous year but had gone unrecognized. Because *P. andrewsi* was so common at this site, it was assumed that all but one of the eggs were laid by this species (Andrews 1932; Brown and Schlaikjer 1940). However, Van Straelen (1928) suggested the eggs were laid by two distinct taxa. Examination of the specimens in the collections of the American Museum of Natural History shows that eggs from at least four distinct taxa were collected at Bayn Dzak. Russian expeditions to Mongolia also recovered a variety of eggs from Bayn Dzak, and Rozhdestvensky (1960) speculated that the largest type of egg may have been laid by ankylosaurs rather than *Protoceratops*. Sochava (1969) examined the microstructure of the eggshell and concluded that the *Protoceratops* eggs might even have been laid by hadrosaurs. More recent studies of eggs and eggshells from Mongolia (Mikhailov 1991; Sabath 1991) have tentatively attributed specific types of eggs to protoceratopsians. Six distinct egg types were found at Bayan Mandahu by the Sino-Canadian expeditions in 1988 and 1990.

Abbreviations

AMNH, American Museum of Natural History, New York; IVPP, Institute of Vertebrate Paleontology and Paleoanthropology, Beijing; ZPAL, Palaeozoological Institute of the Polish Academy of Sciences, Warsaw.

Stratigraphy

Upper Cretaceous, ?Middle Campanian. Djadokhta "Age" of Jerzykiewicz and Russell (1991).

Material

IVPP V9606, a nearly complete skull, collected in June 1988 at Bayan Mandahu by J.-J. Zheng.

IVPP V10605, partial skull found on June 10, 1988, by K. Aulenback (Tyrrell Museum) near Dune Sayr, Bayan Mandahu.

IVPP V10596, quadrate, lower jaws, vertebrae, ribs, humerus, femur, tibia, and other fragments from a single individual. Found on July 12, 1990, in the North Canyon (Map No. 118 of Jerzykiewicz et al. 1993) by X. Chen (IVPP).

IVPP V10604, partial skull, vertebral centra, and rib from a single individual. Found on July 13, 1990, in the North Canyon by L. Hou (IVPP).

Description

IVPP V9606 (Fig. 1) is an almost complete skull, 54 mm long from the rostrum to the quadrate and 50.5 mm between the rostrum and the occipital condyle. This is 7 mm longer than the smallest skull of *Bagaceratops*, but is shorter than the

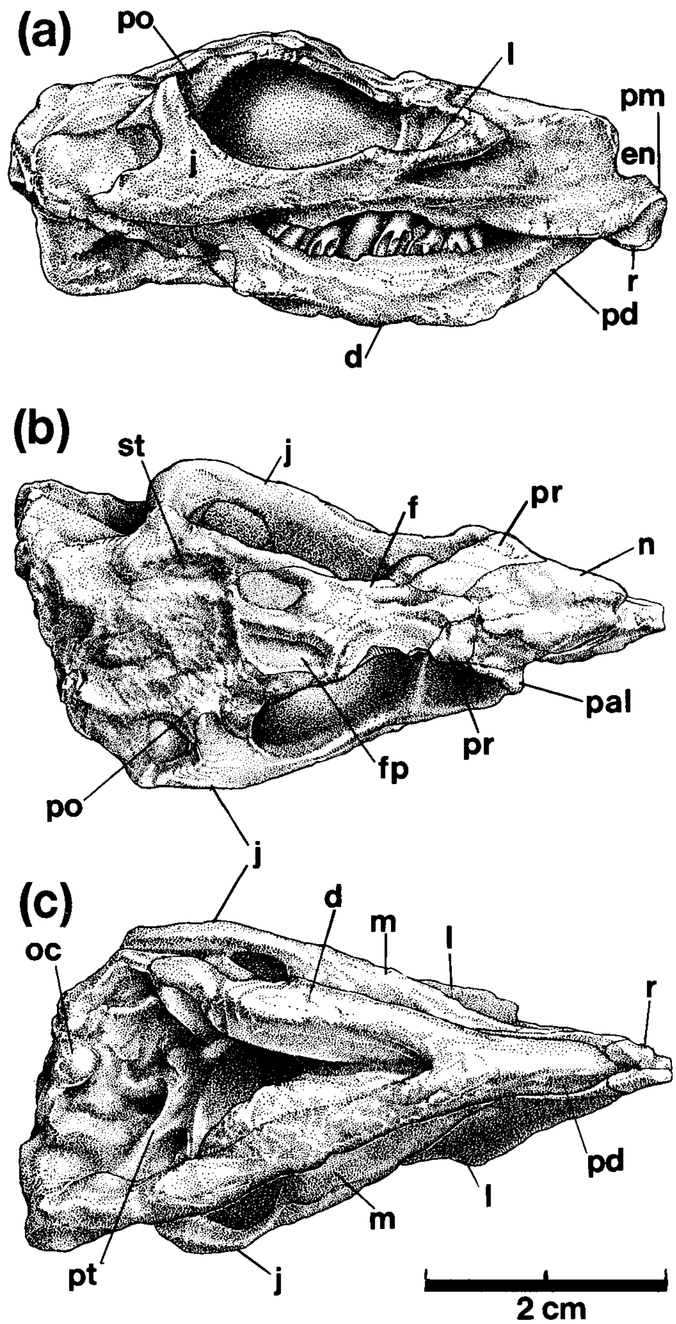

FIG. 1. cf. *Protoceratops andrewsi*, IVPP V9606. Skull in (*a*) right lateral, (*b*) dorsal, and (*c*) ventral views. d, dentary; en, external naris; f, frontal; fp, frontoparietal depression; j, jugal; l, lacrimal; m, maxilla; n, nasal; oc, occipital condyle; pal, palpepral; pd, predentary; pm, premaxilla; po, postorbital; pt, pterygoid; pr, prefrontal; r, rostral; st, supratemporal fenestra.

smallest skull of *P. andrewsi* (ZPAL MgD-I/7, Maryańska and Osmólska 1975). Postmortem deformation has damaged the posterior region of IVPP V9606 on the right side, and there has been some dorsoventral compression. In dorsal outline, the skull is triangular (Fig. 1*b*), as expected in juveniles (Kurzanov 1990), the rostral and predentary bones making up the sharply pointed beak. The orbit is relatively large and, at 17 mm, makes up almost a third of the overall length of the skull. The large size is expected in such an immature individual, as is the rather elongate, rounded shape of the orbit (Kurzanov 1990). An immature skull of *Bagaceratops rozhdestvenskyi* (ZPAL MgD-I/123) has orbits that are nearly two thirds of the basal length of the skull. In IVPP V9606, the occipital region of the skull has been damaged somewhat, but there does not appear to have been much development of the crest.

IVPP V10605 (Fig. 2) represents a smaller individual, although it is not complete enough to give meaningful measurements. The front of IVPP V10605 was lost to erosion, so it is impossible to determine the size of this skull. The maximum anteroposterior crown length of the maxillary teeth are 80% the length of those of IVPP V9606. The foramina for the labial nerves and blood vessels are relatively large. Most of the remaining bones are thin and platelike and generally lack well-defined margins. Those on the right side have been eroded, whereas those on the left side were clearly damaged before burial.

IVPP V10604 (Fig. 3) includes only the front of the skull, but it is a smaller specimen, with a dentary 20.5 mm long. It is better preserved than the others. There are five maxillary teeth and probably five dentary teeth. The posterior region of the maxilla is incomplete, but it was clearly a short, deep bone.

The smallest specimen is IVPP V10596, with a dentary length of 17 mm. Until recently, the smallest published specimen, AMNH 6499, of *Protoceratops* was a dentary 23 mm long.

Sutures cannot be seen clearly on any of the skulls, which is a condition normally indicative of maturity. However, sutures cannot always be discerned on unquestionable juveniles from Bayan Mandahu, so this is probably an artifact of preservation. This was also noted by Brown and Schlaikjer (1940) for specimens from Bayn Dzak. Furthermore, even the most immature specimen of *Bagaceratops* shows midline fusion between the nasals and between the parietals, demonstrating that coossification began early in protoceratopsians. This is also true of *Breviceratops* where the internasal suture disappears in all but the smallest specimens (Kurzanov 1990). A juvenile *Protoceratops* from Mongolia still shows separation between the nasals (Maryańska and Osmólska 1975).

The rostral, a uniquely ceratopsian bone, is situated at the tip of the snout of IVPP V9606 (Fig. 1*a*). It is a small, sharply pointed bone, firmly united to the premaxilla.

The internarial processes of the platelike premaxillae (Fig. 1*a*) were destroyed by erosion in IVPP V9606 and are only partially preserved in IVPP V10604 (Fig. 3). The premaxilla of IVPP V10604 is relatively large in comparison with the maxilla, and it would seem that the allometric growth rate would have been much higher in the maxilla. As in *Bagaceratops*, *Leptoceratops*, and some specimens of *Protoceratops*, the premaxilla is edentulous in IVPP V9606. IVPP V10604 (Fig. 3) has at least one premaxillary tooth. The ventral margin of the premaxilla is concave in lateral aspect, similar to juveniles of *P. andrewsi*. Like *Protoceratops* and *Leptoceratops*, there is no additional antorbital fenestra between the maxilla and premaxilla of IVPP V9606. But like *Bagaceratops* and a juvenile of *Breviceratops* (Kurzanov 1990), it would appear that an additional antorbital fenestra may have been present in IVPP V10604 because the premaxilla is barlike behind the external naris (Fig. 3).

The maxilla has a relatively straight ventral margin in all specimens. Most of the antorbital fossa, a shallow triangular pit, is found on the maxilla and lacrimal (Figs. 1*a*, 3). The edentulous portion of the maxilla is relatively short in IVPP V9606, as in *Protoceratops*, but in contrast with *Bagaceratops*

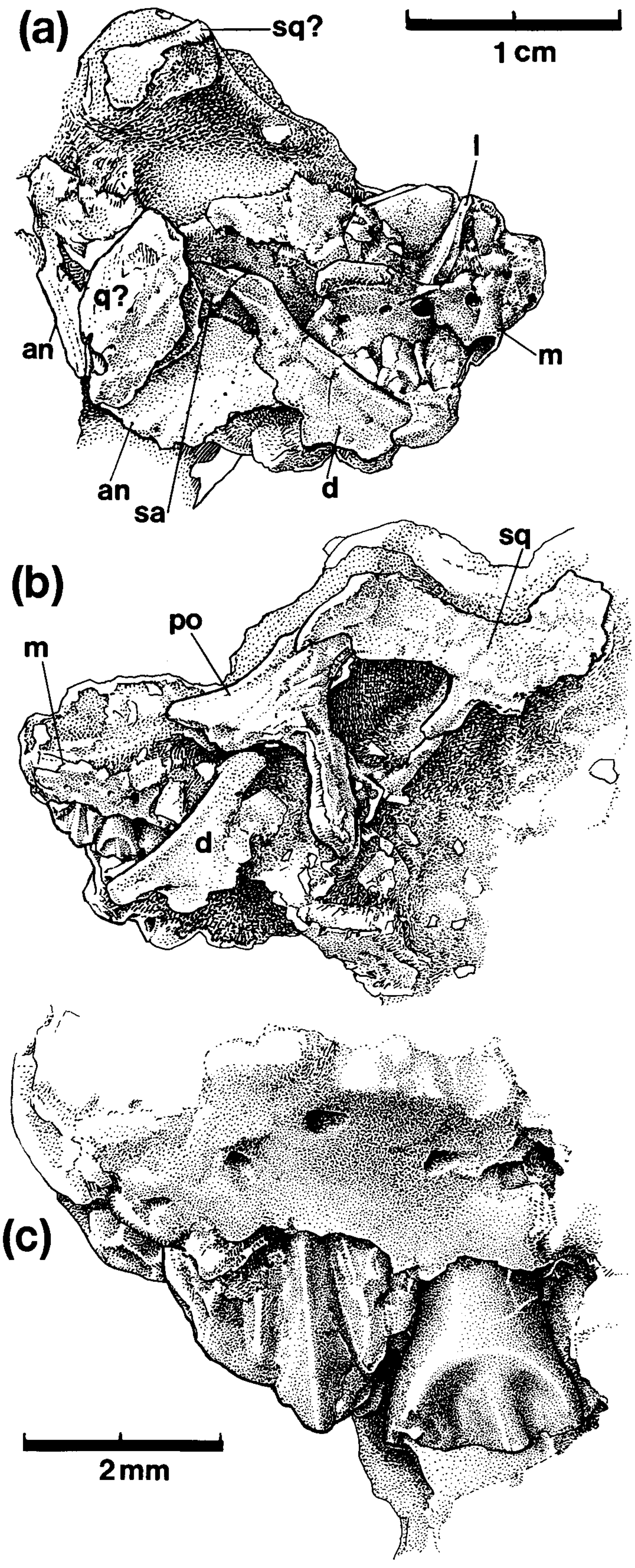

FIG. 2. Protoceratopsian embryo, IVPP V10605. Partial skull in (*a*) right lateral and (*b*) left lateral aspects. (*c*) Enlargement of anteriormost maxillary teeth from left side. an, angular; d, dentary; l, lacrimal; m, maxilla; po, postorbital; q, quadrate; sa, surangular; sq, squamosal.

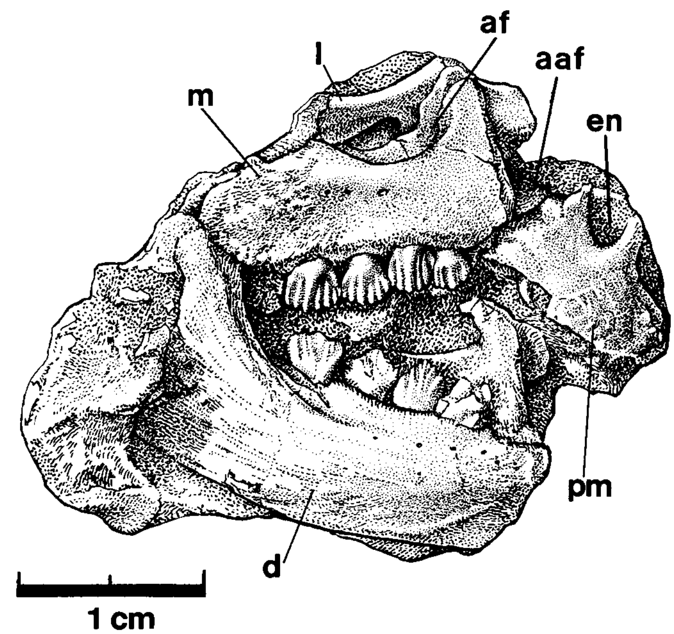

FIG. 3. cf. *Bagaceratops* sp., IVPP V10604. Partial skull of a probable embryo in right lateral aspect. aaf, anterior antorbital fenestra; af, antorbital fossa; d, dentary; en, external naris; l, lacrimal; m, maxilla; pm, premaxilla.

where at least 25% of the maxilla is devoid of teeth (Maryańska and Osmólska 1975). Seven maxillary teeth can be seen in IVPP V9606, but more may be obscured by the coronoid process. At least five teeth were present in IVPP V10604. In IVPP V10605, four maxillary teeth can be seen on the right side (Fig. 2a), and it is doubtful that there were more than five. Seven teeth are found in an immature specimen of *Breviceratops kozlowskii* (ZPAL MgD-I/116), and eight teeth were found in the maxilla of a specimen (ZPAL MgD-I/7) of *P. andrewsi* that is about 10% larger than IVPP V9606. Tooth counts in ceratopsians are not taxonomically meaningful, but do give some indication of the age of an individual because additional tooth rows are added during growth. The teeth are typical for protoceratopsids, and each has a median keel (Fig. 2*b*) on the labial surface extending from base to apex. The keel is posterior to the middle of the tooth. Fine accessory ridges on the labial surface give the distal end of the crown an uneven margin. In IVPP V10604, the accessory ridges are relatively more pronounced in comparison with the median ridge (Fig. 3). To an extent, this can be attributed to the young age of the specimen because larger, more mature specimens from Bayan Mandahu have much greater disparity between median and accessory ridges. However, the disparity is more pronounced in IVPP V9606 (Fig. 1*a*) and IVPP V10605 (Fig. 2*c*) than it is in IVPP V10604, which suggests there may be a taxonomic difference. The maxillary teeth, especially those in the middle part of the maxilla, are more important for taxonomic determination than mandibular teeth (Maryańska and Osmólska 1975). The teeth of *Bagaceratops* and *Protoceratops* are quite similar, but the "pockets" anterior and posterior to the median ridge tend to be deeper in *Protoceratops* and tend to have a broader U shape. Using this criteria, the teeth of IVPP V10604 are similar to those of *Bagaceratops*.

The external surface of the paired nasals is smoothly convex in IVPP V9606, and there is no sign of a median horn core like that seen in all specimens of *Bagaceratops rozhdestvenskyi*, all specimens of *Breviceratops kozlowskii* (Kurzanov 1990), and at least one immature specimen (ZPAL MgD-II/7) of *P. andrewsi* (Maryańska and Osmólska 1975). Most small specimens of *Protoceratops* have broad, flat nasals (Brown and Schlaikjer 1940). All juvenile protoceratopsian specimens have short nasals (Kurzanov 1990).

As in immature specimens of *Bagaceratops* (Maryańska and Osmólska 1975), *Breviceratops* (Kurzanov 1990), and *Protoceratops* (Brown and Schlaikjer 1940), the lacrimal is a thin bone that lies more horizontally than vertically in both IVPP V9606 (Fig. 1*a*) and IVPP V10604 (Fig. 3). Mature specimens have thicker and more vertical lacrimals.

In IVPP V9606, as in all immature specimens of protoceratopsians (Kurzanov 1990), the prefrontal is a relatively larger bone than it is in mature specimens.

The jugal is shallow and elongate. It is a Y-shaped bone with an almost horizontal ventral margin in IVPP V9606. The posterior or quadratojugal process does not turn ventrally to any significant degree (Fig. 1*a*).

The ventral process of the postorbital is obscured by the jugal in IVPP V9696 (Fig. 1*a*) because this part of the skull is telescoped, but it is almost perpendicular to the dorsal ramus in IVPP V10605 (Fig. 2*b*).

As in all small protoceratopsians, the frontal is extensively exposed along the dorsal orbital margin of IVPP V9606 (Fig. 1*b*). There is a pair of shallow pits near the back of the frontals, which correspond to the frontoparietal depressions of Maryańska and Osmólska (1975). The position and degree of development is comparable with those of "male" skulls of *Protoceratops* (Brown and Schlaikjer 1940), although these depressions are restricted to the frontals, as in mature specimens of *Breviceratops* (Kurzanov 1990). The frontoparietal suture is not clear, but seems to have been too far forward for the frontal to have contributed to the anterior margin of the supratemporal fenestra. This also seems to be the arrangement in a juvenile specimen of *Breviceratops* (Kurzanov 1990).

The posterior margin of the parietal appears to have been destroyed before burial. However, the configuration and slope of the parietal suggests there was an unfenestrated, relatively small frill in IVPP V9606. The left postorbital and most of the left squamosal of IVPP V10605 give a strong indication of the brevity of the temporal region and frill (Fig. 2*b*). The fused parietals formed a rather platelike dome over the braincase of IVPP V9606, as in immature specimens of *Bagaceratops* and *Breviceratops* (Maryańska and Osmólska 1975).

The palpebral was relatively short, small and thick (Fig. 1*b*). As in *Breviceratops* (Kurzanov 1990), it contacts the prefrontal almost exclusively.

The individual occipital and palatal bones are difficult to discern in IVPP V9606. The basioccipital makes up most of the small, ball-shaped occipital condyle (Fig. 1*c*). The foramen magnum is small, 4 mm in diameter.

The mandible of IVPP V9606 is 48 mm long and is relatively shallow, with an almost straight ventral margin. Although the shape might be considered primitive for protoceratopsians, it is the same in juvenile specimens of *Protoceratops* (Maryańska and Osmólska 1975; Kurzanov 1990).

As in other protoceratopsians, the predentary is a triradiate bone, pointed anteriorly where it covers the symphysis and extending posteriorly on both sides to cover the ventral surfaces of the dentaries. The dentary of IVPP V9606 is 27 mm in length, about 4 mm longer than the smallest dentary recorded to date (AMNH 6499), a specimen that Brown and Schlaikjer (1940) felt was an embryo because none of the teeth were erupted. The dentary of IVPP V10605 (Fig. 2*a*) is incomplete, but would have been shorter than that of IVPP V9606. The length of the dentary of IVPP V10604 (Fig. 3) is 20.5 mm long. The smallest specimen is IVPP V10596 with a dentary length of 17 mm. The dentary teeth are obscured by the maxillary teeth in IVPP V9606 and V10605, but four teeth are present in V10604 and V10596.

The large splenial of IVPP V9606 extends anteriorly to the symphysial border. It is a thick deep plate on the medial surface of the mandible, in contrast with the thin splenial of *Bagaceratops rozhdestvenskyi*.

Discussion

The smallest dentary described by Brown and Schlaikjer (1940) was 23 mm long. This specimen was considered to be an embryo because none of the teeth were erupted when the animal died. The smallest skull of *P. andrewsi* found by the Polish–Mongolian expeditions was only slightly larger (Maryańska and Osmólska 1975). The specimens described in this paper are close to the same size as the specimens discovered earlier and have dentaries 27 mm long or less. Because the estimated body length of even the largest of these animals (IVPP V9606) would have been less than 25 cm (five times the length from the rostrum to the occipital condyle), all could have curled inside the 12–15 cm long eggs that have been attributed to protoceratopsians (Sabath 1991). Size suggests that the smallest of the protoceratopsians found in central Asia are indeed embryonic.

The straight ventral border of the mandible and the straight, rather elongate snout of IVPP V9606 are reminiscent of *Bagaceratops*. However, the jugal and parietosquamosal frill are relatively smaller, and there are no premaxillary teeth. IVPP V9606 also differs from *Bagaceratops rozhdestvenskyi* in the presence of a shallow antorbital fossa, the lack of an anterior antorbital fenestra, the lack of a nasal horn core, the depressions on the frontals, the relatively longer and lower snout, and the shallower mandible. IVPP V9606 seems to be an immature specimen of either *Protoceratops* or *Breviceratops*. The absence of a nasal horn suggests that *Protoceratops* is a more likely identification. More mature specimens from Bayan Mandahu have been identified as *P. andrewsi*, but no specimens of *Breviceratops* have been recognized. Neither IVPP V10605 nor IVPP V10596 are complete enough for identification, although the maxillary teeth of the former are more like those of *Protoceratops*. IVPP V10604 appears to have an accessory antorbital fenestra, and does not have a very pronounced median ridge on the maxillary teeth, and is closer in these characteristics to *Bagaceratops*. At least one large skull from Bayan Mandahu (Field No. 180688-2, Map No. 29 of Jerzykiewicz et al. 1993) can be identified as *Bagaceratops* because of the presence of a large anterior antorbital fenestra between the maxilla and premaxilla. The presence of a premaxillary tooth in IVPP V10604 is not consistent with the identification as *Bagaceratops*, because *Bagaceratops rozhdestvenskyi* lacks premaxillary teeth.

The possible presence of both *Bagaceratops* and *Protoceratops* embryos at Bayan Mandahu is surprising, although at least three protoceratopsian taxa had been recognized in the field for adult specimens. Because the embryos are found in nodules that often form a desert lag, the stratigraphic levels and sedimentological associations are uncertain. In Mongolia, *Bagaceratops* comes from younger beds than *Protoceratops* (Dodson and Currie 1990). This suggests that the beds at Bayan Mandahu represent a greater time span than those at Bayn Dzak in Mongolia, and the two taxa may be coming from distinct levels. This hypothesis will be tested as more mature protoceratopsians that were collected in-situ are prepared and identified.

Maryańska and Osmólska (1975) list evolutionary trends of cranial characters of protoceratopsids. The embryonic specimens from Bayan Mandahu show that many of the ''primitive'' characters are found in all small or juvenile specimens, including a relatively straight snout, short frill, a shallow mandible with a straight ventral margin, and a poorly developed ridge on the surangular.

Several thousand dinosaur eggs have been collected from Upper Cretaceous sites in Central Asia. Many of the fossilized eggs are eroded or broken when discovered, providing ample opportunities to identify embryonic bones if present. Embryos were reported in two eggs in one nest (AMNH 6509) by Brown and Schlaikjer (1940), but were never described. Recently, these eggs were CT (computed tomography) scanned by J.R. Horner (Museum of the Rockies) and independently by the second author. The scans suggest that there are no embryos in those eggs, and that the inclusions that had been interpreted as bones were in fact crystals. Sochava (1972) did report on the discovery of a few embryonic bones adhering to a ''protoceratopsian'' eggshell fragment, although there was not enough of the skeleton present to confirm the identification, and the material was recovered from beds where protoceratopsians are unknown (Currie and Eberth 1993).

In 1983, Barsbold and Perle reported on the discovery of a group of juvenile hadrosaurs in the Djadokhta Formation at Toogreeg. Ten hadrosaurs were found at a single site. All of these individuals are the same size, and all are very immature. In comparison with the embryonic hadrosaurs (52 cm in total length) found in eggs at Devil's Coulee in southern Alberta (Horner and Currie, in press), the Mongolian hadrosaurs (35 cm) are much smaller. The clustered distribution of the 10 Mongolian hadrosaur babies, and their small size, strongly suggests that the site was a nest of eggs, even though the eggs themselves were not preserved.

Coombs (1980) reported on a pair of *Psittacosaurus* skulls from the Lower Cretaceous Oshih formation of Mongolia. These skulls are 28 (AMNH 6535) and 42 (AMNH 6536) mm long. *Psittacosaurus* is much smaller than *Protoceratops* at maturity, but smaller species have relatively larger eggs and it is conceivable that one or both of these specimens may represent embryos.

At present, there are no other published records of embryonic dinosaurs from Central Asia. The absence of embryos in the thousands of eggs collected from Cretaceous sediments of China and Mongolia may represent a taphonomic condition whereby embryonic bone was dissolved in the decomposing contents of the eggs. It is hard to understand otherwise why embryonic remains are so rare in Asia, whereas they are relatively common in eggs found in North America. If this is correct, embryonic dinosaurs from Central Asia may only have been preserved when the eggs were broken so that the liquid contents drained. The absence of eggshells associated with the apparent embryos of protoceratopsians at Bayan Mandahu is predictable under this scenario.

Acknowledgments

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