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The giant rhinoceros *Paraceratherium* from the late Oligocene at Aktau Mountain, southeastern Kazakhstan, and its biochronological significance

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With 3 figures and 1 table in the text

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Abstract: An incomplete lower jaw of a giant rhinoceros from the lower part of the Aktau Formation is identified as *Paraceratherium zhajremensis*, which is a valid species of *Paraceratherium* distinguished by its large size and deep dentary below and posterior to the M3. It indicates an Oligocene (probably late Oligocene, Tabenbulukian) age for the lower part of the Aktau Formation below *Gomphotherium*-producing strata of the upper Aktau Formation that are of early Miocene age.

Zusammenfassung: Ein unvollständiger Unterkiefer aus der Unteren Aktau-Formation wird als *Paraceratherium zhajremensis* bestimmt. Damit wird das Alter der Fundschichten, die unter den frühmiozänen Schichten mit *Gomphotherium* liegen, als – vermutlich spätes – Oligozän festgestellt.

Introduction

The Ili depression of eastern Kazakhstan represents the western portion of a paleo-Tien Shan basin that extended eastward into western China. Nonmarine Cenozoic strata deposited in the Ili depression are best exposed at and around Aktau Mountain in the southern foothills of the Dzhungarian Alatau (Fig. 1). The Cenozoic section exposed at Aktau Mountain is about 2.5 km thick and mostly of Neogene and Quaternary age (e. g., DMITRIYEVA & NESMEYANOV 1982, LAVROV & RAYUSHKINA 1983). However, the lower third of this section has been assigned by some workers to the Paleogene (BAZHANOV & KOSTENKO 1961). Indeed, Ergilian (late Eocene) mammals as well as mammals of early Miocene age have been documented from the lower part of the Aktau section (e. g., RUSSELL & ZHAI 1987, ABDRAKHMANOVA et al. 1989, TLEUBERDINA et al. 1993, LUCAS et al. 1996b). Here, we document the presence of the giant rhinoceros *Paraceratherium zhajremensis* BAYSHASHOV at Aktau Mountain and discuss its biochronological significance.

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Fig. 1. Map of Kazakhstan showing location of Aktau Mountain.

Systematic paleontology

Order Perissodactyla Owen 1848
Family Hyracodontidae Cope 1879
Subfamily Indricotheriinae Borisyak 1923
Genus *Paraceratherium* Forster Cooper 1911
Paraceratherium zhajremensis Bayshashov in Kuderina et al. 1988

Referred specimen: KAN (Laboratory of Paleozoology, Institute of Zoology, Academy of Sciences of the Republic of Kazakhstan, Almaty) 2/632, right dentary fragment with M1 talonid and M2–3 (Fig. 2).

Horizon and locality: Lower part of Aktau Formation at locality A9 (UTM 44362462E, 4874058N) on the south flank of Orto Say, Aktau Mountain anticline, Ili depression, eastern Kazakhstan.

Description: KAN 2/632 (Fig. 2) is part of a large right dentary. The dentary has a deep horizontal ramus that becomes deeper posteriorly to

reach its maximum depth posterior to the M3, under the gap that separates the posterior end of the M3 from the leading edge of the ascending ramus. Thus, the depth of the horizontal ramus increases from 170 mm (under the M2) to 200 mm (under the M3) to its maximum depth of 215 mm posterior to the M3. However, thickness of the horizontal ramus decreases posteriorly from 70 mm (under the M2) to 65 mm (under the M3) to 50 mm posterior to the M3.

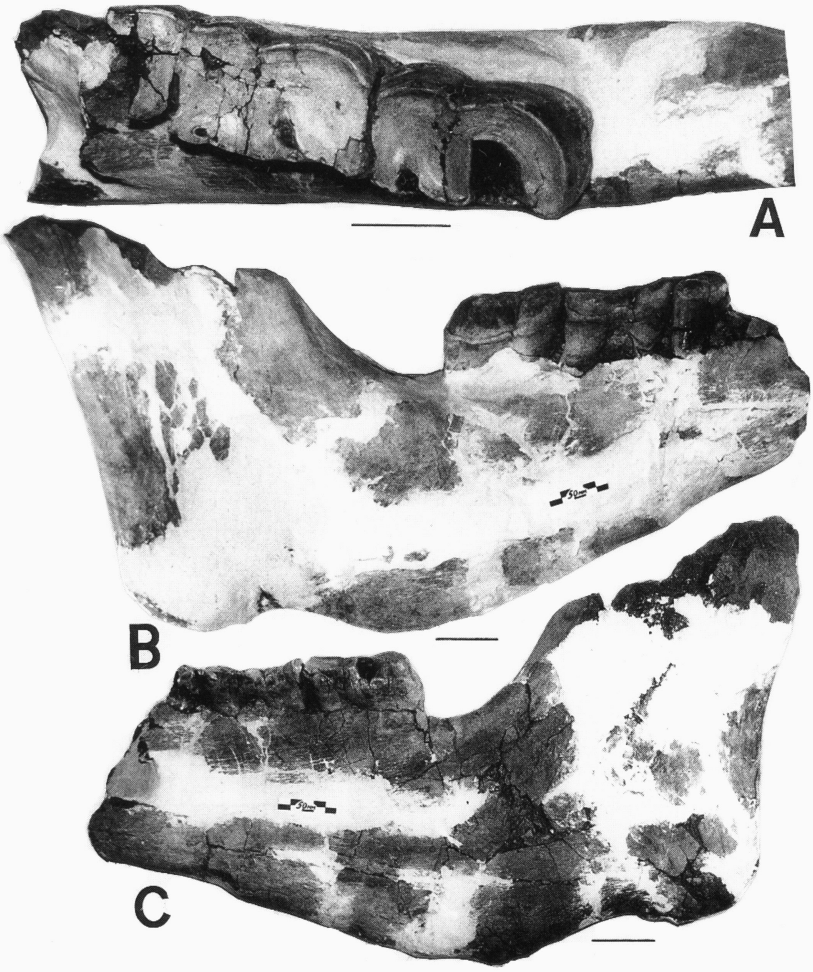

Fig. 2. *Paraceratherium zhajremensis* from Aktau Mountain, Kazakhstan. KAN 2/632, right dentary fragment with part of M1 and complete M2–3, occlusal (A) labial (B) and lingual (C) views. Bar scales are 50 mm long.

The ascending ramus is plate-like and inclined slightly posteriorly. The mandibular angle is slightly produced so that there is a distinct indentation of the ventral edge of the dentary between the angle and the point of maximum depth of the horizontal ramus posterior to the M3. The height of the preserved portion of the ascending ramus is 360 mm, and the mandibular condyle is well above the occlusal plane of the lower molars.

The M1–3 are well worn. Only the talonid portion of the M1 is preserved, and it is broad and deeply worn so that dentine is exposed across the occlusal surface of the hypolophid, which is almost as broad as the M2 protolophid. A prominent labial cingulid is present, and preserved labial enamel is slightly rugose and lineated.

In occlusal view, the M2 is rectangular antero-posteriorly. Deep wear has obliterated most of the crown morphology, exposing dentine over much of the occlusal surface. The protolophid and hypolophid of the M2 are of nearly equal width. An antero-posteriorly oriented metalophid connects the hypolophid to the protolophid. The entoconid is the tallest cuspid after deep wear, and enamel forms a small lingual invagination of the crown (talonid basin). A prominent labial cingulid is present, and the labial enamel is slightly rugose and lineated.

The M3 is also a rectangular tooth in occlusal view with a prominent labial cingulid and slightly rugose and lineated enamel. The crown preserves a transverse paralophid followed by an equally broad protolophid. A shallow, lingual trigonid basin is still covered with enamel. The metalophid is antero-posteriorly oriented and as tall as the protolophid and hypolophid it connects. The confluent hypolophid-metalophid form a ridge that is convex labially with its highest point being the entoconid. A deep, enamel-covered talonid basin separates the protolophid and the hypolophid lingual to the metalophid. A low, antero-

Table 1. Dental measurements (in mm) of selected *Paraceratherium*.

taxon	M2L	M2W	M3L	M3W
P. bugtiense[1]	70–75	45–48	71–79	74–79
P. prohorovi[2]	71–83	50–60	80–96	50–60
P. transouralicum[2]	69–80	46.5–61	80–92	50–60
P. orgosensis[3]	87–90	64–71	89–99	58–67
P. zhajremensis (Atasui)	84	55	90	–
P. zhajremensis (Aktau)	96	61	104	60

[1] from Forster Cooper (1924)
[2] from Gromova (1959)
[3] from Chiu (1973) and Xu & Wang (1978)

posterior ridge bounds the talonid basin lingually. A posterior cingulid is present on the M3. Dental measurements of KAN 2/632 are reported in Table 1.

Discussion: LUCAS & SOBUS (1989) last revised the giant indricotheres and recognized only one valid genus, *Paraceratherium* FORSTER COOPER 1911 (= *Baluchitherium* FORSTER COOPER 1913, = *Indricotherium* BORISYAK 1915, = *Aralotherium* BORISYAK 1939, = *Dzungariotherium* CHIU 1973). LUCAS & SOBUS (1989) recognized four valid species of *Paraceratherium: P. bugtiense* (PILGRIM 1908), *P. transouralicum* (PAVLOVA 1922), *P. prohorovi* (BORISYAK 1939) and *P. orgosensis* (CHIU 1973). LUCAS & SOBUS were unaware that BAYSHASHOV (in KUDERINA et al. 1988) had named the species *P. zhajremensis* for an incomplete lower jaw found in the Oligocene Zhanaarkin svita at Atasui in central Kazakhstan. We regard *P. zhajremensis* as a valid species of *Paraceratherium* distinguished by its large size and very deep horizontal ramus under and posterior to the M3.

The Aktau Mountain specimen shares this unique dentary morphology with the holotype lower jaw of *P. zhajremensis* (compare Fig. 2 to KUDERINA et al. 1988: fig. 3). However, in dental measurements (especially the lengths of the M2–3), the Aktau Mountain dentary is larger than the holotype of *P. zhajremensis* (Table 1). It is much larger dentally than *P. bugtiense, P. prohorovi* and *P. transouralicum,* and has slightly longer but narrower lower molars than specimens of *P. orgosensis* from Xinjiang, northwestern China (Table 1). Significantly, the dentary of *P. orgosensis* (CHIU 1973: pl. 1, XU & WANG 1978: pl. 2) has a relatively shallow horizontal ramus with a flat ventral edge and thus lacks the pronounced deepening under and posterior to the M3 seen in the holotype of *P. zhajremensis* and the Aktau Mountain dentary. Dentaries of the other species of *Paraceratherium* also have a shallow horizontal ramus with a flat ventral edge (FORSTER COOPER 1924: fig. 7, GRANGER & GREGORY 1936: fig. 4, GROMOVA 1959: figs. 2–3, pls. 1–2, 4). Thus, based on dentary morphology and size, we identify KAN 2/632 from Aktau Mountain as a specimen of *P. zhajremensis* somewhat larger than the holotype.

Biochronological significance

The lower part of the Aktau Formation has produced only one fossil mammal, the giant indricotheriine hyracodontid rhinoceros *Paraceratherium zhajremensis* (Fig. 3). Previous reports of *Paraceratherium* from the Aktau Formation were of fragmentary teeth and postcrania from localities at Kyzyl Say, 3–4 km southwest of Orto Say, identified as *Paraceratherium* sp. and *P. prohorovi* (SAVINOV 1963, ABDRAKHMANOVA et al. 1989). It seems likely that they too represent *P. zhajremensis.*

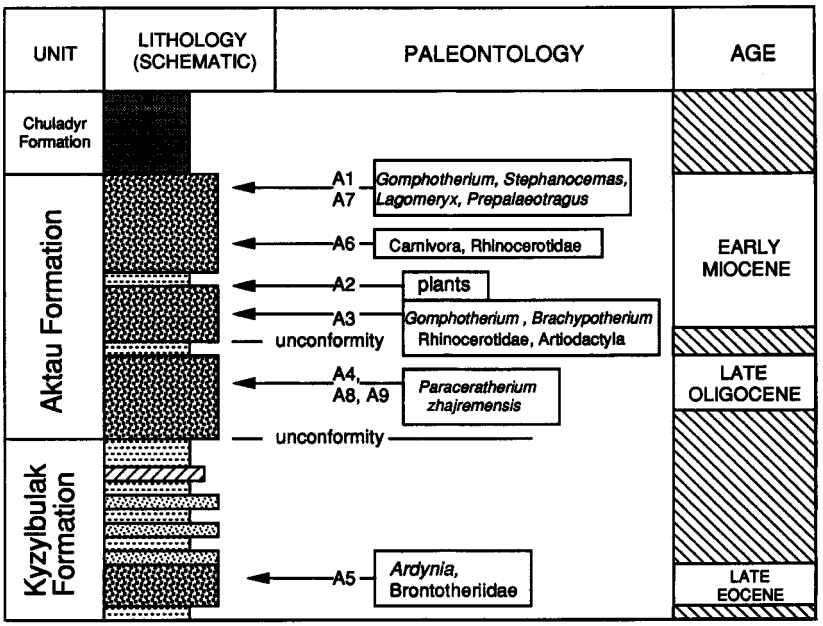

Fig. 3. Summary of lithostratigraphy and mammalian biostratigraphy and biochronology at Aktau Mountain, eastern Kazakhstan (modified from Lucas et al. 1996b).

The oldest records of *Paraceratherium* are from China and Mongolia in strata of Shandgolian (early Oligocene) age (Russell & Zhai 1987, Dashzeveg 1993) and from Rupelian marginal marine strata north of the Aral Sea in western Kazakhstan (Lucas & Emry 1996). The genus is most common in Tabenbulukian (late Oligocene) deposits in Asia, and its youngest record is of early Miocene age at Bugti, Pakistan (Raza & Meyer 1984). *Paraceratherium* thus has a temporal range of nearly 10 Ma, from early Oligocene to early Miocene (Lucas 1994). However, other than at Bugti, there appears to be no incontrovertible evidence that any occurrences of *Paraceratherium* are of Miocene age (Lucas et al. 1996a).

Paraceratherium occurrences with reasonably well dated, associated mammal faunas geographically closest to Aktau Mountain are in the Aral Formation along the north shore of the Aral Sea in western Kazakhstan (Lopatin 1994) and in the Shawa Formation of northwestern Xinjiang,

China (QIU & QIU 1995). Based on micromammals, both of these occurrences are no younger than MN1 of the European succession of mammal zones (BRUIJN et al. 1992), and probably older. MN1 is of latest Oligocene age because the Oligocene-Miocene boundary (= base of Aquitanian) occurs within overlying zone MN2 (STEININGER et al. 1990).

P. zhajremensis was originally described from Atasui in central Kazakhstan where it was collected in association with a paleoflora of probable late Oligocene age (KUDERINA et al. 1988). We thus tentatively consider the Aktau Mountain occurrence of *P. zhairemensis* to be of late Oligocene (Tabenbulukian) age (Fig. 3), though it could be slightly older.

The upper part of the Aktau Formation has yielded a mammalian fossil assemblage of unquestionable early Miocene age. Documented taxa are *Gomphotherium angustidens, Gomphotherium* cf. *G. angustidens, Brachypotherium aurelianse, Lagomeryx valessensis, Procervulus gracilis, Stephanocemas actauensis, S. aralensis, Prepalaeotragus actauensis* and Caprinae? (ABDRAKHMANOVA et al. 1989, BAYSHASHOV 1991, TLEUBERDINA et al. 1993). These mammal occurrences bracket a Miocene flora first reported by LAVROV & RAYUSHKINA (1983) and subsequently published by RAYUSHKINA (1987, 1993).

In the European succession of MN zones (BRUIJN et al. 1992), *Gomphotherium* and *Brachypotherium* occur in zones MN 4–8, *Stephanocemas* in zones MN 5–8, *Procervulus* in MN 3–5 and *Lagomeryx* in MN 3–7. This suggests correlation of the upper Aktau Formation assemblage with zone MN 5 of the European succession, an age of latest early Miocene (late Burdigalian) on the marine chronostratigraphic scale (STEININGER et al. 1990).

Paraceratherium from the lower part of the Aktau Formation suggests a late Oligocene age, so the Paleogene-Neogene boundary at Aktau Mountain is within the Aktau Formation (Fig. 3).

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