

An extended range of the multituberculate *Kryptobaatar* and distribution of mammals in the Upper Cretaceous of the Gobi Desert

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The Late Cretaceous multituberculate mammal *Kryptobaatar dashzevegi* Kielan-Jaworowska, 1970 is the most common mammalian taxon in the Upper Cretaceous (?lower Campanian) rocks of the Djadokhta Formation at Bayan Zag¹ (= Bayn Dzak) and Tögrög (= Toogreek), and in the beds of Ukhaa Tolgod in the Gobi Desert. *Kryptobaatar* is also common in the Bayan Mandahu Formation (equivalent of the Djadokhta Formation), Inner Mongolia, China, represented there by *K. mandahuensis*. *Kryptobaatar* has not been reported as yet from the younger (?upper Campanian) Baruungoyot Formation nor from its stratigraphic equivalents, the red beds of Hermin Tsav (= Khermeen Tsav). In this paper we report the discovery of an incomplete skull of *Kryptobaatar dashzevegi* at Hermin Tsav I. It is the second mammal species common to the Djadokhta and Baruungoyot Formations (the first being *Deltatheridium pretrituberculare*). We provide a corrected list of mammals found in the Late Cretaceous localities of the Gobi Desert, and we argue (albeit inconclusively), that mammal evidence shows that the Ukhaa Tolgod beds might be closer in time of deposition to the Djadokhta Formation than to that of the Baruungoyot Formation.

Key words: Mammalia, Multituberculata, *Kryptobaatar*, Deltatheroidea, Cretaceous, stratigraphy, Gobi Desert.

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Introduction

The stratigraphy of the Upper Cretaceous terrestrial formations of the Gobi Desert is continuously debated. Uncertainty is due to the lack of marine intercalations and radiometric age data. Gradziński et al. (1977) presented an overview of the earlier literature on the subject, re-defined the three most important Upper Cretaceous formations of the Gobi Desert (Djadokhta, Baruungoyot, and Nemegt), and provided lists of fossils for each. They stated (1977: 302): “All fossils discovered so far are endemic at the specific level, and most of them at the generic level. In this situation, evaluation of formational ages as based upon ‘stages of evolution’ of vertebrate and invertebrate assemblages, or upon correlation with European or North American fossil range zones must be regarded as tentative”.

A subsequent review of the stratigraphy of the Late Mesozoic strata of the Gobi Desert was published by Jerzykiewicz and Russell (1991), who provided emended lists of fossils for different “ages” of the Gobi Desert. New discover-

ies in the years since have prompted us to provide a revised account.

Following publication of the papers by Gradziński et al. (1977) and Jerzykiewicz and Russell (1991), new fossiliferous sites have been revealed in the Gobi Desert. In Mongolia the most important is the locality of Ukhaa Tolgod (“Brown Hills”), discovered by Demberlyin Dashzeveg and worked by the teams of the Mongolian Academy—American Museum of Natural History Expeditions (MAE) during several field seasons beginning in 1993. The Ukhaa Tolgod beds proved to be rich beyond expectation, yielding over 800 skulls of mammals, often associated with postcranial skeletons, numerous dinosaurs (e.g., skeletons of ankylosaurids, theropods, and protoceratopsids), the bird *Mononykus*, lizards, and many others. Although several papers discussing or describing the Ukhaa Tolgod mammals have been published in popular and scientific journals (e.g., Dashzeveg et al. 1995; Novacek, Dashzeveg, and McKenna 1994; Novacek, Norell et al. 1994; Novacek et al. 1997; Rougier et al. 1996, 1997, 1998; Horovitz 2000; Wible and Rougier 2000), the

¹ We follow Benton’s (2000) spelling of the Mongolian geographic names and formations.

only list of mammalian taxa from Ukhaa Tolgod is that of Dashzeveg et al. (1995), and this requires revision.

Of special interest in China is the Bayan Mandahu region, Inner Mongolia, extensively explored recently in search for dinosaurs and mammals. Sino-Canadian Expeditions working there between 1987 and 1990 found skulls of mammals in the Bayan Mandahu Formation, an equivalent of the Djadokhta Formation (see Dong 1993; Jerzykiewicz et al. 1993). Chinese paleontologists of the Institute of Vertebrate Paleontology and Paleoanthropology in Beijing are investigating this mammal material. To our knowledge, these mammals remain undescribed. A faunal list was presented by Wang et al. (2001), but this appears to be incomplete, as it lists only three taxa, including *Kryptobaatar*. Subsequently, the Sino-Belgian Expeditions explored this region beginning with 1995. From the collection assembled, Smith et al. (2001) described a new species of the multituberculate *Kryptobaatar*, but no further list of the mammals has been published.

Institutional abbreviations.—IMM, Inner Mongolian Museum, Hohhot, China; PSS-MAE, Mongolian-American Museum Expeditions; PM, Paleontological Center of the Mongolian Academy of Sciences, Ulaanbaatar; GISPS, Paleontological and Stratigraphic Section of the Geological Institute, Mongolian Academy of Sciences, Ulaanbaatar; ZPAL, Institute of Paleobiology, Polish Academy of Sciences, Warsaw.

Systematics

Order Cimolodonta McKenna, 1975

Superfamily Djadochtherioidea

Kielan-Jaworowska and Hurum, 2001

Family Djadochtheriidae Kielan-Jaworowska and Hurum, 1997

Genus *Kryptobaatar* Kielan-Jaworowska, 1970

Kryptobaatar dashzevegi Kielan-Jaworowska, 1970

Figs. 1, 2.

Synonyms: *Gobibaatar parvus* Kielan-Jaworowska, 1970; *Tugrigbaatar saichanensis* Kielan-Jaworowska and Dashzeveg, 1978.

Comment.—*Kryptobaatar dashzevegi* is one of the best known multituberculate species, described in detail in numerous publications by Kielan-Jaworowska (1970, 1980, 1998), Kielan-Jaworowska and Dashzeveg (1978, referred to as *Tugrigbaatar saichanensis*), Kielan-Jaworowska and Gambaryan (1994), Gambaryan and Kielan-Jaworowska (1995), Rougier et al. (1996), Kielan-Jaworowska and Hurum (1997), Wible and Rougier (2000); see also Smith et al. (2001) for description of *K. mandahuensis*. We confine our description to the new specimen (PM 120/108) found at Hermiin Tsav I in the Gobi Desert (Mongolia), during the 2000 Nomadic Expedition “Dinosaurs of the Gobi” (see Kielan-Jaworowska et al. 2002) by the third author, and to a comparison with previously described materials. For description of Hermiin Tsav beds see Gradziński and Jerzykiewicz (1972).

Description.—PM 120/108 is an incomplete skull, slightly compressed laterally, with the right zygomatic arch and left postorbital process (with broken tip) preserved, and damaged basicranial and occipital regions. The dentaries are missing. The state of preservation of the bone and teeth is poor and the sutures are hardly discernible. The bones of the cranial roof are strongly broken, preserved in the middle part of the roof and missing anteriorly and posteriorly.

Both I2s, covered with a honey-colored enamel band (limited to the anterior part of the teeth), are arranged obliquely and meet one another at the tips. The I3s are missing. On the right side only P1–P3 have been preserved; on the left side P2, P3, M1, and M2 are present. P1 and P2 are three-cusped; P3 is four-cusped and smaller than P1 and P2. The cusp formulae of the molars are: M1, 2:4:4:ridge; M2, 1:2:3. On M1 the cusps in the middle of the outer row are broken and the outermost part of the tooth is missing, and therefore we are not sure if there were 4 or 5 cusps in the outer row (Fig. 2A₄). The cuspules on the medial ridge in M1 are not discernible.

Measurements of the teeth are given in Table 1.

Table 1. Measurements (in mm) of upper molars in *Kryptobaatar* species.

Species	Locality	Formation	Catalogue no.	M1 length	M1 width	M2 length	M2 width
<i>K. dashzevegi</i>	Bayan Zag	Djadokhta	ZPAL MgM-I/21	2.5	1.6	2.1	1.9
<i>K. dashzevegi</i>	Bayan Zag	Djadokhta	ZPAL MgM-I/8	2.8	1.5	1.9	1.7
<i>K. dashzevegi</i>	Bayan Zag	Djadokhta	ZPAL MgM-I/10	2.6	1.6	2.0	1.7
<i>K. dashzevegi</i>	Bayan Zag	Djadokhta	ZPAL MgM-I/52	2.8	1.6		
<i>K. dashzevegi</i>	Tögrög	Djadokhta	GISPS 8-2PST	2.9	1.6	1.9	1.6
<i>K. dashzevegi</i>	Tögrög	Djadokhta	PSS-MAE 113	2.9	1.8	2.1	1.9
<i>K. dashzevegi</i>	Ukhaa Tolgod	Ukhaa Tolgod beds	PSS-MAE 101	2.7		1.9	
<i>K. dashzevegi</i>	Hermiin Tsav I	Red beds of Hermiin Tsav I (Baruungoyot)	PM 120/108	2.6	1.4	1.8	1.6
<i>K. mandahuensis</i>	Urad Houqi Banner	Bayan Mandahu	IMM 96BM-II/3	2.8	1.65	1.9	1.75
<i>K. mandahuensis</i>	Urad Houqi Banner	Bayan Mandahu	IMM 96BM-I/4	2.95 (right)	1.85 (right)	2.15 (left)	2.05 (left)

Source: Measurements of ZPAL MgM-I/21 and /10 are from Kielan-Jaworowska (1970); PSS-MAE 101 and 113 from Wible and Rougier (2000); IMM 96BM-II/3 and -I/4 from Smith et al. (2001); all others taken by us. Note that the measurements of GISPS 8-2PST have been corrected with respect to the data of Kielan-Jaworowska and Dashzeveg (1978).

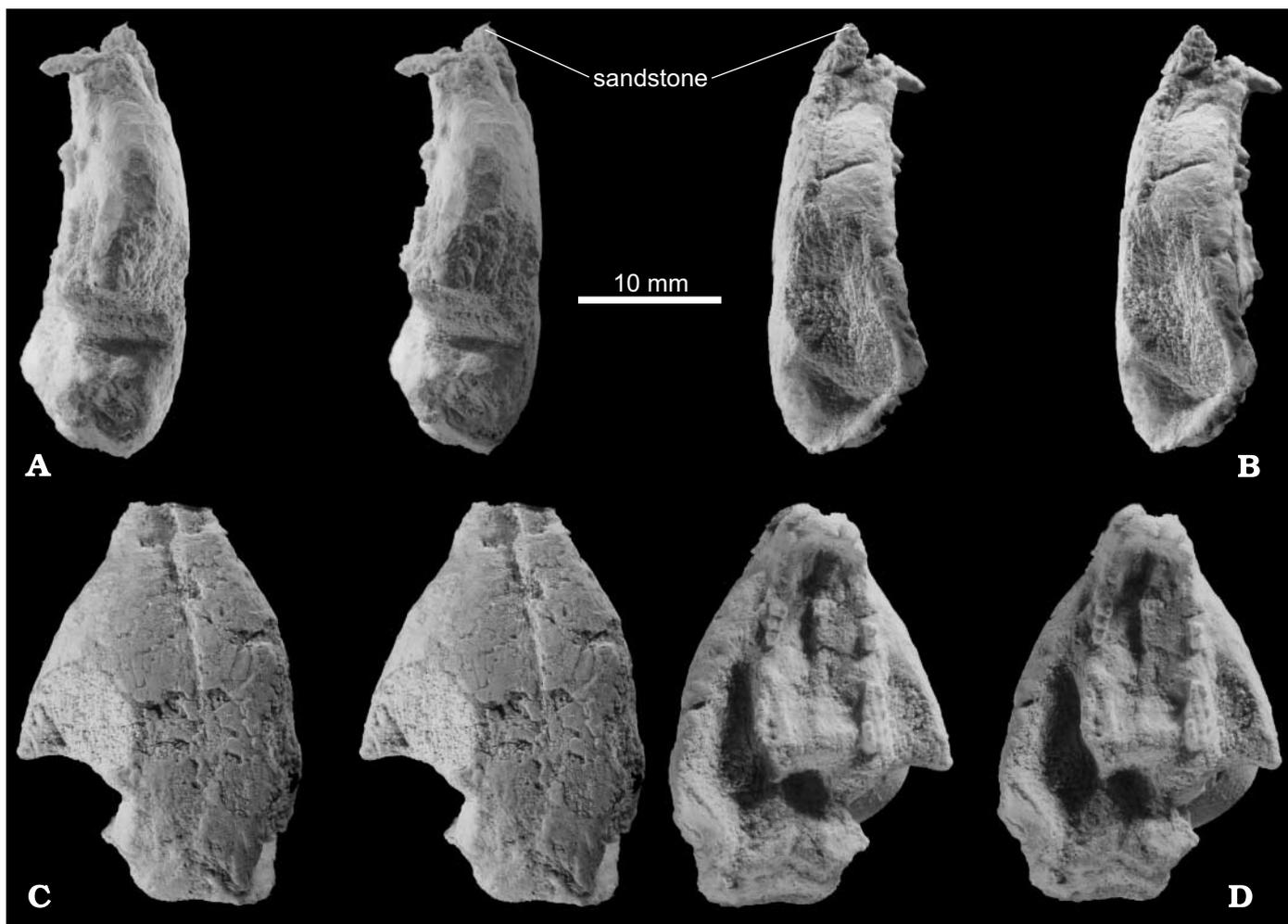


Fig. 1. *Kryptobaatar dashzevegi*, PM 120/108, Hermiin Tsav I, Gobi Desert, Mongolia. Stereo-photographs of the skull (coated with ammonium chloride) in left lateral (A), right lateral (B), dorsal (C), and palatal (D) views. The piece of sandstone preserved in prolongation of the right nasal cavity (Figs. A and B), has been subsequently removed and is not present in Figs. C and D.

Comparisons.—As may be seen in Table 1 and Fig. 2, the length and width of the upper premolars and molars, and cusp formula of M1 in PM 120/108 from Hermiin Tsav I, fall within the range of variability of specimens of *K. dashzevegi* from the Djadokhta Formation at Bayan Zag and Tögrög, and from the Ukhaa Tolgod beds at Ukhaa Tolgod. Kielan-Jaworowska and Hurum (1997) argued that the teeth in *K. dashzevegi*, in particular M1, show a high degree of variability (see also fig. 4 of their paper showing M1 with five cusps in the outer row and five cuspules on the inner ridge, and plate 3: fig. 7 in Kielan-Jaworowska and Hurum 2001, showing M1 with five cusps in the outer row and three cuspules on the inner ridge).

Kielan-Jaworowska and Hurum (1997) recognized within the specimens of *K. dashzevegi* two types of skull structure, referred to as “wide snout” and “narrow snout”. They admitted that the differences between the two types might be in part due to the state of preservation (dorso-ventral *versus* lateral compression), and also to the individual age, the older individuals

having a wider skull. PM 120/108 resembles more the “narrow snout” (Kielan-Jaworowska and Hurum 1997: fig. 3) than the “wide snout” (fig. 2 in the same paper).

Distribution

In Table 2 we present the list of mammalian taxa, described so far (or known to us by the courtesy of persons mentioned in the Acknowledgements) from the Late Cretaceous of the Gobi Desert. This list undoubtedly represents a very small percentage of mammals that could have lived in that area during Campanian–Maastrichtian times. The list includes twelve multituberculate species, belonging to eleven genera, and ten monotypic boreosphenidan genera, plus one unnamed taxon. In addition there are two taxa left in open nomenclature. The multituberculate genera, except for *Buginbaatar* Kielan-Jaworowska and Sochava, 1969, belong to the cimolodontan superfamily Djadochtatherioidea Kielan-

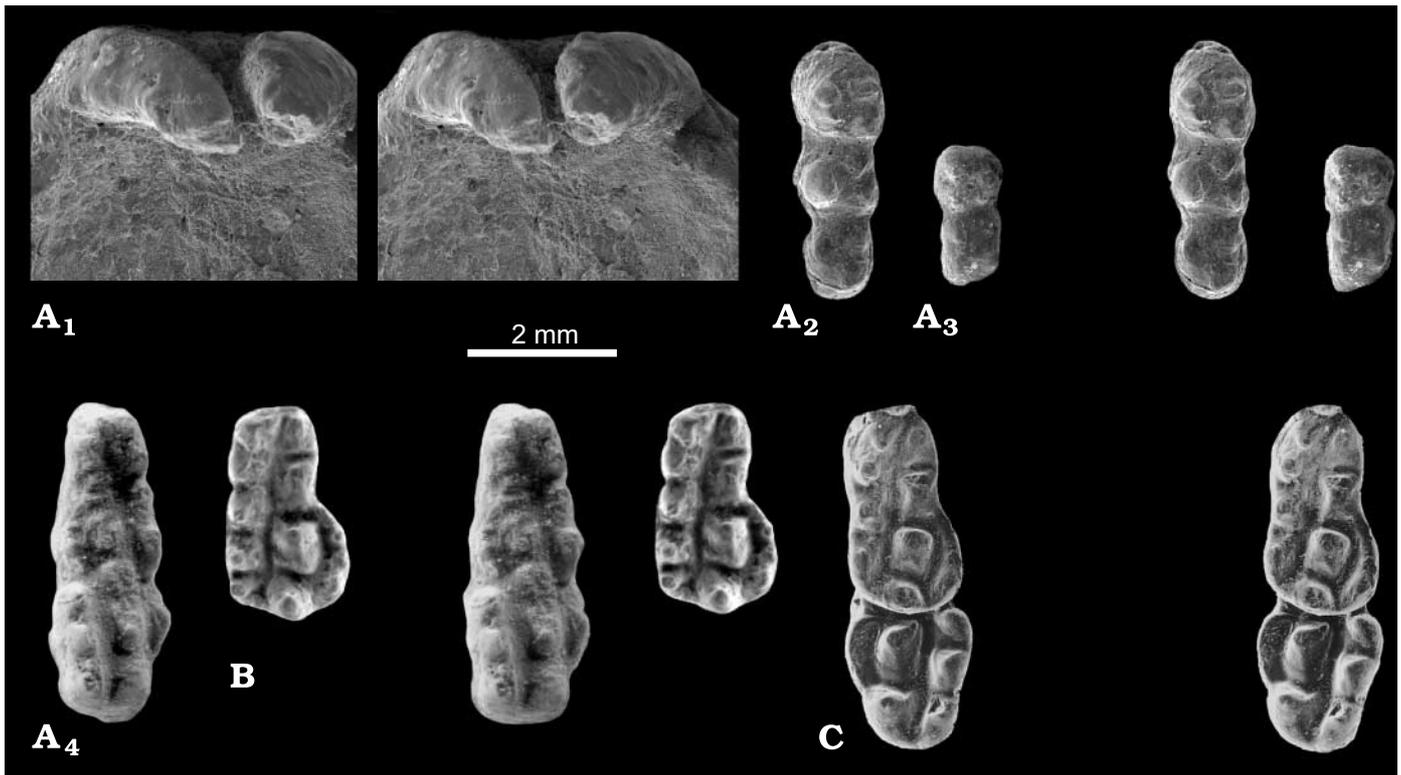


Fig. 2. Comparison of teeth in *Kryptobaatar dashzevegi*. A. PM 120/108, Hermin Tsav I, Gobi Desert, Mongolia; upper incisors (A₁), right P1-P3 (A₂), left P2, P3 (A₃), left M1, M2 (A₄). B. Right M2, ZPAL MgM-I/52, Djadokhta Formation, Bayan Zag. C. Right M1 and M2, ZPAL MgM-I/8, Djadokhta Formation, Bayan Zag. All SEM micrographs in occlusal view. M1 in A₄ appears narrower than it originally was because of break of the middle cusps in outer row and outer margin.

Jaworowska and Hurum, 2001 (the taxon replacing the suborder Djadoctheria Kielan-Jaworowska and Hurum, 1997), which are mostly endemic for Asia. The position of *Buginbaatar* is uncertain. Kielan-Jaworowska and Hurum (1997, 2001) assigned it tentatively to the ?Cimolomyidae.

Boreosphenidan mammals are more diversified at the ordinal level. Szalay and Trofimov (1996) assigned *Asiatherium* to Asiadelphia, an order of marsupials endemic to Asia. They also figured the as yet undescribed "Guriliin Tsav skull" (see Kielan-Jaworowska and Nessov 1990), classifying it as a deltatheroidan (caption to their fig. 22). In our opinion, however, it cannot be excluded that the "Guriliin Tsav skull" belongs to Stagodontidae, a family of Late Cretaceous marsupials otherwise known from North America (see also Rougier et al., 1998). *Deltatheridium* and *Deltatheroides* belong to the metatherian order Deltatheroidea Kielan-Jaworowska, 1975. The systematic position of *Hyotheridium*, which is poorly preserved, cannot be established. The remaining five genera belong to eutherians: *Kennalestes*, *Asioryctes*, and *Ukhaatherium* are referred to the eutherian order Asioryctitheria Novacek et al., 1997, while *Zalambdalestes* and *Barunlestes*, have been placed in the order Anagalida Szalay and McKenna, 1971 (Kielan-Jaworowska et al. 2000; Archibald et al. 2001, but see also Fostowicz-Frelik and Kielan-Jaworowska 2002).

Comparison of the mammal assemblage from the Djadokhta Formation (and equivalents), with that of the

Baruungoyot Formation (and its equivalents) reveals important differences. Only two species *Deltatheridium pretuberculare* and *Kryptobaatar dashzevegi* are common to both formations. All other taxa are different. On the other hand, the Ukhaa Tolgod beds, which have yielded the greatest numbers of mammal skulls and skeletons ever found at any Mesozoic locality in the world, have taxa in common with both formations (Table 2). The Djadokhta Formation taxa prevail in the Ukhaa Tolgod beds, the most common being *Kryptobaatar dashzevegi* (see Kielan-Jaworowska 1998; Wible and Rougier 2000). *Kryptobaatar dashzevegi* is accompanied at Ukhaa Tolgod by other Djadokhta Formation taxa, such as *Djadoctherium matthewi*, *Kennalestes gobiensis*, and *Zalambdalestes lechei*. *Tombaatar sabuli* Rougier et al., 1997 is thus far endemic to Ukhaa Tolgod, although skulls possibly belonging to *Tombaatar* have been recovered from the Bayan Mandahu Formation (personal communication from Thierry Smith). However, the Ukhaa Tolgod assemblage also includes one taxon characteristic of the Baruungoyot Formation, *Chulsanbaatar vulgaris*.

It follows that, as far as mammal assemblages are concerned, the Ukhaa Tolgod beds are more like the Djadokhta Formation than Baruungoyot Formation. As argued by Dashzeveg et al. (1995) the Ukhaa Tolgod beds appear also closer in age to the Djadokhta Formation than to the Baruungoyot. They might represent a somewhat later part of

Table 2. Distribution of mammals in the Upper Cretaceous formations of the Gobi Desert.

Formations, localities Taxa	Djadokhta Formation and equivalents			Ukhaa Tolgod beds	Baruungoyot Formation and equivalents					Equivalents of Nemegt Formation	
	Bayan Zag	Tögrög	Bayan Mandahu	Ukhaa Tolgod	Khulsan	Nemegt	Hermin Tsav I	Hermin Tsav II	Üüden Sair	Guriliin Tsav	Khairchin Uul-I (Bügin Tsav)
<i>Sloanbaatar mirabilis</i>	x			x?							
<i>Bulganbaatar nemegtbaataroides</i>	x										
<i>Kamptobaatar kuczynskii</i>	x			x?							
<i>Djadochtatherium matthewi</i>	x	x	x	x							
<i>Kryptobaatar mandahuensis</i>			x								
<i>Hyotheridium dobsoni</i>	x										
<i>Kennalestes</i> sp.			x								
<i>Kennalestes gobiensis</i>	x	x									
<i>Zalambdalestes</i> sp.			x								
<i>Zalambdalestes lechei</i>	x	x		x							
<i>Deltatheroides cretacicus</i>	x										
<i>Catopsbaatar catopsaloides</i>					x		x				
<i>Tombaatar sabuli</i>			?x	x							
<i>Nessovbaatar multicoelatus</i>								x			
<i>Asioryctes nemegetensis</i>					x	x		x			
<i>Ukhaatherium nessovi</i>				x							
<i>Nemegtbaatar gobiensis</i>					x	?x		x			
<i>Chulsanbaatar vulgaris</i>				x	x	x		x			
<i>Barunlestes butleri</i>					x	x		x			
<i>Kryptobaatar dashzevegi</i>	x	x		x			x				
<i>Deltatheridium pretrituberculare</i>	x		x?	x		x		x			
<i>Asiatherium reshetovi</i>									x		
“Guriliin Tsav skull”										x	
<i>Buginbaatar transaltaiensis</i>											x

Commentary: Taxa in this table have been arranged in stratigraphic and geographic sequences (not in systematic arrangement).

the early Campanian² than the Djadokhta Formation. The drawback of the foregoing argument is that it is based on only one group of fossils, and as such cannot be regarded as conclusive. It would be interesting to make similar faunistic comparisons of the formations involved, based on all the fossils yielded by these formations and beds. The interpretation of the paleoenvironment as seen in the sedimentary rocks in the discussed formations should be considered in relation to the differences in the fossil assemblages.

Djadokhta Formation is described as containing cross-stratified sandstones with caliches, structureless fine-grained sandstones, mudstones and conglomerates (Jerzykiewicz 2000). Baruungoyot Formation consists of sequence of red sandstones, siltstones and conglomerates. The large-scale cross-strata sandstones in both formations are being interpreted to be eolian dune deposits (see e.g., Jerzykiewicz 2000).

The fossil-bearing sandstones at Ukhaa Tolgod are not crossbedded and contain conglomeratic lenses. These deposits are interpreted to be large debris flows triggered by heavy rainfall in dune-fields otherwise stabilized by vegetation (Loope et al. 1998). This model could also be useful for localities like Tögrög (Djadokhta Formation) as an explanation for the „drowning *Protoceratops*” (see Jerzykiewicz 2000: fig 15.7).

Are the mammalian assemblages found in the formations due to environmental and ecological differences and not age? Discovery of the Djadokhta Formation species *Kryptobaatar dashzevegi* (in addition to *Deltatheridium pretrituberculare* reported previously by Kielan-Jaworowska 1975) in rocks corresponding to the Baruungoyot Formation might indicate that the age differences between these two formations might be smaller than previously thought.

² Jerzykiewicz and Russell (1991), Jerzykiewicz et al. (1993), Szalay and Trofimov (1996), and many other authors refer to the Baruungoyot Formation as middle Campanian. A search in the GeoRef database has shown 44 papers with the use of the term middle Campanian in title or abstract between 1958 and 2002. The term is most commonly used for North American and European marine sediments and fossils (34 papers), and to a lesser extent for terrestrial sediments and fossils (7 papers) and for volcanics and tectonics (3 papers). However, the Campanian was established originally in Europe as a marine stage, divided on the basis of ammonites and other marine invertebrates into two substages (Harland et al. 1989). Gradstein et al. (1999) used a tripartite division of the Campanian based on magnetic polarity and highest resolution ammonite subdivisions. This is not available for the Campanian terrestrial deposits of the Gobi Desert and we find that the tripartite division of the Campanian in Asia is inappropriate.

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