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Oligocene-Miocene Vertebrates from the Valley of Lakes (Central Mongolia): Morphology, phylogenetic and stratigraphic implications

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9. Gomphotheres (Proboscidea, Mammalia) from the Early-Middle Miocene of Central Mongolia

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(With 1 text-figure, 3 tables and 1 plate)

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Abstract

Presented here is new fossil proboscidean material from the Miocene Loh Formation of the Valley of Lakes in Central Mongolia. Two, possibly three, different taxa of gomphotheres s. l. are represented in three different localities, but the fragmentary preservation of the couple of cheek teeth and some postcranial bone remains restricts their systematic determination. Only one molar can be identified as cf. *Gomphotherium mongoliense* representing the crown morphology of the bunodont type of the "*Gomphotherium angustidens* group". The residual tooth and remains might belong to more derived, trilophodont gomphotheres of the genus *Gomphotherium*, or perhaps also to shovel-tusked gomphotheres.

Key words: Mongolia, Loh Formation, Miocene, Proboscidea, Gomphotheriidae, *Gomphotherium*.

Zusammenfassung

Diese Arbeit stellt neues Material fossiler Proboscidea aus der miozänen Loh Formation aus dem "Tal der Seen" in der Zentral-Mongolei vor. Aus drei verschiedenen Lokalitäten können mindestens zwei, vielleicht sogar drei, verschiedene Taxa von Gomphotherien s.l. nachgewiesen werden. Jedoch schränkt die schlechte Erhaltung der wenigen Backenzahn- und Knochenreste eine genauere systematische Bestimmung ein. Nur ein Molar repräsentiert den bunodonten Molaren-Typus der sogenannten "*Gomphotherium angustidens* group" und wird hier als cf. *Gomphotherium mongoliense* gehörig bestimmt werden. Alle restlichen Stücke können sowohl fortschrittlicheren, trilophodonten Gomphotherien der Gattung *Gomphotherium*, oder aber vielleicht auch schaufelzahnigen Gomphotherien angehören.

Introduction

The Valley of Lakes (Central Mongolia) was the region of an interdisciplinary Austrian-Mongolian project considering paleontological and sedimentological investigations in

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continental sediments and petrological-geochemical studies and dating of interlayered basalts (DAXNER-HÖCK et al. 1997, HÖCK et al. 1999). The biochronological and stratigraphical datings of this Palaeogene and Neogene sediment-basalt association are based on rodent assemblages and litho-, bio- and chronostratigraphical data.

In this project, sediment sequences of the Hsanda Gol Formation, the Loh Formation, and the Tuyn Gol and Tsagaan Ovoo Formations have been considered. The latter did not yield any fossils, but in the sediments of the Hsanda Gol and Loh Formations rich fossil material – predominantly of mammals and subordinate remains of amphibians and lizards as well as egg shells and gastropods – were found. Throughout these two formations seven informal biozones (A, B, C, C1, D, D1, E) were established (DAXNER-HÖCK et al. 1997, HÖCK et al. 1999) based on rodent assemblages. Remains of proboscideans are rare and have been found in the Loh Formation, more precisely in the D1-rodent assemblage of late Early to early Middle Miocene age; this time span comprises the Chinese mammal stages late Shangwangian to early Tunggurian, which correspond to the European Orleanian (Mammal Neogene units MN 3-5) and Astaracian (MN 6-8) (HÖCK et al. 1999: fig. 22). The material presented here comes from 3 different localities in the Loh Formation: Loh, Ulaan Tologoi, and Builstyn Khudag.

Mastodonts from Mongolia have been presented in the past by ALEKSEYEVA (1959, 1971), BELYAEVA (1952), DUBROVO (1970, 1974, 1976), KUBIAK (1968), and OSBORN (1924); *Zygodolophodon gromovae* (DUBROVO, 1970), *Serridentinus gobiensis* OSBORN & GRANGER, 1932, *Serridentinus mongoliensis* OSBORN 1924, *Serridentinus tolojojensis* BELYAEVA, 1952, *Tetralophodon sinensis* (KOKEN, 1885), *T. aff. sinensis* were determined from Miocene deposits, *Mammut borsoni* and *Anancus sinensis* from Pliocene sediments. But later the systematic identity of most of these taxa has changed; *S. gobiensis* was allocated to *Zygodolophodon* (CHOW & CHANG 1961, TOBIEN et al. 1988) and finally *Z. gromovae* was incorporated into its synonymy (TOBIEN, 1996). The species *S. tolojojensis*, which type locality is Ulaan Tologoi, was first referred to *Gomphotherium* (see SAVAGE & RUSSELL 1983) but more recent was only accepted as *Gomphotherium* sp. or *Platybelodon* sp. (SHOSHANI & TASSY 1996: 370). The genus *Serridentinus* OSBORN 1923 is not in usage anymore and was synonymized with *Gomphotherium* (see SHOSHANI & TASSY 1996: 349f, appendix A). Thus, *S. mongoliensis*, described from the Loh locality by OSBORN (1924), became *Gomphotherium mongoliense*, but is still a taxon of incertae sedis (SHOSHANI & TASSY 1996: 356, appendix C).

Following these systematic changes the taxa described from the Neogene of Mongolia represent Mammutidae (*Zygodolophodon*, *Mammut*), trilophodont gomphotheres (*Gomphotherium* or *Platybelodon*) and tetralophodont gomphotheres (*Tetralophodon*, *Anancus*).

More diverse and richer proboscidean faunas are known from China (see e.g. CHEN 1988; CHOW & CHANG 1961, 1974, 1978, 1983; GUAN 1988, 1996; HSIEH 1962; HU 1962; LI 1976; PEI 1987; YE & JIA 1988; ZHANG 1982). The flood of Chinese proboscidean taxa was revised by TOBIEN, CHEN & LI (1986, 1988). From the Shangwangian and the Tunggurian stage (Early to Middle Miocene) of China the following taxa are known (TOBIEN et al. 1988: tab. 4; GUAN 1996: tab. 13.2): trilophodont gomphotheres s.l. with *Gomphotherium* (*G. connexum* (HOPWOOD, 1935), *G. wimani* (HOPWOOD, 1935), *G. shensiense* CHANG & ZHAI 1978), *Choerolophodon* sp., and *Synconolophus* sp.; tetralophodont gomphotheres s.l. represented by *Tetralophodon xiaolongtanensis* (CHOW &

CHANG, 1974); shovel-tusked gomphotheres s.l. with the taxa *Platybelodon* (*P. grangeri* BORISSIAK, 1928, *P. danovi* OSBORN, 1929, *P. dangheensis* WANG & QUI, 2002), *Amebelodon tobieni* GUAN, 1988 and *Serbelodon zhongningensis* GUAN, 1988, stegodonts with *Stegolophodon hueiheensis* (CHOW, 1959), mammutids like *Zygodolophodon* (*Z. chinjiensis* OSBORN, 1929, *Z. gobiensis*) and Elephantids with *Stegotetrabelodon exoletus* (HOPWOOD, 1935).

Additional Asiatic taxa, considered in this study for comparisons are *Gomphotherium cooperi* (OSBORN, 1932) from the Lower(?) Miocene of the Bugti Hills (Baluchistan, Pakistan), *G. inopinatum* (BORISSIAK & BELYAEVA, 1928) from the Miocene of the Turgai region, Kazakhstan, and undetermined taxa of the "*G. annectens* species group" and the "*G. angustidens* species group" from the Early Miocene of Kazakhstan (LUCAS & BENDUKIDZE 1997).

Methods

For this study Asian proboscidean material has been compared in the Institute of Vertebrate Palaeontology and Palaeoanthropology (IVPP), Beijing. Terminology and measurements follow GÖHLICH (1998), systematics follow SHOSHANI & TASSY (1996, 2005). All specimens presented here are housed in the Naturhistorisches Museum Wien (NHMW), Austria.

A b b r e v i a t i o n s: Odontology: m₃ – lower 3. molar; M¹ – upper 1. molar; P⁴ – upper 4. premolar; dext. – dexter; sin. – sinister.

Systematic Paleontology

Order Proboscidea ILLIGER, 1811

Family Gomphotheriidae HAY, 1922

Genus *Gomphotherium* BURMEISTER, 1837

S y n o n y m y: see SHOSHANI & TASSY (1996: 349f, Appendix A)

O r i g i n a l d i a g n o s i s: BURMEISTER 1837: 795

E m e n d e d d i a g n o s i s: TASSY 1985: 670ff

T y p e s p e c i e s: *Gomphotherium angustidens* (CUVIER, 1817)

cf. *Gomphotherium mongoliense* (OSBORN, 1924)

(Plate 1, Fig. 1)

T y p e s: series of right and left cheek teeth; m₂ dext. and m₃ dext. imbedded in a mandible portion; d₄ sin. and m₁ sin., totally worn down and partly worn, respectively. AMNH² 19152. Figured in OSBORN 1924: fig. 1; OSBORN 1936: figs. 350F and 354.

T y p e l o c a l i t y: Loh, Loh-Formation, Mongolia, Early to Middle Miocene.

² American Museum of Natural History, New York

Loh

L o c a l i t y: Loh, Valley of Lakes, Loh Formation, reference profile: LOH-A, Early to Middle Miocene, D1 biozone.

M a t e r i a l: m_3 sin.-fragment, posterior 3 lophids and posterior part of the 1st pretrite lophid, (2005z0052/0001); m_3 sin./dext.?, very poorly preserved, totally worn down and badly damaged, (2005z0052/0000).

R e m a r k s: The two m_3 remains do not represent one individual, because they represent very different stages of tooth-wear. No additional tooth or bone material is known from this locality.

Description

D e n t i t i o n: For measurements see Table 1.

m_3 sin. (Plate 1, Fig. 1a, b): Small and slender tooth consisting of 4 lophids and small posterior talonid; anterior end of molar broken off; relatively low crown (estimated height of third posttrite half-lophid about 44 mm); simple bunodont crown pattern, with bulky cusps, narrow valleys, strong and thick anterior and posterior central conules – the anterior ones a larger than the posterior ones of the same lophid – on each pretrite half-lophid (strong pretrite trefoils) completely blocking all valleys, and no posttrite conules. 1st lophid only represented by incomplete pretrite half-lophid and big posterior central conule; in 2nd lophid posttrite half lophid damaged, 1st and 2nd lophid strongly worn; 3rd lophid consisting of one strong main cusp and a weaker conelet in each half-lophid; 4th lophid with posttrite cone and pretrite main cone with weak conelet; "talonid" with one strong central and one weak lingual cusp; weak median sulcus; lophids barely transversal; no cement. Even if the anterior end of the molar is missing the total number of 4 lophids can be reconstructed also by means of the second m_3 from Loh.

m_3 (sin/dext.): Small and slender, badly shattered and totally worn down to base of crown, no more crown pattern preserved; 4 lophids still indicated; roots preserved but badly damaged; no more details to observe.

Comparison and discussion

Both m_3 remains are characterized by their small size. The better preserved m_3 (2005z0052/0001) shows a very simple (not complicated) bunodont crown pattern, with blunt and strong main cones and single, small conelets, which can also be suppressed (e.g. 4th posttrite half-lophid), strong and simple pretrite central conules, narrow blocked valleys, and no posttrite central conules. The crown lack progressive features such as elevation of the crown height, diversification of the crown structure, incipient cement deposition, choerodonty or ptychodonty (= furrowing of the main cones). The fact of four lophids in the m_3 indicates trilophodonty (in the intermediate molars). This combination of cheek teeth features excludes all Mammutids, tetralophodont gomphotheres, *Choerolophodon*, stegodonts, and elephantids.

Thus, further discussions concentrate on trilophodont gomphotheres with the taxa *Gomphotherium* and *Synconolophus* and shovel-tusked gomphotheres like *Platybelodon*, *Amebelodon* and *Serbelodon*.

Because lower tusks are not represented in the studied material, comparisons with shovel-tusked gomphotheres are complicated. However, the molars of *P. danovi* and *P.*

grangeri are characterized by high crowns and abundant cement in the transverse valleys (GUAN 1996: 131); the m_3 of these *Platybelodon* species mostly show a more complicated crown structure and often consist of five lophids. Additionally, both taxa differ from the presented m_3 by their larger dimensions (Tab. 1). Comparisons with the shovel tusked species *P. dangheensis* and *Serbelodon zhongningensis* are prevented by the fact that no m_3 are known (*P. dangheensis* is represented by a juvenile mandible with $i_{2,3}$, p_3 , $p_{4,5}$, m_1 , and anterior part of m_2 of both sides; *S. zhongningensis* is known by its upper jaw with both M^2 and M^3 and a piece of a right lower tusk); the m_3 of the single specimen of *Amebelodon tobieni* is not completely erupted and a description is not provided.

Outside of the Indian Subcontinent the genus *Synconolophus* is represented very poorly and is hitherto only known in Southern China, where the only systematically confirmed specimen is an upper intermediate molar, characterized by ptychodonty, choerodonty and cementodonty (TOBIEN et al. 1986: 146). Thus, an allocation to *Synconolophus* can be excluded because of its dental characters, of which none can be observed in the present molars. Besides, *Synconolophus* was stated to be a junior synonym of *Choerolophodon* by TASSY (1983).

The morphology of the present m_3 from Loh corresponds best to that of *Gomphotherium* in its "archaic structure" that shows no elevation of the crown height, no cement, no choerodonty, and no ptychodonty. To highlight again, the crown morphology of the Loh m_3 is characterized by thick and simple pretrite central conules (no postrite ones), associated with a relatively low crown.

The "simple" bunodont crown pattern of the m_3 from Loh, clearly differs from the much more "complex" cheek teeth crowns of the holotype of "*Serridentinus tolojojensis*", lately determined as *Gomphotherium* sp. or *Platybelodon* sp. (SHOSHANI & TASSY 1996: 370).

The m_3 of *G. wimani* (HOPWOOD 1935: pl. VI, fig. 1; TOBIEN et al. 1986: fig. 12) from the Middle Miocene of Kansu, China, is distinctly larger than the present m_3 (Tab. 1) and shows postrite posterior central conules (secondary trefoils). In its diagnosis, *G. wimani* is described to have an advanced molar pattern and tendencies to choerodonty and cementodonty. However, TOBIEN et al. (1986: 131) also mentioned specimens without cement deposits. All in all, the presented m_3 from Loh belong to a smaller species with more simple crown structure.

G. shensiense CHANG & ZHAI, 1978 is only represented by two upper molars (skull fragment with M^2+M^3 , IVPP V 3084, TOBIEN et al. 1986: 135f, fig. 13), thus is not qualified for morphological comparisons. But the measurements of the M^3 (CHANG & ZHAI 1978: 142) indicate it to be a larger, middle sized species, than to which the presented m_3 from Loh belong to. Additionally, the molars of *G. shensiense* differs from the m_3 of Loh by well developed cement covers in the valleys and on the slopes of the loph(id)s.

LUCAS & BENDUKIDZE (1997: fig. 2) described one m_3 from Kazakhstan, that they referred to the *Gomphotherium annectens* species group; the crown pattern of this tooth is also simple bunodont like the present one, but it is somewhat larger and differs especially by very feeble anterior central conules, by valleys that are wider and not well blocked. Another m_3 from the Early Miocene of Kazakhstan that LUCAS & BENDUKIDZE (1997: fig. 3) referred to the *Gomphotherium angustidens* species group is poorly preserved and thus allows no morphological comparisons, but is distinctly larger than the present m_3 from Loh.

Concerning the discussion on the molar sizes it has to be admitted, that only very little is known on the intra-specific size variation of all the discussed species, because of their rare occurrence; however, Miocene proboscideans are known to show a remarkable metrical variability.

The bunodont crown pattern of the presented m_3 from Loh, with narrow valleys and thick and high central conules, corresponds to that of the "*Gomphotherium* group *angustidens*", defined by TASSY (1985: 696, including *G. angustidens*, *G. inopinatum*, and *G. subtapiroideum*). The m_3 from Loh approximates in morphology and falls in the size range of four small sized species, *G. connexum*, *G. inopinatum*, *G. cooperi*, and *G. mongoliense* (Tab. 1).

The outstanding feature of *G. connexum* (figured in HOPWOOD, 1935: pl. 5, figs. 1, 2 and TOBIEN et al. 1986: fig. 2) is its extreme slenderness of the m_3 (in relation to its length), which is different to that of the presented m_3 from Loh as well as to those of *G. inopinatum*, *G. cooperi*, and *G. mongoliense* (Table 1). Additionally, all posttrite half lophids of *G. connexum* consist only of one single, but very strong and blunt cusp. In the presented m_3 of Loh the anterior two posttrite half lophids are damaged, but the third one consist of two cusps, a main cusp and a somewhat smaller conelet. Besides these differences, the m_3 from Loh and that of *G. connexum* coincide by strong, pretrite central conules, and narrow valleys that are completely blocked.

The presented m_3 from Loh morphologically and metrically approximates also those of *G. inopinatum* from the Miocene of Kazhakstan (BORISSIAK & BELYAEVA 1928: pl. II, fig. 4-6; OSBORN 1936: fig. 224). Each half lophid consists of two unequal cusps – the main cusp larger than the median conelet, the anterior three lophids possess anterior and posterior conules, and the latter of the second lophid is duplex (BORISSIAK & BELYAEVA, 1928: 246). However, in *G. inopinatum*, the central conules of the m_3 are more feeble developed (visible also in side view) than in the present Loh specimen, the 3rd lophid totally lacks central conules, and the valleys appear wider (in occlusal view) (BORISSIAK & BELYAEVA 1928: pl. II, fig. 5).

Also the m_3 of the type mandible of *G. cooperi* (OSBORN 1936: fig. 222) from the Bugti Hills in Baluchistan resembles to the m_3 of Loh; they are very similar in size (Tab. 1), and all half lophids consist of two cusps. But unlike in the m_3 of Loh, there is only a posterior central conule developed on the 1st and 2nd lophids, whereas the anterior one is suppressed; the valleys are not completely blocked and the third valley is completely unblocked.

G. mongoliense (OSBORN 1936: figs. 350, 354) was originally described from the same locality (Loh, Loh Formation) like the present m_3 . They correspond well in size and in the simple bunodont crown pattern with strong pretrite anterior and posterior central conules, and narrow valleys that are well blocked. Unlike the m_3 from Loh presented here, the m_3 of the type of *G. mongoliense* consist of four lophids, without a talonid.

However, the systematic identity and validity of the species *G. mongoliense* was recently claimed to be uncertain (incertae sedis in SHOSHANI & TASSY 1996).

Based on all these comparisons, the bunodont m_3 of Loh with the simple bunodont crown pattern corresponds morphologically best with that named as *G. mongoliense*, even with minor differences. However, Miocene proboscideans are known to show a remarkable morphological and metrical variability in the crown structure of the cheek

teeth. Unfortunately, neither the here presented material nor that of the considered species of *Gomphotherium* allow an evaluation of an actual variability.

But because of this known variability it is also difficult to weight and estimate the described morphological accordances and differences of the m_3 from Loh and those of *G. cooperi*, *G. inopinatum*, and *G. connexum*.

In addition, there are still uncertainties concerning the validity and interrelations of the latter species. OSBORN (1936) for example considered *G. inopinatum* and *G. cooperi* to represent a single species, and also TASSY (1996a) noted, that molars of *G. cooperi*, which is assigned by him (TASSY 1985) to the *G. annectens* species group, are also very similar to those of *G. inopinatum*, whereas TOBIEN et al. (1986) claimed *G. connexum* to be similar to *G. inopinatum*, a proposition that LUCAS & BENDUKIDZE (1997) did not accept because of the large central conules in *G. connexum*.

Because of all these problematics and uncertainties the present m_3 from Loh is referred under reserve to *Gomphotherium mongoliense* in the awareness of the uncertain systematic position of this taxon.

Tab. 1: Measurements in mm of m_3 from the Loh locality and compared Asiatic Miocene taxa.

Taxon	locality	length	width
cf. <i>Gomphotherium mongoliense</i> (2005z0052/0001)	Loh, Valley of Lakes, Mongolia, Loh Formation; Early/Middle Miocene	140 estim.	(60)
cf. <i>Gomphotherium mongoliense</i> (2005z0052/0000)	Loh, Valley of Lakes, Mongolia, Loh Formation; Early/Middle Miocene	135 estim.	(60)
<i>G. mongoliense</i> ³	Loh, Valley of Lakes, Mongolia, Loh Formation; Early/Middle Miocene	138	63
<i>G. connexum</i> ¹	Kansu, Sining Fu, China; Miocene	145	51.8
<i>G. inopinatum</i> ²	Turgai region, Kazakhstan, Jilančik Beds; Miocene	130	67
		134	70
		139	62
		142	60
<i>G. cooperi</i> ³	Bugti Hills, Baluchistan, Pakistan; Early Miocene	147	63
<i>G. wimani</i> ⁴	Sining Hsien near Xining, Prov. Kansu, China; Middle Miocene	182,6	68
		185	75
<i>G. annectens</i> species group ⁵	Bestobe, Bestobe Fm., W-Kazakhstan; Early Miocene	165	72
<i>G. angustidens</i> species group ⁵	Kyzyl Say, Aktau Fm, Kazakhstan; Early Miocene	175	76
<i>Platybelodon danovi</i> ³	Kuban region, North Caucasus, Chokrak beds; Middle?/Upper Miocene	168–170	67
<i>Platybelodon grangeri</i> ³	Tairum Nor Basin, Mongolia, Tung Gur horizon; Upper Miocene	192–205	69–68
		218	65

¹HOPWOOD 1935: 15; ²BORISSIAK & BELYAEVA 1928: 244, 247; ³OSBORN 1936: 277, 396, 463, 469; ⁴CHEN et al. 1988: 267; ⁵LUCAS & BENDUKIDZE 1997, tab. 1.

Gomphotheriidae indet.

A few cheek teeth fragments, some undeterminable tooth splinter and some postcranial bones – mostly fragments – were found in Ulaan Tolgoi and Builstyn Khudag, both Valley of Lakes, Loh Formation. Unfortunately there was no m_3 found in Ulaan Tolgoi or Builstyn Khudag that allows direct comparisons with that from Loh, determined above as *Gomphotherium* sp.; but because some other fragmentary tooth positions show morphological differences in the crown structure, it seemed not justifiable to refer the entire proboscidean material presented in this publication to just one taxon. In addition, based on the differing morphology, especially of some calcanei remains, described in the following, it is possible that there is more than one proboscidean taxon represented in the material of Ulaan Tolgoi and Builstyn Khudag.

Ulaan Tolgoi

Locality: Ulaan Tolgoi; not far from the section UTO-A (see HÖCK et al. 1997) surface collections (UTO-B) yielded the presented mastodont material, very probably from the Early to Middle Miocene of the Loh-Formation (pers. comm. G. DAXNER-HÖCK, NHMW, Vienna).

Material: M^{12} dext.-fragment, damaged posterior 2 lophs (2005z0053/0001); P^4 dext., little damaged (2005z0053/0002); several cheek tooth splinter (2005z0053/0000); calcaneus sin., complete (2005z0053/0003); calcaneus dext., incomplete (2005z0053/0005).

Description

Dentition: For measurements see Table 2.

M^1 dext. (Plate 1, Fig. 2): fragmentary, probably trilophodont upper intermediate molar lacking 1st loph; bunodont pattern; lophs anteroposteriorly slightly compressed (less bulky than in the m_3 from Loh); 2nd pretrite half loph strongly worn down with trefoil pattern; all preserved main cusps damaged; both half lophs of 3rd loph consist of strong main cusp and one smaller conelet; 3rd pretrite half-loph with only anterior pretrite central conule; 3rd loph in V-chevron, valleys narrow and blocked by pretrite central conules; posterior cingulum (talon) low and serrated; lingual cingulum in valley between 2nd and 3rd loph serrated; little cement in valleys; posterior root fragmentary preserved. By means of its dimension this intermediate molar is determined as first molar.

P^4 dext. (Plate 1, Fig. 3): almost complete, only little damaged on anterolabial side of 1st loph and along lingual side; both lophs worn; bunodont pattern; lophs anteroposteriorly slightly compressed; 1st pretrite half-loph with weak trefoil pattern; 2nd pretrite half-loph with strong anterior central conule; small posttrite central conule on anterior side of 2nd posttrite half-loph; very little cement in valley; rests of roots.

Tab. 2: Measurements of molars and premolars in mm.

	Locality	Invent.-Nr	length	width	Height
M^1 dext.	Ulaan Tolgoi	(2005z0053/0001)	–	(49)	III 35
P^4 dext.	Ulaan Tolgoi	(2005z0053/0002)	45	38	–
P^4 sin.	Builstyn Khudag	(2005z0054/0001)	(40)	35	–

There are several cheek teeth splinter; which do not fit together, but could represent one tooth, but also more. By their size and the thickness of the enamel these pieces can be attributed to molars. Some of these fragments represent portions of half loph(id)s, that show high and strong main cusps and up to three lower conelets that become strongly lower towards the median sulcus. The morphology of these fragments show a bunodont pattern, but less simple than in the above described m_3 from Loh.

Postcranial material: For measurements see Table 3.

Calcaneus: A left and right calcaneus are preserved; only the left one is almost complete (Plate 1, Fig. 4 a-c). Tuber calcanei mediolaterally compressed; proximolateral articular facies for fibula rhomboid shaped and strongly dorsally convex; medially attaches the large, oval (proximodistal compressed), and flat facies articularis talaris lateralis for the astragalus articulation, only its lateral edge is dorsally concave; medial facies articularis talaris small and roundish, but in both preserved specimens more or less damaged; sulcus calcanei widens slightly in lateral direction and is medially open where it passes between both facies articulares talaris; distinct protuberance plantarly at medial end of sulcus; distal facies articularis cuboidea for articulation with os tarsale quartum (cuboideum) oval (mediolaterally compressed); no evidence for a distal facies for os tarsi centrale (scaphoideum, naviculare).

The two calcanei do not belong to one individual; unlike the left calcaneus, the right one represents a juvenile, which can be determined by means of the end of the tuber calcanei which shows the bone surface of a not yet fused suture.

Left and right calcaneus show some morphological differences; the right and more incomplete specimen differs by a large and very deep dent in the middle of the sulcus calcanei and another depression on the lateral side of the neck of the tuber calcanei. Remarkable morphological differences with the calcaneus of Builstyn Khudag are described below.

Tab. 3: Measurements of calcanei (method of measurement see GÖHLICH 1998: Abb. 137).

calcaneus		Ulaan Tologoi (2005z0053/0003)	Ulaan Tologoi (2005z0053/0004)	Builstyn Khudag (2005z0054/0002)
maximum height of basal part		79 mm	(77)	(72)
maximum depth		149 mm	–	–
maximum width		78 mm	–	–
tuber calcanei	height	75 mm	–	–
	width	50 mm	–	–
facies articularis for fibula	depth	~41 mm		(51)
	width	~32 mm		(30)
lateral facies articularis talaris for talus	depth	~38 mm	(36)	(36)
	width	~60 mm	(65)	–
medial facies articularis talaris for talus	depth	–	–	–
	width	–	–	–
facies articularis cuboidea for t4	height	~45 mm	(45)	(47)
	width	~34 mm	(36)	(30)

Builtstyn Khudag

L o c a l i t y: Builtstyn Khudag; this material comes from surface collectings (named BUK-B) at the bottom of the section BUK-A (see HÖCK et al. 1997). The upper-most part of this section (BUK-A/12+14) was identified by means of the rodent fauna to belong to the biozone E, which probably is of Late Miocene age. Also the examination of the rhinocerotid fauna from this location indicates a younger age than that of Ulaan Tolgoi and Loh (pers. comm. K. HEISSIG, BSPG Munich, and also this volume). However, because the suspense of the exact provenance of the mastodont material, no stratification is possible; it could also be of late Early/early Middle Miocene age as the material from Loh and Ulaan Tolgoi (pers. comm. G. DAXNER-HÖCK, NHMW, Vienna).

M a t e r i a l: P⁴ sin., subcomplete (2005z0054/0001); fragmentary calcaneus dext. lacking tuber calcanei, sustentaculum damaged (2005z0054/0002); fragmentary astragalus dext., lacking medial half of bone including entire trochlea (2005z0054/0003); proximal end of left(?) metatarsal IV? (2005z0054/0004); tooth splinter of a undeterminable molar (2005z0054/0000); three undeterminable bone portions with partial articular facets (2005z0054/0000).

D e s c r i p t i o n

D e n t i t i o n: For measurements see Table 2.

P⁴ sin. (Plate 1, Fig. 5): Sole tooth remain from the locality Builtstyn Khudag; almost complete, lacking only posterior-most end of tooth; crown of almost quadrate shape with anterolingual edge rounded; crown strongly worn down, bunodont wear pattern; thick enamel; very weak trefoil pattern on back of 1st pretrite half-loph, none in front of the 2nd pretrite half-loph; strong contact facet at the anterior end of the tooth; uncommon is the direction of an anterior trefoil tubercle of the 2nd posttrite half-loph, which protrudes more towards the median, than towards the anterior. As usual for P⁴ the tooth is more worn down at its posterior than at its anterior loph. Strong contact facet on anterior end of tooth.

P o s t c r a n i a l m a t e r i a l: For measurements see Table 3.

Calcaneus dext. (Plate 1, Fig. 7): Fragmentary bone lacks the tuber calcanei; sustentaculum and distal side are damaged; lateral facies articularis talaris, facet for fibula, and distal facies articularis cuboidea are preserved but worn. Like the right calcaneus from Ulaan Tolgoi (2005z0053/0003) the lateral side of the neck of the tuber calcanei carries a depression. In contrary to both calcanei of Ulaan Tolgoi, the sulcus calcanei is closed at its medial end (Text-Fig. 1); the medial facies articulares talaris is situated more proximally and contacts the lateral facies articulares talaris; thus, the sulcus does not run between the two facies but ends at their connection. Additionally, the proximolateral, convex facet for the fibula is somewhat longer and continues further proximally in direction to the calcaneal tuber. A further difference between the calcaneus from Builtstyn Khudag and those from Ulaan Tolgoi is a differing angle between the distal and proximal facets (Text-Fig. 1); the angle between the distal facies articularis cuboidea and the lateral facies articularis talaris plus the facet for the fibula is a more acute (smaller) than in the specimens from Ulaan Tolgoi.

Astragalus (talus) dext. fragment (Plate 1, Fig. 6a, b): Medial half of the bone and proximal trochlea tali for the tibia articulation are broken off; on distal side, medial facies articularis calcanea is of triangular shape and distally concave; both, medial facies articularis calcanea and sulcus tali taper medioplantarly; only medial half of distodorsal facies articularis for the os tarsi centrale (scaphoid, naviculare) is preserved, but worn; it is distally convex and dorsoplantarly narrow. Medially projects a strong tuberculum tali, which proximally is separated from the trochlea by three deep depressions.

Metatarsal (?) IV(?) fragment (Plate 1, Fig. 8a, b): Only proximal end of a possible left(?) mt IV is preserved; proximal articular surface of triangular shape, medial margin with distinct notch. In dorsal view, proximal facies articularis ascending towards laterally. Lateral articular facet on proximal end low and proximally convex. Medial side of proximal end strongly weathered. Depth and width of the proximal articular surface are 45 mm and 44 mm, respectively.

A few other bone fragments with articulation facets are very poorly preserved and thus not determinable.

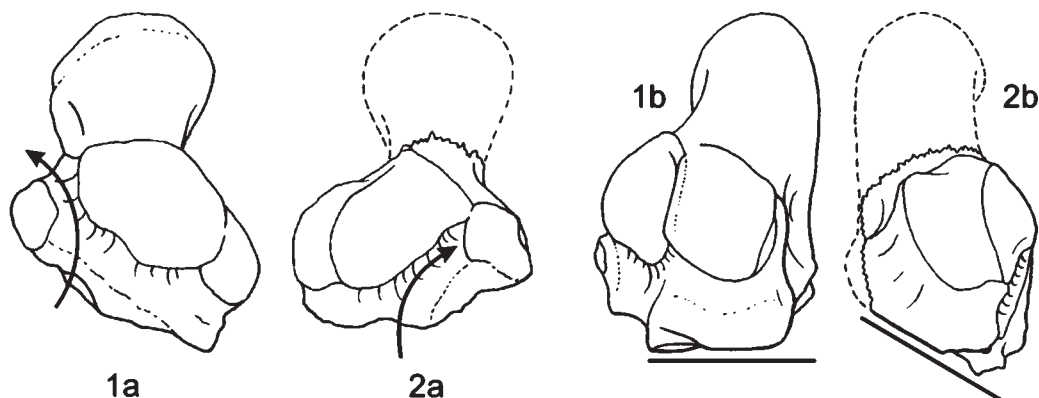
Comparison and discussion

The systematic determination of these Miocene proboscidean remains from in Ulaan Tolgoi and Builstyn Khudag is hampered by divers difficulties. The studied material is scanty and consists of isolated teeth and bones, predominantly in fragmentary condition. Postcranial material of fossil proboscideans is in general poorly studied and described, the reason why there is only meager knowledge about postcranial diagnostic features in different proboscidean taxa. In addition, proboscideans often show a substantial variability in morphology and size of bones and teeth.

In general, the dentition and cranial characters of Proboscidea are better suitable for systematic determinations. Unfortunately no cranial information is available and the lack of upper and especially lower tusks in this presented material restricts the possibility of determination. However, the present specimens of cheek teeth allow a systematic approach.

The fragmentary M^1 and the two P^4 from Ulaan Tolgoi and Builstyn Khudag show a bunodont crown pattern including well developed central conules; the M^1 , even if not complete, was very probable trilophodont, according to its width. This combination of features excludes an affiliation of the teeth material to the zygodont mammutids like *Zygodontophodon*, to tetra- or more lophodont taxon like *Tetralophodon*, to the elephantid *Stegotetrabelodon* or to the stegodontid *Stegolophodon*. The lack of abundant cement contradicts additionally the affiliation to *Stegotetrabelodon* (TOBIEN et al. 1988: 140); the presence of well developed central conules and the fact that the main cusps are not of same size as the conelets (TOBIEN et al. 1988: 194) prevent the allocation to *Stegolophodon*.

The tips of the lophs of the M^1 from Ulaan Tolgoi are already worn and provide no information of how many conelets the lophs were built. However, the M^1 and P^4 show traits of posttrite central conules; thus, their crown pattern can be interpreted to be more derived than that of the m_3 from Loh, determined here as cf. *G. mongoliense*. Unlike the latter, the posterior cingulum of the M^1 is serrated and in both teeth, the M^1 and P^4 , the valleys are somewhat wider and the lophs less bulky in anteroposterior direction.



Text-figure 1: Morphological differences in calcanei in (a) proximodorsal and (b) lateral view, from the localities Ulaan Tologoi (1) and Builstyn Khudag (2) which probably indicate two different taxa of Gomphotheriidae indet.

Some of the additional molar fragments from Ulaan Tologoi (2005z0053/0000) show also crown feature which are differing from that of the m_3 of cf. *G. mongoliense* from Loh; some of the half loph(id) fragments consist of up to three conelets additional to the main cusp, whereas in the m_3 from Loh all preserved half lophids are made up only of a main cusp and a single conelet. This multiplication of the conelets causes a little more complicated bunodont structure and was a feature for the former genus "*Serridentinus*", which was synonymized later with *Gomphotherium*, but of which some species have been referred also to other genera such as *Zygalophodon*, *Amebelodon*, *Archaeobelodon*, and *Paratetralophodon*.

By means of this more complex, bunodont crown pattern, with multiplication of the conelets and posttrite central conules, the possibilities of systematic affiliation of the tooth remains from Ulaan Tologoi and Builstyn Khudag increase; not only species of *Gomphotherium* can be considered but also shovel-tusked gomphotheres. In general, the molars of *Platybelodon* should differ by abundant cement, but not so for *Amebelodon* and *Serbelodon* where cement is absent or in small amounts (GUAN 1996: 131ff). Some species of these shovel-tusked gomphotheres have a tendency to tetralophodonty in the intermediate molars, but which is mostly restricted to the second molar, whereas the M1 stay trilophodont – like the M¹ from Ulaan Tologoi.

Interestingly, the two P⁴ from Builstyn Khudag and Ulaan Tologoi show different features, but the strong attrition of the P⁴ from Builstyn Khudag hampers detailed comparisons. The valley of the P⁴ from Ulaan Tologoi is somewhat wider than in that from Builstyn Khudag. The P⁴ from Ulaan Tologoi shows a clear pretrite trefoil structure in both lophs (on the second loph the posterior branch of the trefoil is not developed); that one from Builstyn Khudag completely lacks a pretrite trefoil pattern in the 2nd loph and the posterior branch of the trefoil in the 1st loph is weaker than in the P⁴ from Ulaan Tologoi; in addition, in the Builstyn Khudag tooth an anterior trefoil of the 2nd posttrite loph is strongly directed towards the median sulcus, and not, as usual, more anterior. The P⁴ from Ulaan Tologoi shows a distinct anterior posttrite central conule in front of

the 2nd loph. This differing morphology in the P⁴ of Ulaan Tologoi and Builstyn Khudag may indicate two different types of gomphotheres in the two localities.

This possibility might be supported by the fact that also the calcanei of these two localities show morphological differences (Text-Figure 1).

The described remains of three calcanei of equal size show distinct morphological differences; that one from Builstyn Khudag (2005z0054/0002) distinctly differs from both of Ulaan Tologoi (2005z0053/0003+4) by a medially blocked sulcus calcanei, which does not pass and run between the medial and lateral facies articularis talaris (Text-Fig. 1). Furthermore, in the Builstyn Khudag calcaneus (2005z0054/0002) the lateroproximal, convex facet for the fibula continues further proximally in direction to the calcaneal tuber. Remarkable is also the angle between the distal facies articularis cuboidea and the proximodorsal lateral facies articularis talaris and the facet for the fibula that differs strikingly in the calcanei of these two localities. The different angle between the articular facets in the calcanei from Builstyn Khudag and Ulaan Tologoi probably indicate not only a morphological difference between two different species, but also an unequal construction of the foot and consequentially a differing mode of motion. On the other hand, the two calcanei remains coming both from the same locality of Ulaan Tologoi also show some morphological differences; the right calcaneus differs from the left exemplary by a very deep depression in the middle of the sulcus calcanei and a distinct depression on the lateral surface of the tuber calcanei, which are absent in the left specimen. However, the right calcaneus of Ulaan Tologoi represents a juvenile, which might also affect the morphology. Based on only these few specimens it is impossible to evaluate the actual importance of these morphological differences and their interpretation as diagnostic feature, variability, sexual dimorphism or pathology. Finishing, it is worth mentioning that the well preserved calcaneus from Ulaan Tologoi (2005z0053/0003) shows no evidence of a distal facet for the articulation with the os tarsi centrale (naviculare) (the poor preservation of both other calcanei prevents this observation); this calcaneo-navicular articulation is also lacking in *G. angustidens* (CUVIER, 1817) (TASSY 1985: 699) and the *G. aff. steinheimense* skeleton from Gweng (Germany) (GÖHLICH 1998: 166, GÖHLICH 1999), but is present in the European amebelodontid *Archaeobelodon filholi* (FRICK, 1933) (TASSY 1985: 597); the condition of this feature is not known for any Asiatic taxon.

Conclusion

In the course of the "proboscidean datum event", which contains actually multiple immigration events of proboscideans from Africa to Asia and Europe (TASSY 1989), primitive gomphotheres and mammutids immigrated during the Early Miocene into Asia Minor and southern Asia. First records are documented in Pakistan, Kazakhstan, China, and Japan in sediments stratified as or slightly younger than MN4 (LUCAS & BENDUKIDZE 1997; TASSY 1996b). Most of the material presented here from the Loh Formation in Central Mongolia (perhaps with the exception of the proboscidea material from Builstyn Khudag, the age of which is unclear) comes from deposits determined to be of late Early to early Middle Miocene age; thus, this material represents proboscideans only slightly younger than the first gomphothere and mammutid immigrants.

The scanty material consisting of a few teeth and fragments of postcranial bones of proboscideans from the localities Loh, Ulaan Tologoi, and Builstyn Khudag represent at least two – possibly three – different taxa of gomphotheres. Systematic determination is complicated by the rarity and the poor preservation of the specimens. Only one tooth fragment – a small sized m_3 from the Loh locality – is determinable. Its simple bunodont crown pattern, with four lophids (plus talonid), each formed by a few and bulky cusps, with narrow valleys and strong pretrite central conules blocking all valley, identifies the molar to be of the "*G. angustidens* group" type. This m_3 corresponds morphologically best with *G. mongoliense* – a taxon which was originally described from the same locality, Loh. However, the systematic identity and validity of the species *G. mongoliense* is until today called into question (incertae sedis in SHOSHANI & TASSY 1996). Very close in size and morphologically somewhat similar are also *G. connexum*, *G. inopinatum*, and *G. cooperi*; but each of these species differs by more or less distinctive crown structure developments. However, all of these taxa are only represented by a few specimens, often only the holotype; thus, the actual morphological variability of all these species can not really be estimated.

The tooth remains from Ulaan Tologoi, the M^1 and P^4 , differ from the m_3 from Loh in a more complex bunodont crown structure, with additional posttrite trefoils, a multiplication of the cusps per loph and slightly wider valleys. Based on the preserved material this material can be identified as trilophodont gomphotheres, but shovel-tusked gomphotheres can not be excluded with certainty. The strong attrition of the P^4 from Builstyn Khudag prevents details comparison of the crown morphology. However, the calcanei represented from both localities, Ulaan Tologoi and Builstyn Khudag, show a distinctly differing development of the sulcus calcanei and a differing angle of some articulation facets which might be of taxonomic relevance and probably indicate two different proboscidean taxa in these two localities. If these two probable taxa really coexisted cannot be clarified here.

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Plate I

cf. *Gomphotherium mongoliense*

Loh locality, Valley of Lakes, Loh Formation, late Early to Early Middle Miocene

Fig. 1: m_3 sin.-fragment (2005z0052/0001), a: lingual view, b: occlusal view.

Gomphotheriidae indet.

Ulaan Tolgoi locality, Valley of Lakes, Loh Formation, late Early to Early Middle Miocene.

Fig. 2: $M^{1?}$ dext.-fragment (2005z0053/0001), occlusal view.

Fig. 3: P^4 dext. (2005z0053/0002), occlusal view.

Fig. 4: calcaneus sin. (2005z0053/0003), a: proximodorsal view, b: medial view,
c: distal view.

Gomphotheriidae indet.

Builtstyn Khudag locality, Valley of Lakes, Loh Formation, late Early to Early Middle Miocene.

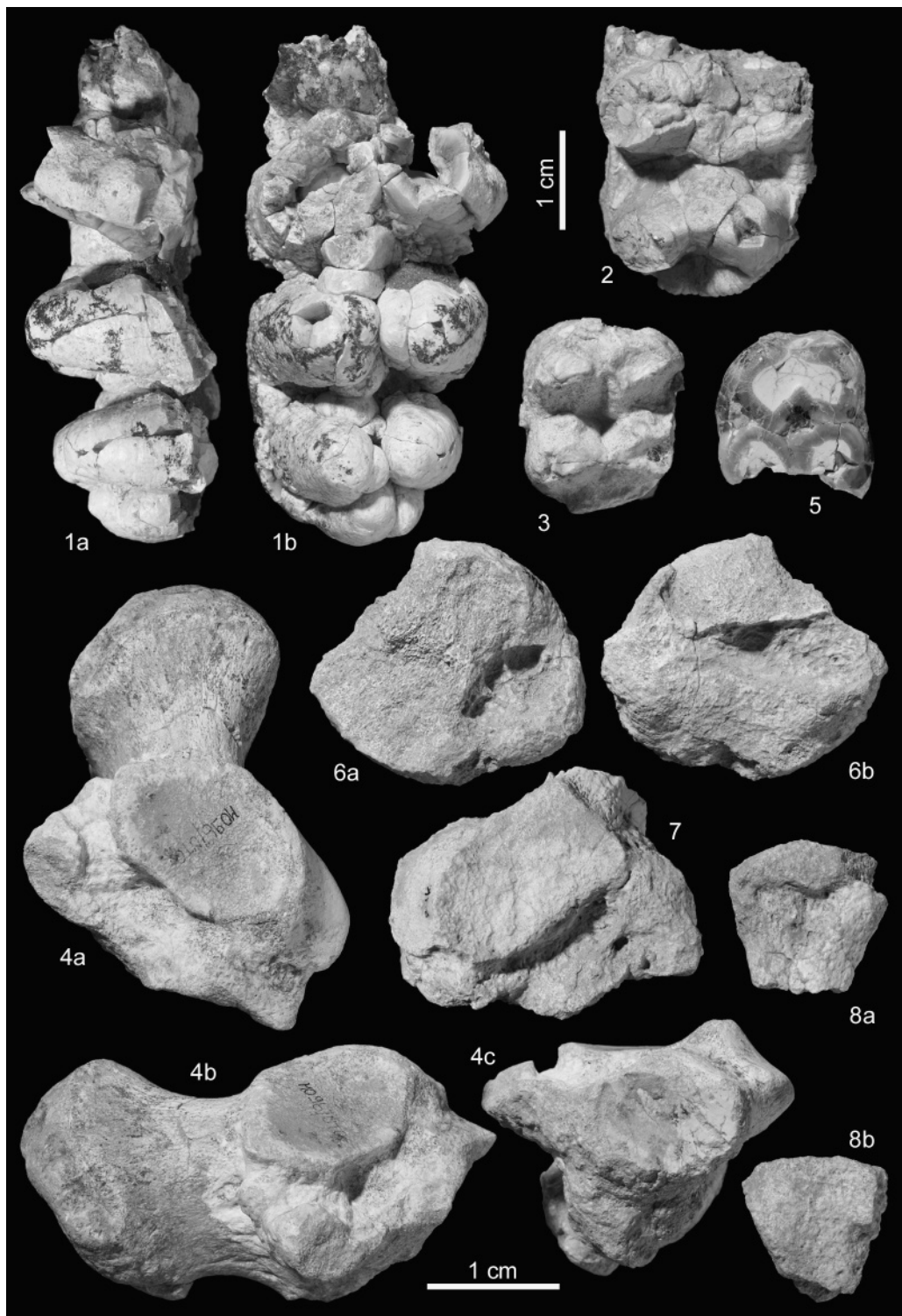
Fig. 5: P^4 sin. (2005z0054/0001), occlusal view.

Fig. 6: astragalus dext. (2005z0054/0003), a, proximal view, b: distal view.

Fig. 7: calcaneus dext. (2005z0054/0002), proximodorsal view.

Fig. 8: metatarsale IV? sin.? (2005z0052/0004), a: lateral view, b: proximal view.

Scale for teeth (Figs. 1, 2, 3, 5) is 1:1.5; scale for bones (Figs. 4, 6, 7, 8) is 1:2.



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