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内蒙古宝格达乌拉地区新发现再沉积古近纪化石材料[1)]

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摘要:报道了发现于宝格达乌拉地区的少量古近纪化石材料(包括零碎的牙齿和头后骨骼)。材料产自不整合覆盖在细粒红层之上的河相沉积物,显示出再沉积特点。经鉴定,它们可归入 *Breviodon minutus*, Rhinocerotidae gen. et sp. indet., Brontotheriidae gen. et sp. indet.及其他未定奇蹄类。材料在时代上确属古近纪无疑,但产出层位的时代尚有疑问。宝格达乌拉地区过去只出产新近纪脊椎动物化石,古近纪的地层和化石都未曾报道。根据新化石点与附近地层的接触关系,我们怀疑这些古近纪化石是后期再沉积在新近纪的宝格达乌拉组中的。新材料的发现提示该地区可能还有更多的古近纪地层。

关键词:内蒙古宝格达乌拉,古近纪,新近纪,奇蹄类,脊齿貘科,犀科,雷兽科,距骨,趾骨
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A NEW FOSSIL SITE WITH A RE-WORKED PALEOGENE ASSEMBLAGE AT BAOGEDA ULA, CENTRAL NEIMONGOL

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Abstract We report a small Paleogene fossil assemblage in a predominantly Neogene basin in the Baogeda Ula area. A small pocket of fluvial sediments rests unconformably above fine-grained red beds. Fragmentary dental and postcranial materials are recovered from the fluvial beds. Many of the fossils show signs of having been reworked. The limited collection contains *Breviodon minutus*, Rhinocerotidae gen. et sp. indet., Brontotheriidae gen. et sp. indet., and others. This assemblage has a Paleogene characteristic, but the age of the fossil-producing sediments is uncertain. Although the possibility exists that this is an unaltered Paleogene deposit, we suspect the Paleogene fossils were reworked into the Neogene Baogeda Ula Formation.

Key words Baogeda Ula, Nei Mongol, Paleogene, Neogene, Perissodactyla, Lophialetidae, Rhinocerotidae, Brontotheriidae, astragalus, phalanx

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1 Introduction

Since the early discoveries of vertebrate fossil localities in central Nei Mongol (Inner Mongolia), initiated by early explorers such as the Swedish explorer J. G. Andersson (1923), the American Museum of Natural History Central Asiatic Expeditions in the 1920–1930s (Andrews, 1932), and the French Jesuit Pierre Teilhard de Chardin (1926), Paleogene mammals were mostly found west of the main caravan trail from Zhangjiakou (Kalgan) to Erenhot (Erlian or Eren Dabasu) in what is now known as the Erlian Basin (Russell and Zhai, 1987). This is in contrast to Neogene fossil sites primarily east of the trail, although western localities are also known (e.g., Amuwusu, Shala, and Damiao) (Fig. 1C). As a result, attentions by Paleogene vertebrate paleontologists were mainly directed to areas west of the present-day Zhangjiakou–Erenhot highway.

In 2007, one of us (XW) chanced upon a Paleogene site near Baogeda Ula, an area known for rich Neogene mammals. Fossil mammals of undoubted Paleogene age are found in a small remnant of an exposure unconformably on top of a presumed Neogene red bed. Fragmentary isolated teeth, often showing signs of being reworked, were collected from light grey channel sandstones and gravels. A subsequent visit in 2008 yielded additional materials. Such an unexpected discovery hints at a somewhat different pattern of Cenozoic depositional histories than was commonly conceived. The following is a brief report to place on record this unique find and to call attention to potential presence of more extensive Paleogene deposits in this area.

Abbreviations: IM, Inner Mongolia localities; IVPP, Institute of Vertebrate Paleontology and Paleoanthropology.

Terminology of Tapiroidea tooth follows Radinsky (1965) while that of Rhinocerotidae follows Qiu and Wang (2007) and that of Brontotheriidae follows Mihlbachler (2008). Measurements of astragalus follow Qiu and Wang (2007), and those of phalanges follow von den Driesch (1976).

2 Geologic setting

The new fossil site, IVPP IM 0708 locality (N44°15′58.2″, E114°31′39.2″), is 20.6 km northwest of the village (Sumu) of Baogeda Ula (Fig. 1C, D). A prominent tableland to the east of Baogeda Ula Sumu is the type section of the Baogeda Ula Formation. Since the initial report of a *Hipparion* fauna by the Bureau of Geology and Mineral Resources of Nei Mongol Autonomous Region (1991), late Miocene mammals from the Baogeda Ula (= Baogedawula) Formation has been the focus of continuous investigation by members of our field team (Qiu and Wang, 1999; Wang et al., 2003; Qiu et al., 2006). The Baogeda Ula Formation is capped by one or more layers of basalt, with dates ranging from middle Miocene to Pleistocene (Luo and Chen, 1990). Such an association of the capping basalts and the underlying Baogeda Ula sediments is easily traced along the southern and western margins of the sheet basalts, which form resistant benches that help to mark the southern and western extent of the Baogeda Ula Formation.

Sediments in the Baogeda Ula Formation range from red mudstones to light grey siltstones and sandstones. Late Miocene fossil localities are mostly found along the western escarpment east and northeast of the Baogeda Ula Sumu (Fig. 1C). The northern-most fossil site so far known is IM 0707 (N44°16′39.0″, E114°31′52.0″), where a single ochotonid cheek tooth was recovered, which is 1.3 km north of IM 0708. Here the sediments are mostly red mudstones, and the color is in a darker red than those to the south.

IVPP IM 0708 locality is a small patch of light-grey, cross-bedded sandstones and gravel

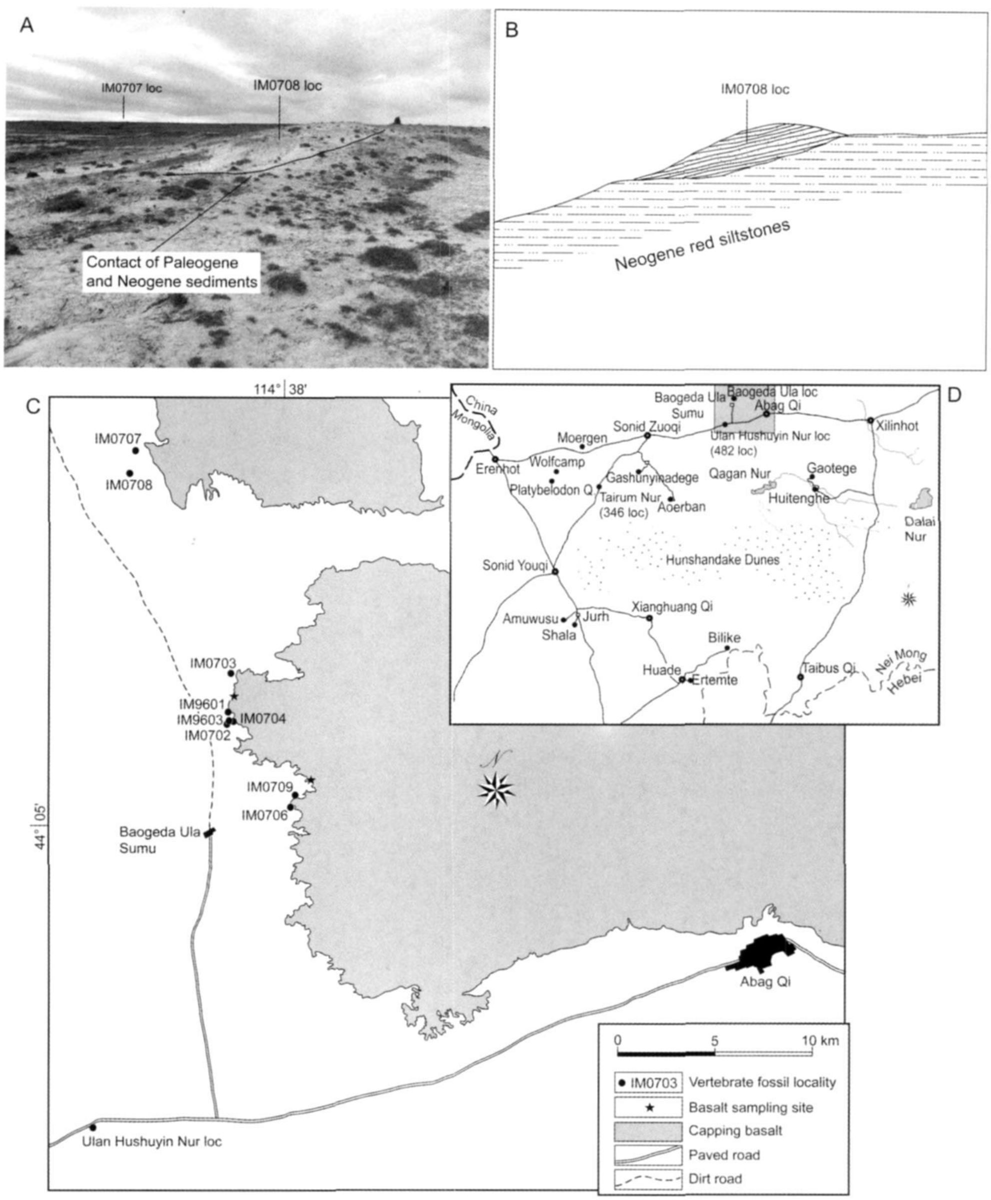

Fig. 1 Geology and location of IVPP IM0708

A. photograph of IM0708 fossil locality (looking toward the east); B. stratigraphic relationships between fossil-producing cross-bedded sandstones and underlying red beds; C. distribution of Baogeda Ula Formation, as indicated by the capping basalt (shaded area) and location of IM0708; D. map of central Nei Mongol showing some major vertebrate fossil localities (solid circles) to the east of the Zhangjiakou–Erenhot highway (formerly Kalgan–Eren Dabasu caravan trail)

beds cutting into the underlying red beds (Fig. 1A, B). Less than one meter (in thickness) of the channel sediments remains and the exposure is no more than 20 m across. Fossils are mixed with well-sorted carbonate nodules carried by the channel, and some fossils show signs of water-born wears that round off the corners and sharp edges. No fossil was found in the underlying red beds so far and two depositional scenarios must be considered. The first is that M0708, along with the underlying red beds, belongs to a Paleogene deposits. The second assumes that the red beds at the M0707 locality (where a single ochotonid cheek tooth was recovered), along with the underlying red beds at M0708, are part of the Baogeda Ula Formation in the late Miocene. In the latter case Paleogene fossils from M0708 must be regarded as re-worked from nearby sites and re-deposited at current location (so far we have not seen evidence of Paleogene taxa mixed with Neogene forms). The water-worn teeth favor the latter scenario. Whether or not such a scenario is correct, the tantalizing Paleogene materials call for a more extensive investigation.

3 Systematic paleontology

Perissodactyla Owen, 1848

Tapiroidea Gray, 1825

Lophialetidae Matthew & Granger, 1925

***Breviodon minutus* Matthew & Granger, 1925**

(Fig. 2A)

Material IVPP V 16912, a right m1 or m2.

Description The tooth is rectangular with a length/width ratio of 8.94 mm/5.43 mm. The trigonid is higher but shorter than the talonid. The protolophid and hypolophid are well developed and parallel to each other with the former being higher. The paralophid is short, bending anterolingually onto the lingual-labially elongated paraconid. The metalophid terminates about 2/3 of the way up from the base of the protolophid, and about 1/3 of the way along the protolophid in occlusal view. The protoconid and hypoconid are obtuse and broad, whereas the metaconid and the entoconid are sharp at the tips. Cingulids can be observed on all sides except the lingual one. The anterior cingulid is developed and stretches along the transverse axis. The posterior one is short but reaches as a lobe at the base of the hypolophid. The labial one is faint and lies at the base between the trigonid and talonid.

Rhinocerotoidea Gray, 1821

Rhinocerotidae Gray, 1821

Rhinocerotidae gen. et sp. indet.

(Fig. 2B)

Material IVPP V 16913, a left lower molar.

Description The tooth is brachyodont. It is 14.42 mm long and 9.16 mm wide. The trigonid is shallow and U-shaped. The paralophid is very low, but long, with the paraconid located very lingually. The protolophid is parallel to the longitudinal axis of the tooth and intersects with the paralophid at a right angle. The metalophid extends slightly posterolingually, making the protolophid-metalophid angle broader. The talonid is deep and L-shaped. It is rounded at the hypolophid-entolophid junction and the entolophid is slightly arched. The hypolophid terminates about half the way up from the base of the metalophid, and about 1/4 the way along the transverse axis of the tooth in occlusal view. Viewed lingually, both metaconid and entoconid present an anterior ridge with that of the latter being sharper. Among all cuspids, the metaconid is the highest, the protoconid and the entoconid are of the same height, the hypoconid is lower, and the paraconid very weak and low. Weak cingulids can be observed on the anterior and labial sides, but no cingulid is present on the lingual side. Posterior cingulid is very strong, forming a small triangular lobe at the base of the entolophid.

Brontotherioidea Marsh, 1873
Brontotheriidae Marsh, 1873
Brontotheriidae gen. et sp. indet.
(Fig. 2C)

Material IVPP V 16914, a left P3/4.

Description The ectoloph is broken, and only the lingual bulge of the paracone and metacone are preserved. The length from the midpoint of the ectoloph to the lingual side is 14.30 mm, and lingual width is 16.27 mm. The bulging paracone and metacone, together with the right angle formed by their remaining lingual anterior and posterior surfaces respectively, indicate a W-shaped ectoloph. The protocone is large, sharp at the tip, and located slightly anterior to the midline of the lingual cingulum. The preprotocrista stretches labially from the protocone and ends at the base of the lingual bulge of the paracone. The postprotocrista is almost perpendicular to and as long as the preprotocrista. It descends posteriorly to the small and low hypocone, which is worn down at the tip. The cingula are well-developed on the anterior and posterior sides, but absent at the base of the protocone; thus they do not join to form a continuous lingual cingulum.

Discussion This tooth is quite doubtable in its position. Its seemingly developed W-shaped ectoloph strongly indicates a molar. Nevertheless, it is so different from a molar or posterior milk premolar in its non-isolated protocone and hypocone which should be isolated from each other and from the ectoloph, thus we cautiously assume it as a premolar. And due to its squared outline, a P3 or P4 is more likely.

Among all the described 20 genera and 37 species of brontotheres in China, this tooth is much smaller than most of them, and is only larger than a few species, such as the smallest brontothere *Nanotitanops shanghuangensis* (Qi and Beard, 1996, 1998; Mihlbachler, 2008) and Brontotheriidae gen. et sp. indet. (Xu and Chiu, 1962). However, neither of them possesses a developed W-shaped ectoloph. No detailed comparisons can be obtained with *N. shanghuangensis* due to the uncertainties in the specific position of the teeth, especially that no P3 or P4 can be affirmed according to Mihlbachler (2008). Besides, IVPP V 16914 differs from IVPP V 2652 (Xu and Chiu, 1962) in the absence of a weak metaloph, the presence of the preprotocrista, and the relatively stronger postprotocrista. In size, it is comparable only to *Microtitan mongoliensis* (Granger and Gregory, 1943) and *Pygmaetitan panxianensis* (Miao, 1982). But unlike both, it has a small hypocone, may have a W-shaped ectoloph, and its preprotocrista is longer and stronger. Compared to all described brontotheres, this tooth is unusual in its combination of a relatively well-developed preprotocrista and postprotocrista, the presence of small hypocone, and small size. However, Mihlbachler (2008) has pointed out that the lingual features of P2-4 have a high degree of intraspecific variability and even exhibit notable bi-

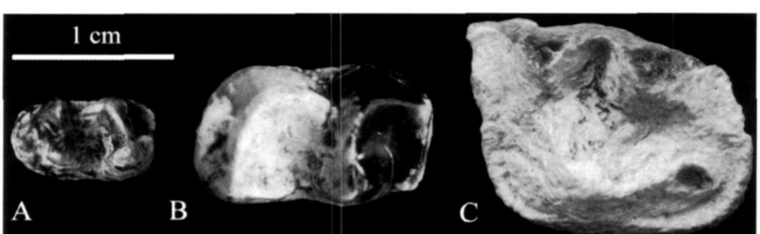

Fig. 2 Occlusal view of perissodactyl teeth from IM0708 fossil locality
A. *Breviodon minutus* (IVPP V 16912); B. Rhinocerotidae gen. et sp. indet. (IVPP V 16913); C. Brontotheriidae gen. et sp. indet. (IVPP V 16914)

lateral asymmetry in the presence and distinctiveness of the hypocone in some species Thus, it casts a shadow on our efforts to place it into known genus We only assign it to a brontothere without any specific designation to any known genus or species

Perissodactyla gen et sp indet
(Fig 3)

Material IVPP V 16915, a right astragalus Measurements see Table 1.

Table 1 Measurements of the astragalus (IVPP V 16915) (in mm or degrees)

Measurements	
maximum height of the body	23 15
maximum width of the body	22 82
medial length of the trochlea	19 68
lateral length of the trochlea	17 58
maximum width of the trochlea	18 62
maximum depth of the trochlea	14 57
distal facet (width× length)	15 90×?
inclination angle of the trochlea	125°
torsion angle of astragalus	16°
navicular facet (width× length)	?
cuboid facet (width× length)	?
proximal calcaneal articulation facet (height× width)	8. 59× 10 61
sustentacular facet (height× width)	7. 16×?

Description The astragalus is almost complete except being partly broken at the distal end and the posterior surface It is 22 82 mm wide and 23 15 mm high The trochlea is almost as long as wide and bears a broad and deep median groove It is inclined from the neck with an angle of about 125°. The crests are parallel to each other and of the same height The medial one is more acute and longer with a protuberance at the proximal end for the medial malleolus of the tibia At the distal end, it attenuates and stretches almost onto the navicular facet On the posterior surface, the proximal calcaneal articulation facet is deeply concave with its two faces almost perpendicular to each other The sustentacular facet is broken at its distal end However, judging from the preserved part, its shape is likely to be broadly oval These two facets are separated by a deep and rounded pit which has an elongated groove extending distal-laterally from it The distal end of the astragalus is roughly rectangular, being wider than long The navicular facet is relatively smooth, and is slightly concave mediolaterally and convex anteroposteriorly. The cuboid facet preserves only the narrow strip at the lateral border of the distal end of the astragalus On the medial side, a deep rounded pit exists at the position where the trochlea connects the neck

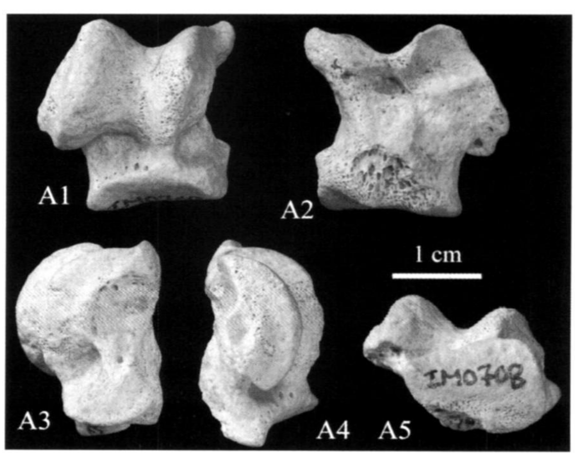

Fig 3 Right astragalus (IVPP V 16915)
A1－5: anterior, posterior, medial, lateral and distal views

Discussion This astragalus must belong to a perissodactyl, however, we are unable to assign it to any known genus or species, and are uncertain about its family position.

Perissodactyla gen. et sp. indet.

(Fig. 4A, B)

Material IVPP V 16916, phalanx I; IVPP V 16917, phalanx II of a lateral digit. Measurements see Table 2.

Table 2 Measurements of the Ph I (IVPP V 16916) and Ph II (IVPP V 16917) (mm)

Measurements	Ph I	Ph II
maximum length	34.52	?
maximum breadth of the proximal end	21.56	?
depth of the proximal end	18.45	?
depth of the distal end	?	10.02
maximum breadth of the distal end	18.82	14.06
anterior width of the distal articulation facet	?	9.13
posterior width of the distal articulation facet	17.09	13.56
minimum breadth of the shaft	18.17	?

Description The Ph I is asymmetrical and columnar-shaped, indicating a lateral digit. Its proximal surface is much broader than the distal one. The proximal facet is dome-shaped and moderately concave, and it is more concave close to the palmar border where a broad notch separates the two proximal prominences. The distal facet has little damage on the mesial side. It is saddle-shaped, being slightly concave mediolaterally and has two weak lateral keels. It faces downward posteriorly and has a distinct "pseudo-articular facet" extending onto the dorsal side. The mesial side of the distal facet is thinner than the lateral side. Viewed from the palmar facet, the proximal prominence on the mesial side is larger than the one on the lateral side. Viewed from the mesial and lateral sides, the shaft tapers gradually from the proximal to the distal end. But the palmar facet is more curved viewed from the mesial side. On the distal end, there is an obvious tubercle but no obvious depression on the mesial side, whereas it is the opposite on the lateral side.

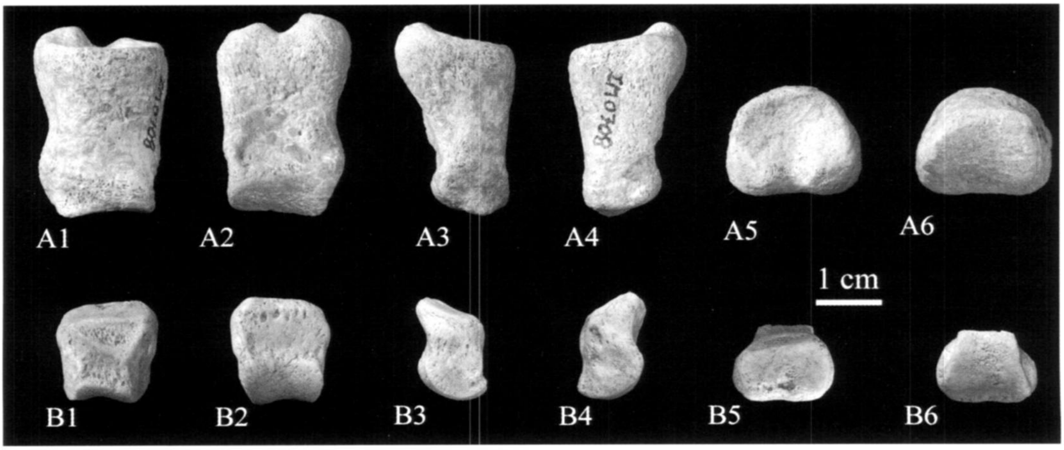

Fig. 4 Ph I (IVPP V 16916) and Ph II (IVPP V 16917) of lateral digit
Row 1 (A1–6), Ph I: dorsal, ventral, mesial, lateral, proximal and distal views;
Row 2 (B1–6), Ph II: dorsal, ventral, mesial, lateral, proximal and distal views

The Ph II has lost its proximal facet. It is stubby, and much shorter and smaller than the Ph I. On the distal facet, the median concavity is deeper and the two lateral keels are more distinct compared to that of the Ph I. The posterior border of the distal facet nearly extends to the transverse midline of the palmar facet. There is relatively deeper depression on both the mesial and lateral sides of the distal end.

4 Remarks about age

The meager fossil materials and very limited distribution of fossiliferous exposures do not permit a detailed assessment of the age relationships of the new locality. If the red mudstones and siltstones below the IVPP IM 0708 are truly part of the Baogeda Ula Formation, as suggested by an ochotonid cheek tooth about 1.3 km north of IM 0708 as well as other extensive exposures of Neogene strata nearby, the fossil-producing, cross-bedded channel sands that cut through the red beds are either part of the Baogeda Ula Formation in the late Miocene or even younger (if the channel sands represent a more recent cutting and filling event after the deposition and partial erosion of the Baogeda Ula Formation).

As for the fossil mammals, dental materials of both the brontothere and *Breviodon* undoubtedly represent a Paleogene assemblage. Brontotheres are restricted to only late Eocene in China and *Breviodon* is further restricted to the middle Eocene of Asia. If the above preliminary assessments are correct, our new fossil mammal materials represent an Eocene assemblage that has been reworked into the Neogene strata. As far as we are aware, such an association has never been demonstrated elsewhere in Nei Mongol, although our works in the Miocene strata in the Aoerban area have shown a reworked Neogene faunal assemblage within a Neogene sequence (Wang et al., 2009). Regardless of the stratigraphic relationship, further field works may reveal the existence of Paleogene strata in areas that previously only yielded Neogene fossils.

Acknowledgements It is a pleasure to dedicate this paper in honor of Dr. Chow Minchen. Throughout his career, Minchen has attempted to fill many of the blanks and gaps, both geographic and chronologic, in Chinese vertebrate paleontology by his pioneering works throughout China. This paper is in the same spirit of discovering fossils in unexpected locations, and we hope it will inspire others to continue the exploration. We thank Wang Yuanqing for the invitation to write this paper, Qiu Zhuding, Yuki Tomida, Yuri Kimura, Hou Sukuan, and Shi Qinqin for helping collect the fossils described wherein. We also thank Wang Banyue, Zhang Zhaoqun and Bai Bin for helpful discussions and Gao Wei for taking the photographs.

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