

内蒙古中部敖尔班地区的 岩石及生物地层¹⁾

王晓鸣^{1,2} 邱铸鼎² 李强² 富田幸光³ 木村由莉³
曾志杰^{1,4} 王洪江⁵

(1 美国洛杉矶自然历史博物馆 洛杉矶 90007)

(2 中国科学院古脊椎动物与古人类研究所 北京 100044)

(3 日本自然科学博物馆地质和古生物部 东京 169-0073)

(4 美国南加州大学综合演化生物系 洛杉矶 90089-0371)

(5 内蒙古锡林郭勒盟文物站 锡林浩特 026000)

摘要:中国北方新近纪地层中,早中新世的哺乳动物化石地点比较稀少,化石面貌也不十分清楚。在内蒙古中部,尽管通古尔台地上有研究历史近百年的新近纪经典地点,但上世纪90年代发现的嘎顺音阿得格,依然是内蒙古目前惟一产出早中新世动物群的小盆地。同内蒙古诸多其他新近纪哺乳动物群一样,嘎顺音阿得格动物群与相邻动物群彼此缺乏时空上的联系,还不易建立可靠的层序关系。

位于苏尼特左旗东南约60 km的敖尔班(曾用名“奥尔班”,见Liddicoat et al., 2007),红色地层大面积出露,是2004年发现的一个新的哺乳动物化石地点。敖尔班剖面总厚50余米,大、小哺乳动物化石共生,岩性特征易识别,有利层位对比,是研究生物地层学的理想地点。自2004年以来,我们连续在敖尔班地区采集化石并进行地层工作,建立了一个较完整的哺乳动物序列,时代跨越早中新世晚期到晚中新世晚期。更加难得的是,敖尔班同一剖面上含有4个哺乳动物化石层位,其上下层序关系一目了然,在内蒙古新近纪地层中仅此一例。敖尔班哺乳动物序列的建立,无疑将对整个内蒙古中部新近纪,尤其是早中新世动物群面貌的了解具有促进作用。本文着重对敖尔班岩石地层进行描述,并结合我们4年来对脊椎动物化石的积累与认识,试图进一步完善内蒙古中部地区的生物地层层序,进而建立这一地区的年代地层框架。对化石的详细描述将适时发表。

根据岩性及接触关系,敖尔班剖面可分为三大段:敖尔班组、巴伦哈拉根层及必鲁图层。敖尔班组(新建组)由一套红色和绿色的泥岩及粉砂岩组成,发育有成熟的古土壤层,厚约42 m,时代属于早中新世中晚期。敖尔班组的层型剖面建立在敖尔班露头出露最厚的中部,下部未见底,顶部与上覆巴伦哈拉根层呈假整合或不整合接触。该组目前已知分布仅局限于敖尔班露头。敖尔班组可进一步划分出三段:下红泥岩段、中绿泥岩段及上红泥岩段。三段呈连续沉积。敖尔班组与巴伦哈拉根层之间的假整合所代表的沉积间断延续了中中新世的大部

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分时段。巴伦哈拉根层为一套橘红色砂岩、粉砂岩及底砾岩,时代大致是最晚中新世至最早晚中新世。不整合于巴伦哈拉根层之上是必鲁图层。两层之间似乎缺失了晚中新世的大部分堆积。必鲁图层的底砾岩是一种切割与充填构造,其中所含钙质结核及相当数量的化石都可能是巴伦哈拉根层原生堆积物再沉积的结果。必鲁图层的分布还需做更多工作,其时代可能是晚中新世晚期。

主要依据小哺乳动物的组合,在敖尔班剖面中可建立 4 个动物群。最早为敖尔班组下红泥岩段产出的下敖尔班动物群。该动物群的特征是,小哺乳动物中在渐新世十分兴旺的一些科,如 Ctenodactylidae, Tachyoryctoididae, Aplodontidae 和 Zapodidae 还相当繁荣;中新世出现的属,如 *Mioechinus*, *Keramidomys*, *Heterosminthus* 和 *Democricetodon* 等占动物群总量的半数以上;大哺乳动物中残留有 *Palaeogale* 和裂爪兽。比下敖尔班动物群稍晚的是上敖尔班动物群,产出于敖尔班组的上红泥岩段。上敖尔班动物群的特征是,小哺乳动物在渐新世中占统治地位的一些科或完全绝迹,如 Ctenodactylidae, 或在种类和数量上明显减退,如 Aplodontidae 和 Zapodidae; 缺少在下敖尔班动物群中还相当常见的一些古老属,如 *Amphechinus*, *Tachyoryctoides* 和 *Sinolagomys* 等;出现了下敖尔班动物群中所没有的 *Megacricetodon*, *Cricetodon* 和 *Alloptox* 属;大哺乳动物中出现了长鼻类和柄杯鹿 (*Ligeromeryx/Lagomeryx*)。经过相当长的一个沉积间断,敖尔班剖面的上部出现了巴伦哈拉根动物群。该动物群中渐新世常见的小哺乳动物科进一步衰落,同时出现了亚洲古北界晚中新世以后常见的跳鼠科 (Dipodidae) 和鼯鼠科 (Siphneidae), 具有明显的中中新世晚期或晚中新世早期生物组合的特点。最后是敖尔班剖面顶部必鲁图层中的必鲁图动物群。必鲁图动物群显然带有中中新世及晚中新世的混合特征,很可能是水流作用再沉积的结果。根据其中最进步分子的成分判断,估计必鲁图动物群的年代是晚中新世的晚期,其特征是,鼠科 (Muridae) 动物高度分化,而野兔科 (Leporidae) 尚未出现;含有晚中新世宝格达乌拉动物群或最晚中新世二登图动物群中大量出现的属种,如 *Lophocricetus grabaui*, *Paralactaga suni*, *Dipus fraudator* 和 *Hansdebruijnina pusilla* 等;但二登图动物群中很繁荣的一些属在必鲁图动物群中未被发现或者发现的个体数量很少,如 *Prospemophilus*, *Paralophocricetus* 和 *Microdon* 等。

关键词:内蒙古,中新世,敖尔班组,岩石地层,生物地层

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A NEW EARLY TO LATE MIOCENE FOSSILIFEROUS REGION IN CENTRAL NEI MONGOL: LITHOSTRATIGRAPHY AND BIOSTRATIGRAPHY IN AOERBAN STRATA

WANG Xiao-Ming^{1,2} QIU Zhu-Ding² LI Qiang² Yukimitsu TOMIDA³ Yuri KIMURA³
Zhijie Jack TSENG^{1,4} WANG Hong-Jiang⁵

(1 Natural History Museum of Los Angeles County Los Angeles CA 90007, USA xwang@nhm.org)

(2 Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences Beijing 100044, China)

(3 Department of Geology and Paleontology, National Science Museum Tokyo 169-0073, Japan)

(4 Integrative and Evolutionary Biology, University of Southern California Los Angeles CA 90089-0371, USA)

(5 Administration Station of Cultural Relics of Xilinguole League, Nei Mongol Xilinhaote 026000, China)

Abstract Vertebrate fossil localities of Early Miocene age are rare in north China in general and in Nei Mongol in particular. Here we report a recently discovered, richly fossiliferous Early Miocene through Late Miocene sequence in central Nei Mongol. The new Aoerban strata from Sonid Zuoqi represent one of the longest exposures in the region, spanning up to 50 m in total thickness, and produce fossils along much of the section with distinct lithologies, resulting in an easily correlated *in situ* fossil collection with excellent stratigraphic documentation.

Three lithologic units are recognized. We formally name the Aoerban Formation at the lower part of the section, which contains three discrete members of fine-grained sediments altered by paleosols: 1) Lower Red Mudstone Member, 2) Middle Green Mudstone Member, and 3) Upper Red Mudstone Member. Resting disconformably above the Aoerban Formation is the Balunhalagen bed, which is characterized by basal conglomerates followed by orange-colored mudstones and siltstones. Cutting into the Balunhalagen bed is the Bilutu bed, which is another unit of channel gravel sediments and overbank deposits.

Paleontologically four discrete faunal units are clearly recognizable, mostly based on small mammals obtained from five wash sites. We distinguish two Early Miocene faunas. The Lower Aoerban Fauna and Upper Aoerban Fauna, produced from the Lower Red Mudstone and Upper Red Mudstone Members, respectively, contain characteristic Early Miocene elements of north China and/or Europe. The Balunhalagen Fauna, derived from the Balunhalagen bed, is characteristic of the Middle to Late Miocene transition. The Bilutu Fauna from the capping Bilutu bed features a mixed composition of Middle and Late Miocene taxa. Both faunal and sedimentological evidence suggest that some of the earlier faunal elements have been reworked into the later Bilutu deposits; thus the Bilutu Fauna is mostly likely of Late Miocene age.

Key words Nei Mongol, Miocene, Aoerban Formation, lithostratigraphy, biostratigraphy

1 Introduction

Impressive progress has been made in Neogene mammalian paleontology in Tunggur and surrounding regions in central Nei Mongol (Inner Mongolia) during the past 30 years. From two classic faunal horizons in the Middle Miocene (Tunggur) and Late Miocene (Ertemte), both discovered by western paleontologists during the early twentieth century, more than half a dozen major fossiliferous exposures are now known (Figs. 1, 4), and abundant small mammal assemblages are recovered from multiple localities thanks to the screen washing technique. Such an explosive growth in our knowledge of mammalian biostratigraphy resulted in a sequence of finely-spaced faunal units that span from Middle Miocene to much of the Pliocene (see Qiu and Wang, 1999 and Qiu et al., 2006 for a summary). Despite this progress, however, large gaps in the faunal sequences remain. This is particularly true in the Early Miocene-only one fauna from small exposures in the Gashunynadege Basin was recently found (Meng et al., 1996). Such a gap is especially glaring given the fact that Early Miocene, a long interval of time, is one of the least known time periods in Chinese Neogene mammalian paleontology.

It is thus particularly gratifying that our recently discovered, beautifully exposed Aoerban strata are endowed with rich large and small mammal fossils. Four major faunal horizons can be identified in the ~50 m strata, spanning the Early to Late Miocene. The Aoerban strata are also extraordinary in that it is the first such section in Nei Mongol to produce Neogene mammalian assemblages spanning such a long time, in contrast to much smaller exposures often containing single faunal horizons more conventionally found in the region. With the superbly exposed strata and distinct lithologic characteristics, fossil localities are easily correlated throughout the section, yielding an *in situ* biostratigraphic sequence rarely possible elsewhere in Nei Mongol.

Recognizing such an unusual circumstance, we took some pains to ensure that our fossil collecting conforms to a high standard of stratigraphic documentation. This preliminary report attempts to record in sufficient detail the geologic and stratigraphic settings, which will pave the way for formal descriptions of the fossil materials.

Abbreviations: IM, fossil localities from Nei Mongol; IVPP, Institute of Vertebrate Paleontology and Paleoanthropology.

2 History of study

Preliminary reconnaissance surveys were carried out by various provincial and regional

hydrological and geological survey teams in the regions surrounding the Aoerban area in the 1960s and 1970s. These surveys conducted initial mapping of the Neogene strata, which led to the recognition of two major rock units, the Middle Miocene Tunggur Formation, following the usage of the Central Asiatic Expeditions of the American Museum of Natural History, and a newly named Baogedawula Formation in the “Pliocene” (Editorial Committee of Stratigraphic Table of Inner Mongolia Autonomous Region, 1978). These two named formations were broadly applied to Cenozoic sediments in much of central Nei Mongol, and were often based on no more than superficial lithological similarities. A large area surrounding the Aoerban strata was designated, mainly on lithological grounds, as the Tunggur Formation by the Bureau of Geology and Mineral Resources of Nei Mongol Autonomous Region (1991), although the Aoerban exposure itself was not specifically treated. The first geologic study exclusively dedicated to the Aoerban exposures appears to be that by Dong Mingxing in his unpublished Master’s thesis (Dong, 1993). He referred to those exposures as the Bilutu region. Dong (1993) did a preliminary paleomagnetic section and analyzed 23 pollen samples, as well as a number of geochemical samples. He did not find any vertebrate fossils.

In 2004, while four of us (Qiu, Li, Tomida, and Kimura) were collecting in the red mudstones in the Gashunyinadege Basin, a local herdsman remarked that there are larger red beds some distance away and volunteered to take us to the “Dahongshan” (“big red hill” in Chinese). Preliminary surveys immediately demonstrated that the new exposures are fossiliferous. A single locality near the top of the lower red mudstone bed, IM0407, was recorded during the 2004 field season and test-sampled for small mammal screening. This initial attempt proved successful, and intensive sampling of small mammals, as well as surface collecting of large mammals, followed in August 2005, July 2007, and May 2008.

3 Lithostratigraphy

The following brief descriptions illustrate, from bottom to top, the major stratigraphic sequences of the Aoerban strata and their main lithological features (Figs. 1–3).

Aoerban Formation It is continuously exposed in a 3×2 km area within N43°20′ ~ 21.5′ and E113°53′ ~ 56′ in Sonid Zuoqi, central Nei Mongol (Fig. 1). The name is derived from a Chinese translation of the Mongolian word “promontory” or “prominent place” on a Chinese topographic map. The stratotype (type section) is along a major wash near the middle of the exposures (Figs. 1, 2), and as far as we are aware, the Aoerban Formation is restricted to the Aoerban exposures only. Exposures several kilometers west and south of the Aoerban are known to produce fossils of different ages from those in Aoerban.

The strata in the Aoerban Formation are completely flat-lying; its lower boundary is not exposed (the basement of the basin is not visible) and its upper boundary is marked by a disconformity with the overlying Balunhalagen Bed (top orange bed) (Fig. 2). The Aoerban Formation is divided into three members; Lower Red Mudstone Member, Middle Green Mudstone Member, and Upper Red Mudstone Member. Contacts between these members are conformable.

The Lower Red Mudstone Member consists of a ~15 m sequence of bright red mudstones and siltstones with multiple layers of paleosols. This member also contains a 1 ~ 2 m thick green, white, or light grey marly nodular bed exposed within a wash along the stratotype section near the base of this member. Vertebrate fossils are abundant throughout the exposures, particularly toward the upper part of the member, which is better exposed. Fifty-seven individual localities are recorded so far and two of these (IM0407 and 0507) were extensively sampled for small mammals (Figs. 1, 3).

The Middle Green Mudstone Member is a ~7 m bed of grayish-green mudstones often con-

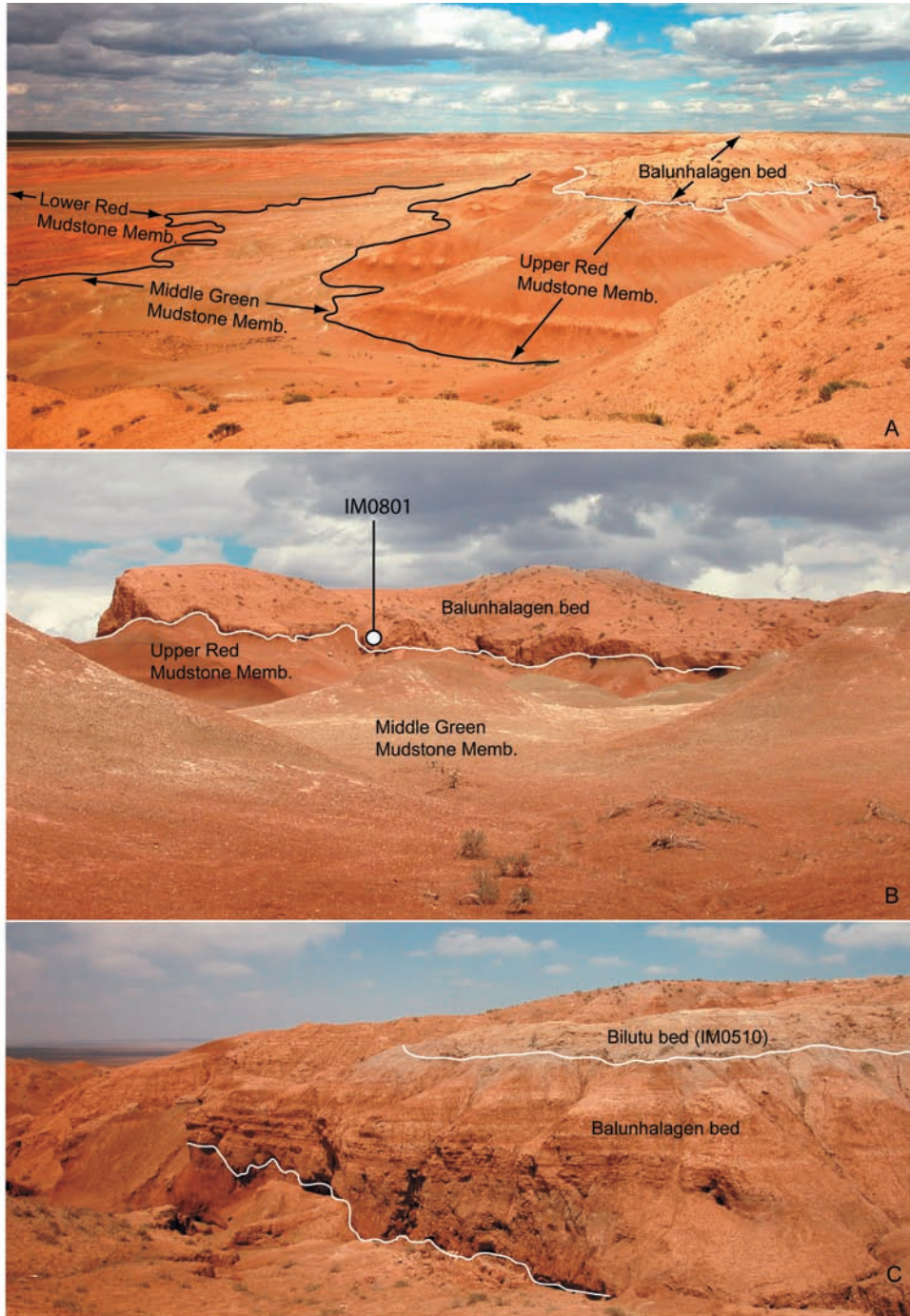


Fig. 2 Exposures of the Aorban Formation, Balunhalagen bed, and Bilutu bed
 A. Aorban exposure looking toward east showing all three members of the Aorban Formation and the Balunhalagen bed at the top; B. a major disconformity separates the Balunhalagen bed and the underlying Upper Red Mudstone Member of the Aorban Formation, photo looking eastward; C. capping Bilutu bed in disconformable contact with underlying Balunhalagen bed, photo near IM0510 looking northeast; black lines indicate boundaries between members of the Aorban Formation, and white lines represent unconformities

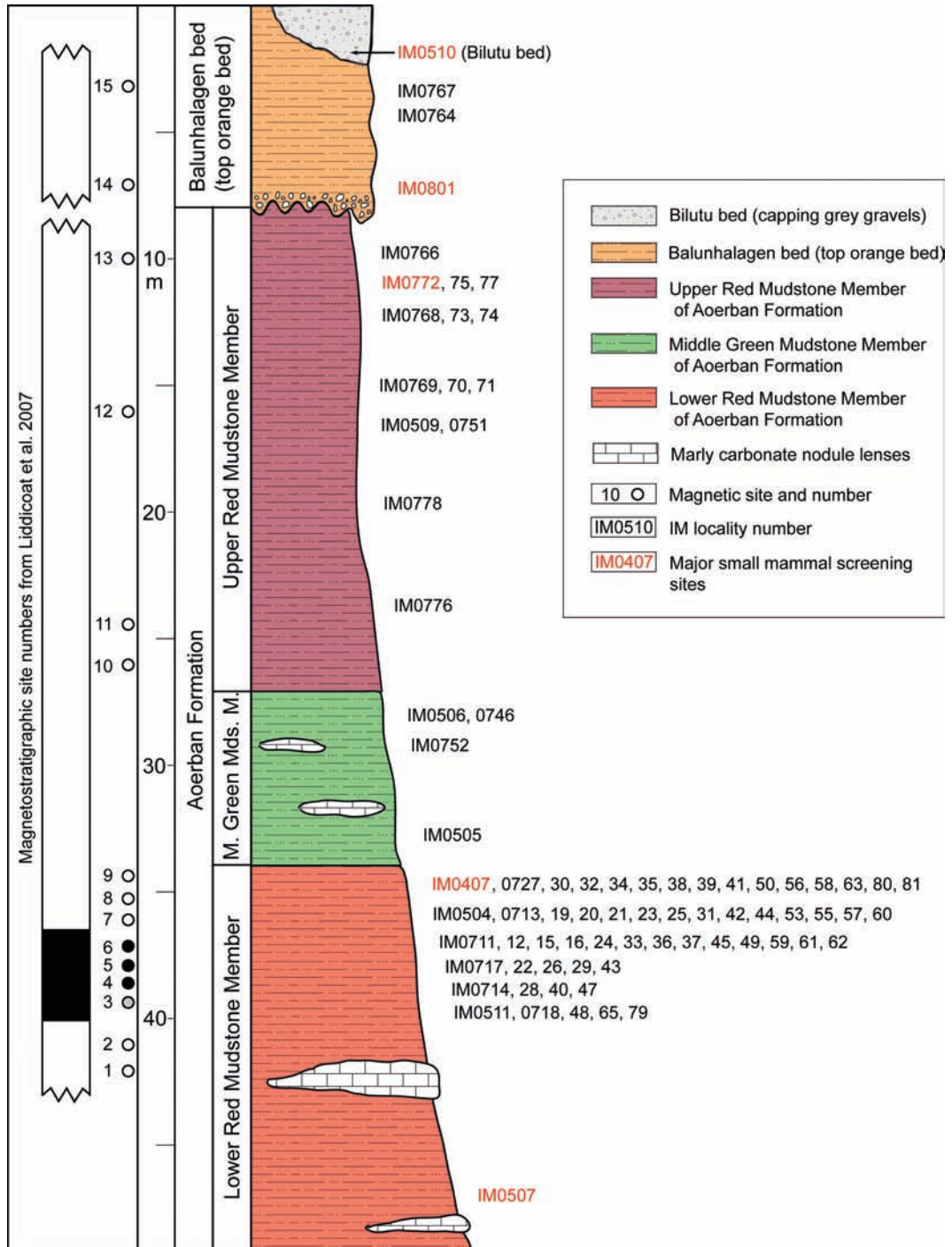


Fig. 3 Measured stratigraphic column along the type section of the Aoerban Formation and thematic relationships of various lithologic units

bed and the gravels often contain carbonate nodule clasts most likely reworked from beds underneath (i. e. Aoerban Formation). Relationships with a capping grey gravel bed are not always

clear. At the IM0510 locality, the gravel bed cuts into the Balunhalagen bed and is itself overlain by a few meters of finer-grained red beds. Elsewhere, however, such a relationship is not clearly visible. Additional field works are required to clarify this relationship. As a result, we refrain from naming a formal stratigraphic unit at this point.

A combination of steep exposures and poor development of paleosols seem to contribute to fewer recoveries of fossils; only three fossil localities are known so far in the Balunhalagen bed. One small mammal wash site, IM0801, has good potential even though only about 120 kg of matrix has been sampled.

Bilutu bed (capping gravel bed) The name Bilutu is a Chinese translation of a Mongolian location name about 8 km northwest of the Aoerban section, and this is the name used by Dong (1993). The Bilutu bed cuts into the Balunhalagen bed at the IM0510 locality, i. e., it is in disconformable or unconformable contact with the underlying orange red siltstones. A basal gravel fills the channel cut and pedogenic carbonate nodules, likely reworked into the Bilutu bed from the underlying Balunhalagen bed (see further discussions in Bilutu Fauna), constitute the main component of the gravel bed. This gravel bed is in turn superposed by up to a few meters of light-red colored, fine-grained sediments at IM0510, but such a relationship is not easily discernable elsewhere. Additional study is necessary for a better understanding of this hiatus, although we suspect the gap in deposition spans several million years in duration. We refrain from naming a formal lithologic unit until further field studies.

A single small mammal wash locality (IM0510) is the only fossil site known so far in the Bilutu bed. As discussed below, mammals from this locality appear to belong to a mixed fauna due to the reworking of sediments below. Judging from the presence of Middle Miocene fossils but not Early Miocene elements, the cut-and-fill structure in the Bilutu bed probably did not cycle through the Aoerban Formation. Instead, the Bilutu cut-and-fill is relatively shallow, i. e., it is restricted within the Balunhalagen bed, as seen in the outcrops (Fig. 3).

4 Biostratigraphy

Lower Aoerban assemblage The Lower Aoerban assemblage includes fossils from many localities in the mudstones from the Lower Red Mudstone Member in the Aoerban Formation (Fig. 3). Materials of small mammals, however, were mainly collected from two sites (IVPP field number IM0407: N43°20'17.4" and E113°53'20.7"; and IM0507: N43°21'00.4" and E113°54'23.3") by screen-washing. About 1.7 ton of matrix from IM0507 and 2.0 tons from IM0407 were sampled and screen-washed in 2005 and 2007, respectively. The assemblage, dominated by small mammals, is composed of at least 44 species and 34 genera, belonging to 5 orders and 15 families (Table 1).

Insectivora Nine genera, belonging to Erinaceidae, Talpidae and Soricidae, are recognized in the collection. Erinaceidae are rather common, and identified to three genera. Small size and lack of metaconule on M1 and M2 are diagnostic of the genus *Amphechinus*, shown in ~320 specimens, including a few mandibular fragments. Twenty-five cheek teeth and two fragmentary mandibles are referred to a similar species of *Mioechinus? gobiensis* from Moergen, Tunggur, which can be distinguishable from *Amphechinus* by slightly larger size and distinct metaconule on M1 and M2. A third erinaceid is represented by one and a half M1, which are much bigger than *Amphechinus* and *Mioechinus?*. Lacking additional diagnostic material, we leave the generic assignment of the larger hedgehog undetermined for the time being.

The Talpidae are represented by 30 isolated teeth and several humeri. Four genera are present; *Proscapanus*, *Yanshuella*, *Quyania* and *Desmanella*. They are comparable in morphology to those from Tunggur, but no specific assignment for any of these genera can be made based on current material. Soricidae is also scarce; 24 specimens, including two mandibular

fragments, are referred to two genera belonging to two subfamilies. On one hand, size difference seems to indicate two species of *Sorex*. On the other hand, a species of *Mongolosorex* found in Lower Aorban is identical with that from Gashunynadege, which is smaller than *M. qiu* from Tunggur.

Rodentia Twenty-two genera belonging to 8 families are recognized in the lower Aorban assemblage. About 220 specimens, including several mandibular fragments, are identified as Ctenodactylidae and assigned to an indeterminate species of *Distylomys*. The Tachyoryctoididae include two genera, *Tachyoryctoides* and *Aralomys*, represented by 11 fragmentary jaws and 29 cheek teeth. Although the specimens of *Tachyoryctoides* show distinct variation in size and morphology, they seem to indicate two species of the genus, a larger one close to *T. kokonorensis* from Xiejia, Qinghai, and a smaller one to *T. obrutschewi* from Taben Buluk, Gansu.

Aplodontidae are represented by 7 jaw fragments and 46 isolated teeth, and three genera are easily distinguishable by size and morphology. The smallest one is *Ansomys*; the medium one is similar to *Ansomys* but distinctly larger with undivided mesostyle on M1, probably representing a new species. The largest one, represented by 16 teeth, has four cusps on molars and many pits surrounded by crests; it seems more closely related to Aplodontidae than to Melissodontidae, which is known from Europe, and may represent a new genus and species.

Three indeterminate species of Sciuridae, belonging to two genera, *Eutamias* and *Atlantoxerus*, are identified based on 18 specimens. The smaller *Eutamias* is close to *E. ertemtensis* from Ertemte in size; the larger *Atlantoxerus* has distinct entoconids on the lower molars and may be an undescribed species.

Eomyids are represented by 110 specimens, including three mandibular fragments, assignable to *Keramidomys*, *Asianeomys*, *Pentabuneomys* and *Ligerimys*. These four genera also occur in the Gashunynadege Fauna. Furthermore, *Asianeomys* is present in the Early Miocene of Xinjiang, and the other three genera are also known in the Miocene of Europe. Pending a detailed comparison with known taxa, we leave the specific assignment of these eomyids undetermined. Nine cheek teeth represent three genera of Gliridae: *Prodyromys*, *Miodyromys* and *Microdyromys*; all are recorded in the Lower and Middle Miocene of central Nei Mongol and Europe.

Zapodidae are common in this assemblage and are very similar to the taxa found in Gashunynadege. Grooved upper incisor, lophodont molars, three-rooted M1 and M2 and double protoloph on M2 indicate two species of *Plesiosminthus*, which are represented by 104 specimens, including 9 jaw fragments and 4 upper incisors. The larger species is comparable to *P. barsboldi* from the Oligocene/Miocene transition of Unkheltseg, Mongolia. The smaller form is similar to *P. promyarion* in size and morphology, but differs in having a more posterior metaloph-hypocone connection on M1 and a consistent connection of the endoloph to protocone on M2; this form probably represents a new species. *Heterosminthus* is represented by 60 specimens, including 3 jaw fragments, and can be assigned to *H. nanus* and an indeterminate species, which is comparable to *H. firmus* or *H. erbajevae*. Until now *Litodonomys* was known only by lower dentition from the Oligocene and Early Miocene of Gansu (Wang and Qiu, 2000; Wang, 2003). Material of this genus in the Lower Aorban assemblage (42 molars) includes the entire molar dentition and indicates one new species, which is smaller than other known taxa. The genus *Sicista* is represented by 25 specimens, including a mandibular fragment, and is assignable to a new species; small size and simpler occlusal pattern, however, may be indicative of its more primitive status. Thirty-two cheek teeth show a similar dental pattern as *Sicista*, but differ from *Sicista* in 1) larger size with undeveloped secondary ridges or spurs on the molars, 2) having distinct anterior cingulum on M1, and 3) having consistent double protoloph on M2. They appear to be an undescribed genus of Zapodidae. An M1 may represent another undescribed genus of the family, which is larger and more subquadrate in its outline than that of the aforementioned

tioned indeterminate form.

Two cricetids, *Eucricetodon?* and *Democricetodon*, are identified based on 34 specimens, including 3 jaw fragments. The indeterminate species of *Eucricetodon?* is comparable to those from Gashunynadege in size and morphology, but the *Democricetodon* is distinctly smaller than that from Gashunynadege, probably representing a more primitive form.

Lagomorpha More than 500 specimens, including a couple dozen jaw fragments, can be referred to Ochotonidae. The large and rooted cheek teeth, represented by about 50 specimens, belong to *Desmatolagus?*; this form occurs frequently in the Early and Middle Miocene faunas of central Nei Mongol. Based on size and morphology of the p3, two forms of rootless ochotonids can be readily distinguished. The larger one, which has a flat or shallow furrow on the anterior wall of the p3, is identified as *Sinolagomys*; the smaller one, which has a deep anterofold on that tooth, should be an undescribed genus. *Sinolagomys* shows distinct morphological variation, and further studies will be necessary to investigate if this is a multi-species sample.

Large mammals At least three specimens in the Lower Red Mudstone Member can be identified as *Palaeogale*: a left jaw fragment with p4–m1 (IM0507), a left jaw with p2–4 and m1, m2 alveolus (IM0712), and a right jaw fragment with p4–m1 (IM0728). Bonis (1981) recognized a single species, *P. minuta*, in the Early Miocene of Europe, and possibly North America as well. It is characterized by the absence of M2, an extremely reduced p2, and a loss of p1. *Palaeogale* is previously unknown in the Early Miocene of Asia, although its European and North American distribution implies an Asian presence as well. The Aoerban materials confirm such a presence for the first time.

Another small mustelid is represented by two partial lower jaws (IM0407 and 0711). Its robust horizontal ramus and trenchant talonid suggest a hypercarnivorous form, although its true identity is yet to be determined.

Foot bones of a large schizotheriine chalicothere were collected, consisting of a calcaneum (IM0731), an astragalus (IM0730), a metacarpal III (IM0750), and several proximal phalanges (IM0715, 0741, 0750). Somewhat intermediate in morphology between *Ancylotherium* and *Phyllotillon*, the Aoerban chalicothere is large in size but does not make an exact match with known forms. Fragmentary rhinocerotid materials are present in the lower red mudstone, including an astragalus (IM0718), enamel fragments (IM0761), foot bone fragments (IM0739), and medial phalanx (IM0753).

Table 1 Aoerban mammals listed by different faunas

Mammal		Taxa	Aoerban		Balunhalagen	Bilutu
			lower	upper		
Insectivora	Erinaceidae	<i>Ampechinus</i> sp.	*			
		<i>Mioechinus?</i> cf. <i>M. gobiensis</i>	*	*	*	*
		<i>Erinaceus</i> sp.				*
		Erinaceidae indet.	*			
	Talpidae	<i>Proscapanus</i> sp.	*	*	*	*√
		<i>Quyania</i> sp.	*	*	*	*
		<i>Yanshuella</i> sp.	*	*	*	*
		<i>Desmanella</i> sp.	*			
		Soricidae	<i>Mongolosorex</i> sp.	*		
	<i>Sorex</i> sp. 1		*	*		
	<i>Sorex</i> sp. 2		*	*		
	Heterosoricinae indet.				*	*√
		Soricinae indet.			*	*

Continued

Mammal	Taxa	Aoerban		Balunhalagen	Bilutu	
		lower	upper			
Rodentia	Ctenodactylidae	<i>Distylomys</i> sp.	*			
	Tachyoryctoididae	<i>Tachyoryctoides</i> sp. 1	*			
		<i>Tachyoryctoides</i> sp. 2	*			
		<i>Aralomys</i> sp. 1	*			
		<i>Aralomys</i> sp. 2		*		
		<i>Ansomys</i> sp. 1	*	*		
	Aplodontidae	<i>Ansomys</i> sp. 2			*	*√
		cf. <i>Ansomys</i> sp. nov.	*			
		Aplodontidae gen. et sp. nov.	*			
	Sciuridae	<i>Eutamias ertemtensis</i>				*
		<i>Eutamias</i> cf. <i>E. ertemtensis</i>	*	*	*	*
		<i>Eutamias</i> sp.	*	*	*	
		<i>Sciurus</i> sp.				*
		<i>Oriensciurus?</i> sp.		*		
		<i>Atlantoxerus</i> sp.	*		*	*
		<i>ProspERMophilus</i> sp.				*
		Sciuridae indet. 1			*	
		Sciuridae indet. 2				*
	Eomyidae	<i>Keramidomys</i> sp.	*	*	*	*
		<i>Leptodontomys</i> cf. <i>L. lü</i>			*	
		<i>Leptodontomys</i> sp.				*
		<i>Asianeomys</i> sp.	*			*√
		<i>Pentabuneomys</i> sp.	*	*	*	*√
		<i>Ligerimys</i> sp.	*			
	Gliridae	<i>Prodyromys</i> sp.	*			
		<i>Miodyromys</i> sp.	*	*	*	*
		<i>Microdyromys</i> sp.	*		*	*
		<i>Myomimus sinensis</i>				*
	Zapodidae	<i>Plesiosminthus</i> cf. <i>P. barsboldi</i>	*			
		<i>Plesiosminthus</i> sp. nov.	*	*		
		<i>Heterosminthus nanus</i>	*			
		<i>Heterosminthus orientalis</i>			*	
		<i>Heterosminthus</i> cf. <i>H. orientalis</i>				*√
		<i>Heterosminthus</i> sp.	*	*		
		<i>Litodonomys</i> sp. nov.	*			
		<i>Sicista</i> sp.			*	*
		<i>Sicista</i> sp. nov.	*	*		
		<i>Lophocricetus grabaui</i>				*
		<i>Lophocricetus</i> sp.				*
		Zapodidae gen. et sp. nov. 1	*			
		Zapodidae gen. et sp. nov. 2	*			
	Dipodidae	<i>Protalactaga grabaui</i>			*	*√
<i>Protalactaga</i> sp.				*		
<i>Paralactaga suni</i>					*	
<i>Paralactaga</i> cf. <i>P. anderssoni</i>					*	
<i>Brachyscirtetes</i> sp.				*		
	<i>Dipus fraudator</i>				*	

Continued

Mammal	Taxa	Aerban		Balunhalagen	Bilutu		
		lower	upper				
Rodentia	Cricetidae	<i>Eucrietodon?</i> sp. 1	*				
		<i>Eucrietodon?</i> sp. 2		*	* ✓		
		<i>Democricetodon tongi</i>		*			
		<i>Democricetodon</i> cf. <i>D. lindsayi</i>				* ✓	
		<i>Democricetodon</i> sp. 1	*				
		<i>Democricetodon</i> sp. 2			*		
		<i>Megacricetodon</i> cf. <i>M. sinensis</i>		*	*	* ✓	
		<i>Cricetodon</i> sp. 1		*			
		<i>Cricetodon</i> sp. 2				* ✓	
		<i>Plesiodipus leei</i>				* ✓	
		<i>Plesiodipus</i> cf. <i>P. progressus</i>			*		
		<i>Plesiodipus</i> aff. <i>P. progressus</i>				* ✓	
		<i>Plesiodipus</i> sp. nov.				* ✓	
		<i>Gobicricetodon</i> cf. <i>G. flynni</i>			*		
		<i>Gobicricetodon</i> cf. <i>G. robustus</i>			*	* ✓	
		<i>Kowalskia</i> sp.				*	
		<i>Sinocricetus</i> sp.				*	
		<i>Nannocricetus</i> sp.				*	
		<i>Microscoptes</i> sp.				*	
		<i>Microtodon</i> sp.				*	
		<i>Anatolomys</i> sp.				*	
		<i>Rhinocerotodon</i> sp.				*	
		Cricetidae indet. 1			*		
		Cricetidae indet. 2				*	
		Gerbillidae	<i>Pseudomeriones</i> sp.				*
							*
		Siphneidae	<i>Prosiphneus</i> sp.			*	
<i>Prosiphneus</i> sp. nov.					*		
Muridae	<i>Hansdebruijnina pusilla</i>				*		
		<i>Micromys chalcus</i>			*		
		" <i>Karninata</i> " <i>hipparionum</i>			*		
Lagomorpha	Ochotonidae	<i>Desmatolagus?</i> sp.	*	*	* ✓		
		<i>Sinolagomys</i> sp.	*				
		<i>Alloptox</i> sp.		*	*	? ✓	
		<i>Bellatona</i> sp.			*	*	
		<i>Ochotona</i> cf. <i>O. lagreli</i>				*	
		<i>Ochotona</i> sp.			*		
		Ochotonidae gen. et sp. nov.	*				
Carnivora	Mustelidae	<i>Palaeogale</i> sp.	*				
		Mustelidae indet.	*				
Proboscidea	Proboscidae	Proboscidea indet.		*			
Perissodactyla	Chalicotheriidae	Schizotheriinae indet.	*				
	Rhinocerotidae	Rhinocerotidae indet.	*				
Artiodactyla	Cervidae	<i>Ligeromeryx/Lagomeryx</i> sp.		*	*		

Note: ✓ – Taxon probably reworked from lower horizons.

Upper Aerban assemblage The Upper Aerban assemblage was mainly obtained from

about 3.5 tons of matrix at one site (IM0772, N43°20'27.4" and E113°54'45.7") in 2008 and surface-collected in 2007 from several sites in the mudstones of the Upper Red Member of the Aoerban Formation. It consists of 26 species from 24 genera, belonging to 5 orders and 13 families (Table 1).

Insectivora Five genera belonging to three families are recognized in the Upper Aoerban assemblage. They are *Mioechinus?* of Erinaceidae (represented by one mandibular fragment and 29 teeth), *Proscapanus*, *Quyania*, and *Yanshuella* of Talpidae (11 specimens), and *Sorex* of Soricidae (10 specimens). All these taxa exhibit minor size and morphological differences from the corresponding forms in the Lower Aoerban assemblage, but no specific assignment can be made at this time.

Rodentia At least 14 genera belonging to 7 families of Rodentia are recognized. Thirty-six specimens, including three mandibular fragments, are identified as an indeterminate species of *Aralomys*, which is comparable in size to the smaller *Tachyoryctoides* (*T.* sp. 2) from the Lower Aoerban assemblage. These specimens are referred to *Aralomys* because the m1 shows patterns of *Aralomys* and the crests on M2 and m2 are distinctly transverse with poorly developed longitudinal connections.

Aplodontidae are represented by 48 isolated teeth and identified as an indeterminate species of *Ansomys*, which also occurs in the Lower Aoerban assemblage.

Three forms of Sciuridae, represented by 20 teeth, can be recognized as *Eutamias* and a questionable *Oriensciurus*. The chipmunks are comparable in size and morphology to those from the Lower Aoerban assemblage. Large size and distinct mesoconid and entoconid on three cheek teeth give a distinct appearance of the tree squirrel, which shows some similarities to *Oriensciurus* from Shanwang, Shandong Province.

Two molars are identified as Eomyidae and assigned to two indeterminate species of *Keramidomys* and *Pentabuneomys*, which are both larger than the corresponding material from the Lower Aoerban assemblage. Nine cheek teeth are tentatively referred to *Miodyromys* of Gliridae. Thirty-nine specimens, including a fragmentary mandible, are identified as Zapodidae and assigned to three genera, *Plesiosminthus*, *Heterosminthus*, and *Sicista*. All these taxa are similar to the corresponding forms from the Lower Aoerban assemblage in size and morphology, except for the more reduced protoloph I on M2 in the *Heterosminthus*.

The family Cricetidae, represented by 119 molars, includes four genera, *Eucricetodon?*, *Democricetodon*, *Megacricetodon*, and *Cricetodon*. The *Eucricetodon?* is smaller with more posteriorly-directed protoloph on M1 and M2 compared to those from the Lower Red Mudstone Member. The *Democricetodon* is larger with more distinct protoloph and more prominent mesoloph on M1 compared to the indeterminate species of the Lower Aoerban assemblage. The *Megacricetodon*, represented by 84 molars, is the most common cricetid, and it is similar to *M. sinensis* in size and morphology. The *Cricetodon*, represented by two fragmentary jaws and 17 isolated molars, is similar to an indeterminate species of the genus from Sihong (Li et al., 1983), except for its more prominent mesoloph and distinct posteroectosinus on M1, characters that may be indicative of its more primitive status.

Lagomorpha Two genera belonging to the family Ochotonidae are recognized in the Upper Aoerban assemblage. Ten specimens with larger and rooted teeth belong to *Desmatolagus?*. One hundred and twenty-four specimens, including 14 jaw fragments, are tentatively assigned to an indeterminate species of *Alloptox*. A precise species assignment of the two genera requires more detailed study.

Large mammals and other vertebrates Thick enamel fragments that can be referred to Proboscidea are found in the Upper Red Mudstone Member (IM0771 and 0772). The meager material, however, do not permit a more specific identification. Several partial antlers (e. g., IM0767 and 0772), as well as dental material and foot bones (especially astragali), indicate

the presence of *Ligeromeryx/Lagomeryx*. Further examination of the substantial variation among the antlers is needed to determine their systematic status. Lastly, turtle shell fragments are especially abundant in the upper red mudstones (IM0751, 0768, 0769, 0770, 0772, 0773).

Balunhalagen assemblage The fossil site (IM0801, N43°20'20.5" and E113°53'48.4") is at the bottom of the Balunhalagen orange mudstone bed, which rests disconformably or unconformably on the Upper Red Mudstone Member of the Aoerban Formation. The fossiliferous sediments are grayish green and yellow coarse conglomeratic fluvialite sandstone deposits. About 120 kg of dirt was sampled and produced 34 species from at least 31 genera, belonging to 3 orders and 12 families (Table 1).

Insectivora About 130 isolated teeth represent three families, which commonly occur in the Neogene. The family Erinaceidae, represented by 117 specimens, is dominant in the assemblage, but includes only one genus *Mioechinus?*. Eight teeth are referred to Talpidae and are identified as belonging to three genera, *Proscapanus*, *Yanshuella*, and *Quyania*. Two taxa from two subfamilies of Soricidae, represented by only five teeth, can be recognized in the collection; at present they are only identified to Heterosoricinae and Soricinae.

Rodentia Eight families are known from the Balunhalagen assemblage. Twenty-seven cheek teeth are referred to *Ansomys* (Aplodontidae), of which two smaller m1/2 with distinct mesoconid and simpler occlusal structure seem to indicate a different species from the other teeth. Four species represented by 26 teeth and belonging to three genera of Sciuridae can be recognized. Both *Eutamias* and *Atlantoxerus* are comparable to those from the lower red mudstones of the Aoerban Formation in size and morphology. An M3 and an m1/2 with rugose enamel in their basins and a distinct entoconid on the elongate lower molar are characteristics shared with flying squirrels.

Specimens of Eomyidae, represented by 28 isolated teeth, are assignable to *Keramidomys*, *Leptodontomys*, and *Pentabuneomys*. Larger size and more heavily built cusps and crests of *Pentabuneomys* are indicative of a more derived species than that from the lower and upper red mudstones.

Eleven teeth are referred to Gliridae and identified as *Microdyromys* and *Miodyromys*, which frequently occur in the Early and Middle Miocene of central Nei Mongol. The family Zapodidae includes only three forms, *Heterosminthus orientalis*, an indeterminate species of *Sicista*, and an undetermined zapodid. The *Heterosminthus orientalis*, represented by 61 teeth, is quite common in the assemblage and appears to be larger than those from Moergen and Tamuqin in average size. An M2 showing lophodont tooth pattern may represent an undescribed zapodid.

Nine teeth are identified as Dipodidae, and they can be assigned to two genera, *Protalactaga* and *Brachyscirtetes*. The *Protalactaga* is larger than *P. major* from Moergen and comparable to *Paralactaga suni* from Ertemte in size. Smaller size and lower crowned teeth of the *Brachyscirtetes* may be indicative of its more primitive condition than in *B. wimani* from Ertemte.

The Cricetidae are relatively diverse, represented by 54 molars, and can be identified to at least five genera. It is notable that *Plesiodipus leei* is absent in this assemblage, but a similar species, *P. progressus*, is present. An M2 and an M3 with lophate cusps and narrow and transverse synclines may represent a new cricetid, but we leave it as indeterminate for now. Nine molars are referred to Siphneidae and identified as *Prosiphneus*.

Lagomorpha Four genera belonging to the family Ochotonidae are recognized in the sample. Two rooted teeth are referred to an indeterminate species of *Desmatolagus?*. Based on the p3s, the other 60 cheek teeth belong to *Alloptox*, *Bellatona* and *Ochotona*. Most p3s in the *Bellatona* have a furrow on the anterolingual wall, the embryonic anterolingual fold, a character that may indicate more derived status for the Bilutu form. An anterolingual fold on two p3s and presence of a posterior process from posteroloph on some M2s definitively indicate presence of *Ochotona* in this assemblage.

Bilutu assemblage The fossil site (IVPP field number IM0510; N43°20'21.4" and E113°54'37.7") is on the upper part of the Aoerban section. The fossiliferous sediments are grayish white muddy sandstone and conglomerates from channel deposits. About 1.1 ton of matrix from this locality was washed in 2007. The Bilutu assemblage, dominated by small mammals, is composed of 54 species from at least 43 genera, belonging to 3 orders and 14 families (Table 1).

Insectivora Seven genera, belonging to three families commonly known in the Neogene and Quaternary of the Asian Palearctic region, are recognized in the assemblage. One hundred and ninety-two isolated teeth are referred to two species of *Erinaceidae*. The smaller hedgehog is represented by 191 specimens, and assigned to *Mioechinus? gobiensis*, which was originally described from Moergen, Tunggur. A large P3 is assignable to *Erinaceus* sp. Talpidae are represented by 32 isolated teeth, identified as *Proscapanus*, *Yanshuella*, and *Quyania*. The new material of *Proscapanus*, in particular, will enrich our knowledge of the genus in Nei Mongol, and advance the study of the relationships with European taxa. Material of shrews is relatively rare and fragmentary, but available specimens belong to two subfamilies of Soricidae. Three molars are referred to Heterosoricinae and five teeth to Soricinae, but they can not be identified below the subfamily level.

Rodentia Thirty-six rodent genera belonging to 10 families are recognized in the collection. Forty-six cheek teeth represent the genus *Ansomys* (Aplodontidae). Sixty-one isolated teeth are identified as Sciuridae and assigned to four genera: *Eutamias*, *Prospermophilus*, *Atlantoxerus*, and *Sciurus*. Among the sciurids, *Eutamias* are dominant and can be easily separated into two different species by size. The smaller one, represented by 31 specimens, is close to *E. ertemtensis* from Ertemte. Seven cheek teeth are referred to an indeterminate species of *Prospermophilus*, and five to *Atlantoxerus*. A P4 is tentatively identified as a possible tree squirrel. Large size, heavily built cusps and crests, extended protocone, and parallel protoloph and metaloph are characteristic of the genus *Sciurus*.

The family Eomyidae are represented by 82 cheek teeth and identified as belonging to four genera, *Leptodontomys*, *Keramidomys*, *Pentabuneomys*, and *Asianeomys*. They are comparable to those from the upper and lower red mudstones of the Aoerban Formation, the Gashunyinadege Fauna, and the Tunggur Fauna in morphology, but show some differences either in size or in crown height. At present their specific assignment is left undetermined.

Three forms of Gliridae are identified based on 24 cheek teeth. Two of them possess concave occlusal surface and relatively complicated dental pattern; one with complete endoloph on M1/2 is assigned to *Microdyromys* and the other with incomplete endoloph to *Miodyromys*. The third glirid is referred to *Myomimus*, and is identical to *M. sinensis* from Ertemte and Harr Obo.

Two hundred and twenty-eight isolated teeth represent three genera of Zapodidae, i. e. *Heterosminthus*, *Lophocricetus*, and *Sicista*. Small size, simple occlusal surface, absence of protostyle on M1, and development of a posterior arm of protoconid on m2 indicate similarity to *H. orientalis* from Tunggur. *Lophocricetus*, represented by 196 molars, is rather common in the collection. Based on size and morphology, an identical species of *L. grabau* from Ertemte and an indeterminate species close to that of Baogedawula can be readily distinguished. Specimens of *Sicista* are larger with stronger cusps and crests than those from the Lower Red Mudstone of Aoerban Formation and more comparable with those from Ertemte.

The family Dipodidae also includes three genera, represented by 16 molars. Two m1s are referred to *Protalactaga* and comparable to *P. grabau* from Tunggur in size. Based on size of the M1s, two forms of *Paralactaga* can be distinguished. The smaller one is close to *P. anderssoni* in size, but with four roots on M1. The larger one has distinctly higher crown, and falls within the size range of *P. suni* from Ertemte and Harr Obo. Six molars are readily identified as *Dipus fraudator* from Ertemte and Harr Obo.

The family Cricetidae, represented by 134 molars, is the most diverse group in the collection, and at least 13 genera have been identified. An M1 and an M2 are assigned to an indeterminate species of *Eucricetodon*?; they are distinctly smaller than the corresponding teeth from the lower and upper red mudstones and may represent a different species. Five molars are referred to *Cricetodon* and are larger than the indeterminate species from the upper red mudstone, and 14 specimens are assigned to a similar species of *Gobicricetodon robustus*. Thirty-five molars are assignable to *Democricetodon lindsayi* and four to *Megacricetodon sinensis*. Three species of *Plesiodipus* are identified. Twelve molars are referred to *P. leei* and *P. aff. P. progressus*, which are commonly known from Moergen and Tamuqin, respectively. Most molars of *P. leei* from this collection show signs of having been reworked. The larger ones, represented by 7 specimens, show high crown, undeveloped anterocone(id) and shallow anterolingual valley, probably indicating an undescribed species. Sixty-three specimens referred to *Kowalskia*, *Sinocricetus*, and *Nannocricetus* represent common co-occurrence of these three genera in Late Miocene and Pliocene faunas. However, their specific assignment is pending for further comparison. An M1 can be referred to a peculiar lophodont hamster *Rhinocerotodon*, which is known from Baogedawula and the Late Miocene of Kazakhstan. The M1 is smaller than the corresponding tooth from Baogedawula, and differs from the latter in having a large enamel island between the hypocone and metacone and a relatively weakly developed anterocone. An M1 and an m2 indicate the presence of *Microscoptes*; these teeth are closer in size and crown height to the indeterminate species from Shala and Baogedawula than to *M. praetermissus* from Ertemte and Harr Obo. An m1 and an M2 clearly indicate the presence of microtoid cricetids *Microtodon* and *Anatolomys*, respectively. They fall within the size variation of the corresponding teeth from Ertemte and Harr Obo, but the *Microtodon* from the Bilutu assemblage differs from *M. atavus* of Ertemte in its lower crown and shallower posterosinusid. The *Anatolomys* is closer in size to *Anatolomys* cf. *A. teilhardi* from Harr Obo. A specific assignment for the two genera, as well as for *Rhinocerotodon*, requires additional material. Six molars are assigned to an indeterminate Cricetidae showing similar dental pattern of *Sinocricetus*, but being clearly larger with higher crown. Other features also indicate that the Bilutu form may be an undescribed species, such as the absence of mesoloph(id)s and a distinctly separate anteroconid on m1. Eight specimens are referred to *Pseudomeriones* (Gerbillidae). The gerbil is comparable in size and morphology to *P. abbreviatus* from Ertemte and Harr Obo, but differs in the lower crown with smaller anterocone on M1. Forty-seven isolated teeth represent one species of the family Siphneidae. Low crowned molars and morphological similarity to those of *Plesiodipus* indicate more primitive status. The taxon may represent a new species of *Prosiphneus*, which is quite different from *P. eriksoni* from Ertemte, but similar to an indeterminate species referred to *Prosiphneus* from Shala. Forty specimens, including a lower dentary fragment with m1-3, are referred to three genera of Muridae, and are identical to *Hansdebruijnja pusilla*, *Micromys chalceus* and “*Karnimata*” *hipparionum* from Ertemte and Harr Obo. Particularly noticeable is the fact that *Hansdebruijnja pusilla* is more advanced than *H. perpusilla* known from Baogedawula.

Lagomorpha About 100 specimens, probably belonging to four genera, are referred to Ochotonidae. Large size and rooted cheek teeth of 11 specimens closely resemble *Desmatolagus*. Twelve p3s, with a deep anterolabial flexid, demonstrate the presence of the genus *Ochotona*, most of which are comparable to *O. lagreli* in size and morphology. Further studies are necessary to determine if some are identical to *O. minor*. Four p3s, without a clear anterolabial flexid, show similarities to the corresponding teeth of a pika from Amuwusu, which were previously assigned to *Bellatonoides* (Qiu et al., 2006). It is, however, obvious that they do not correspond to the diagnosis of the genus given by Sen (2003). Further studies of these specimens may suggest a new taxon intermediate between *Bellatona* and *Ochotona*. Two eroded P3s with anteriorly protruded anteroloph indicate the presence of *Alloptox* in the collection.

5 Age of faunas

Using the above biostratigraphic data, we can begin to assess the age relationships of the various fossil assemblages (Fig. 4).

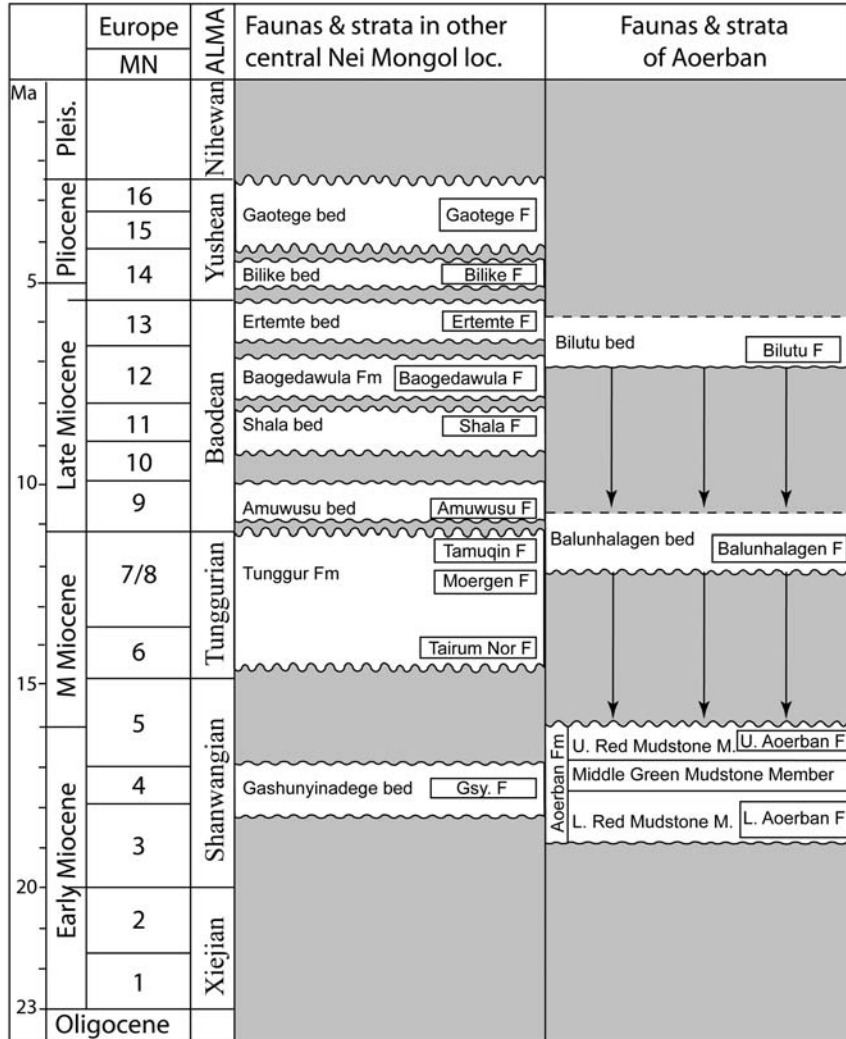


Fig. 4 Aorban faunal sequence in relation to other major central Nei Mongol vertebrate faunas

Lower Aorban Fauna All small mammal families in the Lower Aorban Fauna are already present in the Oligocene. Some of the families are quite well-represented, such as Ctenodactylidae, Tachyorctoididae, Aplodontidae, etc. However, this fauna cannot be Oligocene in age because 17 of the 29 genera of small mammals from the fauna first appear in Eurasia in the Miocene; these include such insectivore genera as *Mioechinus*, *Proscapanus*, and *Sorex*, and such rodent genera as *Atlantoxerus*, *Keramidomys*, *Prodyromys*, *Heterosminthus*, *Democricetodon*, etc. On the other hand, the age of the Lower Aorban Fauna is unlikely to be later than Middle Miocene because common Late Miocene families and genera, such as Dipodidae, Siphneidae, Muridae, Leporidae, *Myomimus* (Gliridae), *Lophocricetus* (Zapodidae), *Sinocricetus*

and *Kowalskia* (both Cricetidae), and *Ochotona* (Ochotonidae), have not appeared yet. Furthermore, this fauna is obviously earlier than Middle Miocene because this assemblage lacks some of the representative and abundant elements from nearby Middle Miocene localities (Tairum Nor, Moergen, and Tamuqin) in central Nei Mongol (e. g., *Protalactaga*, *Plesiodipus*, *Megacricetodon*, *Alloptox*, *Bellatona*, etc.). On the contrary, it has many genera common in older strata of Late Oligocene or Early Miocene age (e. g., *Amphechinus*, *Distylomys*, *Tachyoryctoides*, *Ligerimys*, *Plesiosminthus*, *Eucricetodon?*, etc.). The composition of the Lower Auerban Fauna is closest to that of the Early Miocene Gashunynadege Fauna, as the same families occur in both faunas. Furthermore, all 29 genera from the former locality are present in the latter, further attesting their closeness in age. However, from the stand point of small mammals, the Lower Auerban Fauna seems somewhat older than the Gashunynadege Fauna because it does not have such genera as *Leptodontomys*, *Megacricetodon*, and *Alloptox*, which are present only in the latter and commonly persist into the Middle Miocene. Moreover, Lower Auerban cricetids are less divergent than those in Gashunynadege; in particular the Lower Auerban *Democricetodon* still preserves some primitive characteristics. Outside of central Nei Mongol, the Lower Auerban Fauna is comparable to the Xiejia Fauna in Qinghai, Sihong Fauna in Jiangsu, Suosuoquan Fauna in Xinjiang, and the assemblage from D horizon of the Valley of Lakes regions, Mongolia. The Lower Auerban Fauna shares with Xiejia Fauna the following genera: *Tachyoryctoides*, *Litodonomys*, *Eucricetodon?*, and *Sinolagomys*. However, Xiejia Fauna contains relatively more archaic genera, such as *Parasminthus* and *Yindirtemys* that are more commonly seen in the Late Oligocene. In addition, modern cricetids are still absent from Xiejia, i. e., it is in the "cricetid vacuum" (Li and Qiu, 1980; Qiu and Qiu, 1995). Therefore, we think the Lower Auerban Fauna is younger than the Xiejia Fauna.

Although there are obvious environmental differences, the Sihong Fauna nonetheless shares with the Lower Auerban Fauna the following four genera: *Ansomys*, *Eutamias*, *Microdyromys*, and *Democricetodon*. However, Sihong is obviously younger because of its highly specialized cricetids, with the *Democricetodon* in an advanced stage of development, and the presence of *Megacricetodon* and proboscidean (Li et al., 1983; Qiu and Qiu, 1995).

The composition of the Suosuoquan Fauna is rather complex, which may indicate a long span of ages. The Suosuoquan Assemblage Zone II has in common with Lower Auerban Fauna the following taxa: *Amphechinus*, *Plesiosminthus*, *Asianeomys*, *Litodonomys*, *Democricetodon*, *Sinolagomys*, etc. Despite its frequent presence of the archaic *Parasminthus*, this assemblage zone is similar to the Lower Auerban Fauna in their shared absence of *Leptodontomys*, *Megacricetodon*, and *Alloptox* (Meng et al., 2006). Consequently, the Lower Auerban Fauna is similar in age to that of the Suosuoquan Assemblage Zone II.

The Lower Auerban Fauna shares with the assemblage from D horizon of the Valley of Lakes the following taxa: *Distylomys*, *Tachyoryctoides*, *Plesiosminthus*, *Litodonomys*, *Heterosminthus*, and *Democricetodon* (Daxner-Höck and Wu, 2003). Morphologically, some species of *Plesiosminthus* and *Heterosminthus* from these two faunas are also very similar. We thus consider these two faunas similar in age as well.

The Lower Auerban Fauna has at least 14 genera in common with European faunas. It is worth mentioning that *Democricetodon* sp. from Auerban is quite close in size and morphology to some European primitive species, such as *D. franconicus*. The European first appearance of *Democricetodon* is in the Early Miocene MN4 unit (Mein, 1999), and it appears in Turkey during MN3/4 (Ünay et al., 2001). *Pentabuneomys* and *Ligerimys* are restricted to MN3–4 in Europe (Engesser, 1999), and the latest appearance of European *Eucricetodon?* is MN4 (Mein, 1989). Thus, the age of the Lower Auerban Fauna should fall within Orleanian European land mammal age.

Only two large mammal taxa from the Lower Auerban Fauna offer a certain measure of age

constraint. *Palaeogale* is known in the Early Miocene of Europe, such as Laugnac (MN2), Saint Gérard le Puy (MN2), and Wintershof-West (MN3) (Bonis, 1981). In North America, *Palaeogale* also ranges into the Early Miocene and the latest record appears to be that from the *Aletomeryx* Quarry (Runningwater Formation), Cherry County, Nebraska (Bonis, 1981). Bracketed between Europe and North America, Asia has naturally been suspected to possess *Palaeogale* during the Early Miocene. The Aoerban record now confirms a pan-Palaearctic distribution for this primitive carnivoran. Nonetheless, such an isolated Asian record, far away from related forms in Europe and North America, by itself cannot be used to arrive at a more precise age assessment and our new *Palaeogale* materials are merely consistent with the conclusion derived from the small mammals.

Another large mammal potentially useful for age relationships is the large chalicothere from the Lower Aoerban Fauna. However, based on the fragmentary foot bones, the Aoerban chalicothere appears to be an undescribed taxon somewhat intermediate between *Ancylotherium* (Middle Miocene of Europe and Asia) and *Phyllotilion* (Oligocene to Early Miocene of Asia and Oligocene to Middle Miocene of Europe). Again, the Aoerban chalicothere is consistent with an Early Miocene age, but does not offer further constraint.

In summary, the age of the Lower Aoerban Fauna is likely Early Miocene in the Early to middle Shanwangian Chinese land mammal age, or equivalent to the European MN3-4 (Fig. 4).

Upper Aoerban Fauna Fossils from the upper red bed (Upper Red Mudstone Member of Aoerban Formation) seem to be less abundant than those from the lower red mudstones. As a result, fewer matrices from the upper red mudstone bed are processed. This relative shortage of fossil materials may affect the comparison between faunas from the upper and lower beds. Nonetheless the compositions of the upper and lower Aoerban faunas are very similar, with almost all families of the Lower Aoerban Fauna still present in the Upper Aoerban Fauna, suggesting a similar age. Some points of difference are worthy of notice: 1) the absence or noticeable decline in certain early-appearing families, such as complete disappearance of the Ctenodactylidae and drastic reduction of Aplodontidae and Zapodidae species; 2) the lack of a large number of genera from the Lower Aoerban Fauna, such as *Ampechinus*, *Tachyoryctoides*, *Asianeomys*, *Litodonomys*, *Sinolagomys*, etc.; 3) the appearance of genera absent in the Lower Aoerban Fauna, such as *Megacricetodon*, *Cricetodon*, and *Alloptox*, or presence of relatively advanced species in genera present in both faunas (e. g., species of *Democricetodon*). All of these are suggestive of more advanced status of the Upper Aoerban Fauna.

Compositionally the Upper Aoerban Fauna is also very close to the Gashunyinadege Fauna. Both share many of the same genera, especially those (*Megacricetodon* and *Alloptox*) that are absent from the Lower Aoerban Fauna. However, the Upper Aoerban Fauna lacks some of the early-appearing families and genera (Ctenodactylidae, *Tachyoryctoides*, *Asianeomys*, *Litodonomys*, *Sinolagomys*, etc.) that are present in the Gashunyinadege Fauna as well as the Lower Aoerban Fauna. This seems to suggest its advanced status relative to the Gashunyinadege Fauna. On the other hand, typical Middle Miocene elements, such as *Plesiodipus* and *Bellatona* commonly seen in the Tunggurian Moergen Fauna, are absent from the Upper Aoerban Fauna, indicating that the latter does not extend into the Middle Miocene in age.

As in the Lower Aoerban Fauna, the limited large mammal materials offer relatively little in the age assessment. Presence of proboscidean dental fragments is potentially an important constraint. The first Eurasian appearance of the proboscideans, also known as the "proboscidean datum," was dated to between 18 ~ 19 Ma by Tassy (1990), although Qiu et al. (2001) and Wang and Qiu (2002) contend that the Chinese first appearance was somewhat earlier in the 20 ~ 21 Ma range. In either case, Aoerban proboscidean is consistent with the age estimates derived from small mammals.

A second potentially useful group of large mammals is the basal deer lineage *Ligeromeryx/Lagomeryx*. Early Chinese records include those from Xiacaowan (Li et al., 1983) and Shanwang (Young, 1937), although the former was based exclusively on dental materials, which are not easily compared with other taxa that are established on antlers. In Europe, this group first appears in the French Loire Basin (Chitenay, MN3) (Azanza and Ginsburg, 1997), although these early records seem to be more primitive than the Aoerban materials. In any case, presence of the *Ligeromeryx/Lagomeryx* lineage in the Upper Aoerban Fauna supports an Early Miocene age for these strata.

Therefore, the age of the Upper Aoerban Fauna probably belongs to late Early Miocene, i. e., late Shanwangian Chinese land mammal age, or equivalent to the MN5 of European land mammal zonation (Fig. 4).

Balunhalagen Fauna The Balunhalagen Fauna appears to be more modernized. Elements from the Oligocene are further decreased: not only does the fauna lack Ctenodactylidae and other archaic genera from the Lower Aoerban Fauna, but it also lacks elements of the Upper Aoerban Fauna, such as Tachyoryctoididae, *Plesiosminthus* (Zapodidae), and *Cricetodon* (Cricetidae). On the other hand, families and genera such as Dipodidae, Siphneidae, and *Ochotona*, common in the Late Miocene of the Asian Palearctic, begin to appear. However, certain typical Late Miocene forms (Muridae and modern cricetids) are still absent in the Balunhalagen Fauna. These seem to indicate that the age of the Balunhalagen Fauna is younger than Early Miocene, although possibility exists that it may have reached into the Late Miocene.

Overall, the Balunhalagen small mammals (large mammals are represented by only a few cervid antler and tooth fragments from the upper orange beds) possess characteristics of the Middle Miocene Tunggurian faunal composition: presence of only a few leftover Oligocene remnants; few members of the *Hipparion* fauna, low differentiation of zapodids relative to those in the Early Miocene; dipodids represented by the primitive *Protalactaga*; cricetids lacking modern forms; co-occurrence of common primitive cricetids *Democricetodon*, *Megacricetodon*, *Gobicricetodon*, and *Plesioidipus*; and ochotonids dominated by *Alloptox* and *Bellatona*. In these respects, the Balunhalagen Fauna is very similar to those of Moergen, "346" Locality, and Tamuqin. Of the 26 known genera from Balunhalagen, 20 also occur in the former two localities. The Tamuqin Fauna from the top part of the Moergen section (the Moergen Fauna is stratigraphically below the Tamuqin Fauna) is not very diverse and is characterized by advanced species of *Plesioidipus* and *Gobicricetodon*, as well as by markedly derived characters of the *Bellatona* (Qiu, 1996). In this respect, the Balunhalagen Fauna is more similar to the Tamuqin Fauna. However, it contains a few genera that are previously seen only in the Late Miocene localities in this region. For example, the earliest appearance of *Prosiphneus* is recorded in the earliest Late Miocene Amuwusu locality, and *Brachyscirtetes* and *Ochotona* occur in localities that are of slightly later ages. Although these genera from the Balunhalagen Fauna have morphologies that are more primitive, certain genera, such as *Prosiphneus*, can be found in the Middle Miocene in Gansu Province (Zheng et al., 2004). Therefore, we cannot rule out the possibility that the Balunhalagen Fauna is somewhat later than the Tamuqin Fauna, or even it overlaps with ages represented by the Amuwusu Fauna.

The small mammal fauna from Balunhalagen is generally comparable to assemblages from the lower part of the Dingshanyanchi Formation in the Junggar Basin of Xinjiang Autonomous Region or to the A4 small mammal assemblage in the Qin'an section of Gansu Province (Meng et al., 2008; Guo et al., 2002). However, these latter assemblages seem to more closely resemble the Moergen Fauna, i. e., they are probably slightly earlier than the Balunhalagen Fauna. Small mammals produced from the lower part of the Bahe Formation in Lantian, Shaanxi, are Late Miocene in age. Although the Bahe assemblage shares with the Balunhalagen Fauna the appearance of *Protalactaga*, but the presence of murines and modern cricetids obviously in-

icates an age later than the Balunhalagen Fauna. Additionally, the Balunhalagen Fauna has in common as many as nine genera with European faunas of Astaracian age. Of these, the stage of evolution in *Democricetodon* and *Megacricetodon* is especially similar to those in Steinheim of Germany and Anwil of Switzerland, indicating a comparable age of the European MN7–8.

Only one large mammal, a *Lagomeryx* from IM0767, in the Balunhalagen bed is of potential value for age determination. This four-pronged antler fragment is different from those in the Upper Aorban Fauna, and presumably represents a more advanced stage of evolution. However, the more laterally spread prongs from Balunhalagen bed is different from the more upwardly oriented prongs from Tunggur Formation (Colbert, 1936). Lacking additional specimens for evaluation of individual variation, we are unable to attribute such differences to taxonomic status.

In all, the age relationship of the Balunhalagen Fauna is likely in the neighborhood of Late Middle Miocene to earliest Late Miocene, i. e., Late Tunggurian to earliest Baodean in the Chinese land mammal ages and equivalent to the MN8–9 in the European land mammal zonations (Fig. 4).

Bilutu Fauna There are 43 nominal genera in the Bilutu fossil assemblage. Not only does it contain elements from the lower strata of the Aorban section and the Gashunyinadege localities, it also possesses some genera from the Middle to Late Miocene localities in the central Nei Mongol (e. g., Tunggur, Amuwusu, Shala, Baogedawula, and Ertemte). Two reasons may account for such a complex assemblage. The first is because of certain long-lived genera, such as the insectivores *Mioechinus?*, *Yanshuella*, and *Quyania*, and the rodents *Ansomys*, *Eutamias*, *Atlantoxerus*, *Leptodontomys*, *Miodymomys*, and *Sicista*, as well as the lagomorph *Desmatolagus?*. These forms not only lived through much of the Middle Miocene, some of them even survived into the Pliocene. The second reason is that Bilutu fossils recovered from the channel deposits may have been eroded from the underlying strata and re-deposited in their current positions. These partially reworked fossils are then mixed with later faunal elements to form its current assemblage. The result is the co-occurrence of typical Middle Miocene members of *Democricetodon* and *Megacricetodon* with such genera as *Micromys* and *Dipus* that typically appear in relatively later part of the Late Miocene. So far, this is the only known instance of faunal mixing in central Nei Mongol.

The Bilutu assemblage contains no elements from the lower and upper red mudstone beds (Lower and Upper Aorban faunas). For example, absent from the Bilutu assemblage are common families (e. g., Tachyoryctoididae and Ctenodactylidae) in the Early Miocene of the Asian Palearctic, as well as common genera from the Aorban lower red mudstone beds such as *Ampechinus*, *Distylomys*, *Tachyoryctoides*, *Aralomys*, *Prodyromys*, *Plesiosminthus*, *Litodonomys*, *Sinolagomys*, etc. This seems to suggest that the channels in the Bilutu beds did not cut through the lower Miocene strata. If so, this also rules out the possibility of an Early Miocene age for the Bilutu assemblage.

Reworked fossils undoubtedly affect our assessment of their ages. In order to determine the true age of the Bilutu Fauna, it is necessary to tease out components from the lower strata. As stated above, such Bilutu genera as *Democricetodon*, *Megacricetodon*, *Plesiodipus*, and *Alloptox* (see Table 1) probably belong to reworked elements from Middle Miocene strata. They are abundant in the Middle Miocene Tunggurian strata. Furthermore, teeth of certain larger sized taxa, such as *Plesiodipus* and *Alloptox*, show signs of being water-worn.

More importantly, as a principle, late-appearing taxa in the assemblage are more likely true indicators of their age relationships. Along these lines, we note that of the known genera in the Bilutu assemblage, 20 genera (more than 46%) are found only in the Late Miocene localities in central Nei Mongol. These are the insectivore *Erinaceus*, the rodents *Sciurus*, *Prosperomophilus*, *Myomimus*, *Lophocricetus*, *Paralactaga*, *Dipus*, *Kowalskia*, *Sinocricetus*, *Nannocricetus*, *Rhinocerotodon*, *Microscoptes*, *Microtodon*, *Anatolomys*, *Pseudomeriones*, *Prosiph-*

neus, *Hansdebruijnina*, *Micromys*, and “*Karnimata*”, and lagomorph *Ochotona*. The above genera permit us to restrict the Bilutu Fauna to the Late Miocene. Of these genera, 2, 10, 11, and 18 of them occur in Amuwusu, Shala, Baogedawula, and Ertemte, respectively (Qiu et al., 2006), suggesting the Bilutu Fauna being relatively closer to the latter three faunas.

Murids and leporids appear relatively late in north China, but are quite diverse during the late Cenozoic. These two families are presently not known in the Shala Fauna, indicating an age earlier than the Baogedawula and Ertemte faunas. Although leporids are also absent in the Bilutu Fauna, the murids in the Bilutu Fauna are already beginning to diversify, signaling its closeness to the Baogedawula and Ertemte faunas. Compared to these latter faunas, the Bilutu Fauna has the following characteristics: 1) it possesses *Lophocricetus grabaui*, which is absent in Baogedawula but quite abundant in Ertemte; 2) murids are moderately diverse, with more genera than in Baogedawula but fewer than in Ertemte and with identical species from Ertemte, such as *Hansdebruijnina pusilla*, which is obviously evolutionarily more advanced than *H. perpusilla* from Baogedawula; 3) it has the genus *Rhinocerosodon*, which only occurs in Baogedawula but not in Ertemte; 4) when the same genus is present in both faunas (e. g., *Lophocricetus*), the Bilutu Fauna contains species clearly more primitive (e. g. *Lophocricetus* sp.) than that from Ertemte (e. g. *L. grabaui*); and 5) common genera in Ertemte, such as *Paralophocricetus* (i. e. *Lophocricetus pusillus* Schaub, 1934), *Eozapus*, *Microtodon*, etc., are absent or very rare in Bilutu Fauna. Therefore, it seems reasonable to state that the Bilutu Fauna spans much of the age range from Baogedawula to Ertemte faunas. Overall, it is probably slightly earlier than the Ertemte Fauna and belongs in the middle to late parts of the Late Miocene, i. e., Late Baodean in the Chinese Land Mammal Age or roughly equivalent to the European MN12–13 units (Fig. 4).

6 Magnetostratigraphy

Liddicoat et al. (2007) attempted a preliminary investigation on the magnetostratigraphy of the Aoerban strata. Although the magnetic property is suitable for such an investigation, sampling density is far too sparse to yield much useful stratigraphic information in a period known to be quite busy with frequent magnetic reversals. A subsequent unpublished investigation, by a team from the Nanjing University, with much greater sampling density clearly shows that Liddicoat et al. (2007) has missed several important reversal events (Yang Zhenyü, personal communication). Nonetheless, the normal interval in the lower part of their magnetic section (horizons 3–6 in fig. 5 of Liddicoat et al., 2007; left column in Fig. 3) seems to have correctly captured the long normal zone of C6n (18.7 ~ 19.7 Ma in Ogg and Smith, 2004). Unfortunately, a much greater density is necessary for the rest of the section to properly interpret the magnetic results.

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References

Azanza B, Ginsburg L, 1997. A revision of the large lagomerycid artiodactyls of Europe. *Palaeontology*, **40**: 461–485

- Bonis L de, 1981. Contribution a l'etude du genre *Palaegale* Meyer (Mammalia, Carnivora). *Ann Paleont*, **67**: 37–56
- Bureau of Geology and Mineral Resources of Nei Mongol Autonomous Region, 1991. Regional Geology of Nei Mongol (Inner Mongolia) Autonomous Region. *Geol Mem, Ser 1*, 25. Beijing: Geological Publishing House. 1–725
- Colbert E H, 1936. Tertiary deer discovered by the American Museum Asiatic Expeditions. *Am Mus Novit*, (854): 1–21
- Daxner-Höck G, Wu W Y, 2003. *Plesiosminthus* (Zapodidae, Mammalia) from China and Mongolia: migrations to Europe. In: Reumer J W F, Wessels W eds. Distribution and Migration of Tertiary Mammals in Eurasia. A Volume in Honour of Hans de Bruijn. *Deinsea*, **10**: 127–151
- Dong M X(董明星), 1993. The study of the Tung-gur Miocene and its mammalian fauna in Sunite Zhouqi of Inner Mongolia. Master's thesis. Beijing: China University of Geosciences. 1-33(in Chinese)
- Editorial Committee of Stratigraphic Table of Inner Mongolia Autonomous Region, 1978. Regional Stratigraphic Table of North China: Inner Mongolian Autonomous Region. Beijing: Geology Press
- Engesser B, 1999. Family Eomyidae. In: Rössner G E, Heissig K eds. The Miocene Land Mammals of Europe. München: Verlag Dr. Friedrich Pfeil. 319–335
- Guo Z T, Ruddiman W F, Hao Q Z et al., 2002. Onset of Asian desertification by 22 Myr ago inferred from loess deposits in China. *Nature*, **416**: 159–163
- Li C K(李传夔), Lin Y P(林一璞), Gu Y M(顾玉珉) et al., 1983. The Aragonian vertebrate fauna of Xiacaowan, Jiangsu. *Vert PalAsiat(古脊椎动物学报)*, **21**(4): 313–327(in Chinese with English summary)
- Li C K(李传夔), Qiu Z D(邱铸鼎), 1980. Early Miocene mammalian fossils of Xining Basin, Qinghai. *Vert PalAsiat(古脊椎动物学报)*, **18**(3): 198–214(in Chinese with English summary)
- Liddicoat J C, Wang X M(王晓鸣), Qiu Z D(邱铸鼎) et al., 2007. Recent palaeomagnetic and magnetostratigraphic investigations on and around the Tunggur Tableland, central Nei Mengol (Inner Mongolia). *Vert PalAsiat(古脊椎动物学报)*, **45**(2): 110–117
- Mein P, 1989. Updating of MN Zones. In: Lindsay E H, Fahlbusch V, Mein P eds. European Neogene Mammal Chronology. NATO ASI Ser A, **180**: 73–90
- Mein P, 1999. European Miocene mammal biochronology. In: Rössner G E, Heissig K eds. The Miocene Land Mammals of Europe. München: Verlag Dr. Friedrich Pfeil. 25–38
- Meng J(孟津), Wang B Y(王伴月), Bai Z Q(白志强), 1996. A new middle Tertiary mammalian locality from Sunitezuoqi, Nei Mongol. *Vert PalAsiat(古脊椎动物学报)*, **34**(4): 297–304(in Chinese with English summary)
- Meng J(孟津), Ye J(叶捷), Wu W Y(吴文裕) et al., 2006. A recommended boundary stratotype section for Xiejian Stage from northern Junggar Basin: implications to related bio-chronostratigraphy and environmental changes. *Vert PalAsiat(古脊椎动物学报)*, **44**(3): 205–236(in Chinese with English summary)
- Meng J(孟津), Ye J(叶捷), Wu W Y(吴文裕) et al., 2008. The Neogene Dingshanyanchi Formation in northern Junggar Basin of Xinjiang and its stratigraphic implications. *Vert PalAsiat(古脊椎动物学报)*, **46**(2): 90–110(in Chinese with English summary)
- Ogg J G, Smith A G, 2004. 5. The geomagnetic polarity time scale. In: Gradstein F M, Ogg J G, Smith A G eds. *A Geologic Time Scale 2004*. Cambridge: Cambridge University Press. 63–86
- Qiu Z D(邱铸鼎), 1996. Middle Miocene micromammalian fauna from Tunggur, Nei Mongol. Beijing: Science Press. 1–216 (in Chinese with English summary)
- Qiu Z D(邱铸鼎), Wang X M(王晓鸣), 1999. Small mammal faunas and their ages in Miocene of central Nei Mongol (Inner Mongolia). *Vert PalAsiat(古脊椎动物学报)*, **37**(2): 120–139(in Chinese with English summary)
- Qiu Z D(邱铸鼎), Wang X M(王晓鸣), Li Q(李强), 2006. Faunal succession and biochronology of the Miocene through Pliocene in Nei Mongol (Inner Mongolia). *Vert PalAsiat(古脊椎动物学报)*, **44**(2): 164–181
- Qiu Z X, Qiu Z D, 1995. Chronological sequence and subdivision of Chinese Neogene mammalian faunas. *Palaeogeogr Palaeoclimatol Palaeoecol*, **116**: 41–70
- Qiu, Z X, Wang B Y, Qiu Z D et al., 2001. Land mammal geochronology and magnetostratigraphy of mid-Tertiary deposits in

- the Lanzhou Basin, Gansu Province, China. *Eclogae Geol Helv*, **94**: 373–385
- Sen S, 2003. Lagomorpha. In: Fortelius M, Kappelman J, Sen S et al. eds. *Geology and Paleontology of the Miocene Sinap Formation, Turkey*. New York: Columbia University Press. 162–177
- Tassy P, 1990. The “Proboscidean Datum Event”: how many proboscideans and how many events? In: Lindsay E H, Fahlbusch V, Mein P eds. *European Neogene Mammal Chronology*. New York: Plenum Press. 159–224
- Ünay E, Atabey E, Saraç G, 2001. Small mammals and foraminifera from the Anatolian (Central Taurus) Early Miocene. *Ann Carnegie Mus*, **70**(4): 247–256
- Wang B Y(王伴月), 2003. Dipodidae (Rodentia, Mammalia) from the mid-Tertiary deposits in Danghe Area, Gansu, China. *Vert PalAsiat(古脊椎动物学报)*, **41**(2): 89–103(in Chinese with English summary)
- Wang B Y(王伴月), Qiu Z X(邱占祥), 2000. Dipodidae (Rodentia, Mammalia) from the Lower Member of Xianshuihe Formation in Lanzhou Basin, Gansu, China. *Vert PalAsiat(古脊椎动物学报)*, **38**(1): 10–35
- Wang B Y(王伴月), Qiu Z X(邱占祥), 2002. A new species of *Platybelodon* (Gomphotheriidae, Proboscidea, Mammalia) from Early Miocene of the Danghe area, Gansu, China. *Vert PalAsiat(古脊椎动物学报)*, **40**(4): 291–299(in Chinese with English summary)
- Young C C, 1937. On a Miocene mammalian fauna from Shantung. *Bull Geol Soc China*, **17**: 209–245
- Zheng S H(郑绍华), Zhang Z Q(张兆群), Cui N(崔宁), 2004. On some species of *Prosiphneus* (Siphneidae, Rodentia) and the origin of Siphneidae. *Vert PalAsiat(古脊椎动物学报)*, **42**(4): 297–315(in Chinese with English summary)



第 69 届北美古脊椎动物学会年会暨第 57 届古脊椎动物 与比较解剖学会年会将在英国召开

2009 年是“达尔文年”，既是达尔文的 200 年诞辰，也是他的划时代巨作《物种起源》发表 150 周年。该书不仅完全改变了人类对生命及人类本身的认知，也直接引发了一场科学大革命，奠定了生命科学的基础。

因应“达尔文年”，创立于 1940 年、会员达 2300 多人的北美古脊椎动物学会在其历史上首次把年会举办地移至北美以外、达尔文的故乡——英国。这次会议不仅是一次专业人士的学术盛会，届时将有大量的学术报告和研讨会介绍生命演化研究的最新进展，而且也是生命科学爱好者、相关科普学者及媒体人的一场“盛宴”，将有大量关于进化理论探索和关键人物台前幕后故事的展示，以及参观不列颠各主要生命演化历史“圣地”等活动。

本届年会仅是英国“达尔文年”各项活动之一，其他各纪念活动将贯穿 2009 全年。这种前所未有的纪念方式直接反映了达尔文在人类科学史上的地位，迄今也只有牛顿和爱因斯坦可与之比肩。

会议举办地布里斯托尔市也是英国 BBC 自然历史频道制作部的所在地，BBC 资深媒体人、博物学家 David Attenborough 届时也将推出特别演讲。文化氛围浓郁的布里斯托尔位于英国西部，距首都伦敦两个小时的车程。有关会议及相关详情参见会议网页：<http://www.vertpaleo.org/meetings/index.cfm>

(2009 年北美古脊椎动物学会年会组委会)