

内蒙古高特格上新世哺乳动物群¹⁾

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摘要 简短报道了2000年和2002年采自内蒙古高特格上新统的一批哺乳动物化石。这些材料包括小型和大、中型哺乳动物,计有7目22科41属46种。在群体的结构上,这一哺乳动物群与最晚中新世二登图动物群、早上新世比例克和高庄动物群接近,但其时代比二登图和比例克动物群都晚,而可能比高庄动物群的上部稍早。高特格动物群似乎代表中国新近纪哺乳动物群序列中的一个新成员,时代应为早上新世晚期,或中国哺乳动物年代的榆社期早期,大体与欧洲陆相哺乳动物时代的早露西尼晚期或MN15a的时代相当。动物群的组合指示了一个以温带草原为主,局部地方有灌木丛林和水体的生态环境,与二登图和比例克动物群的情况相似。从晚中新世二登图动物群到早上新世高特格动物群的演替表明,内蒙古中部地区在这一时期的环境似乎渐趋干旱和草原化。

关键词 内蒙古高特格,上新世,哺乳动物群

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PLIOCENE MAMMALIAN FAUNA OF GAOTEGE IN NEI MONGOL (INNER MONGOLIA), CHINA

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Abstract This paper briefly reports a new Pliocene mammalian assemblage collected from Gaotege in central Nei Mongol (Inner Mongolia), China in 2000 and 2002. The Gaotege association consists of 46 taxa referred to 41 genera, 22 families and 7 orders, including small to large sized mammals. The fauna shows close resemblance to those of the Ertemte Fauna of latest Miocene, and the Bilike and Gaozhuang faunas of early Pliocene. However, certain faunal components suggest that it is younger than the Ertemte and Bilike faunas, but somewhat older than the Gaozhuang assemblage of the upper part. It seems likely that the Gaotege association represents a new fauna in the Chinese Neogene mammal sequence, with an age of late early Pliocene (early Yushean, correlated, in European terms, with early Ruscinian or equivalent to MN15a). The Gaotege Fauna reflects a predominantly temperate steppe habitat, with local shrub and freshwater bodies, similar to the Ertemte and Bilike faunas. Faunal changes from Ertemte to Gaotege seem to reflect an environment gradually changing to drier and more grassland conditions.

Key words Gaotege, Nei Mongol (Inner Mongolia), Pliocene, Mammalian fauna

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1 Introduction

In 1924, in a geological reconnaissance tour of Nei Mongol (Inner Mongolia) and Hebei in China, Père Teilhard de Chardin and Emile Licent briefly explored the Cenozoic sediments along the Huiteng River (Chitor-gol) west of the Dalai Nor. Two fossiliferous localities were discovered within a few kilometers of each other: a sequence of red sediments (“Les Terres rouges pontiennes”) in the “bassin du Chitor-gol” cut by the Huiteng River and a sequence of light-gray colored sediments (“Les Terres blanches pliocènes”) on the southern face of a large hill now called Gaotege Ula (Gouchtock oula) (Teilhard de Chardin, 1926a).

In the same year of above description of the geology of Dalai Nor, Teilhard de Chardin (1926b) briefly described and contrasted the vertebrate fossils from these localities. The red beds produced a small assemblage of mammals of “Pontian” ages: *Martes anderssoni*, a hyaenid, *Chilotherium* sp., *Hipparion* sp., a new moschid, *Moschus primaevus*, and two other artiodactyles, a proboscidean, and an *Ochotona*. The white beds, on the other hand, produced a slightly richer assemblage of mammals of apparently younger age: *Erinaceus* cf. *E. mongolicus*, a mustelid, a hyaenid, a rhino, *Hipparion* sp., *Gazella* sp., two or three other large artiodactyles (giraffid, cervid, and camelid), *Castor anderssoni*, *Dipoides* sp., *Prosilphneus* sp., *Ochotona* sp., and a mastodont proboscidean.

Since Teilhard and Licent’s pioneering works in the early 1920s, their “Dalai Nor” localities have not been revisited during the remainder of the 20th century. The American Museum Central Asiatic Expeditions in the late 1920s and 1930s briefly explored areas east of Tunggur, but did not go far enough to reach Teilhard’s localities (Andrews, 1932). An attempt to relocate these localities by one of us (XW) in 1996 was met with failure due to its remote locations. In 2000, the “Dalai Nor” localities were finally relocated and brief explorations confirmed the Gaotege to be a promising locality for small mammals. In 2002, a campaign to systematically screen-wash for small mammals was met with great success. Nearly 2000 specimens of mammals were collected out of 1.2 ton of matrix at 4 sites (DB02-1, 2, 3, 4). Surface collecting from two other sites (DB02-5, 6) yielded additional specimens of large mammals. Furthermore, the mammal sites are associated with fossil fishes, amphibians, reptiles, freshwater mollusks, and plant leaf fragments.

2 Geologic settings

The Gaotege locality (N 43°29′55.3″ and E 115°26′38.3″; Fig. 1) is an isolated hill about 80km southwest of Xilinhot and 26km northwest of Yangdao Sumu (Yendō-soumō in Abag Qi (Banner) of central Nei Mongol. The name Gaotege is derived from Gaotege Ula in Chinese topographic map, which means “Hill of Treasure” in Mongolian. The Gaotege is approximately 8km north of Teilhard’s “Chitor-gol” locality; the latter is a set of red beds mostly exposed along a segment of the Huiteng and Gaogesitai rivers where the two merge. The red beds are fractured by small faults and may have been separated from the Gaotege beds by a layer of basalt (Teilhard de Chardin, 1926a). The sediments at Gaotege, at least 70m in thickness, are predominantly a series of light-colored siltstone and mudstone from fluvio-lacustrine deposits. The fossiliferous sections at the main fossil sites are briefly described below (in ascending order) (Fig. 2). A similar stratigraphic sequence was described by Teilhard de Chardin (1926a: Fig. 20), although he had probably over-estimated the total thickness (his 100m vs. our 70m); our own numbering scheme (first numbers) probably correspond to his (second numbers) in the following manner: 1 = 2, 2 = 2, 3 = 3, 4 = 4 + 5, 5 = 6, 6 = 7, 7 = 8 + 9, 8 = 10.

The Lithological section of Gaotege is overlain by Holocene sands or soils. Its lower part is also covered by Quaternary deposits, and no underlying rock units could be seen.

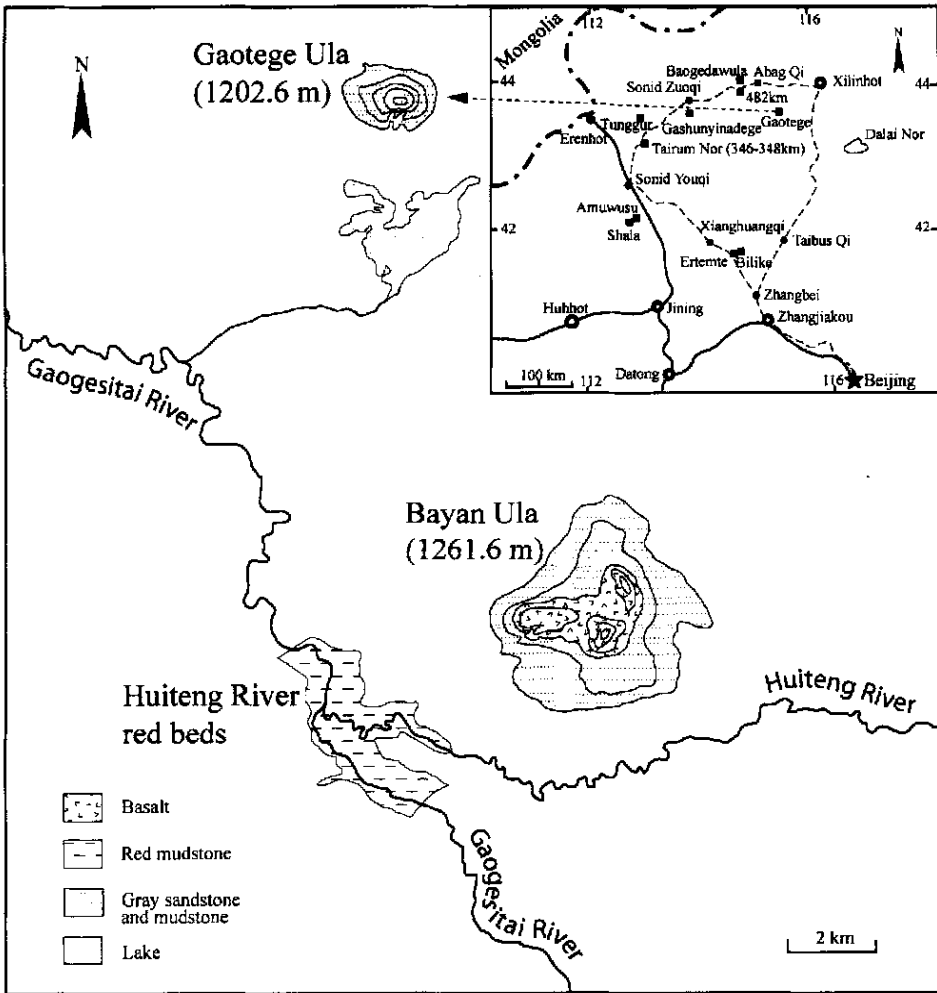


Fig. 1 Geographic location of the fossil site Gaotege in Nei Mongol

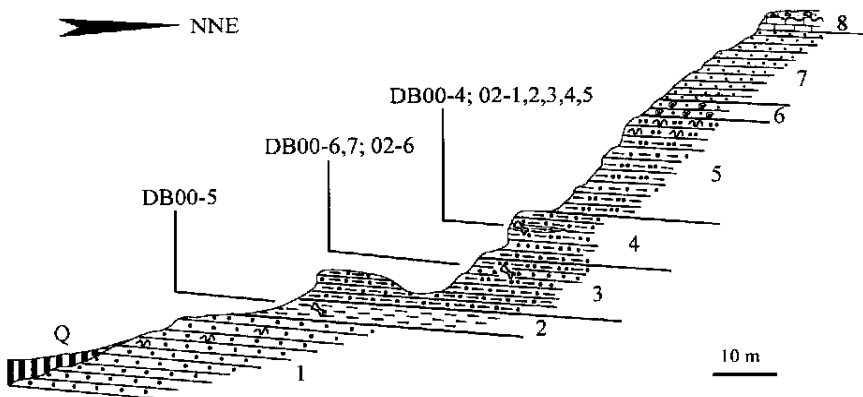


Fig. 2 Section of the fossil locality Gaotege Ula

1. Thin-bedded white siltstone and sandstones. There are some folds locally, probably from sedimentary sliding, and a layer of brownish yellow siltstone with iron-calcareous cement on the top; the lower part is covered by Quaternary deposits > 5m
2. Grayish black and brownish yellow mudstone. The thin-bedded brownish yellow beds occur in the upper part. DB00-5 locality, fish bones and plant leaves 2m
3. Grayish white and green sandy mudstone interbedded with white sandstone. The middle part of this layer is the fossiliferous level (DB00-6, 00-7, 02-6 localities); remains of vertebrates and invertebrates are concentrated in a layer of muddy sandstone. In the upper part, thick-bedded, hard sandy mudstones form the first topographically steep cliff 8m
4. Variegated sandy mudstone interbedded with white sandstone. Small lenticular bodies of sandy mudstone within the sandstone in the middle part are the main fossiliferous level in this locality (DB00-4, DB02-1 ~ 5); above the fossiliferous horizon are thin-bedded grayish black, green, and brown sandy mudstones. Thick-bedded sandy mudstones form the second topographically steep cliff in the upper part 8m
5. Variegated sandy mudstone and muddy siltstone interbedded with white siltstone. The lower part of this layer is made up of alternating beds of grayish white calcareous mudstone and sandy mudstone; the middle is composed of three fining upward cycles; and the upper part is composed of thick-bedded muddy siltstone forming steep outcrops. Some slumping of sediments can be seen on the top. Teilhard (1926a: Fig. 20) recorded some tortoise in this layer 20m
6. Deep grayish green muddy siltstone. It pinches out to the east; the upper part contains abundant snail fragments 2m
7. Brownish yellow muddy siltstone with fine laminations. The colors become greenish gray towards the top and sediments become more sandy 15m
8. Grayish white limestone, locally broken into well-rounded conglomerates. This layer forms the hard cap of the Gaotege hill and dips northward 3m

There are four screen-washing sites (DB02-1 ~ 4); all are from the same middle sandstone horizon in Bed 4 (Fig. 2), which also produced surface collection sites DB00-4 and DB02-5. Surface collection sites DB00-6, 7, and DB02-6 are about 5m lower in Bed 3, as was also Teilhard's "mastodont" site (Teilhard de Chardin, 1926a: Fig. 20).

3 Faunal composition

We briefly report the preliminary results of our two field campaigns and discuss related items of the assemblage in this paper. Detailed descriptions of the material will be presented in the future. Most of the remains are from DB02-1, 2, 3 and 4, and layer 4 of the section is the most fossiliferous horizon. Table 1 shows that all the taxa from DB02-6 are commonly known in layer 4 and no difference can be detected in morphology at present. Thus, the mammalian assemblage from this locality is here considered as belonging to a uniform fauna.

The total number of the mammalian species collected from Gaotege amounts at least to 46 from 41 genera, belonging to 7 orders and 22 families. The assemblage is composed of mammals of different size, but is dominated by small mammals. It is a diverse and abundant faunal complex among Neogene deposits of northern China. Among the small mammals, remains of Chiroptera are absent, probably due to the bias of small amount of sediments processed. Table 1 shows the occurrence of mammal taxa at different sites of the locality.

Insectivora: Material of insectivores is relatively rare, but three families of insectivores, Erinaceidae, Talpidae and Soricidae, were collected from this locality.

Only an m3 from DB02-1 belongs to the family Erinaceidae. It represents a small-sized hedgehog, but evidently larger than that of *Erinaceus mongolicus* from Bilike, Nei Mongol (Qiu and Storch, 2000), a species first used for the Gaotege hedgehog by Teilhard (1926b).

Specimens of Talpidae are also scarce. There are only four cheek teeth in the collection; one damaged M3 is referred to *Yanshuella primaeva* and three teeth (P4, M1 and m3) to *Desmana* sp.

The Soricidae are represented by 42 fragmentary jaws and isolated teeth. Four genera and six species can be recognized, and they are comparable in size and morphology to *Sorex ertemteensis*, *S. pseudoalpinus*, *Sorex* sp., *Petenya katrinae*, *Lunanosorex* cf. *L. lii* and *Sulimskia* cf. *S. ziegleri* from Bilike.

Table 1 Gaotege mammalian fauna listed by sites

		Sites					
Taxa		DB02 - 1	DB02 - 2	DB02 - 3	DB02 - 4	DB02 - 5	DB02 - 6
Insectivora							
Erinaceidae	<i>Erinaceus</i> sp.	*					
Talpidae	<i>Yanshuella primaeva</i>	*					
	<i>Desmana</i> sp.	*					
Soricidae	<i>Sorex ertemteensis</i>	*	*		*		
	<i>Sorex pseudoalpinus</i>				*		
	<i>Sorex</i> sp.		*				
	<i>Petenya katrinae</i>	*	*				
	<i>Lunanosorex</i> cf. <i>L. lii</i>	*	*	*			
	<i>Sulimskia</i> cf. <i>S. ziegleri</i>	*					
Rodentia							
Sciuridae	<i>Eutamias ertemtensis</i>	*	*				
	<i>Prospemophilus orientalis</i>	*					
	<i>Sciurotamias</i> sp.	*	*				
Castoridae	<i>Castor anderssoni</i>	*	*		*	*	*
	<i>Dipoides</i> sp.		*		*	*	*
Zapodidae	<i>Sicista</i> sp.	*	*	*			
	<i>Sinozapus volkeri</i>		*				
Dipodidae	<i>Paralactaga suni</i>	*	*	*	*		*
	<i>Brachysciurites</i> sp.	*					
	<i>Sminthoides fraudator</i>	*	*	*	*		
Cricetidae	<i>Sinocricetus progressus</i>	*	*		*		
	<i>Nannocricetus mongolicus</i>	*	*	*	*		
	Cricetidae gen. et sp. indet.	*	*				
	<i>Microtodon</i> sp.		*				
Gerbillidae	<i>Pseudomeriones</i> cf. <i>P. abbreviatus</i>	*	*	*	*		
	<i>Pseudomeriones</i> sp.	*	*	*	*		
Arvicolidae	<i>Aratomys</i> cf. <i>A. bilikeensis</i>	*	*	*	*	*	*
Siphneidae	<i>Prosiphneus</i> spp.	*	*	*	*	*	*
Muridae	<i>Apodemus lii</i>	*	*				
	<i>Apodemus</i> sp.	*	*	*			
	<i>Micromys</i> cf. <i>M. kozaniensis</i>	*	*	*	*		
	<i>Chardinomys</i> sp.	*	*	*	*		
	<i>Huaxiamys downsi</i>	*	*	*	*		
Incertae familiae	Incertae familiae gen. et sp. indet.			*	*		
Lagomorpha							
Leporidae	<i>Trischizolagus</i> sp.	*	*	*	*	*	*
Ochotonidae	<i>Ochotona</i> sp.	*	*	*	*	*	*
Carnivora							
Hyaenidae	<i>Chasmaporthetes</i> sp.					*	
Canidae	<i>Nyctereutes</i> n. sp.		*				
	? <i>Eucyon</i> sp.			*			
Mustelidae	<i>Lutra</i> sp.	*					
	<i>Pannonictis</i> sp.			*	*	*	*
	<i>Mustela</i> sp.						*

Note: Large mammals from historical collections (see Introduction) are not listed due to lack of stratigraphic data.

Rodentia: Rodents are much more common in this sample as compared to insectivores. Twenty-two genera belonging to ten families (Sciuridae, Castoridae, Zapodidae, Dipodidae, Cricetidae, Gerbillidae, Arvicolidae, Siphneidae, Muridae and an indeterminate family) are recognized.

Three forms of Sciuridae are identified based on 11 cheek teeth, two of which can be referred to *Eutamias eremtensis* and *Prospermophilus orientalis* from Ertemte and Bilike, Nei Mongol. The third sciurid is represented by a well-preserved M1/2 and a dp4, assigned to an indeterminate species of *Sciurotamias* on the basis of its subcircular outline and heavy built with a complete protoloph and metaloph, and lack of a protoconule and metaconule.

Thirtyfour specimens, belonging to two genera, are referred to Castoridae. A mandibular fragment with incisor and p4-m2 and 21 cheek teeth are identical to *Castor anderssoni*, and a damaged mandible with p4-m2 and eleven isolated teeth to *Dipoides* sp., as had been recorded by Teilhard (1926b). Both genera, usually represented by limited material, occur frequently in some Neogene localities of North China, such as Baode and Yushe in Shanxi, and Ertemte and Bilike in Nei Mongol (Young, 1927, 1934; Teilhard, 1926a; Qiu and Storch, 2000). The relatively rich material affords an opportunity to compare with specimens from other localities.

Twentyeight molars are identified as Zapodidae, and they can be assigned to two genera *Sicista* and *Sinozapus*. The small sample of *Sicista* shows distinct variation in size and structure. Further study may demonstrate these specimens to represent two taxa as is the case in Bilike. Only an M2 represents the occurrence of *Sinozapus*, which can be referred to *S. volkeri*, previously also known from Bilike.

Dipodids are quite common in this assemblage. One hundred and thirty six specimens, including two fragmentary jaws, represent three genera of Dipodidae, i. e. *Paralactaga*, *Brachyscirtetes* and *Sminthoides*. The dipodid group seems to share the same taxa as the Ertemte and Bilike faunas (Falhbusch et al., 1983; Qiu and Storch, 2000), which are also dominated by *Sminthoides fraudator* (126 specimens).

Nine fragmentary jaws and 128 isolated molars are identified as Cricetidae and can be assigned to *Sinocricetus progressus*, *Nannocricetus mongolicus*, Cricetidae gen. et sp. indet., and *Microtodon* sp. *Nannocricetus* is relatively common (108 specimens), while the microtoid cricetid (*Microtodon*) is represented only by an M1. The components of cricetids are comparable to the Ertemte and Bilike faunas, but *Kowalskia*, commonly known in the two faunas, is absent, and a markedly larger form, which is unknown from Ertemte and Bilike, is present in this assemblage.

Thirtyfour specimens are referred to *Pseudomeriones* of Cerrillidae. Based on size and the morphology of the third molars, a similar form to *Pseudomeriones abbreviatus* and an indeterminate species of the genus can be readily distinguished. The former seems to be slightly larger than *P. abbreviatus* from Ertemte and Bilike, and shows some differences on the third molars. The indeterminate species is obviously larger than *P. abbreviatus*. Detailed study may lead to the recognition of a new species, representing an advanced record of this family.

Arvicolidae are rather common in the collection. Nearly 500 specimens, including some fragmentary jaws, are assigned to *Aratomys*. The vole can be matched with *A. bilikeensis* from Bilike and *A. multifidus* from Chono-Khariakh, Mongolia in size and morphology (Qiu and Storch, 2000; Gromov and Poljakov, 1977), but differs slightly from them in the presence of a vestige of third rootlet on m1 in a few specimens (rootlet on m1 is present in about 10% of the specimens in *A. bilikeensis*, but is always lacking in *A. multifidus*). This may be interpreted as a taxon more derived than *A. bilikeensis*.

Siphneidae are represented by 136 isolated teeth, which are identified as *Prosiphneus*, a taxon also obtained by Teilhard. These specimens show obvious variations. On the basis of m1 morphology, i. e. the shape of Cp, direction of S13 and Sb2 and depth of Sb3, some specimens can be referred to *Prosiphneus* cf. *P. eriksoni* known from Bilike, and some to an indeterminate species.

Muridae are the most abundant and diverse rodent family in the collection (712 specimens), and four genera, *Apodemus*, *Micromys*, *Chardinomys* and *Huaxiamys*, are identified. *Apodemus* is relatively scarce and only represented by 15 molars from three sites. They can probably be assigned to

A. lii and an indeterminate species similar to those from Bilike (Qiu and Storch, 2000). Two hundred isolated teeth are referred to *Micromys*. The *Micromys* differs from *M. chalceus* from Ertemte in having a t7 and 5 roots on all M1, but can be comparable in size and morphology to *Micromys kozaniensis* from Bilike and *M. tedfordi* from Yushe, Shanxi (Storch, 1987; Wu and Flynn, 1992; Qiu and Storch, 2000). Nevertheless, the more frequent presence of a central rootlet on M2 and the absence of five or six roots on M2 as in *M. tedfordi* suggest that the Gaotege taxon is more advanced than *M. kozaniensis* but more primitive than *M. tedfordi*. *Chardinomys* is the most common murids in the assemblage and represented by 354 specimens, including some fragmentary jaws. Compared with the named species *C. bilikeensis*, *C. yusheensis* and *C. nihewanicus*, the Gaotege *Chardinomys* is closer to *C. bilikeensis* in morphology but with higher crown, less backward slanting cusps on M1, less prominent precingulum (without cingulum on t1 of M1), and 4-5-rooted M1 (3-4 rooted in *C. bilikeensis*). This may be indicative of its more derived condition than in *C. bilikeensis* but more primitive status than in *C. yusheensis* and *C. nihewanicus*. One hundred and forty three teeth are referred to the genus *Huaxiamys*. Compared with the two known species (Wu and Flynn, 1992), this taxon is closer to *Huaxiamys downsi* than *H. primitivus* in having more anteriorly protruding wall of t2, wider valley between t2 and t3 on M1, reduced or absent tma on m1 and three-rooted m1 and m2. It seems to be more derived than the *Huaxiamys* sp. from Bilike in having three roots on m2. However, two M1s from DB02-1 are obviously smaller with less anteriorly protruded wall of t2, low and weak connections between t1 and t2, and t4 and t5, and a visible t12. Thus, the possibility of another more primitive species of *Huaxiamys* in this collection cannot be ruled out.

Three larger-sized lophodont and semihypsodont molars, two M1 or M2 and an m1 with simple occlusal structures, are assigned to an uncertain family. The M1 or M2 has one lingual and two buccal synclines, and the m1 has two lingual and one buccal synclines. The lingual synclines of M1 or M2 and the buccal syncline of m1 are anteriorly directed. The buccal synclines on M1 or M2 are nearly transverse, whereas the anterior and posterior lingual synclines on m1 are slight anteriorly directed and posteriorly directed, respectively. The three teeth can not be referred to any known genera of families with similar dental pattern, such as Siphneidae, Spalacidae and Rhizomyidae. Further investigation may demonstrate this material to be a new genus and species, probably related to the family Spalacidae of Europe.

Lagomorpha: Two families, Leporidae and Ochotonidae of the order Lagomorpha, are recognized in the assemblage.

The leporids are represented by 22 specimens and are assigned to an indeterminate species of *Trischizolagus* sp. It is close to *T. mirificus* from Bilike in size, but differs from the latter in having three distinct anterior folds on P2.

Ochotonids are more common than leporids in this locality (112 specimens including more than 20 fragmentary jaws), and all the material can be referred to one species of *Ochotona*. It is close to *O. lagreli* from Ertemte and larger than *O. minor* from Ertemte and Bilike. Further studies will be necessary to determine if it is identical to *O. lagreli*.

Carnivora: Six genera, belonging to three families, are recognized in the Gaotege Fauna.

A posterior half of right P4 and an anterior half of right p3 are tentatively identified as a possible *Chasmaporthetes* hyaenid. High-crowned main cusp on the lower premolar and tightly compressed carnassial notch on P4 exclude these from members of felids. Of the two known Pliocene hyaenids (Qiu, 1987), the Gaotege p3 is more readily identifiable with *Chasmaporthetes* because of its more slender outline in contrast to the robust premolars in *Pliohyaena*.

The family Canidae is represented by two forms. An isolated right m2 from the DB02-2 site is readily identified as *Nyctereutes*. Measured at 10.6 × 7.9 mm for maximum length and width, this specimen is the largest among known Chinese *Nyctereutes*, *N. tingi* and *N. sinensis*. Yet it has a complex talonid with a well-developed entoconid and entoconulid, characters that are absent in *N.*

tingi (Tedford and Qiu, 1991). Other features also indicate that the Gaotege form may be an undescribed species: a distinct paraconid and a large buccal cingulum. The second canid, ? *Eucyon* sp., is represented by a right m1 trigonid and a partial right m1 trigonid, both from DB02-3 (m1 trigonid, 6.4 × 11.4 mm). A long trigonid blade and low metaconid give these two specimens a very canid appearance. The size of the trigonid is much larger than known Pliocene *Vulpes* (Qiu and Tedford, 1990), and falls to the lower end of measurements for *Eucyon davisi* but is much smaller than that of *E. zhoui* (Tedford and Qiu, 1996).

The family Mustelidae includes three species. A partial right ramus with p4-m1 from DB02-1 clearly indicates a river otter *Lutra*. *L. licenti* from Nihewan (Teilhard de Chardin and Piveteau, 1930: 105), with an m1 length of 13 mm and p2-m2 length of 36mm, is slightly larger than the Gaotege form (p4: 4.1 × 7.9; m1: 6.5 × 12.5; alveolar length of p2-m2: 30.6mm). Judging from the published figures (Teilhard de Chardin and Piveteau, 1930: pl. 20, fig. 4), *L. licenti* also has broader lower p4 and m1, less imbricated premolars, and a more anteriorly restricted m1 hypoconid, characters that may indicate more derived status for the Nihewan form.

A second mustelid is represented by a partial left ramus with m1 from DB02-6, a partial left ramus with p3 from DB02-5, two partial right m1 from DB02-4, and a right dp4 from DB02-3. A rather short rostrum, as indicated by imbricated premolars, suggests that this Gaotege form may belong to the genus *Pannonictis*. The Gaotege *Pannonictis* is considerably smaller (m1: 4.4 × 10.7; dp4: 3.3 × 8.3) and less robust than *P. pachygnatha* from Nihewan (Teilhard de Chardin and Piveteau, 1930) and Yushe (Teilhard de Chardin, 1945).

A third mustelid is a left jaw fragment with a broken p4 and m1 (length: 4.3 mm). Small size and highly hypercarnivorous lower carnassial (lack of metaconid and entoconid) indicate the genus *Mustela*. Teilhard (1945: fig. 7) figured, but not described, an articulated skull and mandible from the "Villafranchien de Yushê" and referred it to the living species *Mustela* cf. *M. altaica*. No early Pliocene record from China is available for comparison.

Other large mammals: We were unable to substantially improve on the historical records of large ungulates. We recorded a *Gazella* horncore (DB00-4), a few dental and bone fragments of a hipparion horse (DB00-5, DB00-6), an upper cheek tooth of a cervid, and a proboscidean tusk, taxa previously mentioned by Teilhard (1926b).

4 Age of the fauna

Small mammals play a valuable role in dating and correlating faunas because of their rapid evolution and high degree of specialization. In northern China, especially in central Nei Mongol, Neogene terrestrial deposits are widespread with dense fossil record of small mammals. Typical Chinese small mammal localities include: Xiejia in Qinghai; Sihong in Jiangsu; Cashunynadege, Tunggur, Amuwusu, Shala, Ertemte, and Bilike in Nei Mongol; Mahui, Gaozhuang and Mazegou in Shanxi; and Daodi in Hebei (Table 2). A biochronology for the Neogene has preliminarily been established by seriating of faunas, particularly microfaunas (Qiu and Qiu, 1995; Flynn et al., 1997; Qiu and Wang, 1999). This affords a good framework for dating and correlation of the Gaotege Fauna.

The co-occurrence of Arvicolidae, Siphneidae and Muridae in the Gaotege Fauna excludes the possibility of an early and middle Miocene fauna, for instance the Xiejia and Tunggur faunas, and makes a reasonable comparison with faunas of late Miocene and Pliocene, such as the Ertemte Fauna of late Baodean (latest Miocene), the Bilike of early Yushean (early Pliocene). The Ertemte, Bilike and Gaotege faunas share the most families and genera in common (Table 2), implying a close affinity in the three faunas in the central Nei Mongol. Nevertheless, the Gaotege Fauna appears to be younger than the Ertemte Fauna because of its disappearance of the more archaic families, Apolodontidae, Eomyidae and Giridae, which appear in the Ertemte Fauna, and

appearance of a modern family, Arvicolidae. In contrast to the Ertemte Fauna, the Gaotege Fauna is closer to the Bilike Fauna. This is demonstrated by: 1) the closer community structure and composition of small mammals, sharing 13 of 15 families and nearly 90 % genera with Bilike; 2) the similar tendency of extinction or decline of some "old" genera that are very common in Ertemte, for example, *Eozapus*, *Lophocricetus* and *Microtodon*; 3) the occurrence of some typical Pliocene genera, *Desmana*, *Aratomys*, *Chardinomys*, *Huaxiamys* and *Trischizolagus* (Table 2); and 4) the presence of 17 taxa conspecific or similar species with those of Bilike, amounting to almost 50 % of the total species. The strong similarities of the Gaotege assemblage to the Bilike Fauna are indicative of the close age of the two faunas. It is likely, however, that the Gaotege Fauna is somewhat younger than the Bilike Fauna. This is suggested by the disappearance of the family Giridae (taxa of the family occur in localities ranging from middle Miocene, such as Tunggur, to early Pliocene, Bilike for example, in the central Nei Mongol), the decline of Zapodidae, the appearance of an indeterminate family, the occurrence of *Sciurotamias*, the larger-sized cricetid, and the disappearance of some genera that are not commonly known in the late Pliocene, such as *Lophocricetus* and *Orientalomys*. It is also indicated by the presence of some species in Gaotege that exhibit derived character states in some specimens, i. e., *Pseudomeriones*, *Aratomys*, *Micromys*, *Huaxiamys* and *Trischizolagus*.

Table 2 Micromamalian genera occurring in the Ertemte, Bilike and Gaotege faunas

Taxa		E	B	G	Taxa		E	B	G
Insectivora					Eomyidae	<i>Leptodontomys</i>	—		
Erinaceidae	<i>Erinaceus</i>	—	—	—	Giridae	<i>Myomimus</i>	—	—	—
Talpidae	<i>Quypantia</i>	—	—	—	Zapodidae	<i>Eozapus</i>	—		
	<i>Yanshuella</i>	—	—	—		<i>Sicista</i>	—	—	—
	<i>Desmana</i>	—	—	—		<i>Sinozapus</i>	—	—	—
Scoricidae	<i>Sorex</i>	—	—	—		<i>Lophocricetus</i>	—	—	—
	<i>Zelceina</i>	—	—	—	Dipodidae	<i>Paralactaga</i>	—	—	—
	<i>Alloblaninella</i>	—	—	—		<i>Brachyscirtetes</i>	—	—	—
	<i>Paenepetenya</i>	—	—	—		<i>Sminthoides</i>	—	—	—
	<i>Cokia</i>	—	—	—	Cricetidae	<i>Sinocricetus</i>	—	—	—
	<i>Paranourosorex</i>	—	—	—		<i>Nannocricetus</i>	—	—	—
	<i>Paenelimmocetus</i>	—	—	—		<i>Kowalskia</i>	—	—	—
	<i>Petenya</i>	—	—	—		<i>Anatolomys</i>	—	—	—
	<i>Lunanosorex</i>	—	—	—		<i>Microtodon</i>	—	—	—
	<i>Parasoriculus</i>	—	—	—		<i>Microscoptes</i>	—	—	—
	<i>Sulimskia</i>	—	—	—	Gerbillidae	<i>Pseudomeriones</i>	—	—	—
Rodentia					Arvicolidae	<i>Aratomys</i>	—	—	—
Apodontidae	<i>Pseudaplodon</i>	—	—	—	Siphneidae	<i>Prosiphneus</i>	—	—	—
Sciuridae	<i>Eutamias</i>	—	—	—	Muridae	<i>Apodemus</i>	—	—	—
	<i>Tamiasciurus</i>	—	—	—		<i>Orientalomys</i>	—	—	—
	<i>Sinotamias</i>	—	—	—		<i>Hansdebruijnja</i>	—	—	—
	<i>Sciurus</i>	—	—	—		"Kamimata"	—	—	—
	<i>Prospemophilus</i>	—	—	—		<i>Micromys</i>	—	—	—
	<i>Atlantoxerus</i>	—	—	—		<i>Chardinomys</i>	—	—	—
	<i>Sciurotamias</i>	—	—	—		<i>Huaxiamys</i>	—	—	—
	<i>Pliopetaurista</i>	—	—	—		<i>Allorattus</i>	—	—	—
	<i>Petinomys</i>	—	—	—	Lagomorpha				
Castoridae	<i>Castor</i>	—	—	—	Leporidae	<i>Alilepus</i>	—	—	—
	<i>Dipoides</i>	—	—	—		<i>Trischizolagus</i>	—	—	—
					Ochotonidae	<i>Ochotona</i>	—	—	—

E = Ertemte B = Bilike G = Gaotege

Carnivorans from Gaotege are generally consistent with the above assessment. *Chasmaporthetes* ranges from Mahui through Mazegou formations in Yushe and does not offer further constraints within Pliocene (Tedford et al., 1991). The earliest Chinese occurrence of *Nyctereutes* is in the Nanzhuangou Member of Gaozhuang Formation in the Yushe Basin (Tedford et al., 1991).

Paleomagnetic correlation derives an age of 4.5Ma for the base of the Nanzhuanggou Member, providing a lower limit for the Gaotege *Nyctereutes* (Tedford, 1995). Both mustelid taxa from Gaotege indicate more primitive status than their relatives from Nihewan.

The Gaotege assemblage also shows close affinities with the Gaozhuang Fauna and both share numerous genera in common (Qiu and Qiu, 1995). However, the occurrence of *Scaptochirus*, *Allocricetus* and *Germanomys* in the Gaozhuang Fauna suggests a younger age for the fauna (at least the Gaotege Fauna is older than the assemblage from the Nanzhuanggou Member). The Daodi Fauna of late Pliocene is obviously younger than the Gaotege Fauna because of its appearance of *Eucastor*, *Germanomys*, *Pliopentalagus*, and *Hypolagus*.

The Gaotege assemblage appears to represent a new composition in the sequence of mammalian faunas of the Chinese Neogene, which is younger than the Bilike Fauna known from the central Nei Mongol in age. The fauna is most probably attributable to the early Yushean of the Chinese land mammal age, and can be correlated, in European terms, with early Ruscinian or equivalent to lower MN15. Table 3 shows the position of the Gaotege Fauna in the seriation of the Chinese Neogene faunas and the proposed correlations between Chinese and European Mammal Units.

Table 3 Proposed position of Chinese micromammalian faunas in the middle and later Neogene, and correlations between European and Chinese Mammal Units

Epoch	China		Europe	
	Mammal Units	Local faunas	Mammal Units	MN
Pliocene	Yushean	Daodi	Ruscinian	16
		Mazegou		15
		Gaozhuang (up.) Gaotege Bilike Harr Obo		14
Miocene	Baodean	Ertemte	Turolian	13
		Mahui		12
		Tianzhu		11
		Baogeda Ula Shala	Vallesian	10
		Bahe		9
Tunggurian	Tunggur	Quantougou	Astaracian	8
		Tunggur		7

5 Paleoecology

Like those in the Ertemte and Bilike faunas, all the families of micromammals in the Gaotege Fauna, except the eurytopic ones, have either a Holarctic or Palearctic distribution (i. e. Castoridae and Zapodidae are restricted to Holarctic Region, and Dipodidae, Cricetidae, Gerbillidae, Siphneidae and Ochotonidae are confined to or mainly distributed over the Palearctic Region). None of them, however, is confined to the present tropical or subtropical areas of South China or to the Oriental Region. This implies that the Gaotege faunal composition is identical to those in the temperate region in China. The diversity of Dipodidae, the presence of Gerbillidae, Siphneidae and Ochotonidae indicate a generally steppe or open environment. Zapodidae are usually inferred to have inhabited in shrubs. In addition, *Desmana*, *Castor*, *Dipoides* and *Lutra* would require water environment, which is also confirmed by the remains of fishes and mollusks. However, grassland

was the predominant habitat at the central areas of Nei Mongol during the early Pliocene.

It is clear that the community structure of the small mammals in the southern central Mongolian Plateau was essentially stable during the late Miocene and early Pliocene, but faunal changes had taken place in the interval from the Ertemte to Gaotege faunas. The changes mainly include: 1) considerable faunal turnover and decline of soricids; 2) gradual disappearance of flying and tree squirrels; 3) extinction or decline of some genera of Zapodidae; 4) flourishing and increase of high-crowned voles. Such changes may be caused by a regional trend toward more arid climate and increased grassland habitat.

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