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青海柴达木盆地晚中新世深沟小哺乳动物群[1)]

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摘要:描述了2002-2005年间在青海德令哈深沟上油砂山组采集的小哺乳动物化石。化石共有16种,隶属食虫目、啮齿目和兔形目的12科,代表了迄今青藏高原发现种类最多、材料最丰富的小哺乳动物群。深沟动物群的组成与陕西蓝田灞河组下部层位发现的小哺乳动物组合最为接近,两者有相似的群体结构,共有 *Sciurotamias*, *Lophocricetus*, *Protalactaga*, *Myocricetodon*, *Nannocricetus*, *Pararhizomys* 和 *Ochotona* 7属。但由于深沟动物群含有略进步的属、种,其时代似乎稍晚,很可能属晚中新世早期,或者中国陆生哺乳动物时代的保德期早期,与欧洲MN10上部或MN11下部的时代相当。深沟动物群指示了一个温带开阔干旱草原为主体的景观。晚中新世柴达木盆地的气候似乎没有现在这样干燥,在草原中尚有一些灌丛甚至林地。动物群的组成及所指示的生态环境都表明,青藏高原在中新世以后有过较大幅度的上升。

深沟动物群中含有一鼠科新种——细弱许氏鼠(*Huerzelerimys exiguus* sp. nov.)。*Huerzelerimys*属过去只发现于欧洲,新种为该属在亚洲的首次发现。其特征为:与现知最小种 *H. minor* 相比,其臼齿更小,M1中t1的位置相对靠后,t6和t9间有超过50%的标本具一弱脊连接,m1和m2的唇侧齿带狭窄、附尖弱小。

Ochotonoma primitiva (Zheng & Li, 1982)是动物群中较为多见的一种鼠兔。该种最先发现于甘肃天祝,并作为 *Ochotona* 属描述。正型地点的标本不多,但尺寸和形态完全落入深沟标本的变异范围,因此认为同属一种。该种的特征增订为:中等大小的鼠兔。P2冠面长三角形,舌侧长度明显大。p3的下前边尖宽大,一般具有两个前褶或凹槽,而且至少有一褶具水泥质充填物;连接前边尖和后边尖间的齿桥(dentine isthmus)宽;前褶(paraflexis)比 *O. anatolica* 的短而狭窄,向后延伸没有 *O. csarnotana* 的那样明显。

关键词:青海柴达木盆地深沟,晚中新世,上油砂山组,小哺乳动物群
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LATE MIOCENE MICROMAMMALS FROM THE QAIDAM BASIN IN THE QINGHAI-XIZANG PLATEAU

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Abstract　This paper deals with an assemblage of small mammals collected from the upper Youshashan Formation at Shengou, Delingha, Qinghai Province during the field seasons of 2002–2005. The Shengou micromammalian fauna is composed of 16 species from 12 families belonging to the orders Insectivora, Rodentia and Lagomorpha. It is the most diverse and abundant micromammalian fauna known from the vast Qinghai-Xizang Plateau. One species of Muridae (*Huerzelerimys exiguus*) is described as new, and represents a new record of the genus in China. The Shengou Fauna appears to closely resemble the assemblage from the lower part of the Bahe Formation of Shaanxi, but slightly younger than the latter. It is most probably attributable to early Late Miocene, or the early Baodean of the Chinese Land Mammal Ages, correlated, in European terms, with late MN10 or early MN11. The fauna reflects a faunal distribution of the modern temperate region in China, and suggests a dry and open environment. Nevertheless, the climate in Qaidam area was unlike the exact situation of the present day, but was less arid with more vegetation during the early Late Miocene than it is today. Both habitats and composition of the fauna may imply that the Qinghai-Xizang Plateau had undergone a definite uplift in relation to the loess plateau after Miocene.
Key words　Shengou, Qaidam, Qinghai; Late Miocene; Youshashan Formation; micromammals

1　Introduction

The Qaidam Basin, with Cenozoic deposits up to 15 000 m, is the lowest and largest internally drained basin on the Qinghai-Xizang (Tibetan) Plateau. Investigation of vertebrates in the basin was first made by Birger Bohlin in 1930s, and some large mammals, fishes, and turtles were collected from the Tuosu Nor and Huaitoutala-Olongbuluk areas in the northeastern corner of the basin (Bohlin, 1937). After a long hiatus, biostratigraphic investigation in the vertebrate fossils in the Qaidam resumed at the end of last century (Wang et al., 2007).

The Shengou fossil locality (36°56′96.0″N and 97°14′21.5″E) is located about 50 km southwest of Delingha (Fig. 1). The Shengou profile consists of a series of fluvial deposits, mainly of grayish brown and grayish green sandstones, mudstones and fine gravels, attributed to the Youshashan Formation of Late Miocene age (Yang et al., 1994). The lower part of the section is more fossiliferous, and nearly 200 specimens representing 16 taxa were collected by dry and wet screening of more than 5 tons of matrix from the site (CD 0227, near bottom of layer 3) and equivalent horizons adjacent to the site in the field seasons of 2002, 2004 and 2005. Fig. 2 shows the lower part of the section and the lithological section of fossil-bearing beds.

Upper Youshashan Formation

1. Light-brownish yellow sandy mudstones interbedded with slaty sandstone. The basement contact is not visible　>15 m
2. Grayish green and brownish yellow medium/fine-grained sandstones; poorly indurated, with well developed cross-stratification in the upper part; clumpy sanstone containing remains of fishes, turtles and mammals at the bottom　10 m
3. Grayish brown sandstones and mudstones. Blocky mudstones in the upper part are poorly bedded, while muddy sandstones in the lower part with clear cross bedding. Sandstones at the bottom are iron-calcareous cemented, distinguished from other similarly cemented sandstones of the section by their darker color and thicker bedding. Containing fishes, turtles, ostrich egg shells and mammals　12 m
4. Dark tan sandstones with gravels and cross-stratification at the bottom, gradually becoming grayish green sandstones and mudstones toward the top　8 m

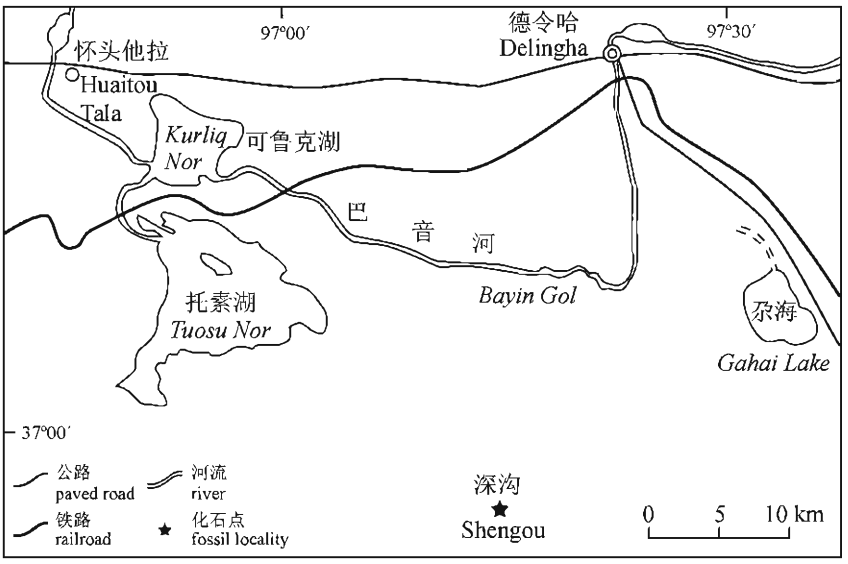

Fig. 1 Geographic location of the Shengou fossil site

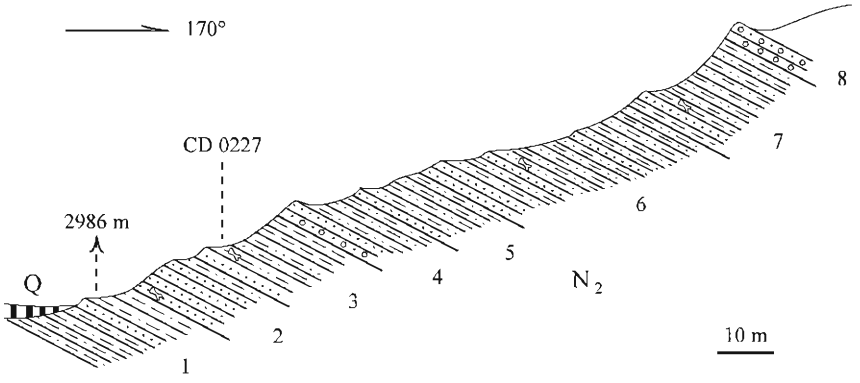

Fig. 2 Section of the Shengou fossil locality

5. Dark tan sandstones with iron-calcareous cement in the lower part, alternating beds of grayish yellow and grayish white sandy mudstones in the middle and upper parts 9 m
6. Grayish brown poorly iron-calcareous cemented blocky sandstones in the lower part, with developed horizontal and cross-stratification, and remains of larger mammals; alternating beds of grayish brown sandy mudstones and platy sandstones in the middle and upper parts 30 m
7. Grayish white mudstones interbedded with a layer of medium-bedded brownish yellow sandstone in the lower part; brownish yellow sandy mudstones in the upper part, with remains of larger mammals 18 m
8. Brownish yellow conglomerates. The gravels are well-sorted, but poorly-rounded, generally 1 ~ 2 cm in diameter. Containing remains of fishes and turtles >2 m

The present paper describes the assemblage of small mammals from this locality. Although the assemblage is relatively small with limited materials in some taxa, it represents the most diverse and abundant micromammalian fauna hitherto known from the Cenozoic deposits of the Qinghai-Xizang Plateau, where fossil vertebrates are poorly recorded.

2 Systematics

Insectivora Bowdich, 1821
Talpidae Fischer von Waldheim, 1817
Talpinae gen. et sp. indet.
(Fig. 3A)

The indeterminate talpine is represented by a talonid of an m1 or m2 (V 15454). The talonid is 1.20 mm long and 1.75 mm wide. The hypoconid and entoconid are sharp-pointed, and the metastylid and entostylid are prominent. The crista obliqua and the postcristid are low with the former joining the metastylid. The talonid basin is short but rather wide. There is a weak postcingulid.

Judging from the presence of a metastylid and a short talonid basin on the lower molar, the taxon may probably be allied either to *Scaptonyx* or *Scalopoides*.

Soricidae Fischer von Waldheim, 1817
Soricidae gen. et sp. indet.
(Fig. 3B-D)

A mandibular fragment with m2, an upper incisor and a damaged m2 are assigned arbitrarily to the indeterminate shrew (V 15455.1-3). The upper incisor (1.60 mm long and 1.15 mm high) is slightly fissident, with relatively short but strongly and evenly curved apex, blunt talon, and undeveloped labial cingulum. The m2 on the mandible (1.35 mm × 0.90 mm) is subrectangular, with somewhat anteroposteriorly compressed trigonid basin, high and long entocristid, moderately wide postentoconid valley, and prominent precingulid. The incisor and m2 are similar to those of *Sorex* in morphology, but the material is too rare to allow identification below the family level.

Rodentia Bowdich, 1821
Sciuridae Gray, 1821
***Sinotamias* Qiu, 1991**
***Sinotamias* sp.**
(Fig. 3E, F)

Material A dp4 (1.05 mm × 0.75 mm), an m1/2 (1.50 mm × 1.45 mm), a posterior portion of m3; V 15456.1-3.

Description The dp4 has large and closely situated metaconid and protoconid, which are separated by a narrow fissure. The entoconid is merged into the elevated posterointernal crest. The ectolophid is weak and no indication of a mesoconid is present. The m1 is subquadrate with a high metaconid. The indistinct entoconid is completely incorporated in the low posterointernal crest, forming a curved entoconid corner. The anterolophid is high and connects to the protoconid. The ectolophid, bearing no mesoconid, extends posterointernally and is inflected internally to the hypoconid. The buccal valley is constricted and deep. The m3 is moderately expanded posteriorly with a heavy posterolophid incorporated by the hypoconid and entoconid.

Remarks The three teeth correspond, in essential features, with the diagnosis of *Sinotamias*, which is known from North China and thought to be a ground squirrel similar to *Prospermophilus* and rock squirrel *Sciurotamias* in certain characters (Qiu, 1991; Qiu and Storch, 2000). The Qinghai taxon is similar to *S. gravis* Qiu, 1991 in morphology, but is larger in size.

***Sciurotamias* Miller, 1901**
***Sciurotamias* cf. *S. pusillus* Qiu et al., 2008**
(Fig. 3G-I)

Material Two M1/2 (1.90 mm × 2.35 mm, 2.00 mm × 2.55 mm); 1 m1/2 (2.15

mm × 2.10 mm); V 15457.1-3.

Description The teeth have heavily built cusps and strong crests. The M1/2 is wider than long with a high and prominent protocone. The protoloph and metaloph are rather high and converge toward the protocone, with the metaloph distinctly constricting at the protocone. The anteroloph and posteroloph are complete, but low, with the latter being thick lingually. A protoconule is absent, and the mesostyle is indistinct.

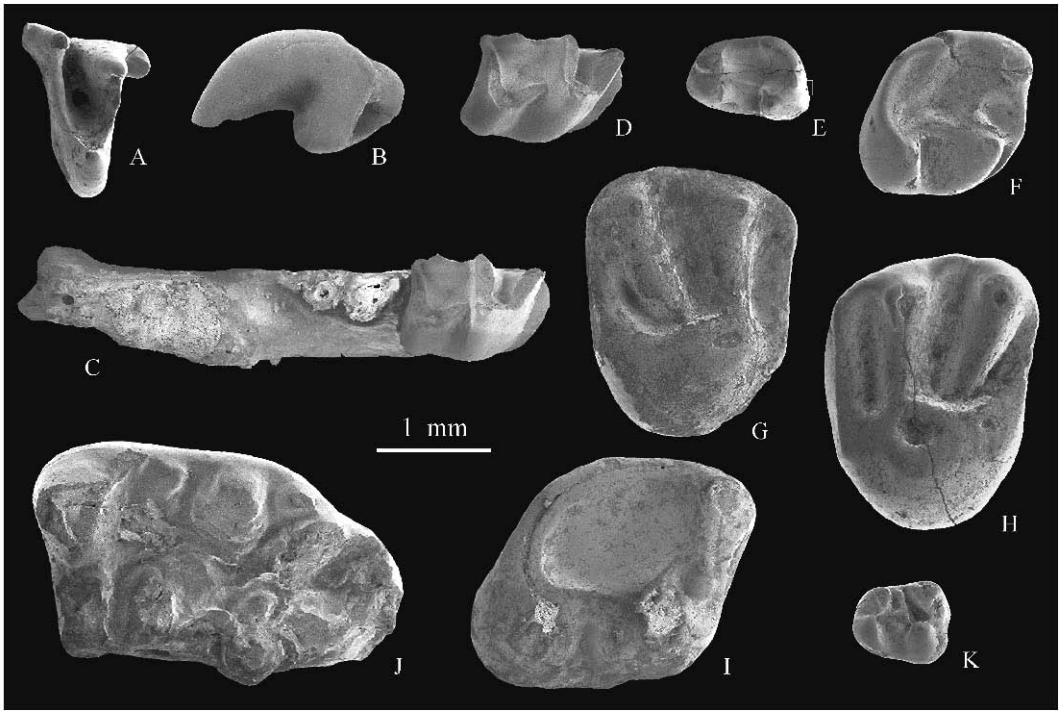

Fig. 3 Occlusal view of insectivores, sciurids and eomyid

A. Talpinae indet., damaged l m1 or m2 (V 15454); B-D. Soricidae indet., B. l I sup. (V 15455.2), C. damaged right mandible with m2 (V 15455.1), D. r m2 from the mandible of Soricidae indet.; E-F. *Sinotamias* sp., E. l dp4 (V 15456.1), F. r m1/2 (V 15456.2); G-I. *Sciurotamias* cf. *S. pusillus*, G. r M1/2 (V 15457.1), H. l M1/2 (V 15457.2), I. r m1/2 (V 15457.3); J. *Pliopetaurista* sp., damaged l m3 (V 15458); K. Eomyidae indet., l p4 (V 15459.1)

The m1/2 is subrhomboidal with a high metaconid and curved entoconid corner. The entoconid is completely merged with the posterolingual crest. The anterolophid joins the protoconid and closes the narrow trigonid basin with the metalophid. The ectolophid, bearing no mesoconid, is short, but high and straight. The notch between the entoconid and the metaconid is wide and shallow. The buccal valley is narrow.

Remarks The size, the heavily built cusps and crests of cheek teeth, the slight convergence of protoloph and metaloph on M1/2, the dissolved entoconid, and the short ectolophid on m1/2 agree with the corresponding characters of *Sciurotamias*. By its smaller size, higher and stronger cusps and crests, and more contracted protocone, the rock squirrel can be easily distinguished from *S. wangi*, *S. leilaoensis*, *S. praecox* and *S. forresti*. The Shengou species is similar to *S. pusillus* from Lantian in size and morphology, but differs from it in less contracted protocone (Teilhard de Chardin, 1940; Zheng, 1993; Qiu, 2002; Qiu and Ni, 2006; Qiu et al., 2008).

Pteromyinae Baird, 1855
***Pliopetaurista* Kretzoi, 1962**
***Pliopetaurista* sp.**
(Fig. 3J)

The indeterminate species of the flying squirrel is represented by a damaged m3 (3.45 mm long, V 15458). The m3 is posteriorly expanded and rapidly narrows. The high metaconid is equidistant from the protoconid and entoconid. The mesoconid and hypoconulid are striking in appearance, but the metastylid is weak. The hypoconulid possesses accessory crests that extend through the talonid basin to connect with the protoconid and mesoconid. There is a small cusp between the hypoconulid and the entoconid. The anterolophid is poorly developed. The talonid basin enamel is coarse.

The flying squirrel is closely allied to *Pliopetaurista* (Mein, 1970). In dental pattern, it is similar to *P. rugosa* and *P. speciosa* from the Late Miocene of China (Qiu, 1991; Qiu and Ni, 2006), but more definite assignment awaits more complete evidence.

Eomyidae Depéret & Douxami, 1902
Eomyidae gen. et sp. indet.
(Fig. 3K)

Two p4 (V 15459.1-2) are referred to an eomyid rodent with bunodont cheek teeth. The p4 is longer than wide, and narrower anteriorly than posteriorly. The protoconid is connected to the metaconid by a weak crest. An anterolophid is lacking. A mesolophid is present, extending to the edge of the tooth in one specimen. The longitudinal crest is thin, connecting the metaconid to the hypoconid. The posterolophid is short and joins the posterior arm of hypoconid.

Small size and the general morphology of the teeth prevent assignment of the two teeth to any family other than Eomyidae. Nevertheless, a longitudinal crest joining metaconid to hypoconid in p4 is unusual in eomyids.

Zapodidae Coues, 1875
Lophocricetinae Savinov, 1970
***Lophocricetus* Schlosser, 1924**
***Lophocricetus* cf. *L. xianensis* Qiu et al., 2008**
(Fig. 4A-H; Table 1)

Material Thirty-three isolated teeth (2 P4, 9 M1, 6 M2, 2 M3, 11 m1, 3 m2; some damaged), V 15460.1-33.

Measurements (see Table 1)

Table 1 Measurements of molars of *Lophocricetus* cf. *L. xianensis* (mm)

Tooth	Length			Width		
	N	Mean	Range	N	Mean	Range
P4	2	0.53	0.50~0.55	2	0.53	0.50~0.55
M1	8	1.76	1.65~1.85	8	1.19	1.15~1.20
M2	5	1.36	1.35~1.40	5	0.98	0.95~1.00
M3	2	0.83	0.80~0.85	2	0.83	0.80~0.85
m1	6	1.48	1.35~1.55	8	1.03	0.90~1.15
m2	3	1.42	1.25~1.50	3	1.17	1.10~1.30

Description P4 is bud-like and single-rooted, with a central cusp and two cuspules. Principal cusps of the molars are evidently more prominent in relation to the crests. M1 is dis-

tinctly longer than wide; the protocone and hypocone are slightly anterior to the paracone and metacone, respectively; the protostyle is small, but present in all nine specimens; a hypostyle is absent; the mesocone is distinct; the mesoloph is variably developed, extending to the edge in one, to the half way in two, and absent in two; the endoloph is thick posteriorly, and connects the mesocone to the paracone in six specimens, and to the protoloph in three; the posteroloph is usually connected to the metaloph by a short and thick crest in the eight determinable specimens. M2 is elongated, and wider anteriorly than posteriorly; the lingual principal cusps are larger than the labial ones; the protostyle is present as either an unrestricted cusp or a projecting spur attached to the protocone; the mesoloph is usually prominent, reaching the labial edge in three out of seven specimens; the anteroloph is single in all teeth; the anterior endoloph is weak, either connects to the paracone (in one specimen) or to the protoloph (five specimens). M3 is subtriangular with an anteroloph, protocone and paracone; a small metacone and a hypocone are visible.

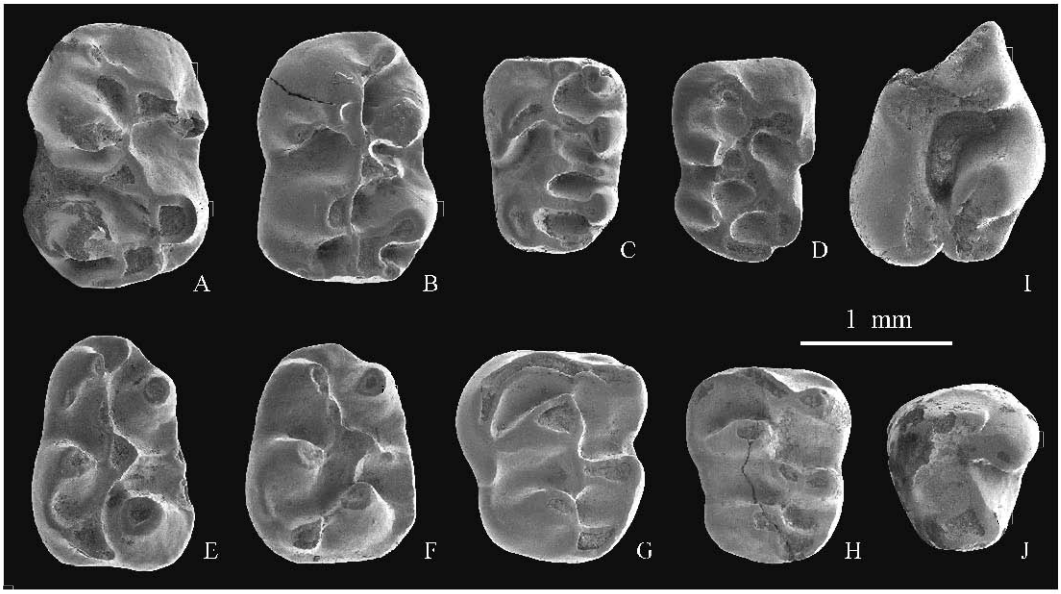

Fig. 4 Occlusal view of zapodids and dipodids

A–H. *Lophocricetus* cf. *L. xianensis*, A. r M1 (V 15460.1), B. l M1 (V 15460.2), C. l M2 (V 15460.3), D. r M2 (V 15460.4), E. r m1 (V 15460.5), F. r m1 (V 15460.6), G. l m2 (V 15460.7), H. l m2(V 15460.8); I. *Protalactaga* sp., damaged l M2 (V 15461); J. *Stylodipus*? sp., l M3 (V 15462)

The m1 is variable in outline; the protoconid is either opposite or slightly anterior to the metaconid, while the hypoconid and entoconid are distinctly arranged alternately in location; the mesoconid is pronounced and extends a long ectomesolophid that reaches the labial edge and terminates with a small ectostylid in four of the nine specimens; the ectolophid is interrupted or nearly so posteriorly in most of the teeth; the mesoconid connects to the metaconid and hypoconid; the ectocingulid is indistinct and a posterior stylid is absent; the posterolophid is cusp-like. The m2 has a long labial arm of anterolophid that turns posterobucally to join the protoconid; the protoconid is connected to the labial side of metaconid at the point of junction with the metaloph; a mesoconid is indistinct; the entoconid is connected to the protoconid by the rather strong anterior ectolophid; the posterior ectolophid is low and thin; a cusp-like posterolophid is present; the stylids and ectocingulid are indistinct.

Comparisons The presence of a protostyle and absence of a hypostyle (previously posterostyle) on M1 and M2 argue for the inclusion of the taxon from Shengou in *Lophocricetus*

rather than *Paralophocricetus* (Zazhigin et al., 2002; Qiu et al., 2008).

The Shengou lophocricetine can be easily distinguished from *L. grabaui* and *L. vinogradovi* by its smaller size, weaker developed protostyle, presence of mesoloph on M1 and M2, endoloph often joining protoloph, posteroloph connecting to metaloph rather than to metacone on M1, and absence of posterior stylid on m1 (Savinov, 1970; Qiu, 1985). In addition, it differs from *L. vinogradovi* in having only a single anteroloph on M2. It is similar to *L. saraicus* in having a mesoloph on M1 and M2, in the posteroloph connecting to the metaloph by a short and thick crest on M1, but differs from the latter in smaller size and in the endoloph frequently connecting to the protoloph on M1. The Shengou form has an ordinary structure of the posterolingual part of the hypocone on M1 and M2 as most species of the genus, by which it is distinguishable from *L. reliquus*. It differs from *L. gansus* in larger size and in having stronger protostyle on M1 and M2. The two M1 and two m1 referred to *L. minuscilus* fall within the size range of the corresponding Shengou teeth, but they have a more labial position of the endoloph-paracone and posteroloph-metacone contact on M1, and a more lingual position of the hypoconid-entoconid contact on m1. It is similar to *L. complicidens* in having a distinct mesocone on M1, a long mesoloph on M2, and a small anteroconid on m1, but differs from the latter in smaller size, weaker protostyles on M1 and M2, poorly developed ectocingulids and stylids on m1 and m2, and unbilobed posterolophid on m1.

The Shengou lophocricetine shows a strong resemblance to *L. xianensis* from the Bahe Formation of Lantian, Shaanxi in morphology, differs from it only in slightly larger size and the absence of double anterolophs on M2. The larger size and the single anteroloph might be interpreted as more advanced characters in the Shengou species than in *L. xianensis* from Lantian.

Both *L.* cf. *L. xianensis* from Shengou and *L. xianensis* from Lantian are essentially comparable to *L. minuscilus* from the Petropavlovsk Fauna of Kazakhstan (equivalent to MN10). This suggests their close evolutionary grade. There is a possibility that these Shengou specimens can be referred to *L. minuscilus* in further study. Nevertheless, in view of the scarce material on which our knowledge of *L. minuscilus* is based, such identification must wait until more adequate material is discovered.

Dipodidae Fischer von Waldheim, 1817
Protalactaga Young, 1927
Protalactaga sp.

(Fig. 4I)

A posterior portion of an M2 (V 15461) represents the occurrence of a primitive five-toed jerboa in this fauna. The mesocone is moderately developed and the mesoloph is robust, extending labially and terminating thickly. The strong metacone joins the hypoconule by a short metaloph II. The endoloph is thick and connects the mesocone to the hypocone. The posteroloph is short, failing to reach the base of the metacone.

The broken tooth seems to fall within the size range of the M2 of *Protalactaga grabaui* from Quantougou, Gansu and Tunggur, Nei Mongol (Qiu, 1996, 2000). Morphologically, however, it is similar to *P. lantianensis* from Bahe, Shaanxi in having a posteriorly directed metaloph and a short posteroloph, but differs from the latter in smaller size (Li and Zheng, 2005).

Stylodipus Allen, 1925
Stylodipus? sp.

(Fig. 4J)

The questionable taxon is represented by a left M3 (V 15462). The tooth has a cres-

cent protocone and a conical paracone. The hypocone and metacone on this specimen are fused into a high and prominent cusp connecting mesially with the protoloph. There are two roots.

The specimen could not be referred to *Protalactaga* described above, because of its different dental pattern. It is similar to an M3 of dipodine, especially that of *Stylodipus*, but a possibility of the specimen assignable to the genus *Dipus* can not be excluded.

Gerbillidae Alston, 1876
Myocricetodontinae Lavocat, 1961
***Myocricetodon* Lavocat, 1952**
***Myocricetodon lantianensis* Qiu et al., 2004**
(Fig. 5; Table 2)

Material A right maxillary fragment with M1 and M2, 17 isolated teeth (3 M1, 4 M2, 2 m1, 7 m2, 1 m3), V 15463.1–18.

Measurements (see Table 2)

Table 2 Measurements of molars of *Myocricetodon lantianensis* (mm)

Tooth	Length			Width		
	N	Mean	Range	N	Mean	Range
M1	3	1.65	1.60 ~ 1.70	4	0.98	0.95 ~ 1.00
M2	4	1.13	1.00 ~ 1.20	4	0.93	0.90 ~ 0.95
m1	2	1.63	1.60 ~ 1.65	2	1.03	1.00 ~ 1.05
m2	6	1.10	1.05 ~ 1.15	6	0.95	0.90 ~ 1.00
m3	1	—	0.75	1	—	0.70

Description M1 is elongated with a half-oval shaped occlusal outline; the anterocone is single-cusped or weakly divided by a shallow vertical groove that disappears in moderate wear; the lingual and labial main cusps are slightly alternately arranged; the hypocone and the metacone are nearly confluent; the anterolophule is distinct and connects the anterior arm of the protocone with the anterocone; the entoloph (longitudinal crest) is prominent, joining the hypocone with the paracone; the posteroloph is weak with the lingual branch delimiting a small hyposinus between the hypocone and the posteroloph; a poorly developed cingulum is present between the protocone and hypocone. M2 is subrectangular and narrower posteriorly than anteriorly due to the reduction of the matacone and hypocone; the protocone and paracone are fused to form an anterolingual-posterolabially directed ridge at a moderately worn stage; the labial anteroloph is rather robust, but the lingual branch of anteroloph is very weak or absent; the anterolophule is short and robust, connecting the anterior arm of protocone to the anteroloph; the entoloph is variable in development, joining the anterior arm of the hypocone with the paracone or the connection of protocone and paracone; the posteroloph disappears in early wear.

The anteroconid of m1 is high and single-cusped with a long, swollen labial and a rudimentary lingual branch of anterolophid; the main cusps are alternating, with the protoconid and hypoconid being posterior to the metaconid and entoconid, respectively; the two labial cusps are subtriangular in grinding surface, while the two lingual ones are elliptical; the anterolophulid is short and thick, joining the anteroconid to the connection of protoconid and metaconid; the ectolophid is weakly developed or lacking, connecting the entoconid to the protoconid if it is present; the hypoconid joins the entoconid by its anterior arm; the posterolophid is prominent, bearing a marked hypoconulid. The m2 is subrectangular with alternate and anteroposteriorly compressed main cusps; the labial branch of the anterolophid is prominent, while the lingual branch is absent; the anterior arm of protoconid joins the connection between the metaconid and

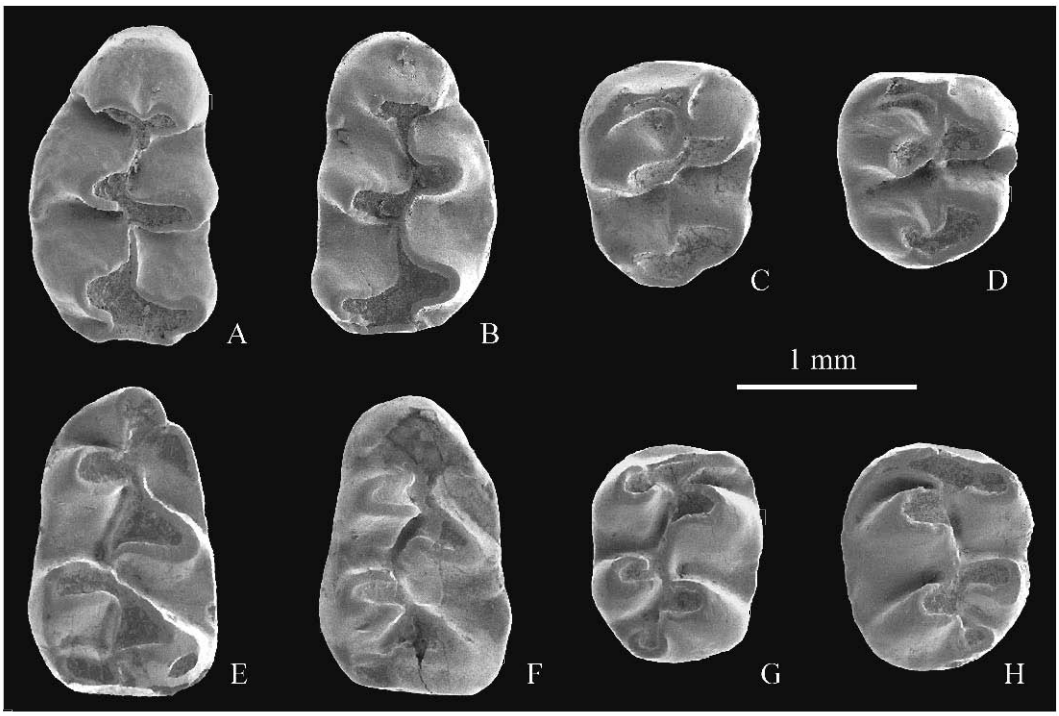

Fig. 5　Occlusal view of *Myocricetodon lantianensis*
A. l M1 (V 15463.2); B. r M1 (V 15463.3); C. r M2 (V 15463.4); D. r M2 (V 15463.5); E. r m1 (V 15463.6); F. r m1 (V 15463.7); G. r m2 (V 15463.8); H. l m2 (V 15463.9)

the anterolophid; the ectolophid is complete and curved, joining the protoconid with the hypoconid; the posterolophid bears a marked hypoconulid. The m3 is subtriangular; the protoconid and metaconid are relatively pronounced, and the entoconid is reduced; a hypoconid is absent, but a crest is present at the place of the cusp.

Comparisons　The characters of above described teeth fit the diagnosis of *Myocricetodon* (Jeager, 1977a), and the specimens can be referred to *M. lantianensis* from the early Late Miocene Bahe Formation of Shaanxi, China. *Myocricetodon* is quite diverse, with more than 10 species distributed in the Middle Neogene of western Europe, northern Africa, southwestern Asia, as well as northern China (Lavocat, 1952, 1961; Jaeger, 1977a, b; Wessels et al., 1987; Lindsay, 1988; Tong and Jaeger, 1993; Qiu, 2001; Qiu et al., 2004).

The Qinghai species can be readily distinguished from *M. seboui*, *M. ouaichi*, *M. eskihisarensis* and *M. chinjiensis* by its lack of an enterostyle on M1 and M2. By having a distinct "normal" longitudinal crest in the molars, it is distinguishable from *M. cherifiensis*, *M. parvus*, *M. irhoudi*, *M. ouedi*, and *M. ternanensis*. Like *M. lantianensis*, the other three species (*M. sivalensis*, *M. trerki*, and *M. liui*) have a "normal" longitudinal crest, but the anterocone on the M1 of these taxa are distinctly bilobed, and cingula and accessory cusps in their molars are clearly developed. The Shengou gerbil is similar to *M. plebius* from the Middle Miocene Quantougou Formation of Gansu in dental pattern, but different in larger size with relatively stronger cusps and crests, in M1 having a weakly divided anterocone and more fused metacone and hypocone, m1 having a more prominent labial branch of anterolophid, and more reduced m3.

Minor differences of the Shengou species from the Lantian *M. lantianensis* are the presence of a shallow vertical groove in the anterocone of M1, and of an incipient lingual anterolophid on m1. These differences might be interpreted as being derived features for the Qinghai population.

Cricetidae Rochebrune, 1883
Nannocricetus Schaub, 1934
Nannocricetus primitivus Zhang et al., 2008

(Fig. 6A–I; Table 3)

Material A right maxillary fragment with damaged M1, 15 isolated teeth (2 M1, 4 M2, 1 M3, 5 m1, 3 m2; a few are broken or very broken), V 15464.1–16.

Measurements (see Table 3)

Table 3 Measurements of molars of *Nannocricetus primitivus* (mm)

Tooth	Length			Width		
	N	Mean	Range	N	Mean	Range
M1	3	1.65	1.60 ~ 1.70	1	1.15	1.15
M2	4	1.29	1.20 ~ 1.35	3	1.07	1.00 ~ 1.10
M3	1	1.00	1.00	1	0.95	0.95
m1	2	1.50	1.45 ~ 1.55	3	0.93	0.85 ~ 1.00
m2	2	1.23	1.20 ~ 1.25	3	1.08	1.05 ~ 1.10

Description The anterocone of M1 is wide, unequally bilobed with the lingual lobe slightly smaller than the labial lobe, and separated by a moderately deep groove; the anterolophule joins the protocone with the lingual anterocone or the junction of the lingual and the labial ante-rocones; the protolophule I (anterior protoloph) is absent in 2 of 3 specimens, and blurred in one; the protolophule II is developed, but short; the entoloph is short and low, connecting the anterior arm of hypocone with the yoke of the posterior arm of protocone and the protolophule II; there is a remnant of a mesoloph; a metalophule I is absent; the posteroloph touches the posterior base of the metacone, and encloses no posterosinus; the sinus is relatively wide; there are three roots. The anteroloph of M2 is distinct, with the labial anteroloph being relatively developed than the lingual one; the protolophule is double, connected symmetrically with the anterior and posterior arms of the protocone, respectively; a very short mesolophule is present, touching the metacone in one specimen; there is no trace of a metalophule I, but a tiny metalophule II connecting the posterior arm of hypocone or the posteroloph is visible; four-rooted. M3 is subtriangular in shape due to the reduction of the metacone and hypocone; as the M2, the anteroloph and the two protolophules connected with the protocone arms are developed; the metacone and hypocone enclose a small pit with the posteroloph; there are three roots.

The anteroconid of m1 is slightly bifid, and a cleft at its apex is seen only in fresh teeth; the anterolophulid is narrow and low, joining the junction of metalophulid and the anterior arm of protoconid with the middle of anteroconid; the short ectolophid is nearly in alignment with the hypolophulid and the posterior arm of protoconid; a mesolophid is absent; the posterolophid is relatively strong, running from the hypoconid to the base of entoconid. The labial anterolophid of m2 is much stronger than the lingual one; the anterolophulid is very short, joining the anterolophid with the metalophulid; the ectolophid is relatively prominent, connecting the posterior arm of protoconid with the hypolophulid; there is no sign of a mesolophid; the posterolophid is distinct, but does not enclose the posterosinusid.

Comparisons The cricetine is essentially similar to *Nannocricetus mongolicus* from Ertemte and Harr Obo, Nei Mongol in brachyodonty, having a bilobed anterocone of M1 and bifid anteroconid of m1, well developed endoloph and ectolophid, and absence of mesoloph on all upper molars (Wu, 1991). However, it differs from this species in smaller size and less elongated molars with more rounded cusps, narrower anterocone(id)s, single anterolophule and three-rooted M1. The Shengou *Nannocricetus* is more similar to *N. primitivus*

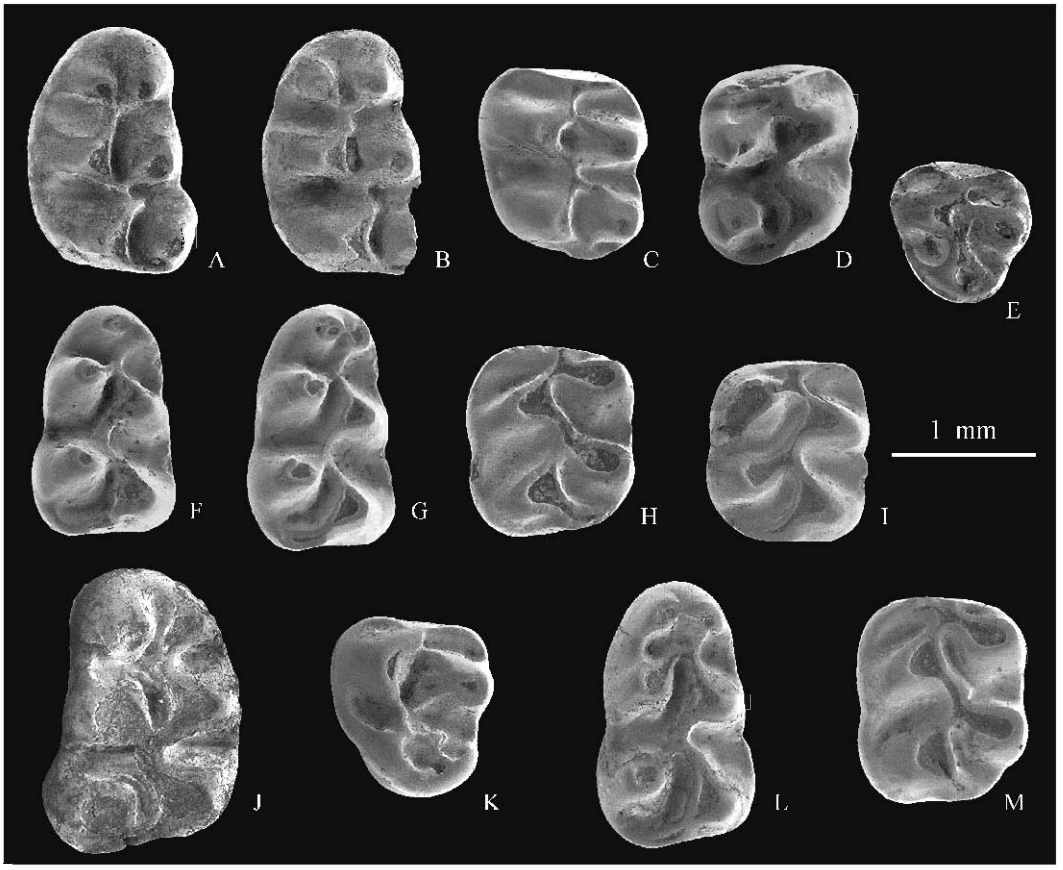

Fig. 6　Occlusal view of cricetids

A–I. *Nannocricetus primitivus*, A. l M1 (V 15464.1), B. l M1 (V 15464.2), C. l M2 (V 15464.3), D. r M2 (V 15464.4), E. l M3 (V 15464.5), F. r m1 (V 15464.6), G. r m1 (V 15464.7), H. l m2 (V 15464.8), I. r m2 (V 15464.9); J–M. *Sinocricetus* sp., J. r M1 (V 15465.1), K. l M3 (V 15465.2), L. r m1 (V 15465.3), M. l m2 (V 15465.4)

from Lantian, Shaanxi (Zhang et al., 2008). Minor differences of the former from the latter are the posteroloph of M1 touching the posterior base of the metacone rather than extending to the posterolabial corner of the tooth as in *N. primitivus*, and anterolophulid of m1 being slightly stronger. These may probably be interpreted as advanced characters for the Shengou cricetine.

Sinocricetus Schaub, 1930

Sinocricetus sp.

(Fig. 6J–M)

Material　A right maxillary fragment with M1, 12 isolated teeth (2 M1, 2 M3, 5 m1, 2 m2, 1 m3; a few very broken), V 15465.1–13.

Measurements (length × width)　M1: 1.80 ~ 1.85 (2) mm × 1.25 (1) mm; M3: 1.25 (2) mm × 1.05 (1) mm; m1: 1.70 ~ 1.80 (3) mm × 1.00 ~ 1.15 (4) mm; m2: 1.40 ~ 1.55 (2) mm × 1.15 ~ 1.20 (2) mm; m3:— × 1.15 (1) mm.

Description　The anterocone of M1 is wide and nearly equally bilobed; an obvious anterior pit is present below the groove separating the anterocone; the lingual anterocone is connected to the anterior arm of protocone by a distinct anterolophule, while the labial anterocone joins the

short labial spur of anterolophule; the protolophule I is absent, the protolophule II is developed; the entoloph is short, connecting the anterior arm of hypocone with the junction of the posterior arm of protocone and the protolophule II; the mesoloph is prominent, reaching half way to the edge of the tooth; a metalophule I is absent, the metalophule II is short, directed posteriorly to touch the posteroloph; the sinus is narrow; there are three roots. The labial anteroloph of M3 is much more developed than the lingual one; a low double protolophule is present; the reduced metacone and hypocone enclose a small pit with the posteroloph; there are three roots.

The anteroconid of m1 is wide and slightly bifid; the anteroconid joins the junction of metalophulid and the anterior arm of protoconid by a distinct or another weak anterolophulid; the short ectolophid is nearly in alignment with the hypolophulid and the posterior arm of protoconid; a mesolophid is absent; the posterolophid is strong, but fails to approach the base of entoconid. The labial anterolophid of m2 is strong; the short anterolophulid joins the anterolophid with the metalophulid and the anterior arm of protocone; the ectolophid is distinct, joining the posterior arm of protoconid with the hypolophulid and the anterior arm of hypoconid; there is no sign of a mesolophid; the strong posterolophid nearly extents to the base of entoconid. The entoconid of m3 is very reduced; a rudimentary mesolophid is visible.

Comparisons The specimens described cannot be referred to *Nannocricetus primitivus* because of larger dimension, presence of mesoloph on M1, and narrower sinus(id)s of molars, but in most characters correspond to the diagnosis of *Sinocricetus* emended by Wu (1991). These characters are the bilobed anterocone of M1 and the bifid anteroconid of m1, the presence of labial spur, mesoloph and metalophule II on M1, the obliquely forward-directed metalophulid and hypolophulid on m1. The Shengou hamster differs from *Sinocricetus zdanskyi* from Ertemte and Harr Obo (latest Miocene) and *S. progressus* from Bilike (Early Pliocene) in smaller size, lower crown, and narrower anterocone(id) of M1/m1 with less separated cusp(id)s and narrower sinus(id)s (Wu, 1991; Qiu and Storch, 2000). These characters probably indicate more primitive features for the Shengou taxon.

Muridae Illiger, 1811

Huerzelerimys Mein et al., 1993

Huerzelerimys exiguus sp. nov.

(Figs. 7-8; Table 4)

Etymology "Exiguus", Latin-exiguous; referring to relatively small size and weak dental longitudinal crests and labial cingulids of the new species of *Huerzelerimys*.

Holotype A left M1; V 15466 (1.85 mm × 1.20 mm).

Type locality Shengou, Delingha, Qinghai Province.

Stratum typicum Youshashan Formation, early Baodean, early Late Miocene.

Paratypes A mandibular fragment with an m1; 39 isolated teeth (12 M1, 6 M2, 2 M3, 11 m1, 8 m2; some M1 and m1 damaged), V 15467.1-40.

Measurements (see Table 4)

Table 4 Measurements of molars of *Huerzelerimys exiguus* (mm)

Tooth	Length			Width		
	N	Mean	Range	N	Mean	Range
M1	10	1.86	1.75~1.92	10	1.20	1.15~1.25
M2	5	1.24	1.20~1.30	5	1.16	1.00~1.20
M3	2	0.75	0.75~0.75	2	0.83	0.80~0.85
m1	7	1.62	1.55~1.75	9	1.06	1.00~1.15
m2	7	1.21	1.10~1.30	7	1.13	1.05~1.20

Diagnosis *Huerzelerimys* with molars smaller than those of the *H. minor*. M1 with a rela-

tively posterior placement of t1 and a weak t6－t9 connection in more than 50% of the specimens; m1 and m2 with narrow labial cingulum bearing weak cuspules.

Description A thick end of the ridge marking the lower border of the masseteric scar below the anterior root of m1 and a prominent mental foramen placed high in the bend of the curved diastema can be seen in the madibular fragment.

The t1 of M1 is rounded or slightly elliptical with its anterior limit being almost opposite to the posterior limit of the t3, united to the t2 by a short and narrow crest, and showing a trend of connection with the t5 on three of eleven specimens; the t3 is closed to the t2 and smaller than the t1, without a distinct posterior spur; the t4 is slightly posterior to the t6 and similar to t6 in size, united to t5 by a crest that is as high as the connection of t5－t6, and united to t8 by a low or narrow crest; the t6 is connected to t9 by a very low and thin crest in seven out of 11 specimens, completely separated from t9 in three teeth; the orientation of the t8－t9 pair is an acute angle to perpendicular to the longitudinal axis of the molar; the t12 is crest-like in eight cases, absent or as a remainder in three; an immature prestyle between t2 and t3 is present in two teeth; a t1 bis is absent; there are three main roots, and a trace of central rootlet can be seen in one tooth. The t1 of M2 is rounded and well developed, united to the t5 at the anterolingual wall of the cusp, and elongated to join the t4 in one tooth; the t3 is small and attached to the t5; the t4 is slightly posterior to t6, united to t5 by a crest as high as the connection of t5－t6, and united to the t8 usually by a distinct crest; the t6 is convergent to the t9, but separated from the cusp in five of six cases and shows a low connection to it in one specimen; the t9 is larger than the t3; the t12 is distinct, but crest-like. The t1 of M3 is small or as a crest connected to the t5 and fused with the t4; the t3 is very minute or absent; the t4, t5 and t6 merge into a strong chevron; there is no t9, nor t12.

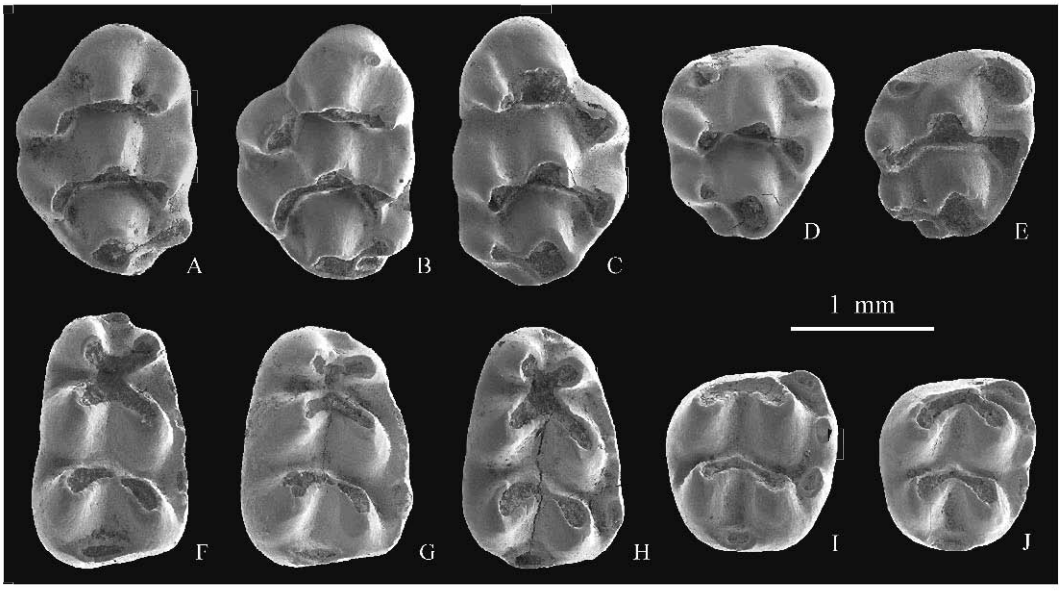

Fig. 7　Occlusal view of *Huerzelerimys exiguus* sp. nov.
A. l M1, Holotype (V 15466); B. l M1 (V 15467.1); C. r M1 (V 15467.2); D. r M2 (V 15467.3); E. r M2 (V 15467.4); F. r m1 (V 15467.5); G. r m1 (V 15467.6); H. r m1 (V 15467.7); I. r m2 (V 15467.8); J. r m2 (V 15467.9)

The anteroconid of m1 is usually asymmetrical with the lingual lobe larger than and anteriorly to the labial one; a minuscule tma usually attached to the anterolingual lobe is present in all the determinable specimens; the anteroconid joins the protoconid-metaconid connection in

all cases except in one unworn tooth; the labial and lingual principle cuspids are similar in size and shape, with the labial one situated slightly posteriorly relative to the lingual cuspids; there is no longitudinal connection between the two posterior pairs of tubercles; the labial cingulum is narrow but continuous from the labial anteroconid to the posterolabial border of the tooth; a small c1 is present in two specimens, and a c2 is not developed; the posterior tubercle is low and ridge-like; there are two roots on the specimens that preserve this part. The labial anteroconid of m2 is small, low and united to the anterior wall of the protoconid; the two chevrons are similar in shape and size; a low and thin medial ridge extends from the posterior chevron to connect the protoconid in four of the eight teeth; a longitudinal spur from the posterior chevron can be seen in two specimens; the labial cingulum extends posteriorly from the anteroconid to the hypoconid; a small cusp between the protoconid and hypoconid is present in five teeth, a tiny c2 in five; the posterior tubercle is low, flattened oval or ridge-like; two roots are present.

Comparisons The described specimens are comparable to those of *Progonomys sinensis* from the Bahe Formation, Shaanxi in size and general morphological characters, such as the lengthened and slender molars with weak longitudinal connections, the reduced tma and the weak labial cingulum with undeveloped c1 on m1 (Qiu et al., 2004). However, the Shengou taxon differs from the Lantian murid in slightly larger size, somewhat higher frequency of t1 posterior spur on M1, greater frequency of t6 and t9 being convergent or connected on M1 and M2, more distinct tma on m1, and slightly developed c1 and c2 on m1 and m2.

Characters of these specimens fit the diagnosis of *Huerzelerimys* as given by Mein et al. (1993). These characters are the poor development of the longitudinal connections between tubercles, the absence of t7 but a weak connection between t4 and t8 on upper molars, M1 and M2 having a well-developed t9 and a thin connection between t6 and t9 in more than 50% of the specimens, M3 having no t9, m1 having a tiny tma and moderately developed cingular margin. The teeth are similar to those of *Progonomys* and *Hansdebruijnia* in size and certain aspects of morphology, but cannot be referred to *Progonomys* because of their much more frequent connections between t6 and t9 on M1 and M2, and higher percentage of a small tma on m1, nor to *Hansdebruijnia* because of their disconnection of t1–t5 and t3–t5, poor connection of t6–t9 on M1, weak development of tma, and the absence of medial ridge on m1.

Huerzelerimys is a murid genus previously known from the Late Miocene of Europe, and includes four species, *H. minor*, *H. vireti*, *H. turoliensis* and *H. oreopitheci* (Engesser, 1989; Mein et al., 1993; Freudenthal and Suarez, 1999). The Shengou new species can be easily distinguished from all the European taxa by its smaller dimension (Fig. 8), more backward position of t1 on M1, and weaker labial cingulum with undeveloped c1 on m1. In addition, it differs from *H. minor* from MN10, *H. vireti* from MN11 and *H. oreopitheci* from MN12 in M1 having more divergent t6 and t9. *H. turoliensis* from MN11–12 is a relatively large-sized species of the genus with relatively hypsodont molars, high frequency of connection between t6 and t9 and reduced t12 on M1, and distinctly reduced t9 on M2.

Huerzelerimys is thought to have evolved from *Progonomys*. The phyletic lineage *Progonomys–Huerzelerimys* is considered to be characterized by an increase in size, a forward shift of t1, a strengthening of the connection between t4 and t8, a gradual convergence and union of t6 and t9 and reduction of t12 in M1, a development of tma and labial cingulum in m1 (Mein et al., 1993). Such an observation appears to be confirmed by our Asian discovery. Changes in dental morphology from *Progonomys sinensis* of Lantian, Shaanxi to the new species *Huerzelerimys exiguus* from Shengou, Qinghai are fully compatible with Mein and others' determination. Apparently teeth of *Progonomys sinensis*, if slightly increasing the size (re-examination of the sample of *Progonomys sinensis* from the type locality shows that the measurements of molars given by Qiu and others in 2004 are mistaken, see the remeasurements in Fig. 8), somewhat shifting forward the t1, further strengthening the connection of t6 and t9, slightly developing the tma and labial

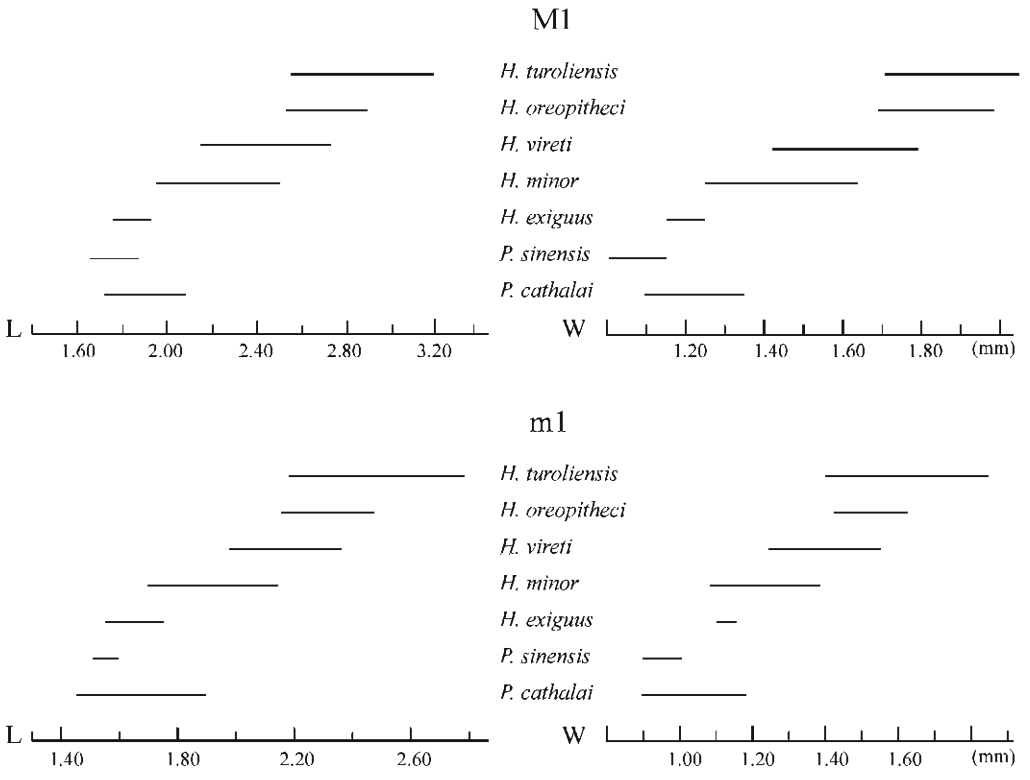

Fig. 8　Size ranges of the first molars of *Progonomys cathalai*, *P. sinensis*, *Huerzelerimys exiguus* and other known species of *Huerzelerimys*

Dimension data for *P. cathalai* and the European *Huerzelerimys* are from Mein et al. (1993), and for *P. sinensis* are re-measured

cingulum, would converge into the molar pattern in *Huerzelerimys exiguus*. Therefore, it is reasonable to consider that *Huerzelerimys exiguus* is closely allied to *Progonomys sinensis*.

The lineage *Huerzelerimys minor*– *H. turoliensis* shows a similar evolutionary trend as the *Progonomys*– *Huerzelerimys* lineage, i. e. increasing size, gradually strengthening longitudinal connections, reducing t12, developing tma and labial cingulum in the course of time. The small size, the relatively backward position of t1, the weak and high frequently interrupted connection between t6 and t9, the narrow labial cingulum bearing weak cuspulids on m1 in *Huerzelerimys exiguus* can be interpreted as primitive characters. Thus, the new species is more primitive than *H. minor* and represents the most primitive form of the genus. The age of *Huerzelerimys exiguus* can probably be correlated with late Vallesian or MN10 of Europe.

Family incertae sedis

***Pararhizomys* Teilhard & Young, 1931**

***Pararhizomys* sp.**

(Fig. 9O)

The indeterminate species of *Pararhizomys*, belonging to an indeterminate family, is represented by an m2 (V 15468, 3. 65 mm × 3. 85 mm). The tooth is rooted and high-crowned, with two labial and a long transverse lingual reentrants. The dentine tracts (enamel crown base) are smooth.

Pararhizomys is a genus endemic to the Mongolian Plateau and Northern China, with two

species, *P. qinensis* and *P. hipparionum*, documented in the faunas of Miocene and Pliocene ages (Teihard and Young, 1931; Kowalski, 1968; Zhang et al., 2005). The Shengou taxon is larger than *P. qinensis* from the lower Bahe Formation of early Late Miocene. It is similar to *P. hipparionum*, but differs in having a larger and wider size of m2, and more transverse lingual reentrant of it. The dentine tract height of the Shengou form is close to that of the type specimen of *P. hipparionum*, but smaller than that of the Qin'an population. This may indicate that the Shengou form is in the same evolutionary stage of *P. hipparionum* from the type locality, but is slightly more advanced than that of the Qin'an population.

Lagomorpha Brandt, 1855
Ochotonidae Thomas, 1897
Ochotonoma Sen, 1998
Ochotonoma primitiva (Zheng & Li, 1982)

(Fig. 9A-M; Table 5)

Emended diagnosis Midium-sized ochotonid. P2 subtriangular due to anteroposterior extension of the lingual part; p3 anteroconid large and wide, usually with two anterior folds or depressions and at least one fold filled with cement, and wide dentine isthmus linking the anteroconid and posteroconid; p3 paraflexis shorter and narrower than in *O. anatolica*, less posteriorly extending than in *O. csarnotana*.

Material Three maxillary fragments including 1 P3, 1 P4, 2 M1, 2 M2 (V 15469.1-3); two mandibular fragments with p4-m3 and p4-m2, respectively (V 15469.4-5); 50 isolated teeth (12 P2, 16 P3, 7 P4/M1, 3 M2, 12 p3), V 15469.6-55.

Measurements (see Table 5)

Table 5 Measurements of cheek teeth of *Ochotonoma primitiva* (mm)

Tooth	Length			Width		
	N	Mean	Range	N	Mean	Range
P2	12	1.27	1.15~1.35	11	2.11	2.00~2.20
P3	14	1.60	1.35~1.80	9	3.17	2.75~3.50
P4/M1	9	1.75	1.50~2.10	8	3.23	3.15~3.60
M2	4	1.95	1.85~2.04	4	3.09	3.00~3.20
p3	12	2.23	2.05~2.40	11	2.05	1.80~2.40
p4	2	2.15	2.00~2.30	2	2.25	2.15~2.35
m1	2	2.15	2.05~2.25	2	2.30	2.05~2.55
m2	2	2.25	2.10~2.40	2	2.23	2.10~2.35
m3	1	—	1.15	1	—	1.80

Description All the teeth lack roots. P2 is subtriangular due to anteroposterior extension of the lingual part; there is a deep cement-filled anterior flexus starting on the level of one third of the tooth width on the lingual side and directed toward the posterolabial corner of the tooth; a more or less strong ridge is present in the lingual wall in all the teeth; the enamel band is thick on the lingual border and anterior wall of the anterior flexus, whereas on labial border and anterior part of the posterior wall of anterior flexus it is thin or absent; the shaft of this tooth is curved backward. P3 is trapezoidal in outline of the occlusal surface and distinctly wider than long; the anteroloph covers about two third of the occlusal surface; the U-shaped paraflexus starts on the level of less than one third of the tooth width on the labial side and is filled with cement; the wide and short hypostria, filled with more or less cement in most of the teeth, separates a relatively longer protocone and a shorter hypocone; the enamel band is thick on the lingual border of the tooth and lingual wall of the paraflexus. P4 and M1 have general ochotonid

structure; the two lophs are similar in shape and connected on the labial side of tooth; the hypostrias are deep, filled with cement and slightly plicated on the labial part of posterior wall; the lingual margin of the two lophs is sharp; the enamel band is thick on the anterior border of the two lophs, whereas on the posterior border of the anteroloph is almost absent. M2 has an anteroloph similar to that of P4 and M1, and a posteroloph with a small and posterointernally directed process on its posterior border.

p3 is subtriangular in occlusal surface with the anteroconid and posteroconid linked by a rather wide dentine isthmus; both the anteroconid and posteroconid are wider than long; the anteroconid is large, but variable in shape from oval to subrhomboidal, usually with two anterior folds or depressions persisting along the shaft, and with three anterior folds (one anterolabial flexid and two anterolingual flexids) in one tooth; the anteroconid has one or two folds with cement; the anterolabial flexid (protoflexid) is always slightly deeper than the anterolingual one (paraflexid), both of which extend obliquely backward to the same level; the "second colonette" of anteroconid extends in width beyond the protoconid in one or two specimens; the posteroconid is subrectangular and wider than long, with a comparable length of internal and external borders, and a short anterior border and long posterior one, the margins of the two flexids are smooth; the hypoflexid (posteroexternal flexid) is wide, filled with cement, and is almost as deep as, and nearly parallel to the protoflexid; a mesoflexid can be traced in one or two teeth; the enamel band is thick on the border of protoconid and metaconid, while on the posterointernal corner of the tooth is thin or absent. The p4 – m2 are of structure of general ochotonids; the trigonid is narrower than the talonid; the talonid of m1 is wider than that of p4 and m2. The m3 is single lopphid and narrower than the talonid of m2.

Comparisons Characters of the described specimens correspond to the diagnosis of *Ochotonoma* given by Sen (1998). These are one P2 anterior flexus; M2 with a posterolingual process; large p3 anteroconid with two anterior flexids or depressions, filled with cement; smooth borders of p3 protoflexid and paraflexid. Except the type species *Ochotonoma anatolica* Sen, 1998 from the Pliocene locality of Calta, Turkey, another three species, *O. primitiva*, *O. csarnotana*, and *O.* sp. have been recognized from the Neogene deposits of Eurasia (Zheng and Li, 1982; Sen, 1998, 2003; Popov, 2004).

Ochotonoma primitiva was originally described by Zheng and Li (1982) as *Ochotonoides primitivus* from Tianzhu, Gansu. Qiu (1987) considered it as a variable individual of *Ochotona lagreli* because of its small size and lack of placation on protoflexid and paraflexid of p3. Sen (1998) is right to transfer it to the genus *Ochotonoma*. The pikas from Shengou is identical with *Ochotonoma primitiva* from Gansu in dental pattern, both of which have wider dentine isthmus linking the anteroconid and posteroconid, shorter and narrower paraflexis on p3, and the p3 of the population from Gansu completely falls within the variation exhibited by the teeth from Qinghai. The Gansu pika is relatively smaller, but remeasurement of its p3 shows that it falls within the size range of Qinghai teeth.

The Shengou ochotonid differs from *O. anatolica* and *O. csarnotana* in larger size, in more prominent anteroconid folds, and wider dentine isthmus linking the anteroconid and posteroconid on p3. In addition, the paraflexis of p3 is longer and wider in *O. anatolica*, and extends more distinctly posteriorlly in *O. csarnotana*. It differs from the indeterminate species from Kömürlük Dere, Turkey and Apolakkia, Greece in less broadened anteroconid, weaker second colonette, and longer metaconid-entoconid complex.

The occurrence of *Ochotonoma* in China represents the eastern extension of distribution for the genus. It is likely that *Ochotonoma primitiva* from Qinghai is an earlier species of the genus. The relatively shorter protoflexid and paraflexid, the more distinct flexids on the anteroconid of p3 might be of primitive characters for the genus.

It seems that *Ochotonoma* and *Ochotonoides* were probably closely allied. *Ochotonoma*

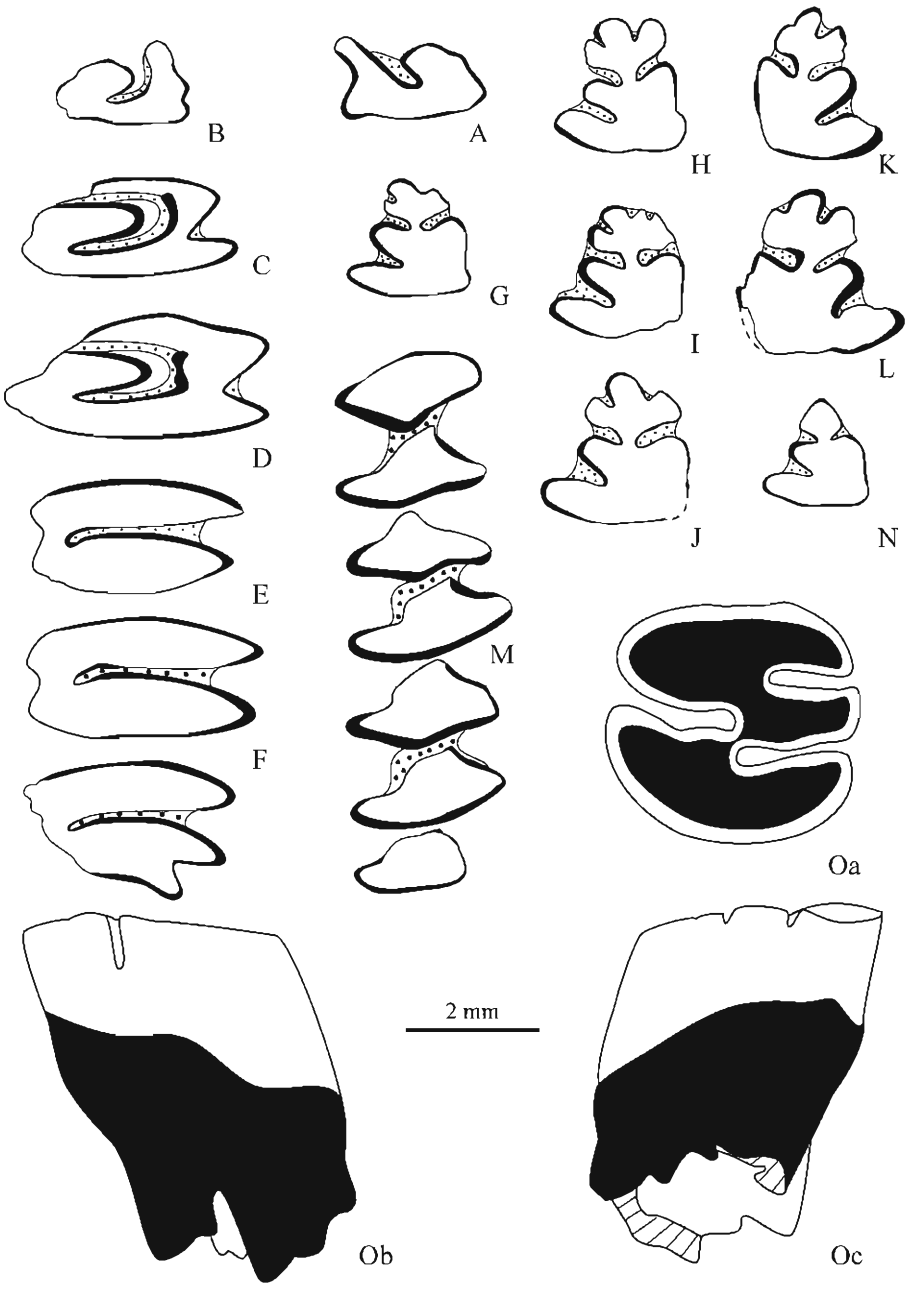

Fig. 9 Teeth of ochotonids and *Pararhizomys*

A–M. *Ochotonoma primitiva*, A. l P2 (V 15469.6), B. r P2 (V 15469.7), C. r P3 (V 15469.8), D. r P3 (V 15469.9), E. l P4/M1 (V 15469.10), reverse, F. r M1–2 (V 15469.1), G. l p3 (V 15469.44), H. l p3 (V 15469.45), I. l p3 (V 15469.46), J. l p3 (V 15469.47), K. r p3 (V 15469.48), L. r p3 (V 15469.49), M. l p4–m2 (V 15469.4); N. *Ochotona* sp., l p3 (V 15470.1); O. *Pararhizomys* sp., r m2 (V 15468); A–Oa. occlusal view, Ob. lingual view, Oc. labial view

probably gave rise to the genus *Ochotonoides*. An increase of size and complication of enamel margins of protoflexid and paraflexid would change the p3 of *Ochotonoma* into one similar to that

of *Ochotonoides*. Such a conclusion, however, needs to be borne out by a finding of intermediates between the two ochotonids.

Ochotona sp.

(Fig. 9N)

Material Two p3 (one damaged, 1.70 mm × 1.65 mm; — × 1.40 mm); V 15470.1–2.

Description The p3 is triangular in shape of occlusal surface. The anteroconid and posteroconid are linked by a relatively wide dentine isthmus. The anteroconid is rhomboid with a sharp end directed anteriorly. The posteroconid is rectangular and wider than long, with the internal and external borders of comparable length and shorter anterior border than posterior one. The protoflexid is deeper than the paraflexid, both of which are directed towards the midline of the tooth and are inclined slightly posteriorly. The margins of the two flexids are smooth. The hypoflexid is almost as deep as the protoflexid, but wider. All these flexids are filled with cement. The enamel band is relatively thick in the perimeter of posteroconid, except for the anterior wall of hypoconid.

Remarks The only adult p3 cannot be referred to *Ochotonoma primitiva* for its small size, simple and wider occlusal pattern of anteroconid, and shorter protoflexid and paraflexid. It has a general structure of the genus *Ochotona*, and falls within the range exhibited by *Ochotona lagreli* from Ertemte, Nei Mongol both in size and dental pattern. However, we consider it inadvisable to settle its species status because of the paucity of material.

3 Discussion

Biochronology The Shengou assemblage described is composed of 16 species, representing 12 families in the orders Insectivora, Rodentia and Lagomorpha. Most taxa in this association cannot provide clear information about the age of the fauna, because of their scarce material or great stratigraphic range. However, the fauna includes some elements that can help to identify its age, such as *Myocricetodon*, *Nannocricetus*, *Lophocricetus* and *Huerzelerimys*. The genus *Myocricetodon* made their first appearance in Middle Miocene, surviving into Early Pliocene in Africa and becoming extinct by the end of Late Miocene in Eurasia (Wessels, 1999; Qiu et al., 2004). *Nannocricetus*, *Sinocricetus* and *Lophocricetus* endemic to the northern Asia are documented in the faunas of Late Miocene and Pliocene ages, and *Lophocricetus* first appeared in the early Late Miocene (Zazhigin et al., 2002; Qiu et al., 2008). *Huerzelerimys* are known from the late Vallesian (MN10) to middle Turolian (MN12) of Europe (Freudenthal and Suarez, 1999). *Pararhizomys* first appeared in the early Late Miocene (Lantian) and disappeared after the Late Pliocene (Zhang et al., 2005). All these data, especially the joint occurrence of *Myocricetodon*, *Lophocricetus* and *Huerzelerimys* suggest that an early Late Miocene age is very possible for the Shengou assemblage. *Ochotonoma* was reported from the Pliocene, but its presence in this fauna does not contradict an earlier age for the fauna, because the Shengou *Ochotonoma* is definitely more primitive in morphology than those of western Asia and eastern Europe.

It seems very likely that the Shengou Fauna is correlated with fauna from the lower part of the Bahe Formation of Shaanxi. They have a similar community structure and share *Sciurotamias*, *Lophocricetus*, *Protalactaga*, *Myocricetodon*, *Nannocricetus*, *Pararhizomys* and *Ochotona*. The Shengou Fauna, however, appears to be slightly younger than the Bahe Fauna, because of the progressive status of the murid, and the derived characters of *Lophocricetus* and some other taxa in the former fauna. The fauna is most probably attributable to early Late Miocene, or the early Baodean of the Chinese Land Mammal Ages. It can be correlated, in European terms, with late MN10, if the Bahe Fauna is an equivalence of MN10. Nevertheless, a very early MN11 equivalence of the Shengou Fauna cannot be excluded.

Biogeographic relationships Most taxa of the assemblage are commonly known in the Neogene faunas of central and northern Asia. Except for a few genera endemic to northeastern Asia, quite a number of taxa suggest that the Shengou area had relationships to western Asia, Europe and northern Africa. Four of the identifiable genera (*Myocricetodon*, *Protalactaga*, *Ochotona*, and *Ochotonoma*) are recorded from the Late Neogene of western Asia, and four (*Myocricetodon*, *Huerzelerimys*, *Ochotona*, and *Ochotonoma*) occur in Europe. But only one or two genera (*Myocricetodon* and *Protalactaga*) show affinity with Indian subcontinent and northern Africa. This suggests dispersal or immigration of small mammals among these continents, especially the western Asia and Europe, during the early Late Miocene.

Paleoecology and environmental characters Except the eurytopic families in the studied fauna, such as Soricidae, Talpidae, Sciuridae, Eomyidae, and Muridae, all have a Palearctic distribution. None of them is confined to the present tropical or subtropical areas of South China, or the Oriental Region. This strongly suggests that the Shengou Fauna reflects a faunal distribution like the temperate region in China.

Although Soricidae and Talpidae live in a variety of climates and environments, most of them seem to inhabit areas with more humid environments than in the studied area today. Among the Sciuridae, the genus *Sinotamias* was probably living in a temperate climate and open meadows, like its recent relative, *Spemorphilus*, while the flying squirrel requires some tall trees. *Lophocricetus* probably preferred to shrubs in a temperate climate, like the other zapodids in the present day. Its presence in the fauna in a high percentage indicates that at least a low amount of vegetation surrounded the fossil locality. Both *Myocricetodon* and the dipodid probably inhabited areas with dry and open steppe or even desert, like the recent sand-rats and jerboas. *Ochotonoma* were probably inhabitants of arid and open grassland, much like the extant pikas.

It is likely that the environment in the area surrounding the Shengou locality was dry and open, but unlike the exact faunal situation of the present day in Qaidam area. It seems that the climate at Qaidam was less arid, but warmer and more moist with more vegetation, even arbors, during the early Late Miocene than today.

Similarities in habitat as well as the composition of the Shengou Fauna with the Bahe Fauna seem to suggest that the Qaidam area was close to the Lantian region in altitude during the Late Miocene. The locality producing the Shengou Fauna is at an altitude of about 3 000 m a. s. l., while the Bahe locality is of less than 600 m. This might imply that the Qinghai-Xizang Plateau had undergone a definite uplift in relation to the loess plateau after Miocene, resulting in the remarkable differentiation in environment between the Qaidam and Lantian areas today.

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