第38卷 第3期
2000年 7 月

古 脊 椎 动 物 学 报
VERTEBRATA PALASIATICA

pp.192～202
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新疆乌伦古河流域第三纪哺乳动物地层研究的新成果[1)]

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新疆准噶尔盆地北缘中、新生代地层广泛出露，20 世纪 50 年代，对这一地区的中、新生代地层的系统研究工作业已开展。地质部 631 地质队在该地区进行大面积地质填图，新疆石油管理局开展了有关地质问题的综合性专题研究。1982 年和 1983 年中国科学院古脊椎动物与古人类研究所在新疆石油管理局的支持下，组队前往该区进行中、新生代生物地层研究工作，并于 80 年代末与 90 年代初提交了一批生物地层和古哺乳动物研究文章，进一步提高了该地区第三纪地层的研究程度。由于工作区地处中亚，位于青藏高原以北，西面邻近古土尔盖海峡，东接东亚，因此提高该地区新生代地层及哺乳动物群的研究精度必将深化人们对新生代以来所发生的重大地质事件及其对哺乳动物进化与地理分布的影响的认识。为此，我们再次开展了乌伦古河两岸第三纪中期哺乳动物地层的研究工作，从 1995 年起在乌伦古河中游沿岸考察地层和系统采集化石，取得了新的进展。1998 年曾报道过阶段性成果(吴文裕等，1998)。近年来我们对该区中、新生代生物地层又有了新的认识和重要修正。本文报道近年来的进展、介绍重要的实测剖面和各岩性组之间的接触关系，并分析了各组的地质时代。

在乌伦古河流域，由东向西从二牧场到顶山一带分布着 3 个不同高度的戈壁台地。白垩纪和第三纪地层出露在台地的边缘及被切割的沟谷之中。低台地多半由乌伦古河组组成，两级较高的台地则由第三纪地层组成，各岩层在本区大面积出露，易于横向追索对比。我们在乌伦古河南岸测制了 2 条，在河北岸测制了 5 条大比例尺地层(1:100)剖面，基本上控制了研究区域的第三纪各岩石地层单位的岩性变化、接触关系及分布范围。

可可买登组 总体上呈褐黄色，粒度较粗，砾石磨圆度好，属典型的河流相堆积，主要分布在河南岸夺勒布勒津台地上部，在河北岸仅出露于铁尔斯哈巴合以东的第三级残留台地顶部，厚度薄。该组超覆于哈拉玛盖组之上，在夺勒布勒津台地西部可见其与哈拉玛盖组之间的沉积间断。目前收集到的哺乳动物化石有长鼻目 1 属 1 种，奇蹄目 2 属 2 种，偶蹄目 3 属 3 种和啮齿目 1 属 1 种。动物群性质与内蒙古通古尔动物群相近，其时代应与中中新世通古尔组相当。

哈拉玛盖组 主要由灰白色含砾砂岩夹灰绿色泥质粉砂岩组成。构成河北岸广泛分

1) 国家自然科学基金(编号：04957280)、中国科学院重点项目(编号：KZ952-J1-410)、中国科学院古生物学与古人类学科基础研究特别支持基金(编号：95602和9810)和科学技术部特支费资助。

收稿日期：1999-12-03

布的第 2 级戈壁平台的主体，但在干奇开日希附近，因受断层的影响而出露在一级平台的陡壁上，在河南岸出露于夺勒布勒津台地的上部。在研究区域的多数地区该组与下伏索索泉组呈平行不整合接触，但在夺勒布勒津台地西端该组在岩性上与索索泉组顶部地层呈渐变过渡关系。在该组的数个层位中产有哺乳动物化石，但大多数的化石集中在近底部的两个砂层中。丰富的哺乳动物化石，尤其是小哺乳动物化石表明该动物群与宁夏同心动物群最为接近，时代为中中新世早期。目前收集到的哺乳动物化石有食虫目 2 属 2 种、翼手目 1 属 1 种、灵长目 1 属 1 种、兔形目 3 属 3 种、啮齿目 8 科 17 属 19 种、食肉目 8 属 9 种、长鼻目 3 属 4 种、奇蹄目 2 属 2 种、偶蹄目 5 属 6 种。

索索泉组　以综红色的泥质粉砂岩为主的碎屑堆积。其厚度变化较大，在河南岸的夺勒布勒津地区粒度较粗，厚度大，可达 110m；河北岸粒度较细、厚度较小，在吃巴尔我义剖面仅厚 60m。90 年代初曾依据哺乳动物化石确定其时代为晚渐新世。近年来我们在该套地层的不同层位中发现了较多的哺乳动物化石，依据动物群性质判定该组顶部地层时代应与上覆哈拉玛盖组时代接近，为中中新世早期，而其近底部地层中所含哺乳动物群较甘肃晚渐新世塔崩布鲁克动物群进步，一些成员如短面猬 *Metexallerix* 明显较兰州盆地早中新世的种原始。我们认为该动物群是我国目前已知最早的早中新世哺乳动物群 (Qiu *et al.*, 1999)。因而索索泉组的沉积时代应为早中新世—中中新世早期。目前在该组底部发现的化石有食虫目 2 属 2 种、兔形目 1 属 1 种、啮齿目 5 科 6 属 6 种、奇蹄目 1 属 1 种、偶蹄目 2 属 2 种。该组超覆在原认为的乌伦古河组不同层位的地层之上。

乌伦古河组　20 世纪 90 年代初以来，人们普遍将工作区内广泛分布于索索泉组之下的浅色碎屑岩堆积作为乌伦古河组 (童永生等，1990)，时代为白垩纪。近年来的工作表明，广泛分布于该区的所谓白垩纪“乌伦古河组”实际上至少包括 3 套岩性不同、时代不同的浅色碎屑岩堆积。在二牧场北的“乌伦古河组”由一套灰白色砂岩夹棕色、黄色粉砂岩组成，产恐龙化石，时代应为晚白垩世。在铁尔斯哈巴合北原划为乌伦古河组的地层则由土黄色泥质粉砂岩夹灰黄色砂岩组成，与上覆索索泉组呈整合接触关系，含有丰富的哺乳动物化石，动物群成分与我国甘肃塔崩布鲁克动物群相似，其时代无疑应为晚渐新世。在夺勒布勒津以西的萨尔多依腊地区出露了巨厚的浅色碎屑岩堆积，该套地层中段由富含结核的土黄色泥质粉砂岩夹砂岩组成，发现有梳趾鼠化石，很可能是 *Advenimus*，其时代为早始新世晚期或中始新世早期。因此，到目前为止，“乌伦古河组”包括了晚白垩世、始新世和晚渐新世等不同地质时期的不同性质堆积。因而，过去所认为的不同地点的“乌伦古河组”应解体为不同的岩石单元。其中哪一套地层属于原定义的“乌伦古河组”尚需与最初命名地点的乌伦古河组对比确定。

综上所述，乌伦古河中游两岸分布着一套自始新世到中中新世的第三纪地层，保存了至少 5 个不同时期的化石哺乳动物群 (始新世、晚渐新世、早中新世、中中新世哈拉玛盖动物群和中中新世可可买登动物群)，组成了一条时间跨度较长、较连续的、含哺乳动物化石较丰富的新生代地层剖面。始新世至渐新世是全球气候环境发生重大变动的时期，因此该剖面保存的地质记录为深入研究该地质时期环境变化对脊椎动物的影响提供了极好的条件。铁尔斯哈巴合北侧发现了富含哺乳动物化石的晚渐新世到早中新世的连续地层，因此是研究中国的渐新世 / 中新世哺乳动物地层界线问题的理想地区之一。该地区对研究中亚地区第三纪哺乳动物学、地层学和环境学具有重要意义。

关键词 准噶尔盆地北缘,第三纪生物地层,实测剖面
中图法分类号 P534.61

NEW RESULTS IN THE STUDY OF TERTIARY BIOSTRATIGRAPHY IN THE ULUNGUR RIVER REGION OF XINJIANG, CHINA

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Abstract Stratigraphic sections of 4 Tertiary rock units in the Ulungur River region, northern rim of the Junggur Basin, Xinjiang, are briefly described. These are the Kekemaideng, Halamagai, Suosuoquan and Ulunguhe formations. The contact relationships and biochronology of these rock units are discussed. The Kekemaideng beds are considered to be a formation of probably equivalent to middle Miocene Tunggur Fm. in age. The fauna from the Halamagai Fm. is correlative to early middle Miocene Tongxin fauna. The lower part of the Suosuoquan Fm. is younger than Tabenbulukian and probably of earliest Miocene. The Ulunguhe Fm. in its current usage is a mixture of sediments with different lithologies and different ages ranging from Cretaceous to Oligocene and should therefore be redefined.

Key words North Junggar Basin, Tertiary biostratigraphy

Continental sediments of Mesozoic and Tertiary are extensively exposed in the northern area of Junggur Basin. Since 1950s, geological mapping in this area has been carried out by the Xinjiang Geological Survey and many projects related to petroleum exploration have been conducted by the Xinjiang Bureau of Petroleum Management. One of the projects in collaboration with the Institute of Vertebrate Paleontology and Paleoanthropology in 1982—83 focused on fossil vertebrates and biostratigraphy of Mesozoic and Tertiary. This project generated considerable results (Chen, 1988; Wu, 1988; Qi, 1989; Tong, 1989; Wang and Qi, 1989; Ye, 1989; Tong *et al.*, 1990). Geographically, this region is north to the Tibet-Qinghai Plateau, east to the ancient Turgai Strait, and west to the Mongolian Plateau; therefore it is particularly important in understanding evolution of terrestrial faunas and related geological events taking place in Central Asia during the Tertiary time. In the hope to further the Tertiary study of this region, we started a field project in 1995. Five successive seasons of extensive field investigations over a large area in the Ulungur River region have proved to be fruitful: a series of results have been published (Wu *et al.*, 1998; Wang *et al.* 1998; Bi, 1999,2000; Bi *et al.*, 1999; Meng *et al.*, 1999; Ye *et al.*, 1999; Wu

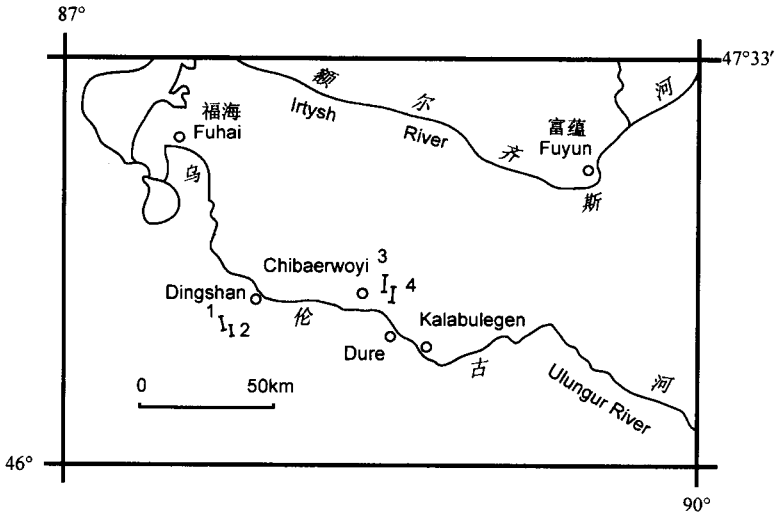

图 1　工作区域及主要实测剖面示意图

1. 夺勒布勒津索索泉组实测剖面；　2. 夺勒布勒津可可买登组实测剖面；
3. 铁尔斯哈巴合乌伦古河组实测剖面；4. 铁尔斯哈巴合哈拉玛盖组实测剖面

Fig. 1　Sketch map showing the area studied, location of the main measured sections

1. The Duolebulejin section of Suosuoquan Fm.; 2. The Duolebulejin section of Kekemaideng Fm.;
3. The Tieersihabahe section of Ulunguhe Fm.; 4. The Tieersihabahe section of Halamagai Fm.

et al., 2000) and much more is expected in the near future. These field and lab studies allow us to make significant changes of the previous consideration of the Mesozoic and Tertiary biostratigraphy in the region. Here present a preliminary report about some of our new discoveries and new thoughts of the Tertiary rock units.

1　Tertiary rock units of the region

1.1　Kekemaideng Fm. at the Duolebulejin section (14.2m in thickness)

Quaternary conglomerates

~~~~~~~~~~ unconformity ~~~~~~~~~~

6. Brownish yellow conglomerates	0.9m
5. Brownish yellow medium and coarse sandstone capped with a 50cm thick layer of grayish green fine sandstone, which contains mammal fossils	0.6m
4. Brownish sandy conglomerates, with well developed cross bedding; ferromanganese nodules locally forming lens	0.3m
3. Yellowish sandstone with thin bands of conglomerates and cross bedding; yielding mammal fossils	3.5m
2. Brownish yellow conglomerates containing sandstone lens, with cross bedding	1.0m
1. Yellowish green sandstone containing mammal fossils	1.0m

---------- disconformity ----------

Halamagai Fm.

Comments: Kekemaideng Fm. is generally a set of brownish yellow sediments with
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coarse particles and well-rounded gravel, representing typical river deposits. It forms the upper part of the platform mainly distributed in Duolebulejin area on the south bank of the Ulungur River. Mammal fossils collected include a genus and species of proboscidean, 2 genera and species of perissodactyls, 3 genera and species of artiodactyls, and 1 genus and species of rodents.

1.2 Halamagai Fm. at the Tieersihabahe section (52.3m in thickness)

Kekemaideng Fm.

---------- disconformity ----------

9. Grayish white coarse sandstone with gravel, medium-and fine sandstone, light grayish green muddy sandstone, representing a sedimentary cycle 2.0m
8. Grayish-green dominated variegated muddy siltstone, capped with a layer of 10cm greenish mudstone 12.1m
7. Alternate layers of grayish white coarse conglomeratic sandstone and variegated (yellowish green dominant) muddy siltstone, with scattered mammal fossils 19.0m
6. Grayish brown, calcareous conglomerates 0.6m
5. Grayish white coarse sandstone, yielding mammal fossils 3.7m
4. Grayish green mudstone, yielding mammal fossils 1.5m
3. Grayish white sandstone with 1m thick coarse sandstone on the top, yielding mammal fossils 5.5m
2. Grayish brown ferrocalcareous cemented conglomerates 0.4m
1. Basal grayish white sandy conglomerates at the bottom grading upwards into grayish green sandstone, containing mammal fossils 7.0m

---------- disconformity ----------

Suosuoquan Fm.

Comments: Halamagai Fm. consists primarily of grayish white gravel sandstone with alternate layers of grayish green mud sandstone. It makes up most of the second stage of the Gobi platform and is distributed widely along the northern bank of the river. Scattered mammal fossils were collected from several levels; more concentrated fossils come from two layers of sandstones at the lower part of the formation. Identified fossils include 2 genera and species of insectivores, 1 genus and species of chiropterans, 1 genus and species of primates, 3 genera and species of lagomorphs, 8 families, 17 genera and 19 species of rodents, 8 genera and 9 species of carnivores, 3 genera and 4 species of proboscideans, 2 genera and species of perissodactyls, and 5 genera and 6 species of artiodactyls.

1.3 Suosuoquan Fm. at the Duolebulejin section (88m in thickness)

Halamagai Fm.

———conformity———

7. Brownish red muddy siltstone intercalated with two layers of grayish green sandstone containing mammal fossils 10.5m

6. Brownish red muddy siltstone embedded locally with conglomeratic sandstone 8.0m
5. Orange conglomeratic coarse sandstone with brownish red muddy siltstone 10.5m
4. Brownish red muddy siltstone with layers of orange sandstone 33.0m
3. Alternate layers of brownish red calcareous mudstone and calcareous sandstone 3.0m
2. Orange sandstone and brownish red mudstone; two layers of sandstone at the lower part yielding mammal fossils 21.0m
1. Brownish gray basal conglomerates containing some fragments of the underlying grayish green mudstone 2.0m

~~~~~~~unconformity~~~~~~~

"Ulunguhe" Fm.

Comments: Suosuoquan Fm. is made up mainly of brownish red muddy siltstone. Its thickness varies considerably from place to place. In the Duolebulejin area on the south bank of the river the sediments are coarser and thicker, reaching up to 110m, whereas on the north bank of the river the sediments are finer and thinner, only about 60m in the Chibaerwoyi section. Most fossils came from the two beds of the lower part of the formation. Fossils include 2 genera and 3 species of insectivores, 1 genus and species of lagomorphs, 6 genera and species of rodents, 1 genus and species of perissodactyls, and 2 genera and species of artiodactyls. We noticed that fossils from the top beds (the 7th) of the Duolebulejin section are similar to those found from the Halamagai Fm. (see additional discussion below).

1.4 Ulunguhe Fm. at Tieersihabahe section (29.2m in thickness)

Suosuoquan Fm.

——————— conformity ———————

7. Yellowish brown mudstone with layers of yellow medium and fine sandstone 10.6m
6. Yellow muddy medium sandstone 1.7m
5. Grayish brown silty sandy mudstone, containing thin layers of sandstone; the lower part containing mammal fossils 0.5m
4. Earthy yellow muddy siltstone and fine sandstone 1.5m
3. Grayish yellow silty mudstone, yielding mammal fossils 3.1m
2. Earthy yellow muddy siltstone and fine sandstone 0.9m
1. Grayish green mudstone, only 0.9m exposed

Comments: The Ulunguhe Fm. is a set of light colored deposits, mainly sandstone with mudstone lens, which underlie the Suosuoquan Fm., according to the data from Tong *et al.* (1990) and the Xinjiang Bureau of Petroleum Management (Peng, 1975). This formation is widely distributed in the middle and lower river region, exposed as badlands along the edges of the lowest Gobi platform. The Ulunguhe Fm. at the Tieersihabahe section is generally in yellowish brown color, and generates a new, rich fauna of at least 31 species of 21 genera, belonging to 17 families of 7 orders. These
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include 4 genera and 6 species of 3 families of insectivores, 1 genus and species of chiropterans, 2 genera and 4 species of lagomorphs, 10 genera and 15 species of 8 families of rodents, 1 genus and species of creodont, 2 genera and species of carnivores, 1 genus and species of perissodactyls, and 5 species of artiodactyls.

2 Contact relationships between rock units

2.1 Contact relationship between Kekemaideng Fm. and Halamagai Fm.

The Kekemaideng beds have previously been considered only to be the upper part of the Halamagai Fm., conformitively overlying the Halamagai beds. Based on our field observation, we believe the two beds are significantly different in their lithologic and biological contents and are probably separated by a sedimentary hiatus. The best preserved and thickest Kekemaideng Fm. is exposed at the west area of the Duolebulejin mesa as we described above. The formation in this region is separated from the underlying Halamagai beds by 30cm thick brownish red, ferromanganese cemented sands and conglomerates, probably representing an ancient weathering crust. The sediments of the formation become courser eastwards, being typical fluvial deposits that overlie directly on the mudstone of Halamagai beds. Because of the lithologic and biological differences and the disconformity between the two sets of beds, we believe Halamagai and Kekemaideng beds should be recognized as two formations, as we used in this study.

2.2 Contact relationship between Halamagai Fm. and Suosuoquan Fm.

The Halamagai Fm. sediments differ lithologically from those of the underlying Suosuoquan Fm. In most areas, an erosion surface at the top of the Suosuoquan Fm. and a layer of basal conglomerates at the bottom of the Halamagai Fm. have been observed. However, there are two layers of grayish green sandstone intercalated within the uppermost part of the Suosuoquan Formation in the Duolebulejin section, which are similar in its lithologic character to that of the Halamagai Fm., indicating gradual change of the sediments from the Suosuoquan Fm. upwards into the Halamagai Fm. In addition, the contained mammal fossils are similar to those of the Halamagai Fm., further suggesting the gradual change between the two rock units in this section. Therefore, the contact between the Suosuoquan and Halamagai formations in the Ulungur River region varies from conformity to unconformity.

2.3 Contact relationship between Suosuoquan Fm. and the underlying rocks

Traditionally, the light colored sediments underneath the red beds of the Suosuoquan Fm. have been assigned to the Ulunguhe Fm. Since the discovery of *Yaxartosaurus* sp. from the "Ulunguhe" Fm. at the Ermuchang section (Wu, 1973), the age of the "Ulunguhe" Fm. in the entire river region has been considered to be Cretaceous. The corollary of this consideration is that a significant gap exists between the mid-Tertiary Suosuoquan Fm. and the Cretaceous "Ulunguhe" Fm. Although a

clear sedimentary hiatus between the Suosuoquan and the "Ulunguhe" formations also occurs in the west area of the Duolebulejin area, this is not the only relationship between the two rock units. In the Tieersihabahe section, we have found a mammal fauna of typical late Oligocene age from the "Ulunguhe" Fm. and are convinced that the late Oligocene mudstone gradually changes from dark green to grayish yellow and then to red color; the latter characterizes the Suosuoquan Fm. Therefore, we believe the deposition between the late Oligocene beds and the Suosuoquan Fm. is continuous at least in the Tieersihabahe section (see further discussion below).

3 Biochronology of the rock units

3.1 Kekemaideng Fm.

Fossils are relatively few in this formation——only 7 genera and species were collected. The composition of the fossils differs considerably from that of the Halamagai Fm. They are, however, similar to that of the Tunggur fauna of Nei Mongol. The most common member from Kekemaideng Fm. is *Dicrocerus grangeri*, which is a typical element of the Tunggur fauna. Another common taxon from Kekemaideng Fm., *Platybelodon* sp., is also similar to *P. grangeri* of Tunggur. Instead of *Eotragus halamagaiensis*, which is frequent in the Halamagai Fm., the common Tunggur bovid genus *Turcocerus* occurs in the Kekemaideng Fm. (Ye *et al.*, 1999). Considered in combination, the age of Kekemaideng Fm. should be roughly equivalent to that of Tunggur Fm. although more precise determination of age requires additional evidence.

3.2 Halamagai Fm.

A rich fauna, at least 49 species of 9 mammalian orders, has been collected from the formation, but most of which came from two lower beds. Considered as a whole, the fauna most resembles the Tongxin fauna of Ningxia. Among the faunal members, *Pliopithecus*, *Alloptox*, *Heterosminthus*, *Protalactaga*, *Tachyoryctoides*, *Gobicyon*, *Platybelodon*, *Zygolophodon*, *Stephanocemas* and *Eotragus*, are all comparable at the evolutionary level to those of Tongxin. In addition, *Anchitherium* and *Palaeomeryx* are similar to those of European Sansan fauna(Ye, 1989). In short, the fauna from the lower part of the Halamagai Fm. is correlative to the middle Miocene Tongxin fauna.

3.3 Suosuoquan Fm.

There are about 13 species collected from the uppermost beds of Suosuoquan Fm., among which 9 genera and species are small mammals and nearly all also exist in the Halamagai fauna. Large mammals are quite fragmentary; identifiable taxa include *Alopecocyon goeriachensis*, *Thalassictis chinjiensis* (Wang *et al.*, 1998), *Lagomeryx* and *Eotragus*. It seems probable that the uppermost part of the Suosuoquan is middle Miocene in age. Because some of the common Halamagai species, such as *Platybelodon* and *Stephnocemas*, are not present in this part of the Suosuoquan Fm.,

it is possible that those from the uppermost part of Suosuoquan may constitute a biozone older than the Halamagai fauna.

Fossils from the lower part of the Suosuoquan are from two beds (beds A and B in the Chibaerwoyi section), but we do not think they are dividable into two biozones on the basis of available evidence. There are a total of 13 species identified from the two beds, 11 of which are small mammals. Among the small mammals, erinaceids (Bi, 2000), zapodids and tachyoryctoids appear more advanced than those of the late Oligocene Taben Buluk fauna of Gansu. On the other hand, *Aprotodon* has been reported from early Miocene of Lanzhou (Qiu and Xie, 1997), whereas *Metexallerix junggarensis* (Bi, 1999) is clearly more primitive than the early Miocene *M. gaolanshanenesis* of Lanzhou but more derived than the early Oligocene *M. hsandagolensis* of Mongolia. In addition, the Suosuoquan *Sinolagomys ulungurensis* is more similar to late ochotonids than those found in the Taben Buluk fauna (Tong, 1989). Moreover, the earliest occurrence of *Cricetodon*, which is also present in the Suosuoquan fauna, is early Miocene (MN1) in Turkey. Therefore, the Suosuoquan fauna from the lower part of the formation should be younger than the Taben Buluk and is probably of early, or earliest Miocene.

3.4 Ulunguhe Fm.

Ulunguhe Fm. was first used by the 631 geological prospecting team in 1960s, but type locality and section of the unit were not specified. Later investigations by the Xinjiang Bureau of Petroleum Management resulted in the division of the Tertiary sediments in the Ulungur River region into Paleogene Honglishan beds (Pg1 + 2), Ulunguhe beds (Pg3), Neogene Suosuoquan beds (N1), Halamagai beds (N2) and Kekemaideng beds (N3). The Ulunguhe Fm. has been widely considered as the light colored sediments underneath the characteristic red beds of the Suosuoquan Fm. In 1970s—1980s, dinosaurs including *Tyrannosaurus* sp., Ceolurosauria indet., *Bactrosaurus* sp. and *Yaxartosaurus* sp. were found from the light colored sediments underneath the Suosuoquan Fm. at the section north to the Ermuchang village. As a result of these discoveries, the age of the Ulunguhe Fm. was then believed to be late Cretaceous (Tong *et al.*, 1990).

Our field investigations reveal that the Suosuoquan Fm. apparently onlaps a ste of light colored sediments of different ages. It rests on the Cretaceous beds at the Ermuchang section, but is continuous with the underlying beds in the Tieersihabahe section, as we described above. In the Tieersihabahe section, the beds below the Suosuoquan Fm. yield a rich fauna of at least 31 species of 21 genera in 7 orders. Among these are typical Tabenbulukian elements such as erineicids, zapodids, ctenodactylids, *Sinolagomys*, *Tachyoryctoides*, and *Didymoconus*. The age of this fauna is undoubtedly of late Oligocene. In the badlands west to the Duolebulejin section, the Suosuoquan Fm. overlies a stack of grayish green sandstones and mudstones, in the

lower part of which a ctenodactyloid, probably *Advenimus*, was collected. This taxon suggests an age of late early or early middle Eocene. Therefore, it is certain that sediments of different ages underlie the Suosuoquan Fm. at different areas of the studied region and the "Ulunguhe" Fm. obviously calls for redefinition.

4 Conclusion

We have briefly reported and analyzed the Tertiary beds ranging from Eocene to middle Miocene in the Ulungur River area on the northern rim of the Junggur Basin. Several mammal faunas have been found from these deposits. These deposits represent a relatively continuous succession of Tertiary beds rich in mammal fossils and provide a great potential opportunity to carry on researches of high-resolution stratigraphy and related issues such as recognition of the Oligocene-Miocene boundary and reconstruction of the relationships between mammal evolution and environmental changes during the period of time recorded in the sediments.

Acknowledgements This work was supported by the National Natural Science Foundation of China (Grant No. 04957280), the Chinese Academy of Sciences (Grant No. KZ952-J1-410) and the Special Funds for Paleontology and Paleoanthropology of CAS (Grant No. 95602 and 9810).

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