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甘肃省党河地区的新生代地层和青藏高原隆升[1)]

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摘要 甘肃省党河流域是亚洲渐新统的经典地区之一,但长期以来人们对这一地区的地层层序和时代的认识并不清楚,命名也很混乱。我们的考察表明该地区新生代地层包括渐新统狍牛泉组(新建组),中新统铁匠沟组(新建组),中新统—上新统和更新统四套;产有代表三个不同时代的哺乳动物群:早渐新世晚期叮当沟、晚渐新世燕丹图和早中新世西水沟三个哺乳动物群。该地区的岩性和地质构造表明,青藏高原在中新世时发生过强烈的抬升。

关键词 甘肃省党河地区,新生代,哺乳动物,青藏高原
中图法分类号 P534.6,Q915.873

党河流域位于甘肃省西部敦煌盆地的南部,祁连山与阿尔金山相接处的党河南山的北侧。在地理位置上属青藏高原北缘(图 1)。该地区新生代地层出露广泛,并产有较丰富的化石,是亚洲古近纪的经典地区之一。早在 20 世纪 30 年代初,瑞典人 Bohlin 就对党河地区新生代地层进行了考察,并称党河地区为 Taben-buluk 地区。尽管他认为在该地区发现的化石代表不同的时代(包括渐新世和中新世),但因该地区地层构造复杂,他并未对地层进行划分,也未命名,对所采化石仅标明其产出地点,而未确定其层位(Bohlin,1937,1942,1945,1946,1960)。20 世纪 50 年代以来,我国的地质工作者对该地区的有关地层均采用了邻近的玉门盆地的岩组名称,而且是众说纷纭,十分混乱。中国地质学会编辑委员会等(1956)首先称该地区的新生代地层为第三纪甘肃系,并将其分为火烧沟统、"白杨河统"和疏勒河统。但他们笼统认为 Bohlin 所报道的哺乳动物化石产自甘肃系。甘肃地质力学区测队(1976)称党河地区的新生代地层为上第三系(=新近系),并将其分为中新统白杨河组和上新统疏勒河组。他们还明确指出 Bohlin 所报道的哺乳动物化石均产自白杨河组的下岩段,其时代为中新世。但甘肃省地层表编写组(1980)和李云通等(1984)将党河地区的新生代地层分为古近系渐新统火烧沟组、新近系上新统疏勒河组和第四系,而无

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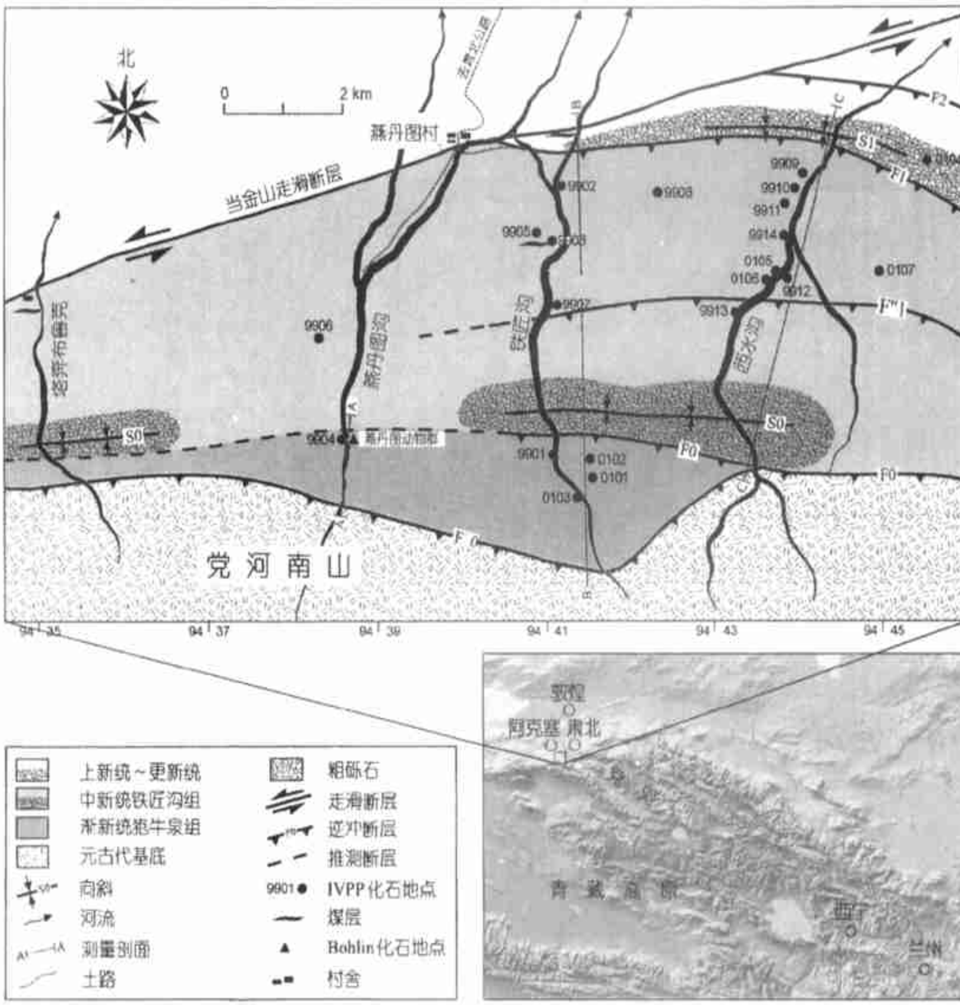

图 1　党河地区地质图和化石地点

Fig. 1　Geologic map of the Danghe area and fossil localities

图中化石点号 9901 等和 0101 等分别为 DH 199901 等和 DH 200101 等的缩写

白杨河组。他们认为 Bohlin 所报道的化石均产自火烧沟组。而甘肃省区调队(1984)认为党河地区的第三系可分为渐新世白杨河组和新近纪疏勒河组,无火烧沟组,Bohlin 报道的哺乳动物化石群产于白杨河组,很可能是白杨河组的上部,时代为晚渐新世。甘肃省地矿局(1989)赞同区调队的意见,但指出 Bohlin 所报道的中新世哺乳动物群的产出层位不清。20 世纪 90 年代以来,青藏高原成为全世界研究的热点,处于青藏高原北缘的党河地区也得到地质学家们的广泛关注。一些中、外学者在该地区做了一些地质构造和古地磁工作。但有关地层时代仍主要基于 Bohlin 对该地区有晚渐新世和中新世地层的看法(Wang, 1997; Guo and Xiang, 1998; Gilder et al., 2001; Van der Woerd et al., 2001)。

1999 年和 2001 年中国科学院古脊椎动物与古人类研究所、甘肃省考古所和甘肃省博物馆共同组队对该地区进行了考察。我们不但发现了更多的哺乳动物化石,确认了产化

石的确切地点和层位,而且区分出代表不同时代的地层,对该地区的新生代地层有了许多新的认识,使一些问题得以澄清。

1 关于党河地区新生代地层的新认识

甘肃地质力学区测队(1976)认为沿铁匠沟出露的地层均为中新统白杨河组。我们沿铁匠沟、西水沟和燕丹图沟测制了三条剖面。根据岩性,沿铁匠沟除了更新统以外,还有三套新生代地层出露。现将铁匠沟剖面简要描述如下(图 2):

更新统玉门砾岩

══════当金山走滑断层(ATF)══════

中新统—上新统 >191m

19~18. 棕色(5YR 5/4) 块状泥岩与绿灰色(5GY 6/1)块状砂砾岩互层,中部含少量褐煤透镜体

══════逆断层(F1)══════

中新统铁匠沟组 >2668m

17~13. 灰红色(10R 4/2)、灰褐色(5YR 5/2) 块状砾岩、角砾岩夹淡红棕色(10R 5/4)砂岩、粉砂岩和泥岩 385m

12~10. 淡红棕色(10R 5/4) 砂岩、粉砂岩、泥岩与灰褐色(5YR 5/2)砂岩、粗砂岩、砂砾岩互层,产哺乳动物和龟化石(DH 199903、199905、199907) 1543m

9. 浅棕色(5YR 5/6)块状泥岩,夹灰绿色(5GY 6/1)砂岩和细砾岩透镜体和薄层状粉砂岩,产哺乳动物和植物化石(DH 199902) 740m

══════逆断层(F0)══════

渐新统狍牛泉组 >1233m

8~7. 红棕色(10R 4/4)、淡红棕色(10R 5/4)泥岩、粉砂岩夹浅红棕色(10R 5/4)砂岩、砂砾岩和砾岩,产哺乳动物化石(DH 200101~200102) 184m

6. 淡红棕色(10R 5/4)块状石英砾岩,夹薄层状砂岩、细砾岩透镜体,产哺乳动物化石(DH 199901) 42m

5~3. 红棕色(10R 4/4)、浅棕色(5YR 6/6)泥岩、粉砂岩夹灰绿色(5GY 6/1)细粒砂砾岩,产哺乳动物化石(DH 200103) 835m

2. 暗红棕色(10R 5/4)块状泥岩与中红棕色(10R 4/6)块状砂质泥岩互层 157m

1. 中红棕色(10R 4/6)块状泥岩 15m

══════逆断层(F′0)══════

震旦系多若诺尔群中岩组:灰白色变质灰岩与变质砂岩

从上述剖面可以看出,铁匠沟的新生代地层,除更新统外,包括了三套岩层,并代表三个不同时代。该地区有关地层岩组的命名,正如前面已指出的,前人均采用邻近的玉门地区的岩组名称,如火烧沟组、白杨河组和疏勒河组等。我们阅读了上述岩组建组时对岩性的原始描述(孙健初,1939a,b[1),1942),并对建组地点玉门地区的有关地层进行了实地考

1) Sun C C(孙健初),1939a. Priliminary Report on Geology of Yumen Oilfield (Shiyouhe, Ganhegou, Sanjuewan Region). (in Chinese, unpublished)

Sun C C (孙健初),1939b. Report on Geology of Yumen Oilfield of Gansu. (in Chinese, unpublished)

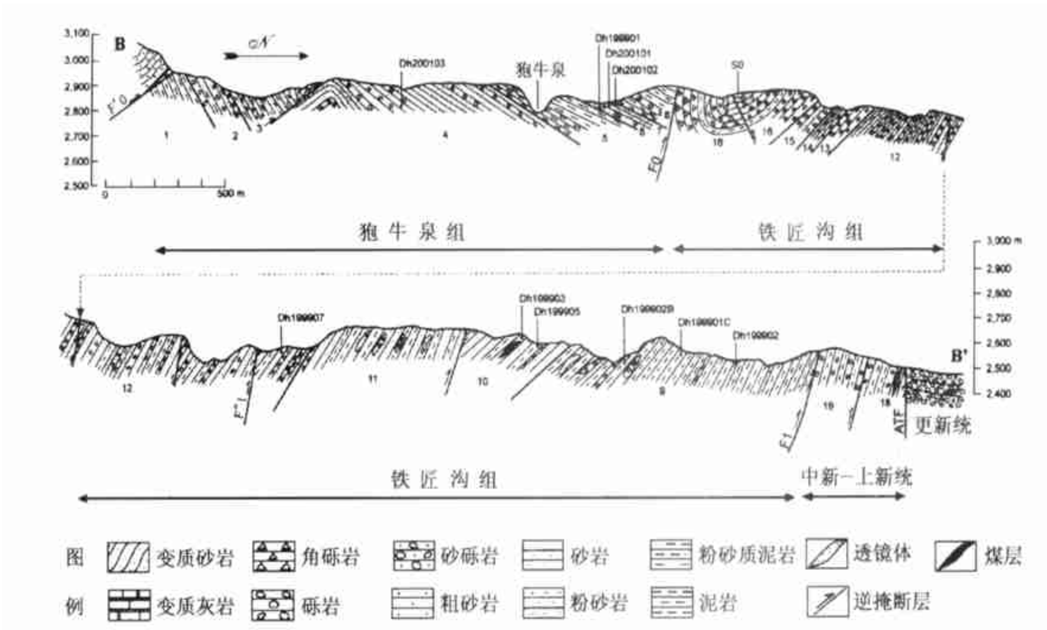

图 2　铁匠沟新生代地层实测剖面

Fig. 2　Measured section of Cenozoic strata in Tiejianggou

ATF,当金山走滑断层(Altyn Tagh Fault) (依 Wang, 1997) ; F0、F′0、F1、F″1 分别为断层代号 (names of faults)

察和比较。我们发现党河地区的中—晚新生代地层与玉门地区的上述岩组岩性的差别很大。火烧沟组的命名地点在玉门地区火烧沟一带。其主要岩性为暗红色或砖红色角砾岩、砂岩和砂质泥岩(甘肃省地层表编写组,1980;李云通等,1984)。而且该岩组的分布被认为仅限于玉门盆地北部(地质部甘肃省第二区测队,1969;甘肃省区调队,1984;甘肃省地矿局,1989;杨藩等,1994)。白杨河组和疏勒河组都是孙健初(1939)建的,建组剖面均位于甘肃玉门市石油沟(孙健初,1939a,b,1942)。白杨河组的岩性是:下部为桔红色黏土质砂岩,往往夹有石膏和油层;上部为深红色黏土及黄白色砾石砂岩(孙健初,1939b)。显然,党河地区晚新生代地层的岩性与火烧沟组和白杨河组的差别明显。党河的岩层如果继续用上述岩组名称显然是不合适的。因此,我们将有关地层分别命名为渐新统狍牛泉组和中新统铁匠沟组。我们对最上部的第三套岩组的认识还不清楚,暂不命名。

在党河地区狍牛泉组主要分布在党河南山北缘,东起西水沟,西至五个泉子(即Taben-buluk)以西的长约30km的东西向延伸的狭长地带,南北向最宽处在铁匠沟附近,约2km。岩性由下往上逐渐变粗。下部为中红棕色和暗红棕色块状泥岩和砂质泥岩,中部为红棕色和浅棕色粉砂岩夹细粒砂砾岩,上部为红棕色和淡红棕色块状石英砾岩和泥岩、粉砂岩夹砂岩、砂砾岩和砾岩。其下以断层与元古代地层接触,其上与中新统铁匠沟组也以断层接触。中新统铁匠沟组也主要呈东西向展布,其分布面积要比狍牛泉组广大得多。它东起肃北蒙古族自治县的拉排沟附近,西到阿克塞哈萨克族自治县的半鄂博附近。东西长约40km余,南北向最宽处也在铁匠沟附近,宽约5km。岩性由下往上也逐渐由细变粗。下部为浅棕色块状泥岩夹灰绿色砂岩和细砾岩和薄层状粉砂岩,中部为淡红棕色砂

岩、粉砂岩、泥岩与灰褐色砂岩、粗砂岩、砂砾岩互层,上部为灰红色、灰褐色块状砾岩、角砾岩夹淡红棕色砂岩、粉砂岩和泥岩。铁匠沟组上部与中新统—上新统或更新统分别以断层接触。

Van der Woerd 等(2001)在西水沟附近作了有关地层构造方面的考察,并测有剖面。在此基础上,Gilder 等(2001)在西水沟采了古地磁样品。尽管 Bohlin 在西水沟所采的哺乳动物化石均属中新世,但他们错误地认为在西水沟出露的新生代地层的时代为晚渐新世—中新世。因此,他们把西水沟剖面的古地磁资料解释为 26~19Ma,也就是说这套地层的时代为晚渐新世—早中新世中期。而我们对哺乳动物化石和岩层的研究表明,西水沟只有中新统铁匠沟组并无渐新统存在,西水沟铁匠沟组下部产哺乳动物化石的岩层的时代为早中新世(详见下节)。基于这一认识,我们将 Gilder 等(2001)的古地磁剖面与 Berggren 等(1995)的古地磁年代的标准剖面比较,认为西水沟剖面的时段应为 20~9.3Ma,即从早中新世中期至晚中新世早期(图 3)。

2 三个不同时代的哺乳动物群的发现

Bohlin (1946)曾指出,在党河地区除了存在渐新世燕丹图哺乳动物群(Yindirte fauna)外,还存在时代较晚的哺乳动物群,其时代可能为晚中新世。但 Bohlin 并未指出这些哺乳动物群的确切产出层位。我们在考察期间,共发现了 21 个脊椎动物化石地点,并发现了许多新的门类。不但所有这些地点的层位都是清楚的,而且确认了 Bohlin 所采化石的层位。这样,我们不但确认了在党河地区的确有晚渐新世哺乳动物群存在,并证明了 Bohlin 的中新世哺乳动物群的时代不是晚中新世,而是早中新世。更有意义的是我们还发现了早渐新世哺乳动物群。这样,党河地区就存在代表不同的时代的三个哺乳动物群:早渐新世晚期、晚渐新世和早中新世。

早渐新世晚期叮当沟哺乳动物群:以铁匠沟南段狍牛泉组下部的 IVPP Locs. DH 199901、DH 200101~200103(中国科学院古脊椎动物与古人类研究所野外地点编号,DH 为党河的缩写,以下同)地点为代表。产有戈壁链兔(*Desmatolagus gobiensis*)、微型链兔(*D. pusillus*)、似西格玛塔塔鼠(*Tataromys* cf. *T. sigmodon*)、圆柱鼠(*Cyclomylus* sp.)、双猬?(*Amphechinus* ? sp.)、cf. *Sivameryx* sp.、*Phyllotillon* sp.、巨獠犀?(*Aprotodon* ? sp.)等。其中 *Sivameryx*、*Phyllotillon* 和 *Aprotodon* 虽已知最早出现的时代为晚渐新世,但 *Desmatolagus gobiensis* 和 *Cyclomylus* 过去只在早渐新世地层中发现,而其余的小哺乳动物的最早出现的时间也是早渐新世。该动物群的时代为早渐新世晚期较合适。

晚渐新世燕丹图哺乳动物群:晚渐新世燕丹图哺乳动物群(Yindirte fauna)是 Bohlin (1946)命名的。他将 Taben-buluk 地区以燕丹图地点的化石为代表的动物群命名为 Yindirte fauna。Li and Ting (1983)在总结中国的古近纪哺乳动物群时,没有使用 Yindirte 动物群,而是用 Taben buluk 作为中国晚渐新世哺乳动物期(Tabenbulukian)。从此,党河地区的晚渐新世哺乳动物群就普遍被称为塔奔布鲁克动物群(Taben-buluk fauna)。由于 Bohlin 的 Yindirte fauna 的命名在先(1946),加上"Taben-buluk"这一名称在地图上没有(地图上只有其汉语"五个泉子"),因此我们建议恢复使用燕丹图哺乳动物群(Yindirte fauna)。通过考察,我们已确认燕丹图哺乳动物群产于狍牛泉组的上部,以燕丹图沟 Bohlin 所采化石点

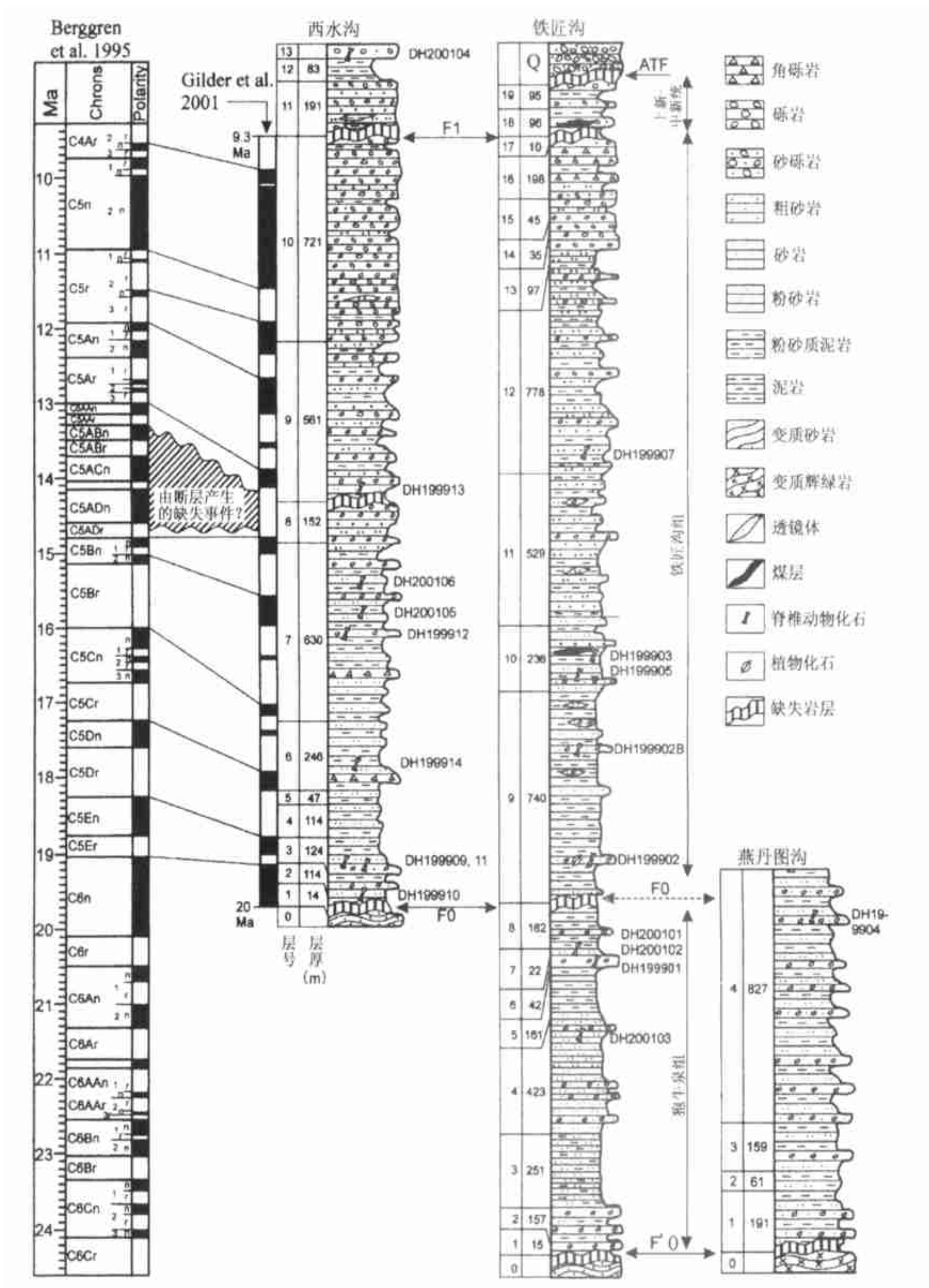

图 3　党河地区新生代地层柱状对比图(断层简写说明同图 2)

Fig. 3　Composite stratigraphic column of Danghe area (Abbreviations see Fig. 2)

和我们的 IVPP Loc. DH 199904 点为代表,所产化石主要为 Bohlin 的晚渐新世燕丹图动物群(Yindirte fauna)的成员(Bohlin,1942,1946)。

早中新世西水沟哺乳动物群:西水沟哺乳动物群产于铁匠沟组的下部。化石地点包括:IVPP Locs. DH 199902、199909~199911、199914 等。所发现的哺乳动物化石有:斜齿豪鼠(*Sayimys obliquidens*)、党河铲齿象(*Platybelodon dangheensis*)、*Turcocerus* sp.、*Amphimoschus* cf. *A. artenensis*、*Schultzogale* n. sp. 和"甘肃猿"("*Kansupithecus*" sp.)等。其中 *Sayimys* 的时代为早—晚中新世,*Amphimoschus* 为早—中中新世。*Platybelodon* 在亚洲的时代分布虽为中—晚中新世,但在非洲在早中新世时已出现,而且党河的 *Platybelodon dangheensis* 显然要比亚洲中中新世的 *Platybelodon* 原始,也比非洲早中新世的 *Platybelodon* sp. 原始(王伴月、邱占祥,2002)。综合分析该动物群,其时代很可能为早中新世。

需要指出的是,西水沟的铁匠沟组的中部 7~9 层根据古地磁的解释,时代似乎应为中中新世。但其中(代表地点为 DH 199912、199913、200105 和 200106)所产哺乳动物化石(*Litodonomys* sp. 和 *Phyllotillon* sp.)的面貌确显得较老。因为 *Litodonomys* 已知的地质时代为晚渐新世,而 *Phyllotillon* 在亚洲已知的地史分布为晚渐新世—早中新世。可惜,所产的哺乳动物化石还太少,这一问题还有待我们进一步工作来解决。另外,铁匠沟剖面的第 10 层的 DH 199903 所产异蹶鼠(*Heterosminthus* sp.)的时代也有类似问题。

3 党河地区新生代地层与青藏高原抬升的关系

在党河地区的新生代地层中最老的地层是狍牛泉组。发现早渐新世晚期哺乳动物化石的层位(DH 200103)距岩层底部有 800m 余,而且它和老岩层呈断层接触,其下部很可能还有岩层缺失。这表明党河地区很可能最早是在最早渐新世,或甚至在始新世末已开始接受沉积。渐新统狍牛泉组以红棕色泥岩和粉砂质泥岩等细碎屑岩为主。岩性表明在渐新世时,党河地区地形还比较平缓,青藏高原的抬升对该地区的影响还不明显。其气候环境与现在华北的比较相似,较干燥。中新统铁匠沟组下部岩性仍较细,为浅棕色泥岩,往上岩性变粗(从铁匠沟剖面看,从第 10 层开始已有大量的砂砾岩出现。而在西水沟剖面,从 7 层开始出现大量的砂砾岩层,再往上则变为以砾岩为主)。根据对砾岩中的砾石的覆瓦状态等的分析表明水流方向是由南向北的。从沉积速率来看,在西水沟的 1~6 层(其古地磁年代约为 20~16Ma)沉积速率为 16.5cm/千年,而 7~10 层(16~9.3Ma)的沉积速率为 36.2cm/千年。这表明在中新世较早期时,该地区仍较平静。但到了中中新世的早期(大约在 16Ma)时,其南侧的青藏高原已明显抬升,而且越往后期越剧烈。

上中新统—上新统的下部也为棕色泥岩,往上也变粗,变为砂砾岩层。代表由细到粗的第二次旋回。因在其中只找到一段象的肱骨,其确切的时代还不清楚。这一旋回究竟是由于气候的巨大变化引起的,还是表明青藏高原又一次剧烈的抬升,目前还不清楚,还有待更多的资料予以证实。更新统(可能包括上上新统)为厚的砾岩层,而且伴随着不同类型的断层(逆断层、走滑断层等),反映了青藏高原的又一次抬升和向北的挤压。

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CENOZOIC STRATIGRAPHY IN DANGHE AREA, GANSU PROVINCE, AND UPLIFT OF TIBETAN PLATEAU

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Summary

The Danghe area, located in the western-most part of the Gansu Province, is southerly bordered by the Tibetan Plateau. It is one of the classic areas in the Asian Paleogene biostratigraphy. Early in the 1930s Bohlin explored this area and collected plenty of mammalian fossils. However, he did not further subdivide the strata he surveyed, nor did he name the strata or give clear indication of the fossil levels. The main reason of his hesitation was the extremely complex tectonic structure of the area (Bohlin, 1937, 1942, 1945, 1946, 1960). Since the 1950s the Danghe strata have been variously assigned to formations founded in the Yumen Basin more than 200 km to the northeast, such as Huoshaogou, Baiyanghe, Shulehe formations and Yumen Gravels. However, no detailed lithologic comparison between the Danghe area and Yumen Basin has ever been carried out. Furthermore, the stratigraphic position of Bohlin's fossils has never been satisfactorily clarified. Since the 1990s when the Tibetan Plateau became an area of intense studies, the Danghe area has gained worldwide attention among geologists. Tectonic and paleomagnetic study has been conducted there. Unfortunately, all these endeavors were based on outdated or wrong stratigraphic data (Wang, 1997; Guo and Xiang, 1998; Gilder at al., 2001, Van de Woerd et al., 2001).

In 1999 and 2001, a joint team of the Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences (IVPP), the Cultural Relic Archaeology Institute of Gansu and the Gansu Provincial Museum made geologic survey of the Danghe area. As a result, a number of stratigraphic problems were clarified based primarily on new interpretation of the rock sequences and the newly found mammalian fossils.

1 Cenozoic stratigraphy of the Danghe area

On closely comparing the lithology of the Danghe area with that of the Yumen Basin, we found it inappropriate to directly apply the formational terminology created in the Yumen Basin to the Danghe strata. Two new formations were established. The Oligocene Paoniuquan Formation is mainly composed of brown and red mudstone and siltstone. The Miocene Tiejianggou Formation includes two parts, the lower part is mainly composed of light brown mudstone and the upper part is mainly composed of sandy conglomerate. As a result, the Tertiary strata in the Danghe area are subdivided into Oligocene Paoniuquan Formation, Miocene Tiejianggou Formation and Miocene-Pliocene beds (unnamed).

The paleomagnetic data from the Xishuigou section was interpreted as belonging to the timespan of 26～19 Ma by Gilder et al. (2001). This interpretation was apparently based on Bohlin's mammalian faunas, which were identified as Oligo-Miocene in age. The newly found fossils (vide infra) demonstrated clearly that the deposits of the Xishuigou section were formed in middle early Miocene-early late Miocene (20～9.3 Ma). Therefore, a new interpretation of Gilder et al.'s paleomagnetic data is suggested (Fig. 3).

2 Mammalian faunas

Late early Oligocene Dingdanggou Mammalian Fauna is collected from IVPP Locs. DH 200101～200103 in the lower part of the Paoniuquang Formation. The fossils include *Desmatolagus gobiensis*, *D. pusillus*, *Tataromys* cf. *T. sigmodon*, *Cyclomylus* sp., *Amphechinus* ? sp., cf. *Sivameryx* sp., *Phyllotillon* sp., and *Aprotodon* ? sp. Among them the earliest occurrence of *Sivameryx*, *Phyllotillon* and *Aprotodon* are known in late Oligocene. However, *Desmatolagus gobiensis* and *Cyclomylus* are known to occur only in early Oligocene. The earliest appearance of the other micromammals is also in the early Oligocene.

The Yindirte Fauna was formally named as a representative Oligocene mammalian fauna by Bohlin (1946). Later it was renamed as Taben-buluk fauna (Li and Ting, 1983, Tong at al., 1995). Since most of the taxa of this fauna were actually collected from the locality Yindirte and Bohlin's Yindirte fauna has priority over the Taben-buluk one, it is preferable to resurrect the Yindirte Fauna. Based on the newly found fossils at IVPP Loc. DH 199904, which are identical with those of Bohlin's Yindirte fauna, we came to the conclusion that the Yindirte fauna is from the upper part of the Paoniuquan Formation.

The localities yielding the Early Miocene Xishuigou Mammalian Fauna are IVPP Locs. DH 199902, 199909～199911 and 199914 in the lower part of the Tiejianggou Formation. The fossils include *Sayimys obliquidens*, *Platybelodon dangheensis*, *Turcocerus* sp., *Amphimoschus* cf. *A. artenensis*, *Schultzogale* n. sp. and "*Kansupithecus*" sp. Among them *Sayimys* is known from early through late Miocene and *Amphimoschus* and *Platybelodon* are from early through middle Miocene. *Platybelodon dangheensis* (Wang and Qiu, 2002) is more primitive than the early Miocene *Platybelodon* sp. from Africa. The Xishuigou fauna is of early Miocene in age.

It is necessary to mention that according to the paleomagnetic interpretation Level 7～9 in the Xishuigou section is middle Miocene in age. However, the mammal fossils found from these levels (*Litodonomys* sp. and *Phyllotillon* sp. from IVPP Loc. DH 199912, 199913, 200105 and 200106) seem to indicate an earlier age than middle Miocene, because *Litodonomys* has so far been known only from late Oligocene and *Phyllotillon* from late Oligocene through early Miocene in Asia. Unfortunately the fossils are too scanty to be conclusive in age determination. Likewise, Level 10 in the Tiejianggou section bearing *Heterosminthus* sp. has the same problem.

3 Possible implications on the uplift of the Tibetan Plateau

The lithology of the Oligocene Paoniuquan Formation (mudstone and siltstone) tends to show that the topography during the Oligocene might have not been strongly contrasting, resulting in purely fine-grained deposits. The upper half of the Tiejianggou Formation is characterized by massive conglomerates. It indicates that in the early middle Miocene (～16 Ma) the Tibetan Plateau uplifted to a considerable elevation, causing intensive weathering. The upper Miocene-Pliocene bed is another coarsening upward sequence, terminating in massive conglomerates. This should be the second cycle of tectonic activity terminating with second pulse of strong uplift in late Pliocene. The thick conglomerates and the slip-faulting system occurred in the Quaternary period represent the last episode of strong uplift combined with northeastward extrusion.

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