第49卷 第3期
2011年7月

古脊椎动物学报
VERTEBRATA PALASIATICA

pp.285－310
figs.1－11

步林在青海柴达木盆地的早期工作记录——经典脊椎动物化石地点与现代地层框架的解译[1)]

王晓鸣[1,2,4] 颉光普[3] 李 强[1] 邱铸鼎[1] 曾志杰[2,4]
Gary T. TAKEUCHI[2] 王伴月[1] 傅铭楷[5]
Asta ROSENSTRÖM-FORTELIUS[6] Håkan WAHLQUIST[7]
董维霖[8] 张春福[9] 王 杨[9]

（1 中国科学院古脊椎动物与古人类研究所,脊椎动物进化系统学重点实验室 北京 100044）
（2 美国洛杉矶自然历史博物馆 洛杉矶 CA 90007）
（3 甘肃省博物馆 兰州 730050）
（4 美国南加州大学 洛杉矶 CA 90007）
（5 芬兰赫尔辛基大学 赫尔辛基 FIN-00014）
（6 芬兰赫尔辛基 Adolf Lindfors väg 5 A 6, FIN-00400）
（7 瑞典民俗博物馆 斯德哥尔摩 102 52）
（8 美国北亚利桑那大学 佛拉格斯塔夫 AZ 86001）
（9 美国佛罗里达州立大学 塔拉哈西 FL 32306）

1931～1932年,博格·步林两次率领中瑞考察团(又名斯文·赫定考察团)到青海省柴达木盆地东部进行考察,在克鲁克湖与托素湖地区首次发现了丰富的新近纪哺乳动物化石。这批化石成为我国早期青藏高原古生物研究的奠基石。直至今日,双湖地区仍是青藏高原脊椎动物化石最丰富、研究程度最高的地区。柴达木盆地新近纪的堆积巨厚且连续,地层构造相对简单,盆地北缘地层出露好,是研究陆生哺乳动物演化的理想地点。然而,双湖地区地层的时代跨度超过13 My, 厚度接近4600 m, 如果化石层位不明,很容易引起动物群成分的混乱。步林对此似乎缺乏足够的认识,对所有采集的化石未做分层处理,导致后人对"柴达木动物群"年代的解释引起不少异议。

步林并非对地层不重视。恰恰相反,他如同在甘肃塔奔布鲁克盆地的工作中那样,在缺乏地形图和地质资料的条件下做了大量的基础地层工作。他利用明显的地物(山顶)和地质构造(背斜)作为参照系统,仔细地记录了化石的出露地点,并编制了一些草图。步林去世后,家属把他的野外记录留给赫定档案馆(Svan Hedin Archives), 在斯德哥尔摩

1) 中国科学院知识创新工程重要方向项目(编号:KZCX2-YW-Q09)、国家自然科学基金重点项目(批准号:40730210)和美国国家科学基金(编号:EAR-0446699, 0444073, 0958704)资助。

收稿日期:2009-12-20

分几处收藏。遗憾的是,如同塔奔布鲁克盆地的情况,步林未能发表很多十分关键的化石地点资料,而发表的地质记录却被多数人忽略,所出版的游记也鲜为人知,个人档案记录更是深埋于历史的文献中。直到 1999 年,本文第一作者才首次接触到一些步林的野外原始资料。经过近 10 年多次对赫定档案馆的访问和对步林原始记录反复的野外核实,最终才将步林的经典地点结合进现代地层顺序的框架中。

本文是继对步林塔奔布鲁克盆地燕丹图动物群经典地点与地层的研究后,进一步对其柴达木盆地化石地点的厘定与复原,是本系列文章之二。目的是将过去混淆于各地点的动物群逐一解译,将不同时代的化石分子置于现代地层与年代框架之中。幸运的是,步林的诸多野外记录都保存完好,结合发表的个人游记及地质记录,他所发表的多数哺乳动物化石都可以恢复到一定地层范围之内,尚能尽量减小经典化石地点的不确定性。本文试图整理步林未发表的珍贵资料,通过综合考证其他已发表的信息,结合作者在 1998 ~ 2010 年多次野外考察的结果,以期理顺柴达木地区经典化石点与现代地层框架的关系。这里将着重探讨经典化石点的生物地层学问题,并将步林柴达木盆地化石地点的野外记录资料译成英文附入文后,至于我们在柴达木盆地发现的其他化石点暂不涉及。

步林主要在三个地区采集了化石:托素湖北岸、怀头他拉村南及泉水梁火车站附近。尽管步林清楚地意识到其化石来自几千米厚的地层,但他统称其为柴达木动物群,成为以后混乱的主要原因。根据对柴达木新近纪的地层古生物考察,我们至少可以辨认出 4 个动物群:中中新世欧龙布鲁克动物群、晚中新世早期托素动物群、深沟动物群和早上新世怀头他拉动物群。

(1) 中中新世欧龙布鲁克动物群。化石主要产于剖面底部克鲁克背斜两翼接近轴部的红色泥岩及绿色砂岩中。该动物群的成员发现较少,步林和我们都找到不多,主要来自两个地点:怀头他拉剖面步林 165 号营地附近及泉水梁火车站东北 800 m 左右处 。包括以下几个种类(括号内为步林的化石编号;该系列号码在步林的柴达木专著中广泛应用):*Olonbulukia tsaidamensis* (Nr. 356), *Lagomeryx tsaidamensis* (Nr. 361), *Stephanocemas* (Nr. 368, 407), ?*Dicroceros* (Nr. 372, 397), ?*Eostyloceros* (Nr. 396, 399, 401), *Acerorhinus tsaidamensis* (Nr. 330, 346, 374, 381)。

(2) 晚中新世早期托素动物群。该动物群最初发现于托素湖北岸的狭长露头。步林对该点的记录最详细,其中各化石层位都被我们一一找到。托素湖的含哺乳动物化石层位局限在诺令根河(连接克鲁克湖与托素湖之间的小河)北岸 100 m 的地层中,是步林所有化石点中能最精确地确定层位的一个点(即步林托素湖化石点都可以恢复到该段 100 m 地层中)。根据目前古地磁测量结果,该点 100 m 地层可以精确到 0.3 Ma 范围之内。相当于含托素动物群层位的化石地点在怀头他拉剖面中也少量存在,但多数化石不特征,估计步林在此也找到不多。托素动物群最丰富的化石点在泉水梁车站东南的狭长露头。步林称做“一般条带”(“General Strips”)。在厚度不到250 m, 北西-南东方向延伸达 8 km 的地层中,化石均匀散布、保存完好,是柴达木目前最丰富的化石点。托素动物群包括以下种类(括号内为步林的化石编号):“*Ictitherium* sp.” (Nr. 542), *Tsaidamotherium hedini* (Nr. 447, 457), *Tossunnoria pseudibex* (Nr. 449, 481, 537), *Qurliqnoria cheni* (Nr. 441), *Qurliqnoria* sp. (Nr. 508), *Olonbulukia tsaidamensis* (Nr. 429), Chalicotheriidae indet.

(Nr. 317), *Hipparion* sp. (Nr. 352, 444, 467, 493, 498, 500, 501, 523, 553), *Acerorhinus tsaidamensis* (Nr. 418, 430, 438, 456, 459, 488, 502-4, 511, 516, 525-7, 536, 538, 555-6), ? *Tetralophodon* (Nr. 458, 487, 524, 530, 534), Giraffidae indet. (Nr. 316, 320), ? *Eostyloceros* (Nr. 334, 349)。另外我们在泉水梁地点也找到大量化石,研究后可望增加更多的成员。

泉水梁是我国少数几个三趾马出现最早的地点之一。该剖面目前还没有古地磁资料,但通过与怀头他拉古地磁剖面的对比,泉水梁三趾马出现的最低层位应大致在 C5r. 1r 反向带与 C5r. 1n 正向带之间(约 11. 12 Ma)。另外托素动物群所代表的时代,是青藏高原首次出现独特种类的时代。牛羊科中具有高原特色的种类包括 *Tsaidamotherium hedini*, *Tossunnoria pseudibex*, *Qurliqnoria cheni* 和 *Olonbulukia tsaidamensis*, 其中 *Qurliqnoria cheni* 可能是现代藏羚羊(*Pantholops*)的祖先类型。

(3) 晚中新世早期深沟动物群。深沟动物群是根据德令哈南部深沟剖面的化石建立的。产该动物群的地层虽然在怀头他拉剖面中段出露,但目前还没找到特征的化石。步林的个别不确定的化石有可能属于深沟动物群。邱铸鼎和李强最近(2008)对深沟的小哺乳动物做了详细的描述,认为与陕西蓝田霸河组下部的小哺乳动物组合最接近。

(4) 早上新世怀头他拉动物群。怀头他拉动物群也处于怀头他拉剖面上部化石不丰富的地段。从步林的野外记录中,惟一能够比较确定的化石是一些驼鸟蛋片。我们也仅增加了几种小哺乳动物(未研)。

关键词:青海,青藏高原,新近纪,哺乳动物,生物地层,年代学

中图法分类号:Q915. 873, P534. 62 **文献标识码**:A **文章编号**:1000 - 3118(2011)03 - 0285 - 26

EARLY EXPLORATIONS OF QAIDAM BASIN (TIBETAN PLATEAU) BY BIRGER BOHLIN—RECONCILING CLASSIC VERTEBRATE FOSSIL LOCALITIES WITH MODERN BIOSTRATIGRAPHY

WANG Xiao-Ming[1,2,4] XIE Guang-Pu[3] LI Qiang[1] QIU Zhu-Ding[1] Zhijie J. TSENG[2,4] Gary T. TAKEUCHI[2] WANG Ban-Yue[1] Mikael FORTELIUS[5] Asta ROSENSTRÖM-FORTELIUS[6] Håkan WAHLQUIST[7] William R. DOWNS[8] ZHANG Chun-Fu[9] WANG Yang[9]

(1 *Key Laboratory of Evolutionary Systematics of Vertebrates*, *Institute of Vertebrate Paleontology and Paleoanthropology*, *Chinese Academy of Sciences* Beijing 100044, China xwang@ nhm. org)
(2 *Natural History Museum of Los Angeles County* Los Angeles 90007, California, USA)
(3 *Gansu Provincial Museum* Lanzhou 730050, China)
(4 *University of Southern California* Los Angeles 90007, California, USA)
(5 *University of Helsinki* Helsinki FIN-00014, Finland)
(6 Adolf Lindfors väg 5 A 6, FIN-00400 Helsingfors, Finland)
(7 *Museum of Ethnography* Stockholm 102 52, Sweden)
(8 *Northern Arizona University* Flagstaff 86001, Arizona, USA)
(9 *Florida State University* Tallahassee 32306, Florida, USA)

Abstract The discovery by Birger Bohlin of a series of vertebrate fossil sites in the twin lakes region (Tuosu Nor and Keluke Nor) of eastern Qaidam Basin during the Sino-Swedish Expedition in 1931 and 1932 was a major milestone in vertebrate paleontology for the Tibetan Plateau. Qaidam fossil mammals collected by Bohlin still represent the best collections from the plateau and serve as an important reference point for a period of time that saw dramatic climatic changes. The more than 4600 m of strata in eastern Qaidam, spanning over 13 million years in time, are ideal for establishing a detailed biostrati-

graphic record, but Bohlin's published specimens lack any reference to stratigraphy, which causes much confusion about the nature of his "Tsaidam Fauna."

Bohlin did, however, make a fairly detailed documentation of locality information, much of which remains buried in archival records in Stockholm. This paper is an attempt to reconstruct Bohlin's fossil localities by synthesizing relevant archives and historical accounts, as well as field observations of our own during the past 13 years. Fieldnotes in Swedish are translated to English and several field sketches are published for the first time. As a result, we are able to relocate many fossil localities that are of stratigraphic and taxonomic importance.

Bohlin mainly collected in three major areas, along the northwestern shore of Tuosu Nor, south of Huaitoutala, and south of Quanshuiliang train station, each with stratigraphic settings of their own. In his published descriptions, all fossils are included in his "Tsaidam Fauna." With the help of his notes and sketches and our field verification, we are now in a position to recognize at least three faunal horizons among Bohlin's collections: middle Miocene (Tunggurian) Olongbuluk Fauna, early late Miocene (early Bahean) Tuosu Fauna, and early Pliocene (Yushean) Huaitoutala Fauna.

Of these fossil sites, Bohlin's Tuosu Nor locality is the best constrained within the modern stratigraphic framework due to the relatively short section present along the northern bank of Tuosu Nor. His fossil localities are confined to a narrow band of about 100 meters in total thickness. Bohlin's Huaitoutala (Ulan-utsur) localities are, however, more scattered both spatially and stratigraphically. Fortunately, only a few localities produced fossils of biochronologic significance, and most are low in the section, probably belonging to the Olongbuluk Fauna.

The majority of Bohlin's Qaidam collections comes from what he informally called the "general strips," which is not far from the present day Quanshuiliang railway station. Approximately 250 m of strata extend laterally for several kilometers. Almost all endemic bovids that Bohlin described, such as *Tsaidamotherium*, *Olonbulukia*, *Qurliqnoria*, *Tossunnoria*, are produced from this area. The Quanshuiliang region also produces some of the earliest occurrences of *Hipparion* in China. Preliminary correlation of the Quanshuiliang section with an existing magnetic section in Huaitoutala suggests that the local first appearance of *Hipparion* is close to the boundary between chrons C5r. 1r and C5r. 1n, about 11.1 Ma.

Key words Qinghai, Tibetan Plateau, Neogene, mammal, biostratigraphy, chronology

1 Introduction

As chief vertebrate paleontologist during the Sino-Swedish Expedition (also known as the Hedin Expedition, 1927-1935), Birger Bohlin (1898-1990) made wide ranging discoveries in much of northern China, particularly in Gansu and Qinghai provinces in and along the northern Tibetan Plateau. He succeeded in amassing a collection of fossil vertebrates that became an important foundation for the study of the geologic history and Cenozoic evolution of mammals in and around the Tibetan Plateau. His groundbreaking work on the geology and vertebrate paleontology of the Qaidam Basin represents the earliest systematic study of a vertebrate fossil-producing region in the Tibetan Plateau.

In the brief field seasons of 1931 and 1932, Bohlin (1935, 1937a) documented a rich vertebrate fossil assemblage from eastern Qaidam (Tsaidam, Caidam, Chaidamu) Basin that includes some of the most enigmatic bovids still puzzling paleontologists today. However, partly due to a lack of detailed documentation of the stratigraphy in Bohlin's published records, much remains uncertain regarding the precise location and stratigraphic context of the more than 200 specimens. Such uncertainties are further compounded by a long span of geologic time, up to 13 m. y. within a sedimentary sequence of almost 5000 m in the vicinity of Bohlin's collecting area. A lack of stratigraphic context has caused confusion about the age of the "Qaidam Fauna," because of its mix of mammals representing a wide range of geologic ages. As a result, a composite "Qaidam Fauna" (or "Tosunor Fauna") was often regarded as earliest late Miocene in age, given its mixed faunal content of middle Miocene and late Miocene components (Qiu, 1990; Qiu and Qiu, 1995; Qiu et al., 1999). Unraveling this tangle of mixed faunas from Bohlin's Qaidam collection is a matter of urgent importance because many of Bohlin's original

specimens are still the best representatives of their kind, often the case for collectors first on the scene, and have not been replicated during subsequent collecting efforts. Such is the aim of our field studies during the past 13 years (1998-2010). With our emphasis on relocating and recalibrating historic collections, we are now in a position to clarify many of Bohlin's field records and to place them in a stratigraphic context.

We take this opportunity to 1) present unpublished field records from the Hedin Archive in Stockholm, Sweden; 2) call to attention Bohlin's published geologic studies and travel accounts that are widely ignored, particularly by the Chinese geoscience community; and 3) integrate, to the extent possible, Bohlin's geologic and locality information into our current biostratigraphic framework. By reconciling Bohlin's field records with a modern understanding of biostratigraphy, we can partition Bohlin's "Qaidam Fauna" into at least three different faunal horizons ranging from middle Miocene to Pliocene. The resulting biostratigraphic framework greatly improves our understanding of mammal evolution in the Tibetan Plateau. This is also an opportunity to demonstrate the importance of historical field records, something Bohlin took pains to preserve but had few means to accomplish. This is the second installment on Bohlin's fossil localities; the first, on the Tabenbuluk region, was published earlier by Wang et al. (2008).

2 Archival materials and methods for this study

The main sources of historical documents are housed in the Sven Hedin Archives in the Museum of Ethnography and National Archives in Stockholm, Sweden. Four of us (XW, MF, AF, HW) studied the Hedin Archives in 1999, 2008, and 2009, and obtained copies of archival materials used in this paper. Another very important source of historical information is Bohlin's (1945) published accounts of the Sino-Swedish Expeditions and his geologic reconnaissance in Gansu and Qinghai provinces (Bohlin, 1960).

Birger Bohlin was well trained as a fossil collector and was quite careful in his documentation of stratigraphy. In many ways, he was well ahead of his time in his efforts to record contextual information in as much detail as possible. Wherever he went in the northern Tibetan Plateau, where almost no prior geographic and geologic information was available, he always spent a substantial amount of time rendering topographic and stratigraphic maps, often at the expense of time for collecting fossils. He was also careful in making geologic sketches and placing the fossils in a stratigraphic context to the extent possible, often recording them in a separate notebook written in Swedish. As a result, he relied extensively on his Chinese field assistants to make the collections for him during his Qaidam trips when he was busy with mapping and geologic reconnaissance. This may have resulted in a somewhat less detailed documentation of individual fossil localities in his Qaidam collections as compared to those in Tabenbuluk (Wang et al., 2008).

Fundamental to an understanding of Bohlin's fossil collections is his numbering sequence. He used a prefix "Nr." for specimens collected in Qaidam Basin (Bohlin, 1937a) but switched to "T. b." for specimens collected in the Tabenbuluk region (Bohlin, 1942, 1946). He appears to have devised a continuous numbering system throughout the expeditions, and the relative sequence roughly corresponds to the date of collection, which was in turn clustered by the location of his camps. Bohlin assigned the numbers T. b. 169-315 to collections obtained during his first visit to the Tabenbuluk region in the summer of 1931. He then used numbers Nr. 316-352 for specimens from Qaidam Basin collected later that year in October 1931 (Bohlin, 1937a:5). He next assigned Nr. 354-556 to the second collection from Qaidam during his May 1932 visit (a "566" for a rhino humerus is probably a typo for "556" in Bohlin, 1937a: fig. 124). Finally he used T. b. 557-593 for collections from Yindirte (Yandantu) during his October 1932 revisit of the Tabenbuluk region. The numbering system also contains

clues to the stratigraphic position of the specimens, although caution should be exercised in interpreting these numbers. The numbers were recorded in Bohlin's field notes for his second trip to Qaidam, often associated with the name of the collector as well as location and/or stratigraphic information (Appendix I). However, this numbering system should not be regarded as a modern catalogue system because specimens were sometimes given identical numbers. For example, a "Cavicorn" astragalus and humerus and a chalicothere tibia share the same number (Nr. 317) in Bohlin's publication (Bohlin, 1937a).

We generally use the official Pinyin system for geographic names, followed in parentheses by spellings of the Sino-Swedish Expedition and other alternatives, except where a non-Pinyin name has been well entrenched in the literature (such as Tabenbuluk).

Abbreviations BB, Birger Bohlin's field camps during the Sino-Swedish Expeditions; CD, IVPP Qaidam fossil locality; IVPP, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing; Nr., Bohlin's field and specimen numbers for Qaidam Basin vertebrate fossils.

3 A brief history of the Qaidam Basin expedition by Birger Bohlin

Elsewhere, we have recounted the Sino-Swedish Expedition, particularly as related to the Tabenbuluk collections(Wang et al., 2008). To avoid repetition, we concentrate on events that are important to the Qaidam Basin collections; readers are encouraged to seek other general accounts, such as Andersson (1934), Bohlin (1944, 1945), Mateer and Lucas (1983), and Weinberg and Green (2002), as well as numerous popular accounts by Sven Hedin (e.g., 1934).

The events leading to the discovery of the Qaidam fossils are rather fortuitous. In June 1931, Bohlin encountered, just north of Dunhuang, Ma Zhongying's army, and he decided to immediately head southward to avoid the potential danger posed by the warring bandits. On June 22, 1931, Bohlin arrived at Tabenbuluk, a small desert oasis fed by a few natural springs ("Tabenbuluk" is Mongolian for "five springs"). He was impressed by nearby Cenozoic exposures and promptly found a few specimens (T. b. 169), which led to much more extensive collecting in the Tabenbuluk area during the 1931 season as well as a subsequent trip to the area in August 1932(Bohlin, 1942, 1946, 1953, 1960).

While working on the late Oligocene Tabenbuluk beds, Bohlin learned from local Mongols that vertebrate fossils had been found in the Qaidam Basin: "During the period of my stay in the Taben-buluk region I was in constant touch with Mongols from different tracts of the Nan-shan; and when they found out about my, in their eyes very strange, interests they willingly gave me information that made me prick up my ears. They knew that their medicine-men used to collect bones in the vicinity of Tossun-nor..." (Bohlin, 1945: 295). Well aware of the rich Chinese history of "dragon bone" collecting, often the first clue of the presence of vertebrate fossils, Bohlin immediately grasped the significance of this tip and prepared for an expedition after his work in the Tabenbuluk region.

On September 17, 1931, Bohlin's party departed from the Tabenbuluk region and set off southward over the Dangjinshan Pass, the main caravan route to enter the Qaidam Basin. Through Da Qaidam (Ikhe-nor) and Xiao Qaidam (Bagha-tsaidamin-nor) during late September, the party finally arrived at the culturally important Huaitoutala (Hoit Taria, Khoitu-taran, Khoit Tara) region northwest of the twin-lakes Keluke Nor (Kurlik-nor, Qurliq-nor, Kurluk Nuur, Hurleg Hu) and Tuosu Nor (Tossun-nor, Toson Nuur, Toson Hu), where two major lama temples were presided over by a Mongolian chief (see Fig. 1).

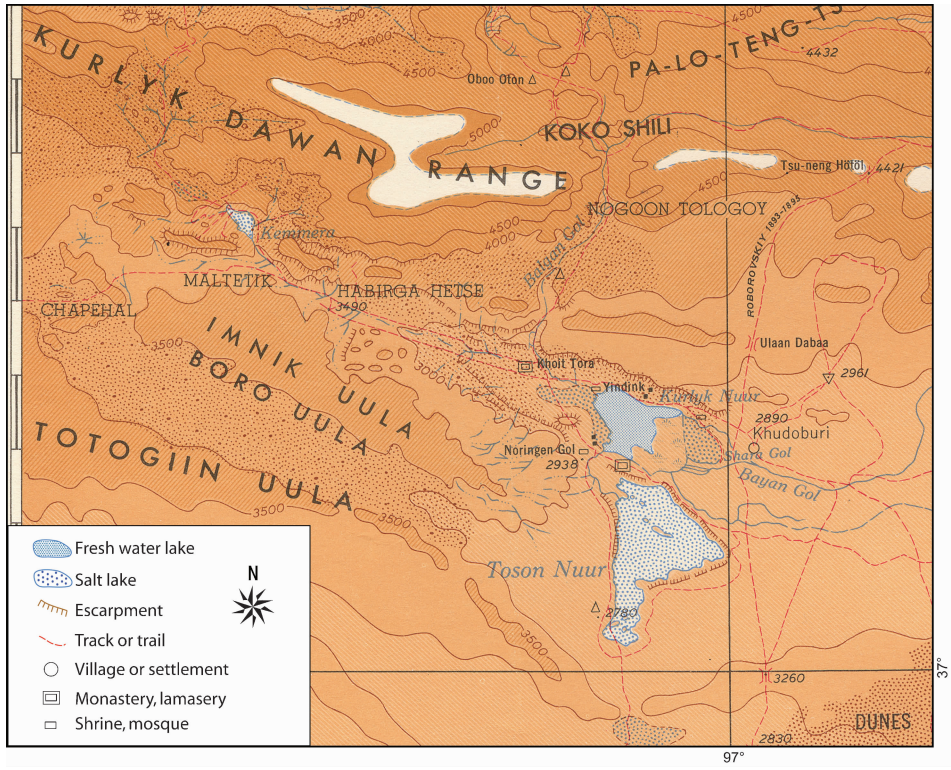

Fig. 1 Sino-Swedish Expedition map, showing various landmarks encountered by Birger Bohlin Some of the geographic names are spelled differently from those recorded by Bohlin. Vertical bars along left margin represent 5′ in latitude. Modified from Sheet NJ 47 (Ch'ing Hai) of the Sven Hedin Central Asia Atlas (Norin and Montell, 1966)

On October 5, Bohlin pitched camp (camp BB 93; one of Bohlin's unpublished sketch maps labeled it as BB 92) "on a little peninsula that juts out in the northern end of the lake [Tuosu Nor]" (Bohlin, 1945:296). He immediately found vertebrate fossils in the vicinity of his camp and collected almost 40 specimens (Nr. 316-352) during a brief stay of six days. On October 11, the party left camp BB 93. After crossing the Noringen River (a name that does not appear on modern Chinese maps) that connects Tuosu Nor and Keluke Nor, Bohlin took note of the badlands west of the twin-lakes, an area of promising potential to be further explored later.

In April 1932, Bohlin returned to the Qaidam Basin, this time via the upper reaches of Danghe (Shargaltain Gol), where he found some late Oligocene vertebrates (Bohlin, 1937b), and over the Danghe Nanshan (Humboldt Range). However, hiking the Nanshan proved too treacherous for Bohlin's camel caravan, and the team had to split up, with Bohlin hiring yaks to cross the mountains and the rest of his camel team going through the western route to rendezvous in the Tuosu Nor area. The camel caravan arrived on or shortly before April 22, but the advance party failed to cross the swollen Noringen River to go back to their Tuosu Nor fossil locality, as was originally instructed by Bohlin, who anticipated that the camel caravan would arrive first. Instead, the camel team settled on an alternative spot called Ulan-utsur (BB 165) "about 10 km to the west of the northern end of Tossun-nor, near the easternmost part of the Boro-ula" (Bohlin, 1945:307). No modern map records the name Ulan-utsur, although Bohlin's field sketches, as well as his published maps, clearly show that BB 165 (Bohlin's field notes have re-

peatedly labeled this as BB 164 in apparent contradiction with his sketch maps) is on the upper reaches of a major dry wash (referred to as "river" in Bohlin's field notes) south of Huaitoutala at the eastern foothill of the Olongbuluk Mountain (Olonbuluk, also known as Boro-ula or Boro Uula). BB 165 is also stratigraphically distinct because it is situated on the western end of a major dome structure (Keluke Anticline of Fang et al., 2007; Wang et al., 2007a), well marked in Bohlin's sketches (see below).

On May 5, Bohlin's party arrived at BB 165. His Chinese assistant, Chang, however, had already collected almost 20 specimens (Nr. 354-371) around the camp from April 23 to May 3. The party stayed in Ulan-utsur for almost a month while Bohlin mapped the geology and explored the Paleozoic rocks that form the Olongbuluk Mountain. Work in the Ulan-utsur region was completed on June 4, when Bohlin's party moved westward along the foothills of the Olongbuluk Mountain. Through the end of June, Bohlin worked on the geology of the Olongbuluk, but did not find more fossils in rocks of similar age as those in Ulan-utsur.

4 Bohlin's Tuosu Nor localities

Bohlin's Tuosu Nor localities are located at the northwestern corner of Tuosu Nor, a triangular saline lake that has no outlet. Fresh water from the adjacent Keluke Nor, immediately to the north of Tuosu Nor, feeds a small river, Noringen Gol, that drains into Tuosu Nor. Cenozoic exposures are mostly confined between the twin lakes, and fossil localities are concentrated in a narrow band along the north bank of a widened Noringen Gol just before it enters Tuosu Nor. Within six days of arriving at the north shore of Tuosu Nor in early October, 1931, Bohlin had accumulated a small collection of about 40 specimens, Nr. 316-352 (mostly fragmentary material according to Bohlin, 1937a), and all collected around camp BB 93 (Figs. 2-4).

A steep, southward facing cliff (probably formed by a fault) forms the north bank of the Noringen Gol and the sandy and silty sediments dip gently toward the north. The stratigraphically lowest exposures at the base of the cliff produced fossil plant leaves and bivalves ("A" in inset of Fig. 3). Fossil mammals were collected from the north face of the cliffs where exposures are relatively flat (darker colored bands in the middle distance above the light colored bands in the foreground in Fig. 2 and "B" in inset of Fig. 3). Further north, partially divided by a narrow water passageway, is another narrow hill of exposures ("C" in inset of Fig. 3) that produced a nearly complete turtle carapace ("Testudinidae sp. H" in Bohlin, 1953:101, pl. IX, figs. 8, 9). Still farther north is an exposure, also divided by water (no longer present in recent satellite photos), that produced fish remains ("D" in inset of Fig. 3). This pattern of fossil distribution is consistent with our own collections made in 1998 and 2002 (Fig. 4), with the exception of a wider distribution of turtle fragments than Bohlin had noted. We are thus confident that Bohlin's plant, mammal, and fish localities in the Tuosu Nor area can be accurately placed within a restricted stratigraphic range.

Fossil-producing strata along the north shore of Tuosu Nor form a long band of exposures with a total thickness of greater than 1000 m. However, the mammal-producing horizons are restricted to a narrow range of slightly more than 100 m of strata toward the lower part of the section (IVPP localities CD9803-9808 and CD0238; Bohlin's B horizon; see Figs. 2-4). As a result, Bohlin's mammal assemblage from the Tuosu Nor area can be confidently placed within 100 m of our measured section, relatively negligible in a region that can have ~5000 m of exposures. Bohlin found the following mammals in Tuosu Nor: a partial skull with horncore of *Olonbulukia tsaidamensis* (Nr. 356), upper teeth and a femur of *Acerorhinus tsaidamensis* (Nr. 330, 346, 354), a phalanx of *Hipparion* sp., a giraffid calcaneum and astragalus (Nr. 316, 320), a chalicothere distal tibia (Nr. 317), two ?*Eostyloceros* (probably belongs to *Euprox*) antlers (Nr. 334, 349), and a number of postcranial elements of "Cavicornia" (Nr. 317,

318, 321, 324, 329, 358). Of the above taxa, *A. tsaidamensis* is now known from a much wider range of ages from middle to late Miocene in Qaidam (Deng and Wang, 2004b; Wang et al., 2007a). Bohlin's horse specimen likely belongs to *Hipparion teilhardi*, as we have found a partial jaw of this species from the Tuosu Nor mammal beds (Deng and Wang, 2004a). Bohlin's chalicothere, on the other hand, may be related to *Chalicotherium* cf. *C. brevirostris*, which has been found in the Huaitoutala section (Wang and Wang, 2001).

Fig. 2 Comparison of Hedin Archive photo (top) of the Tuosu Nor badlands taken in October, 1931 (Bohlin, 1960: pl. IV, fig. 13) and a recent photo (bottom) from the same position
Photos are looking northeast toward the north bank of Tuosu Nor. Bohlin's photo was apparently taken in the morning with harsh, westward casting shadows, and our own matching photo was taken in similar conditions. Note that the previous water level was higher such that a wider area was inundated and two "fingers" of water were present in 1931 (see also Fig. 3). Reproduction of archive photo by permission from the Sven Hedin Foundation, Stockholm, Sweden. Recent photo taken at N37° 12′ 16. 9″ E96° 51′ 23. 0″ by X. Wang on September 6, 2008

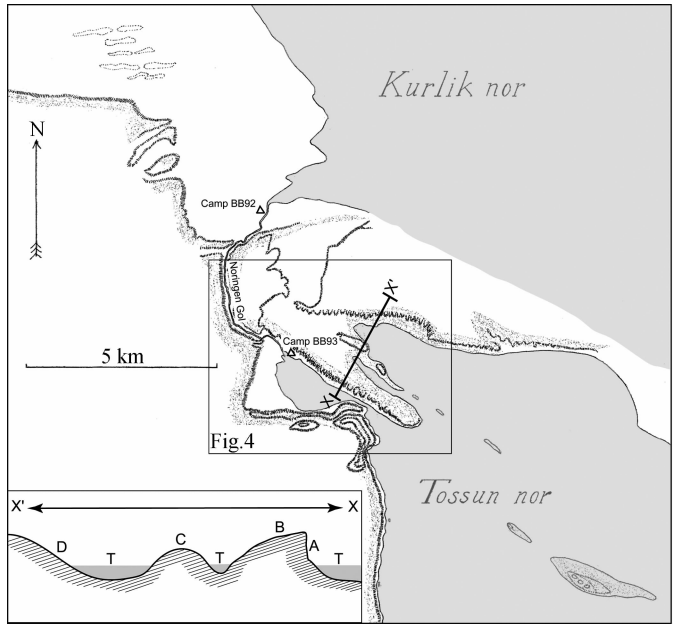

Fig. 3 Modified sketch map of the twin-lakes (Tuosu Nor and Keluke Nor) area by Birger Bohlin
Shaded areas for water were added and the south shoreline for Keluke (Qurliq) Nor is incomplete in the original drawing. Cross-section (X-X′) in the inset is adopted from Bohlin (1960: fig. 12). His fossil layers are: A, plants and bivalves; B, mammals; C, turtles; D, fishes; T, water level of Tuosu Nor. Note that the water level was higher compared to today (Fig. 4). Also note that camp BB 93 is much closer to the fossil localities (as compared to BB 92, which was mislabelled in some of Bohlin's sketches) and probably is what Bohlin referred as their "working camp" (Bohlin, 1945:296). Reproduction of archival map by permission from the Sven Hedin Foundation, Stockholm, Sweden

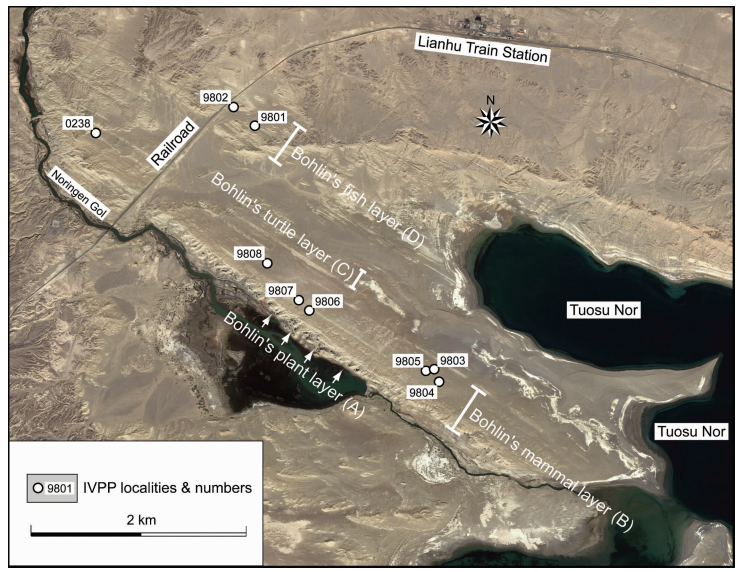

Fig. 4 Satellite image of the northwestern shore of Tuosu Nor with IVPP fossil localities plotted, as well as Bohlin's fossil layers
Our fossil localities are almost exactly the same as those described by Bohlin (1960: fig. 12) (Fig. 3), lending further confidence that Bohlin's Tuosu Nor collections can be precisely placed in our stratigraphic framework. Note that the water level has dropped substantially compared to the early 1930s, and as a result, Bohlin's fish (D), turtle (C), and mammal (B) producing layers are no longer divided by water (Figs. 2, 3)

Bohlin also discovered a fossil plant and bivalve layer at the foot of the cliff facing the Noringen River ("A" in Figs. 3, 4). He passed his fossil plant collections to Ralph Chaney for study, who included them in what he called the Kucha Flora, named after the Kucha Formation in Xinjiang (Chaney, 1935). Chaney listed only a cattail (*Typha latissima*) from the Tuosu Nor locality, which indicated a wetland paleoenvironment for the fossil-producing horizon. In our 1998 field season, we collected a fossil seed of a water chestnut (*Trapa*) (Fig. 5), associated with *Typha* leaves and freshwater snails. Our plant and invertebrate locality (IVPP locality CD9806) is from a greenish, finely laminated mudstone bed, stratigraphically somewhat higher than Bohlin's plant horizon.

5 Bohlin's Ulan-utsur (south of Huaitoutala) localities

On October 11, 1931, before leaving the Tuosu Nor area, Bohlin noticed the vast exposures at the foothills of the Olongbuluk Mountain, a few km west of Tuosu Nor, but did not spend time to explore further. He was able to revisit the Qaidam Basin in May through June of 1932, this time concentrating on the northern and eastern foothills of the Olongbuluk Mountain. During a period of more than a month (22 April through 4 June), Bohlin's party collected more than 200 specimens (Nr. 354-556) in this vast area. Occupied with making copies of route maps from the previous months of his journey during the first few days of his arrival at camp BB 165, Bohlin was content in letting his assistants, Chang and Li, to do the collecting. When he did turn his attention to the newly collected specimens at hand, he began by making a geologic sketch "with the greatest possible wealth of detail in the matter of dry river-beds and plateau-remains" (Bohlin, 1945:308; 1960: fig. 12). Localities for individual specimens were generally not recorded in his published sketch, and some of the specimens presumably could not be precisely plotted because they were collected by his assistants while he was busy making maps (recollections of general directions and distances by Chang and Li were often quite vague and prone to exaggeration; see below).

Fortunately, Bohlin was able to write down a detailed description for most Ulan-utsur specimens collected in a small red notebook. This record (Appendix I), when cross-referenced to two unpublished field maps and one summary map prepared after the field seasons, each with individual topographic features (hill tops) designated by a unique number, proves invaluable in reconstructing much of the stratigraphic context of Bohlin's collection (Figs. 6, 7). Bohlin chose not to publish these data on his plane table map (Bohlin, 1960: fig. 12), an omission that has caused much confusion to later paleontologists.

Collections made before Bohlin's arrival at Camp BB 165 on May 5 by Chang from April 22 to May 5 (Nr. 354-378) consist of "the great elephant scapula... blocks containing the pelvis and a posterior extremity of a rhinoceros" (Bohlin, 1945:307). The elephant scapula is Nr. 378, illustrated by Bohlin (1937a: pl. I, fig. 12), and was from "ca 8 li SW of camp" near "pt 38" (i. e., about 8 Chinese li southwest of Camp BB 165). Using Bohlin's unpublished field sketch, point 38 is approximately 2 km southwest of BB 165 (one Chinese li is 500 m after 1949, but in the early 1900s the distance may have been somewhat longer by Qing Dynasty practice; the distances in Bohlin's field notes must be rough estimates by his assistants, and as such, are prone to exaggeration, in this case, by nearly 100%). The rhino hind limb probably includes Nr. 372-377 (only Nr. 374, a sacrum, was illustrated by Bohlin), packed in 11 blocks and shipped in 8 packages, and is from "ca 3 li S of camp" near "pt 120." Although we could not find point 120 on Bohlin's sketches, this locality is presumably close to the axis of the Keluke Anticline. Another notable specimen is a partial antler of *Stephanocemas* (Nr. 368) (Bohlin, 1945:307), collected on May 1 but without locality information, except Bohlin's note of "basal red beds" (see additional comments about Nr. 368 in correlation below). It appears

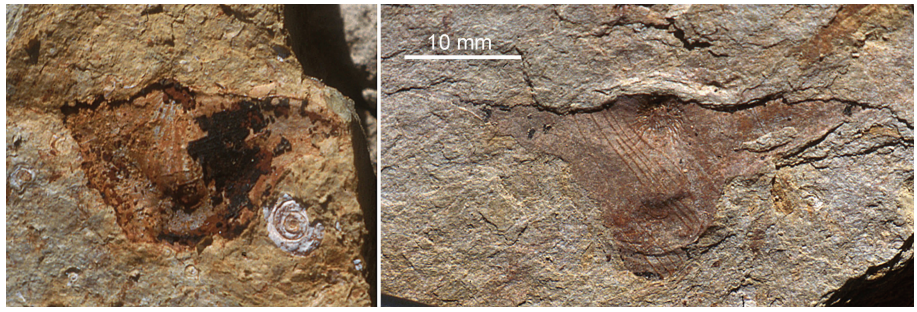

Fig. 5 Two fossil fruits of the water chestnut, *Trapa* sp., from the basal cliff horizon of the Tuosu Nor beds (layer A in Figs. 3, 4), IVPP locality CD9806 (N37°12′19.4″ E96°51′24.4″)
Note the presence of snail shells and other plant fragments, an association also recorded by Bohlin (1960: fig. 12). Scale is applicable to both photos

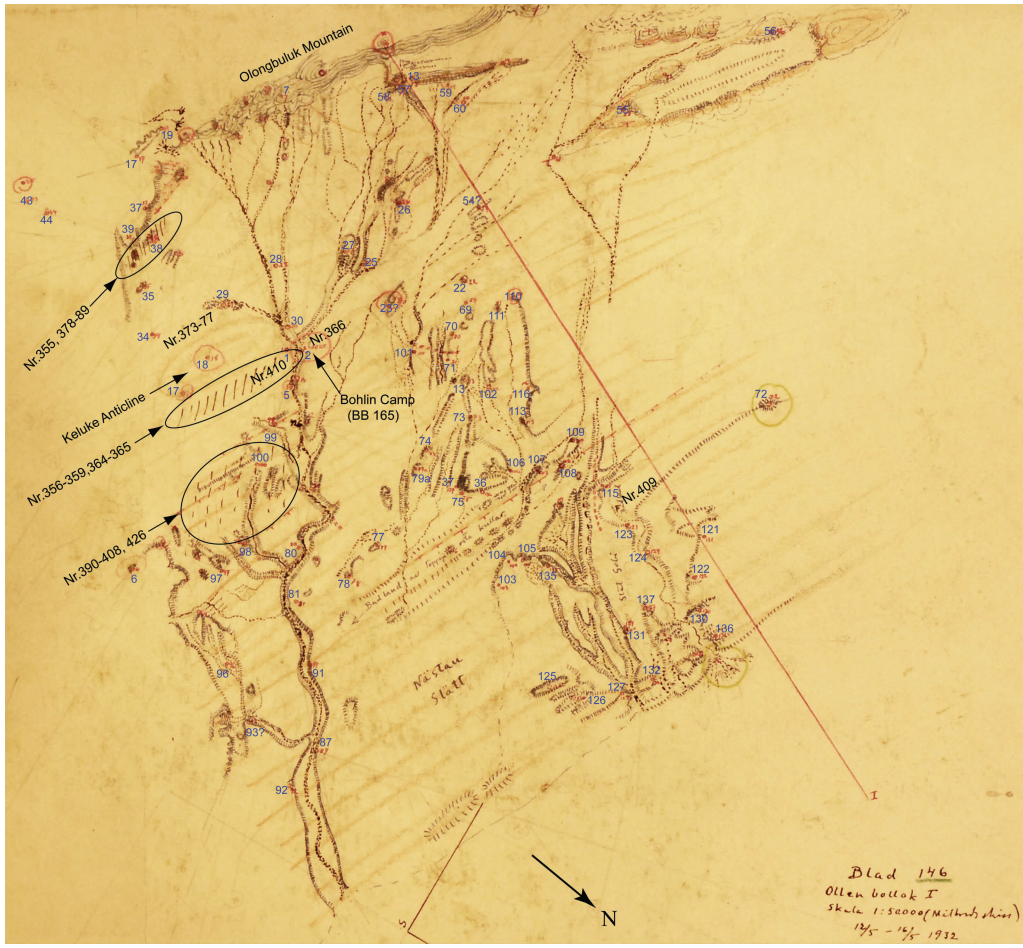

Fig. 6 Unpublished field sketch made by Birger Bohlin in May 12-16, 1932 ("Blad 146, Ollen bollok I")
Small numbers in blue are topographic markers (hill tops) used for triangulation of locations (some can be verified in Bohlin, 1960: fig. 12). Original numbers are difficult to reproduce and are here substituted by printed numbers. Long, light colored pencil lines are Bohlin's interpretation of bedding planes along strike. Short, hatched lines indicate fossiliferous areas. Location of Bohlin's fossil locality numbers (black) are our own interpretation mainly based on his field notes. Printed geographic names are added by us. Reproduction of archival map by permission from the Sven Hedin Foundation, Stockholm, Sweden. Riksarkivet, Sven Hedins kartsampling, Arkivnumber 720811, Omslagsnumber 354, Bladnumber 1-8

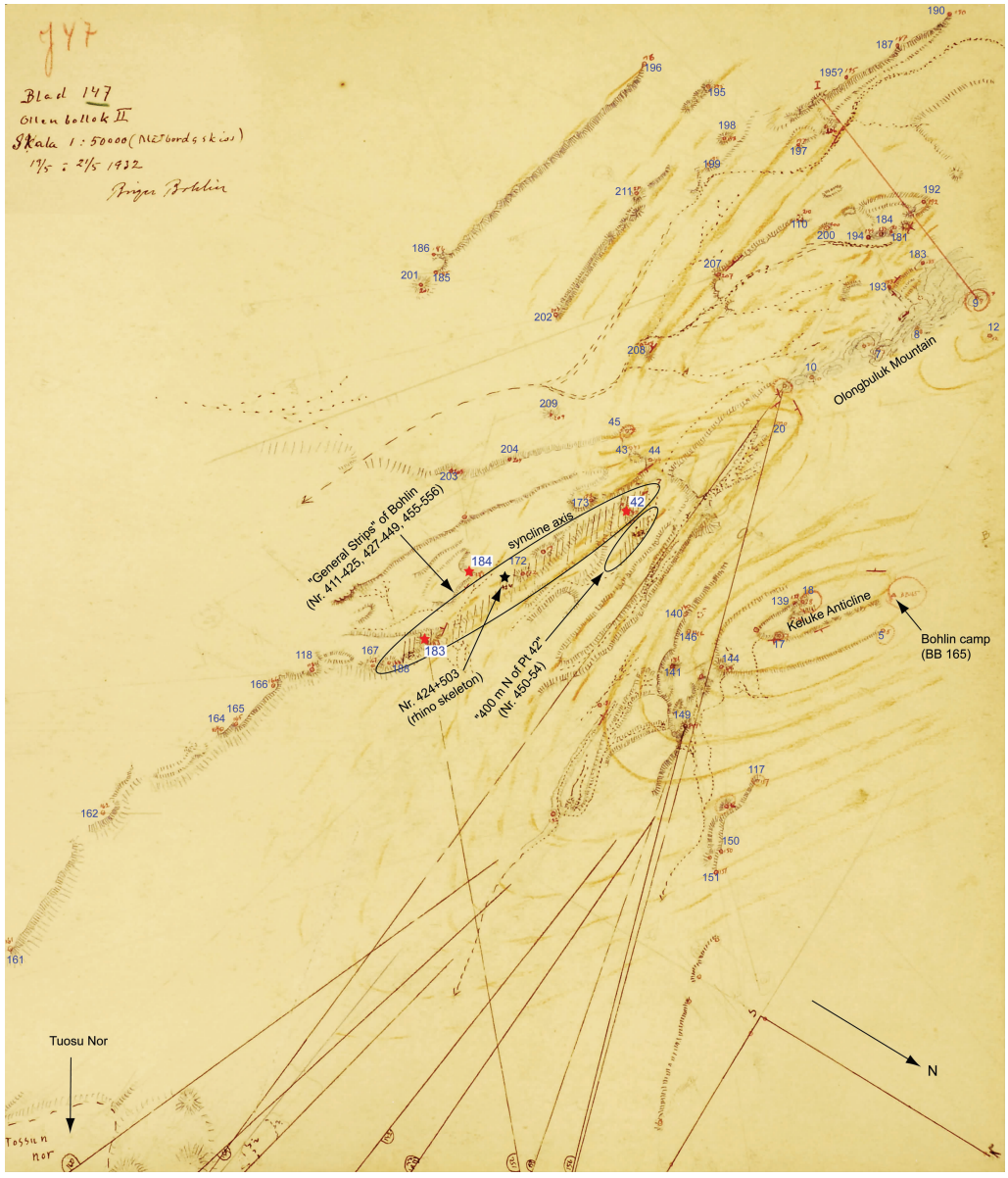

Fig. 7 Unpublished field sketch made by Birger Bohlin in May 19-21, 1932 ("Blad 147, Ollen bollok II") Small numbers in blue are topographic markers used for triangulation of locations, a few of which are identically numbered in his May 12-16 map, which can be used for cross referencing localities. Original numbers are difficult to reproduce and are here substituted by printed numbers. Faint pencil lines are Bohlin's interpretation of bedding planes, which show a combination of an anticline (near BB 165 at axis) and a syncline to the south. Short, hatched lines indicate fossiliferous areas. Location of Bohlin's fossil locality numbers (black) are our own interpretation mainly based on his field notes. Red stars are our own emphasis for key reference point numbers that were specifically mentioned in Bohlin's field notes to denote the location of fossil localities. Printed geographic names are added by us. Reproduction of archival map by permission from the Sven Hedin Foundation, Stockholm, Sweden. Riksarkivet, Sven Hedins kartsampling, Arkivnumber 720811, Omslagsnumber 354, Bladnumber 1-8

that Chang had mainly collected in areas around camp in or near the basal red beds (Nr. 356-359, 364-365) (hatched area northeast of Camp 165 in Bohlin's May 12-16 field sketch; Fig. 6).

Collecting activities during Bohlin's first two weeks (May 6-18) were also near camp BB 165. During this time Bohlin was occupied with either copying maps made on his way to Qaidam or making a new map for the Ulan-utsur area (Fig. 6). Mostly "small and fragmentary finds" were obtained (Bohlin, 1945:307), and Chang continued to make the majority of the collections. Most specimens collected appear to belong to two fossiliferous areas: those that came from "S of river, few li below camp" (Nr. 356-359, 364-365; here the river refers to the largely dry wash that runs through Camp 165 and "below" probably means downstream toward the northeast). Although "a few li" does not offer much precision, we interpret the hatched lines near point 100 in Bohlin's May 12-16 field sketch as localities for Nr. 390-408, 426 (Fig. 6). Based on Bohlin's sketch of the dry river bed topography, these localities are probably equivalent to IVPP localities CD9809-9811. Finally, Bohlin personally collected a sample of "eggshell" (Nr. 409) from north of point 115 on May 16. This is the stratigraphically highest fossil horizon (furthest north from the axis of Keluke Anticline) in the Huaitoutala section, likely to be of similar age as our own IVPP locality CD9822, which also produced ostrich eggshells nearby.

On May 19, 1932, as Bohlin's work progressed to the point that he began to work in areas beyond the immediate vicinity of his camp (BB 165), he "struck the sediment-strips that had yielded the most and the best of my collections" (Bohlin, 1945:308) (Bohlin, however, recorded that Chang had collected a tortoise from this area on May 16; if so, they may have independently discovered this fossiliferous region). He immediately began to make another field sketch to document this new area, as he must have realized its importance (Fig. 7; his earlier map made on May 12-16, Fig. 6, does not show the "strips"). Unfortunately, we did not have the benefit of this field map during our own field work in 1998-2006, and we were able to re-locate this important region only in 2007 (aided by Bohlin's summary map, Fig. 8), after many years of false starts.

Bohlin used the term "General Strips" ("Stråk" in his notes in Swedish) to refer to this highly fossiliferous band, a series of northwest-southeast oriented escarpments stretching more than 12 km in length. The western end of the "General Strips" starts near the present day Quanshuiliang railroad station. The "General Strips" stretch eastward toward Tuosu Nor along the same orientation as the Olongbuluk Mountain range. On the southern limb of the Keluke Anticline, the sediments consist of alternating rusty sandstones and layers of concentrated small carbonate nodules. Our own explorations in 2007, 2008, and 2010 proved to be as productive as those by Bohlin's party, and we have recorded 40 fossil sites in 2007, 111 sites in 2008, and 31 sites in 2010 (Fig. 9). Our 2007 fossil localities roughly correspond to Bohlin's "General Strips", whereas our 2008 and 2010 localities extend further east, more than doubling the area explored by Bohlin (Bohlin undoubtedly would have found many more fossils further to the east of his strips. That his party stopped collecting where they did may be due to the distance from camp—the eastern end of his strips is more than 6 km from BB 165, a substantial trek for a daily round trip).

Bohlin's notebook made extensive use of reference points 42, 183, and 184, as well as locality Nr. 424 (which is "a couple of hundred m N of pt 184"). This was clearly marked as a long stretch of hatched lines between point 42 and 184 (Fig. 7). Bohlin (1945:308) remarked that "the first finds were a couple of inferior mandibles from rhinoceros [probably Nr. 413 and 424, collected on May 19, which were not figured in later publications]; but we soon found that the ground between the badland-hills was more or less evenly strewn with bones, beautifully weathered-out from the sediments." In his narrative account Bohlin (1945:308) made specific

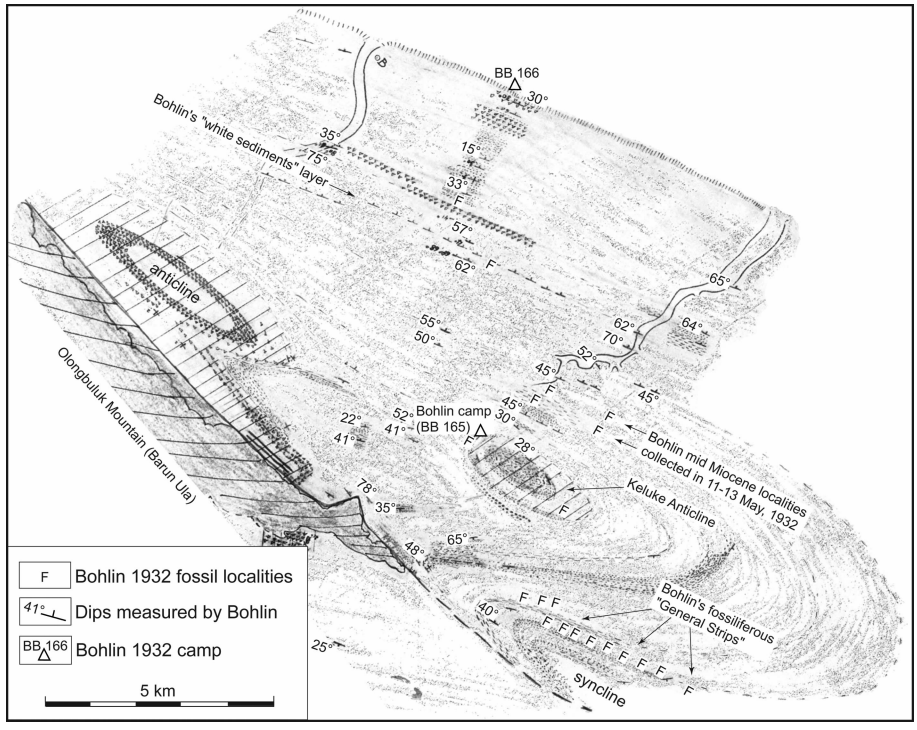

Fig. 8 Summary map by Birger Bohlin indicating fossil mammal localities ("F"s)
Original lettering, difficult to reproduce, is here substituted by printing. Large ovals are anticlines formed by Cenozoic beds and pencil shading indicates Bohlin's interpretation of the bedding. Geographic names or geologic structures, such as Olongbuluk Mountain, Keluke Anticline, and General Strips, are added to help with orientation. Note camp BB 165 is near the axis of the Keluke Anticline at the southern end of a big wash (shown in double solid lines). Reproduction of archival map by permission from the Sven Hedin Foundation, Stockholm, Sweden

mention of two other taxa from the "General Strips": "The original specimen of *Tsaidamotherium hedini* was picked up loose from the surface of the ground, as was also the most beautiful skull of *Tossunnoria pseudibex*." The former was first published by Bohlin (1935) in a separate paper from his monograph (Bohlin, 1937a). Although Bohlin neglected to publish the field numbers for *Tsaidamotherium hedini*, we consider that Nr. 447 ("parietal region and occiput (mostly) of a very compact, bony skull"—Bohlin field notes) and Nr. 457 ("occipital region of artiodactyl skull with wide, joined horn base"—Bohlin field notes) most likely correspond to the two partial skulls described (Ex. 1 and 2 of Bohlin, 1935). If so, these came from near reference points 183 and 42, respectively. *Tossunnoria pseudibex*, the "most beautiful skull" must be Nr. 481 (Bohlin, 1937a: pl IV fig 3; pl V fig 1-3), which is from near the locality for Nr. 424.

On May 27, Bohlin's party encountered a partial skeleton of a rhino (Nr. 503, near the locality for Nr. 424) (Bohlin, 1937a: pls. VII-IX). A food supply shortage nearly cut short their days of excavations, but fortunately the field party was able to purchase flour from a caravan from Xining at the last moment, thus saving the party from a hasty departure. From May 19-June 3, Bohlin collected 140 specimens (Nr. 411-449, 455-556) from the "General Strips." Most of the specimens were in reference to points 42, 183, and 184, and Bohlin's collections probably cannot be further teased apart stratigraphically within the "General Strips" (although fossils collected near point 184 are stratigraphically somewhat higher than the rest).

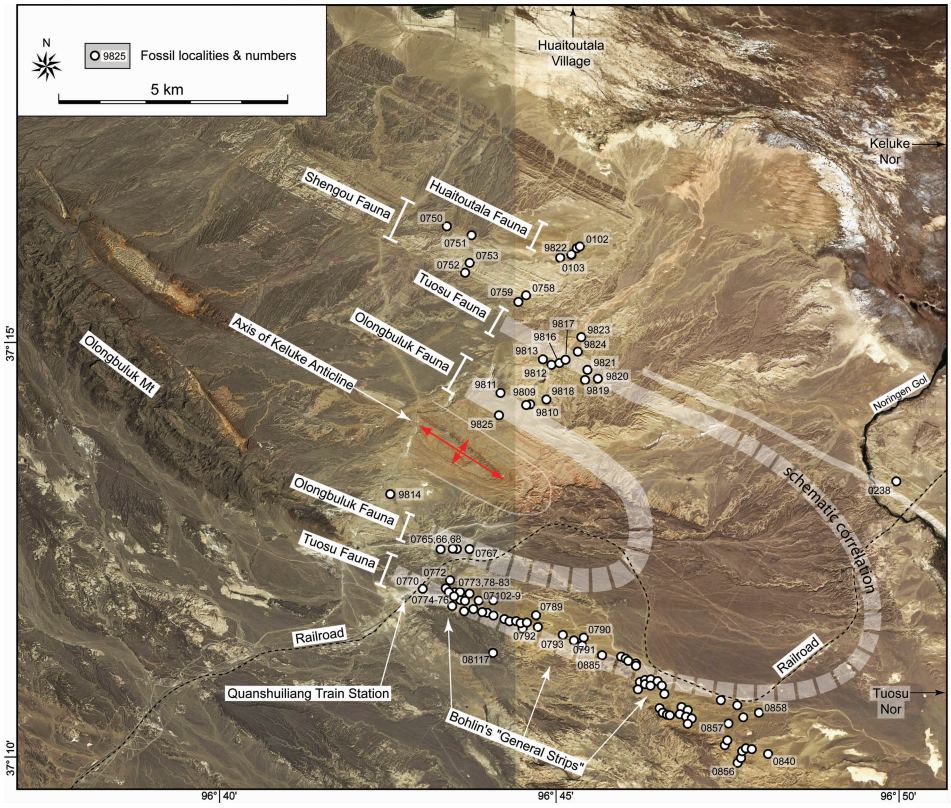

Fig. 9 Satellite image of vertebrate fossil localities in the Huaitoutala-Olongbuluk area found during the past 13 years (2010 localities, further southeast, fall outside of the map)

Note the overall similarity in the distribution of our localities to those of Bohlin's localities in Figs. 6-8. Such a similarity, along with some of the identical faunal elements collected by Bohlin and ourselves, lends confidence in our interpretation of the stratigraphic context of Bohlin's collections. Stratigraphic relationships between north and south limbs of the Keluke Anticline are indicated by light bands where strata are visible on the satellite image and are speculated with dashed bands where sediments are not well exposed

Fossil-producing strata along the "General Strips" consist of <300 m of sediments based on the stratigraphic span of our 2007 localities (our 2008 and 2010 localities add to this stratigraphic span because the eastern localities tend to be more widespread; see Fig. 9), a narrow span relative to the total thickness of the Huaitoutala section.

There is, however, a small band of fossiliferous sediment at the northwestern end of the "General Strips," marked by hatched lines in Bohlin's field sketch (Fig. 7) and three Fs in his later summary map (Fig. 8). Descriptions of Nr. 450-454("N slope of strip towards W from pt 183," "Strip 3-400 m N of pt 42," "level 450, possibly somewhat lower level"—Bohlin field notes) seem to match this band. This short band, mostly formed by yellowish, greenish, and rusty sandstones, likely corresponds to IVPP locality CD0765-0768 on the north side of the present-day railroad tracks (Fig. 9). Our own measurements suggest that this bed is ~400 m below the "General Strips," a significantly lower stratigraphic position even in Qaidam's thick sequences, and produced fragmentary antlers tentatively identified as *Dicroceros*. Although Bohlin did not distinguish this band from his "General Strips" in his field notes, fossils from this horizon should be kept separate pending further investigation, as surely was Bohlin's original intention (he made the distinction in his maps; see below).

6 Age relationships of Tuosu Nor and Olongbuluk localities

Much progress has been made in establishing a biostratigraphic and geochronologic framework for Qaidam Basin vertebrate fossils (Fang et al., 2007; Wang et al., 2007a,b). A 4600 m paleomagnetic section along the dry wash south of Huaitoutala was closely tied to some of our fossil localities along the wash. Fossil localities further away from the paleomagnetic section, such as the Tuosu Nor section, which includes Bohlin's fossil mammal assemblage from the Tuosu Nor area, were correlated to the paleomagnetic section by means of visual correlation in satellite images (Wang et al., 2007a: figs. 3, 11).

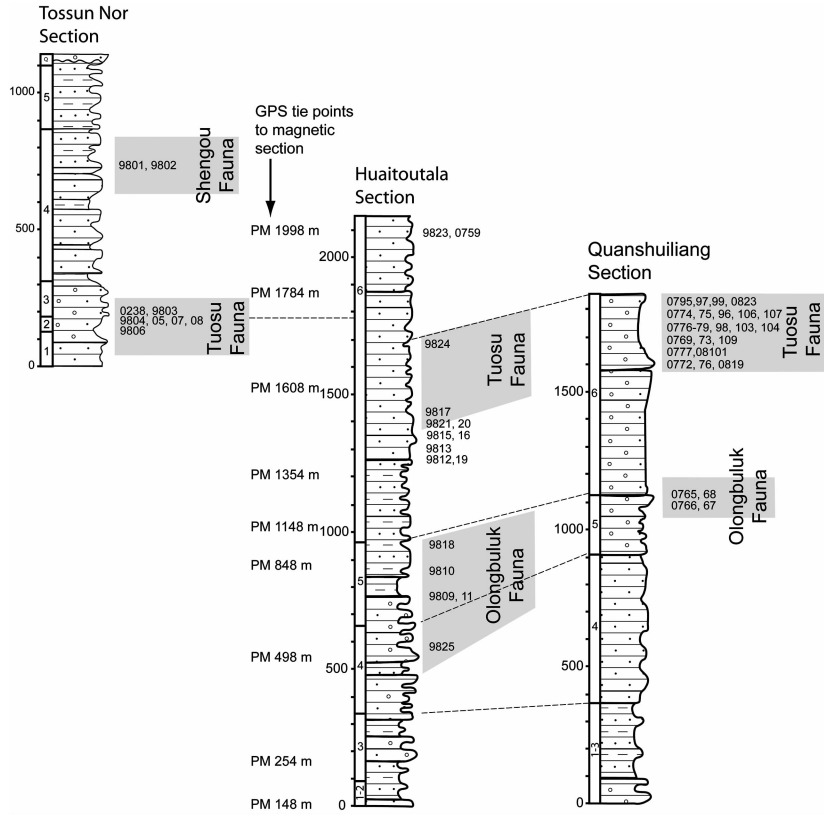

Fig. 10 Faunal and stratigraphic correlation of Bohlin's Tuosu Nor, Huaitoutala, and Quanshuiliang sections, modified from Wang et al. (2007a: fig. 11)

A part of the Huaitoutala section and the entire Quanshuiliang section were re-measured during the 2009 field season in greater detail. Our earlier thickness estimates (Wang et al., 2007: fig. 11) probably represent a 15%~20% over-estimate, using a formula of approximation from the Chinese geologic survey manual, which is now corrected. The lower parts (beds 1-5) of these two sections, which are close to each other on the opposite sides of the Keluke Anticline, can be correlated based on lithostratigraphic criteria. The distant upper sections (bed 6) are difficult to correlate on the basis of lithology because of lateral facies changes (the fine pebbly carbonate nodules in the "General Strips" are completely absent in the Huaitoutala section), and as a result, the measured thickness is the only criterion for correlation in bed 6. We also provide several GPS tie points for Huaitoutala paleomagnetic section ("PM" followed by bed thickness measurements; data provided by Meng Qingquan), which permit a more direct integration of fossil horizons and magnetic zones (see dashed lines linking fossil and magnetic sections in Fig. 11). Note that Fang et al.'s (2007: fig. 8) section includes a 148 m red bed below the axis of the Keluke Anticline (Meng Qingquan, pers. comm.), resulting in an upward shift of 148 m when compared to our section (left column)

The Quanshuiliang localities (Bohlin's "General Strips") lie on the opposite (south) side of the Keluke Anticline from the paleomagnetic section in the north limb (Fang et al., 2007). Large areas to the east of the Keluke Anticline axis are poorly exposed such that physical tracing of individual beds around the anticline is not possible (see Fig. 9). Instead, we chose to correlate by measured sections. Bohlin identified an anticline-syncline pair in his sketches (Figs. 7, 8)—the Keluke Anticline at Camp 165 coupled with a shallow syncline immediately south of his "General Strips." The axis of the syncline passes through N37°11′53″ E96°43′30″ at a direction of 130°-150°, i. e., essentially the entire fossiliferous strata along the "General Strips" belong to the south limb of the Keluke Anticline (or the north limb of the syncline), with the strata generally dipping toward the southwest. Using a combination of lithostratigraphic criteria and bedding thickness, we arrive at an approximate correlation (Fig. 10) between sections on either side of the Keluke Anticline. We hasten to point out, however, that the lithology of the "General Strips" is quite different from its correlative section north of the anticline—multiple layers of concentrated carbonate nodules, abundant in the "General Strips", are absent from north of the axis. Such an abrupt lateral change in lithology (more coarse-grained fluvial facies to the south) without transitional strata (eroded away above the anticline axis) remains a source of uncertainty in our correlation. However, in the absence of an independent paleomagnetic section south of the anticline, this is the best correlation we can achieve at the moment.

This correlation reveals that the Quanshuiliang assemblages in the "General Strips" correspond to the Tuosu Fauna in the Huaitoutala section. Based on taxa described by Bohlin (1935, 1937a) from the "General Strips" and our own newly collected material, the Tuosu Fauna can be characterized by its unique presence of such endemic bovids as *Tsaidamotherium hedini*, *Tossunnoria pseudibex*, *Qurliqnoria cheni*, and *Olonbulukia tsaidamensis*. The last species also occurs in the lower strata (Nr. 356, Olongbuluk Fauna), if our reconstruction of Bohlin's locality is correct. Ongoing research of our newly collected specimens will likely shed additional light on its faunal composition.

If the above historic locality reconstruction and correlation are correct, we face the inevitable conclusion that Bohlin's "Qaidam Fauna" consists of at least three recognizable faunal horizons: the middle Miocene Olongbuluk Fauna (Nr. 355-360, 364-66, 378-408, 410, 451-454, and others), the late Miocene Tuosu Fauna (Nr. 316-352, 411-450, 455-556), and the early Pliocene Huaitoutala Fauna (Nr. 409). Of these, we can recognize the first two faunal horizons from the characteristics of Bohlin's mammal assemblage, whereas the latter is recognizable only on the basis of our own small mammal collection (Wang et al., 2007a).

We may thus sort out Bohlin's mixed "Qaidam Fauna" into the following components. The middle Miocene Olongbuluk Fauna consists of *Olonbulukia tsaidamensis* (Nr. 356), *Lagomeryx tsaidamensis* (Nr. 361), *Stephanocemas* (Nr. 368, 407), ? *Dicroceros* (Nr. 372, 397), "? *Eostyloceros*" (Nr. 396, 399, 401), and *Acerorhinus tsaidamensis* (Nr. 330, 346, 374, 381). The earliest late Miocene Tuosu Fauna includes "*Ictitherium* sp." (Nr. 542), *Tsaidamotherium hedini* (Nr. 447, 457), *Tossunnoria pseudibex* (Nr. 449, 481, 537), *Qurliqnoria cheni* (Nr. 441), *Qurliqnoria* sp. (Nr. 508), *Olonbulukia tsaidamensis* (Nr. 429), Chalicotheriidae indet. (Nr. 317), *Hipparion* sp. (Nr. 352, 444, 467, 493, 498, 500, 501, 523, 553), *Acerorhinus tsaidamensis* (Nr. 418, 430, 438, 456, 459, 488, 502-4, 511, 516, 525-7, 536, 538, 555-6), ? *Tetralophodon* (Nr. 458, 487, 524, 530, 534), Giraffidae indet. (Nr. 316, 320), "? *Eostyloceros*" (Nr. 334, 349). See Wang et al. (2007a, 2009) for additional faunal components.

The above sequence, however, necessitates some adjustment of the paleomagnetic correlation. The presence of *Hipparion* in the Tuosu Fauna (amply confirmed by our own collections) constrains it to early late Miocene at the earliest (a distal tibia identified as "*Hipparion* sp." was present in strata as low as Nr. 453, although no dental material of either hipparionine or

anchitheriine horses is available, qualifying this identification). Correlation with published magnetostratigraphy (Fig. 11) further suggests that the local first occurrence of *Hipparion* falls near the boundary between chrons C5r. 1r and C5r. 1n (11. 12 Ma in Lourens et al., 2004), making this a critical locality to explore the important first appearance datum (FAD) of *Hipparion* in east Asia.

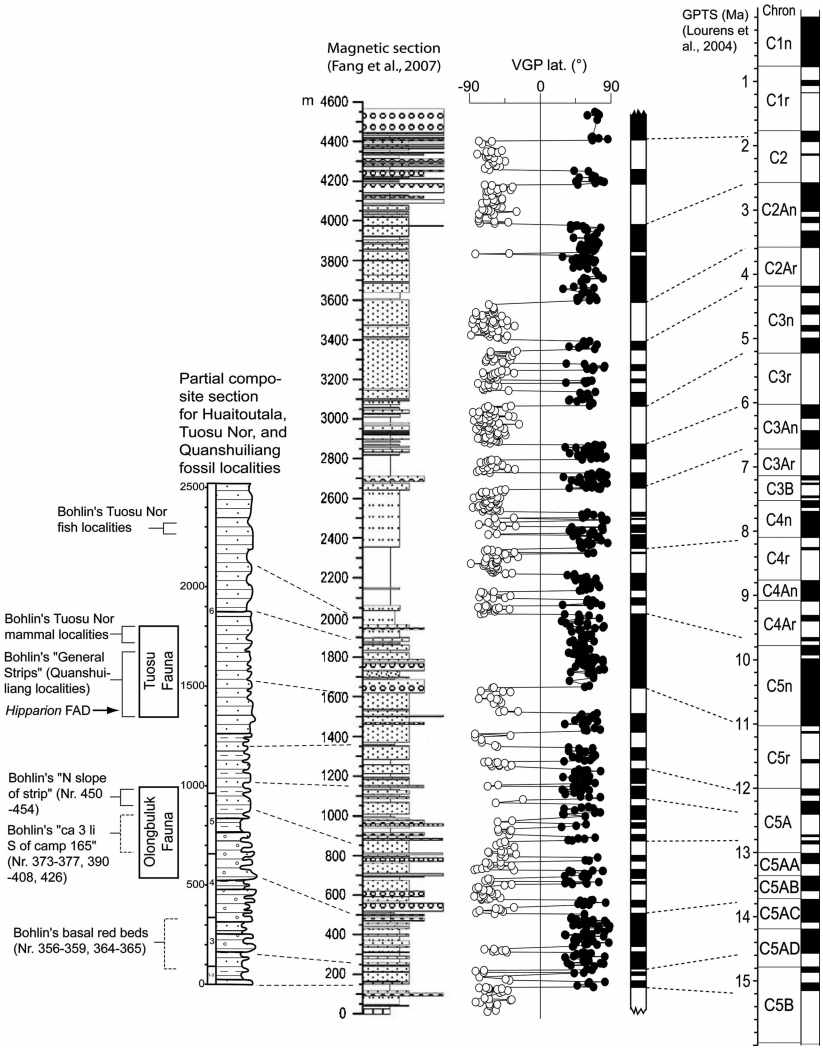

Fig. 11 Correlation of a composite section of the Tuosu Nor-Huaitoutala-Quanshuiliang fossil sections with the paleomagnetic section by Fang et al. (2007), showing estimated ranges for most of Bohlin's important fossil localities and our estimated lowest occurrence of *Hipparion* at the boundary of chrons C5r. 1r and C5r. 1n
We use several GPS tie points (listed in Fig. 10) for correlation between our measured section and that of Fang et al. (dashed lines)

Within the long Huaitoutala section, the period of time represented by the Shengou Fauna, established on fossils from the Shengou section, south of Delingha (Qiu and Li, 2008; Wang et al., 2007a), is undoubtedly present as well. However, due to the relatively unfossiliferous strata in the upper part of the Huaitoutala section, both Bohlin's and our collections lack diagnostic taxa to define a local fauna.

7 Conclusion

Birger Bohlin was conscientious in his documentation of vertebrate fossil localities at a time when the prevailing standard was minimal and the recording of biostratigraphy often neglected. Despite his meticulous efforts, however, he was limited by a lack of suitable topographic maps. Nonetheless, Bohlin did much to document his fossil localities to the best of his abilities. Unfortunately, however, Bohlin did not publish the locality information, and as a result, his "Qaidam Fauna" represents a mixture of specimens coming from several thousand meters of sediments that span more than 10 million years in time from middle Miocene to Pliocene. This has had the effect of either misleading later workers about the true nature of the fauna or impeding adoption of the Qaidam sequence as an important Neogene reference section, despite its vast potential with an impressively continuous sedimentary record.

By critically examining Bohlin's published and unpublished records, combined with our own geologic observations and independent collections, we are now in a position to tease apart Bohlin's published records into at least three discrete stratigraphic horizons with recognizable faunal components. We can confidently place Bohlin's Tuosu Nor mammal, fish, turtle, and plant localities within narrowly defined ranges of stratigraphic levels. As a result, Bohlin's fossil assemblage from the north shore of Tuosu Nor can be assigned to a late Miocene age, with nearly the same degree of precision as our own recent collections. Collectively, this faunal assemblage is now defined as the Tuosu Fauna (Wang et al., 2007a).

Specimens collected by Bohlin's party from the much larger "Ulan-utsur" area west of the Tuosu Nor localities, on the other hand, are more heterogeneous, with faunal components ranging from middle Miocene to early Pliocene. Enough hints were preserved in the scattered narrative descriptions, numbering sequence of specimens, and unpublished sketches that a basic understanding of his fossil localities is emerging as we attempt to unscramble individual localities and stratigraphic positions.

Fossils collected from the vicinity of Camp BB 165 mostly belong to the presently recognized Olongbuluk Fauna in the middle Miocene. Materials from four localities just north of Bohlin's "General Strips" probably also belong to the Olongbuluk Fauna, although specimens collected from this small area are generally not age diagnostic.

The Quanshuiliang mammal assemblage, based on Bohlin's collections along his fossiliferous "General Strips" and our own collections from the same strata in 2007-2010, represents the richest Neogene fossil area in the Tibetan Plateau with its highly endemic bovids (such as *Tsaidamotherium*, *Tossunnoria*, *Qurliqnoria*, and *Olonbulukia*) signalling the beginning of a zoogeographic differentiation possibly caused by the rising Tibetan Plateau. Also of great paleontologic significance, the Tuosu Fauna in Quanshuiliang yields the earliest immigrant *Hipparion* horse in the earliest late Miocene in East Asia, as has been suspected by previous workers (Qiu, 1990; Qiu and Qiu, 1995; Qiu et al., 1999).

Acknowledgements We dedicate this paper to the late professor Sun Zhencheng, who had been most generous in sharing his knowledge about Qaidam Basin accumulated during his career. We thank the numerous participants of our Qaidam fieldwork, whose hard work and diligent collecting have made possible our current understanding of the biostratigraphy: Qiu Zhanxiang, Chang Meeman, Chen Shanqin, Xie Junyi, Ni Xijun, Liu Juan, Wang Ning, Chen Gengjiao, Alex Wang, and our drivers Shi Fuqiao, Feng Wenqing, Li Qiang, and Wang Qiuyuan. For correlation of magnetostratigraphy, we benefited from extensive discussions with Song Chunhui, Gao Junping, and Meng Qingquan of Lanzhou University, the latter provided original GPS data for magnetic sites. For access to the Sven Hedin and Birger Bohlin archives, we thank the numerous courtesies and assistance offered by the staff of the Museum of Ethnography (Stockholm) and

the National Archives (Stockholm) and colleagues, Lars Werdelin of the Swedish Museum of Natural History (Stockholm) and late Solweig Stuenes of Uppsala University (Uppsala). Michael Woodburne read an earlier version of this paper and improved the English. We are also grateful for assistance in archive research and translation by Irene Svensson and helpful assistance by Yanping Song. Funding for fieldwork and travel are provided by the Knowledge Innovation Program of the Chinese Academy of Sciences (KZCX2-YW-Q09), CAS/SAFEA International Partnership Program for Creative Research Teams, National Natural Science Foundation of China (No. 40730210), National Science Foundation (US) (EAR-0446699, 0444073, 0958704), National Geographic Society (Nos. 6004-97 and 6771-00), Swedish Museum of Natural History (Stockholm), and the Research Committee of Long Island University.

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Appendix I Records of fossil localities and specimens from Bohlin's "little red" field notebook

All texts are translations from Swedish. These records pertain to the 1932 Qaidam fossil vertebrates collected from April 22 to June 3, 1932. Numbers (Nr) correspond to those in Bohlin (1937). Dates (in the format of date. month) are all in 1932. Square brackets "[ ]" indicate annotations by translators (MF and ARF). Reproduction of archival materials by permission from Sven Hedin Foundation, Stockholm

Nr	Date	Coll.	Locality	Strata	List of specimens
354	6.5				a few bone fragments, probably indeterminate
355	30.4	Chang	lok near 378	Basal Reds	large metapodial[?] bone, association of frags uncertain
356	28.4	Chang	N of anticline 1/2-1 li from red sediments in it [the anticline]	Basal Reds	fragm of artiodactyl phalanx and other small things
357	28.4	Chang		Basal Reds	fragm of diaphysis of large long bone
358	28.4	Chang		Basal Reds	lower end of metapodial (cannon) of middle sized artiodactyl
359	28.4	Chang		Basal Reds	small astragalus of artiodactyl. Rest?
360	22.4	Chang		Basal Reds	a couple of tooth crowns of ? cervid molar, fragment of tortoise shell, bone probably of fish
361	23.4	Chang		Basal Reds	deer antler ? how complete
362	29.4	Chang		Basal Reds	diverse frags, possibly useful in part
363	29.4	Chang		Basal Reds	rib frags
364	29.4	Chang		Basal Reds	numerous frags of some large bone
365	29.4	Chang	loc approx 356	Basal Reds	fragm of ? humerus
366	29.4	Chang		Basal Reds	few small frags of ? deer antler
367	29.4	Chang		Basal Reds	? deer antler, lots of fragments
368	1.5	Chang		Basal Reds	deer antler fragments
369	1.5	Chang		Basal Reds	? deer antler fragments
370	3.5	Chang		Basal Reds	a few frags
371	3.5	Chang		Basal Reds	worn lower molar of ? cervid
372		Chang		Basal Reds	fragm of deer antler
373		Chang	ca 3 li S of camp	Basal Reds	5 blocks 1 package
374		Chang	ca 3 li S of camp	Basal Reds	1 block 2 packages
375		Chang	ca 3 li S of camp	Basal Reds	3 blocks 4 packages
376		Chang	ca 3 li S of camp	Basal Reds	2 blocks 1 package
377		Chang	ca 3 li S of camp	Basal Reds	2 blocks 2 packages
378		Chang	ca 8 li SW of camp	Basal Reds	large scapula, 4 blocks 4 packages
379	9.5	Chang	loc approx = 378	Basal Reds	numerous frags of ? humerus (articular ends seem to be completely missing)
380	9.5	Chang	loc approx = 378	Basal Reds	upper articulation of large humerus, damaged
381	9.5	Chang	loc approx = 378	Basal Reds	fragm of lower articulation of large humerus
382	9.5	Chang	loc approx = 378	Basal Reds	many fragments of ? rhinoceros molar
383	9.5	Chang	loc approx = 378	Basal Reds	fragm of compact diaphysis (? humerus)
384	9.5	Chang	loc approx = 378	Basal Reds	some larger bone frags (partly ? humerus)
385	9.5	Chang	loc approx = 378	Basal Reds	lots of fragments ? Useful

386	9.5	Chang	loc approx = 378	Basal Reds	short, wide phalanx, probably rhinocerotid
387	9.5	Chang	loc approx = 378	Basal Reds	lots of frags of some large bone (? whether useful)
388	10.5	Chang	loc approx = 378	Basal Reds	fragm of margin of tortoise shell, a couple of smaller frags
389	10.5	Chang	loc approx = 378	Basal Reds	phalanx, probably of rhinocerotid, fragm of rib
390	11.5	Chang	S of camp river, few li outside camp	S of River	fragm of mastodont tooth, a couple of bad bone frags
391	11.5	Chang	S of river, few li below camp	S of River	defect astragalus of ? cervid
392	11.5	Chang	S of river, few li below camp	S of River	antler [or horn] base with fragm of cranium roof, small poor piece
393	11.5	Chang	S of river, few li below camp	S of River	lower end of small cannon[bone]
394	11.5	Chang	S of river, few li below camp	S of River	upper end of small radius (small artiodactyl, articular surface about 1 cm wide)
395	11.5	Chang	S of river, few li below camp	S of River	fragm of ventral shell of tortoise, a vertebra (? artiodactyl) etc
396	11.5	Chang	S of river, few li below camp	S of River	fragm of deer antler, possibly identifiable, fragm of small calcaneus (tuber), fragm of ? ulna (small), fragm of ? *Mastodon* tooth
397	12.5	Chang	S of river, few li below camp	S of River	quite good deer antler, 2 packages
398	12.5	Chang	S of river, few li below camp	S of River	a couple of frags of ? tortoise shell
399	12.5	Chang	S of river, few li below camp	S of River	fragm of cranium with antler base, a poor fragm of maxilla with tooth roots and a third poor fragm, everything ? cervid
400	13.5	Chang	S of river, few li below camp	S of River	fragm of large bone, bad
401	13.5	Chang	S of river, few li below camp	S of River	3 packages, one with frags of deer antler, one with frags of large bone (? what), one mainly tortoise remains
402	13.5	Chang	S of river, few li below camp	S of River	fragm of trochlea humeri (middle size artiodactyl) + other fragment
403	13.5	Chang	S of river, few li below camp	S of River	tortoise remains
404	13.5	Chang	S of river, few li below camp	S of River	
405	13.5	Chang	S of river, few li below camp	S of River	v. small astragalus of artiodactyl (size fits approx 394), fragm of tortoise shell, fish remains
406	14.5	Chang	a couple of li down river on S side	S of River	astragalus same kind as 405, tortoise fragm
407	14.5	Chang	a couple of li belowcamp S of river	S of River	fragm of deer antler (? normal)
408	14.5	Chang	a couple of li belowcamp S of river	S of River	fragm of tortoise shell
409	16.5	Bohlin	N of Pt 115		eggshell, 2 packages
410	16.5	Chang	almost 1 li N of red sediments E of camp		fragm of large tortoise shell
411	19.5	Bohlin	on [illegible] surface W of Pt 184 (in valley bottom)	GS 184	nearly complete short bone (? sesamoid of some kind)
412	19.5	Bohlin	between pt 183 and pt 184	General Strips	few bone frags (? what), a bad artiodactyl astragalus
413	19.5	Bohlin	near pt 183	GS 183	fragm of rhinoceros lower jaw, 3 packages +1 +1
414	19.5	Bohlin	loc approx as 413	GS 183	fragm of arch of large vertebra
415	19.5	Li	at pt 183	GS 183	fragm of large postcranial bone (? what)
416	19.5	Li	between pt 183 and pt 184	General Strips	fragm of ? bovine tooth, diverse bone frags (i. a. tortoise remains)
417	19.5	Li	pt 183	GS 183	vertebra (fragm)
418	19.5	Li	between pt 183 and pt 184	General Strips	calcaneus, rhinocerotid, complete
419	19.5	Li	at pt 183	GS 183	? whatever is this; 1 package frags, 1 block
420	20.5	Li	between pt 183 and pt 184	General Strips	scapula, probably rhinocerotid
421	20.5	Li	between pt 183 and pt 184	General Strips	pelvis fragm
422	20.5	Li	between pt 183 and pt 184	General Strips	fragm of ? femur, probably rhinocerotid
423	20.5	Li	between pt 183 and pt 184	General Strips	two horns, one at least a cavicornian
424	19.5	Bohlin	a couple of hundred m N of pt 184	GS spm 424	fragm of lower jaw, rhinocerotid (posterior part to alveolus for m3), lots of small frags, among them teeth, 3 packages
425	21.5	Li	between pt 183 and pt 184	General Strips	rib (fragm)
426	16.5	Chang		S of River	large tortoise, 1 block 2 packages
427	23.5	Bohlin	W of pt 183	GS 183	a couple of frags of tortoise shell, 2 frags of vertebrate bone with articular surfaces
428	23.5	Bohlin	near loc for BB 424	GS spm 424	fragm of tortoise shell

429	23.5	Bohlin	near loc for BB 424	GS spm 424	two horn bases, bovid
430	23.5	Bohlin	near loc for BB 424	GS spm 424	diverse bone (1 end phalanx of ? rhinocerotid, one carpal (or tarsal) bone, fragm of tortoise shell)
431	23.5	Bohlin	between pt 183 and loc for BB 424	General Strips	bad bone frags
432	23.5	Bohlin	somewhat lower than 183-finds and others	General Strips	one fragm of ostrich shell
433	23.5	Bohlin	between pt 183 and loc for BB 424	General Strips	frags of elephant tusk (a lot of small pieces)
434	23.5	Bohlin	near loc for BB 424	GS spm 424	fragm of scapula and ulna-radius from same place, frags mixed
435	23.5	Li	loc approx ′ = 424	GS spm 424	fragm of lower end of large femur
436	23.5	Li	near pt 183	GS 183	diverse frags at least partly of vertebra
437	23.5	Li	near pt 183	GS 183	epistropheus ? of argali-like animal
438	23.5	Li	near pt 183	GS 183	upper end of radius, rhinocerotid
439	23.5	Li	near pt 183	GS 183	cranial fragment with horn bases, bad
440	23.5	Li			small epistropheus of artiodactyl, one quite well preserved bone = ?
441	23.5	Li	near pt 183	GS 183	a couple of complete horns of larger antelope (possibly wild goat)
442	23.5	Li	near pt 183	GS 183	fragm of horn, probably same species as 441
443	23.5	Li	near loc for BB 424	GS spm 424	laterally strongly compressed symmetrical bone (not quite 1 square decimetreat at surface)
444	23.5	Li	near pt 183	GS 183	one tooth (? Dp) and tooth fragm of ?????? *Equus* ??????
445	23.5	Li	near pt 183	GS 183	jaw fragment with M2 and M3 of "small" ? antelope ′ + tortoise frags
446	23.5	Li	near pt 183	GS 183	fragm of [illegible; cranium?], tortoise frags
447	23.5	Li	near pt 183	GS 183	parietal region and occiput (mostly) of a very compact, bony skull
448	23.5	Li	near pt 183	GS 183	rhinocerotid mandible (fragment) 2 packets
449	23.5	Li	near pt 183	GS 183	diverse fragments (? at least partly a horn/antler?)
450	24.5	Bohlin	N slope of strip towards W from pt 183	GS 183	diverse bone frags i. a. Lower end of a humerus of medium size ? antelope
451	24.5	Bohlin	Strip 3-400 m N of pt 42	General Strips	i. a. horn (bovid), a pisiform, an [illegible] of a small artiodactyl humerus
452	24.5	Bohlin	level 450, possibly somewhat lower level	General Strips	i. a. upper and lower ends of artiodactyl ulna, rest poor
453	24.5	Bohlin	level 450/452	General Strips	lower end of tibia, perissodactyl
454	24.5	Bohlin	level 450/452/453	General Strips	horn of bovid
455	23.5	Li	near pt 183	GS 183	fragm of ? *Mastodon* tooth
456	24.5	Li	near pt 183	GS 183	upper end of radius, ? rhinocerotid
457	24.5	Li	at pt 42	GS Pt 42	occipital region of artiodactyl skull with wide, joined horn base, "*Chilotherium*"-like
458	23.5	Li	near pt 183	GS 183	"Stosszahn" fragm of elephant tusk, tip appears [illegible], two packets
459	24.5	Li	near pt 183	GS 183	a complete tarsal or carpal bone of perissodactyl (plus some frags); one packet fragm of large bone with joint surface
460	24.5	Li	near pt 183	GS 183	? horn
461	24.5	Li	near pt 183	GS 183	fragm. of skeletal bone (? rhinocerotid), some tooth [?] frags, undertain whether of this [specimen]
462	23.5	Li	near pt 183	GS 183	fragm of cranium with horn (bovid), probably same species as 451
463	24.5	Li	near pt 183	GS 183	fragm of occipital region with condyles
464	23.5	Bohlin	near loc for BB 424	GS spm 424	"complete" cannon bone (metatarsal) of lesser artiodactyl
465	23.5	Bohlin	183-strip towards W	General Strips	vertebra, reasonably complete
466	23.5	Bohlin	183-strip towards W	General Strips	fragm of tortoise shell and horse tooth
467	23.5	Bohlin	N slope of hill with pt 42	GS spm 424	astragalus of perissodactyl
468	23.5	Bohlin	183-strip towards W	General Strips	fragm of larger postcranial bone (with part of joint surface)
469	23.5	Bohlin	183-strip towards W	General Strips	base of deer antler
470	23.5	Bohlin	strip couple of hundred m N of pt 42	GS Pt 42	fragm of (?) end phalanx, tortoise fragm
471	23.5	Bohlin	183-strip	General Strips	fragm of atlas, large fish vertebra, etc.
472	23.5	Bohlin	183-strip	General Strips	upper end of metacarpus (cannon), probably same species as 464
473	25.5	Bohlin	183-strip	General Strips	diverse bones and bone frags
474	25.5	Bohlin	183-strip	General Strips	fragm of tortoise shell
475	25.5	Bohlin	183-strip	General Strips	skull cap of cranium with horns, very broken, 2 packets
476	26.5	Bohlin	S of pt 42	GS Pt 42	fragm of horn of cavicornia etc.

477	25.5	Bohlin	strip N of pt 42 (=470)	GS Pt 42	lower end of humerus with trochlea, lesser artiodactyl
478	26.5	Bohlin	N of pt 42	GS Pt 42	few frags of tooth roots in cranium
479	26.5	Bohlin	hill of pt 42	GS Pt 42	a horn
480	26.5	Bohlin	hill with pt 42	GS Pt 42	fragm of tortoise shell
481	25.5	Bohlin	near loc for BB 424	GS spm 424	posterior part of cranium with both horns preserved (though lacking tips). Horns flat, broad, diverging at nearly 90 degree angle. 2 packets
482	26.5	Bohlin	hill of pt 42	General Strips	poor frags of ? metacarpus of artiodactyl
483	26.5	Li	183-strip	General Strips	articular end of small scapula, poor things
484	25.5	Li	near pt 183	GS 183	fragm of corpus of large limb bone
485	26.5	Li	183-strip	General Strips	? rib fragm
486	26.5	Bohlin	hill with pt 42	General Strips	a horn
487	23.5	Bohlin	strip N of pt 42	General Strips	packet containing some 30 frags of *Mastodon* teeth (probably 2 teeth), 4 pieces go together to two complete "OK", a package of jaw frags, a package with large frag crumbly and rotten, 2 packets smaller frags, 2 packets smaller frags, of which one with frags of [illegible], one block poor things
488	25.5	Bohlin	183-strip	General Strips	half pelvis of probably rhinocerotid, ischium-part at least complete, 4 packets
489	25.5	Bohlin	183-strip	General Strips	mandible of young individual of ? artiodactyl
490	25.5	Bohlin	183-strip	General Strips	some bone frags (? what)
491	25.5	Li	near pt 183	GS 183	a horn
492	25.5	Li	near pt 183	GS 183	fragm of skull cap with horn bases
493	27.5	Li	near488 in 183-strip	General Strips	metatarsal of horse, part of corpus missing
494	27.5	Li	near488 in 183-strip	General Strips	cervical vertebra of artiodactyl, ? cranial fragm
495	27.5	Li	near488 in 183-strip	General Strips	lower end of metacarpus plus a couple frags of upper end
496	27.5	Li	hill with pt 42	GS Pt 42	fragm of maxilla, teeth nearly destroyed, probably rhinoceros
497	27.5	Li	hill with pt 42	GS Pt 42	maxillary tooth of rhinoceros (unworn, several frags)
498	27.5	Li	hill with pt 42	GS Pt 42	lower end of horse radius
499	27.5	Li	hill with pt 42	GS Pt 42	a horn, same species as 486
500	28.5	Bohlin	183-strip	General Strips	a nearly complete astragalus, ? horse
501	28.5	Bohlin	183-strip	General Strips	lower end of humerus, large artiodactyl
502	28.5	Bohlin	183-strip	General Strips	diverse frags of mammal, tortoise, and fish, nothing particularly good
503	27.5	Li	near "424"	GS spm 424	skeleton of rhinocerotid (? *Chilotherium*) [roman numerals with detailed description of parts, continued five pages later]
504	27.5	Li	a couple of li W of pt 183	General Strips	cranium of rhinocerotid ? *Chilotherium*, 2 packets, one block
505	28.5	Li	183-strip	General Strips	i. a. fragment of tusk (= earlier finds, tip with enamel)
506	28.5	Li	183-strip	General Strips	mandible frag
507	29.5	Bohlin	E of pt 183	GS 183	diverse small things, i. a. a reasonably complete astragalus of small artiodactyl
508	29.5	Bohlin	183-strip near E of pt 42	General Strips	[? deer] horn with part of cranium
509	29.5	Bohlin	same hill as 508	General Strips	corpus of large vertebra, ? elephant
510	29.5	Bohlin	same hill as 509	General Strips	diverse bone frags, i. a. fragm of jaw with 3 tooth roots (a couple of epistr fragms, and epiphysis of limb bone, 3 fragms, somewhat further east
511	29.5	Bohlin	E of pt 183 along base of strip	GS 183	fragm of large humerus (rhinocerotid), lumbar vertebra, probably artiodactyl, 3 packets
512	29.5	Li	near loc for BB 424	GS spm 424	horn [= antler], probably cervid
513	29.5	Bohlin	N of pt 183 at foot of strip	GS 183	fragm of small scapula, probably artiodactyl
514	29.5	Bohlin	42-hill	GS Pt 42	horn with cranial fragm, cavicornia, artiodactyl, same type as e. g. 508
515	30.5	Bohlin	183-strip	General Strips	an atlas, nearly complete, probably medium sized artiodactyl
516	30.5	Bohlin	near loc for BB 424	GS spm 424	fragm, probably of two vertebrae ? *Mastodon*, patella of rhinocerotid
517	30.5	Bohlin	183-strip	General Strips	good 1st phalanx of small artiodactyl, fragm of lower end of humerus
518	31.5	Bohlin	183-strip	General Strips	fragm of cervical vertebra, strongly curved bone frag, ? what
519	30.5	Bohlin	near loc for BB 424	GS spm 424	? horn (surface looks like that, base with smooth cavity)
520	31.5	Bohlin	somewhat more S than other finds in 183-strip	General Strips	fragm of horn, ? same species as 481

521	31.5	Bohlin	183-strip	GS spm 424	fragm of atlas (medium size), small astragalus of artiodactyl
522	31.5	Bohlin	183-strip near find 424	General Strips	a nearly complete epistropheus [= axis] (? medium artiodactyl)
523	31.5	Bohlin	183-strip	General Strips	an unworn equid tooth (? M2/)
524	29.5	Li	183-strip near find 424 = 528	General Strips	tibia of "elephant", 3 packets frags, 4 larger pieces
525	30.5	Chang	near BB 424 and 503	GS spm 424	mandible of rhinocerotid, 5 packets of frags
526	31.5	Bohlin	at find 503	GS spm 424	mandible of rhinocerotid, one branch nearly complete, symphysis and part of other branch. Teeth missing except for enamel fragment, but should still be useful
527	1.6	Chang	183-strip	GS spm 424	upper end of large humerus, few small frags ? of same bone, 2 packets
528		Li	[none]		? astragalus of elephant
529	1.6	Bohlin	183-strip	General Strips	fragm of cavicorn horn (base), probably same species as "508", isch-part of small pelvis, a couple of frags?
530	1.6	Chang	183-strip	General Strips	numerous frags of ? a *Mastodon* tooth
531	1.6	? Feng	183-strip	General Strips	cavicorn horn, probably same species as "508"
532	1.6	Li	183-strip	General Strips	equid hoof, phalanx, probably carnivore, tortoise frags
533	1.6	Bohlin	near 424	GS spm 424	fragm of carnivore cranium with alveoli (roots) of upper canine, 1 (or 2) premolars
534	1.6	Li	183-strip	General Strips	? navicular of *Mastodon*
535	1.6	Chang	183-strip	General Strips	small astragalus (artiod), phalanx 1 equid, phalanx 2 artiod, horn cavicorn, poor, toothed bone of large fish
536	1.6	Chang	183-strip	General Strips	fragm of *Mastodon* tooth, small frag of rhinocerotid occiput with one condyle, upper end of metapodial bone, ? cranial fragm
537	1.6	Chang	183-strip	General Strips	fragm of probably ruminant skull, posterior part
538	1.6	Chang	183-strip	General Strips	fragm of atlas, ? carpal bone (? equid), lower end of small artiodactyl humerus, small scapula (cf, 513), fish bone
539	2.6	Bohlin	E of pt 42 hill, somewhat more northerly strip than 183	GS Pt 42	few frags of ? fibula (? rhinocerotid), fragm of horn (? same species as 481)
540	2.6	Bohlin	loc = 539		few frags of deer antler, etc., small intermedium carpi of small artiodactyl
541	2.6	Bohlin	loc = 239	GS Pt 42	i. a. lower end of ? metapodial of ? *Mastodon*, one condyle of cannon bone (large), strongly rolled ? tarsal bone of ? equid
542	2.6	Bohlin	W of pt 42 in same strip	GS Pt 42	fragm of lower end of rhinocerotid metapodial, fragm of *Mastodon* tooth (3 frags join), fragm lacking teeth of probably carnivore mandible (etc.)
543	2.6	Li	183-strip	General Strips	enamel frags of mastodont tooth ? useful
544	2.6	Bohlin	W of pt 42	GS Pt 42	corpus of cervical vertebra (? "*Chilotherium*"-like), fragm of atlas, probably ruminant, lower end of small tibia, etc. A horn = 508
545	2.6	Bohlin	E of pt 42	GS Pt 42	complete metapodial bone of carnivore
546	2.6	Chang	near 424	GS spm 424	femur (missing lower end) of carnivore, fragm of vertebra
547	2.6	Chang	near 424	GS spm 424	posterior part of cranium with horn base of "*Chilotherium*"-like animal, rather broken
548	2.6	Chang	near 424	GS spm 424	fragm of joint surface of *Mastodon* bone
549	2.6	Chang	loc = 548	GS spm 424	fragm of pelvis with joint[illegible], *Mastodon*
550	2.6	Chang	loc = 549	GS spm 424	probably fragm of same bone as 549
551	2.6	Chang	loc = 550	GS spm 424	2 packets of frags, same loc as 549 and 550, probably belongs to them
552	1.6	Chang	near 424		fragm of large vertebra (*Mastodon*)
552	ca 30.5	Chang	at large skeleton find		scapula from large skeleton find (artiodactyl, large) 1 packet fragments, 1 block
553	3.6	Li	W of pt 42 in same strip	GS Pt 42	mandibular tooth of ???? *Equus*???? Note enamel considerably less plicated than in *Hipparion mediterraneum* (fig. in Weber), phalanx, ? equid
554	3.6	Li	W of pt 42 in same strip	GS Pt 42	cervical vertebra, rhinocerotid
555	3.6	Li	W of pt 42 in same strip	GS Pt 42	radius, upper and lower ends, equid, calcaneus of rhinocerotid
556	3.6	Li	W of pt 42 in same strip	GS Pt 42	lower end of humerus, upper end of ulna, rhinoce-rotid, 2 packets