Reconstruction of paleoenvironments in the lower reaches of Heihe and Juyan Lake area

- migration of river course and Juyan lakes -

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1. Introduction

On the north slope of Qilian Mountains, broad alluvial fans extend toward northernmost end of the Heihe drainage basin (Figs.1 and 2). Juyan terminal lakes, such as Sogo and Gashun Lakes are situated in desert environments. Recently they have dried up, excluding temporary supply of water. In addition, another large lake, Old Juyan Lake existed in the east. It had dried up in the historical age.

Topography and surface geology of Juyan and Old Juyan Lake areas in the lowest reaches of Heihe were investigated preliminarily from the late July to middle August, 2002. During this field trip, we visited Sogonur, Tien-e-hu, Gashunur, and old lake areas, and observed and checked the topography, lake sediments, and vegetation. And also visited archaeological sites, and checked topographical features such as irrigation patterns surrounding the sites. This part of the field trip was jointed with the history group of " Oasis Project: Historical evolution of the adaptability in an oasis region to water resource changes" by Research Institute for Humanity and Nature (RIHN) Kyoto.

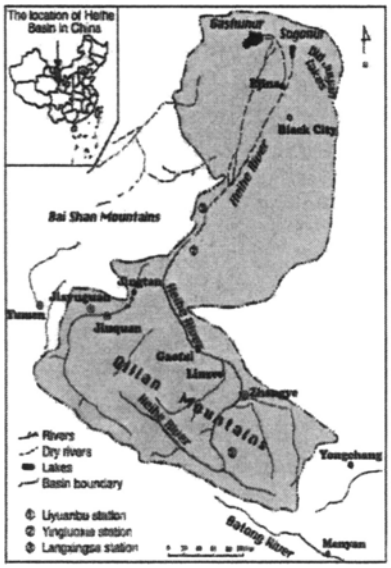

Fig.1 Map showing Heihe Basin and the Location of Juyan lakes

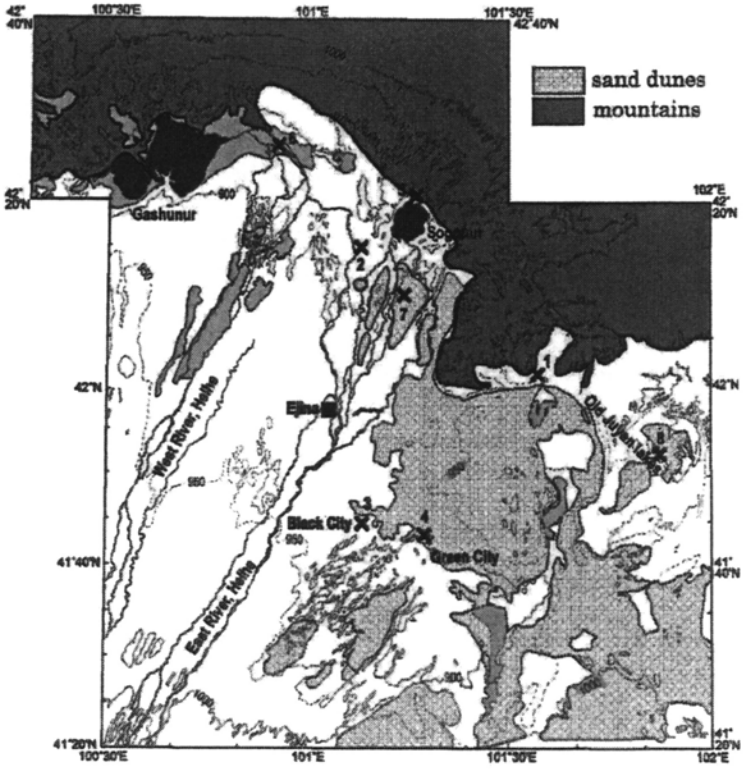

Fig.2 Topography of the lower reaches of Heihe and Old Juyan lake area. Contour lines are simplified from Topographical Map by Russia.

In this report, gravel bars and lake sediments around Tian-e-hu are described, and the migration processes of the terminal lakes, river course and sand dunes are discussed in relation to historical evidence.

2. Yardan mounds around Tien-e-hu in the Old Juyan lake area

In the latest July and middle August, 2002, the water was supplied and filled the small lake of Tien-e-hu (Swan Lake) temporarily (Photo 1). Tien-e-hu is a small lake, at northwest end of the Old Juyan Lake area. Near the northern shore of Tien-e-hu, there were two areas of exposed lake sediments; one, a type showing yardan topography, is situated around the lake (Photos 2 and 3), and another, a type of table mountain-like, extends to west of the lake. The both types are composed of lake sediments. The first type is remnant from wind erosion. The top of the yardan topography shows flat surfaces having some different heights.

By the lakeshore of 2002, many mounds of yardan topographies are situated, having height of 1 to 1.5 meters (Loc.1 in Fig.2, Photo 3). Those are very good outcrops of the former lake bottom sediments, actually composed of alternation between thin lake sediment and sands, probably of aeolian origin. This suggests cyclic changes had been continued in the past too, between high water and low water or dry-up condition

Dated sample, a small amount of shells, was collected from the middle part of a yardan mound. The result of AMS-method radiocarbon dating is 4580 cal.y.BP [cal.BC 2680-2575:PLD-1901].

In the northern part of the lake, higher and larger Yardan mounds are distributed like table mountains. The height is about 11 to 12 meters above the lake water level of 2002. We couldn't find any dated samples from them so far, but their ages are probably older than those near the present lakeshore.

Mischke et al. (2002) investigated this sediment by using ostracoda, and indicated that the lake existed at least 2700 to 5400 cal.y.BP.

3. Gravel bars around Tien-e-hu

There distribute a number of gravel bars surrounding Tien-e-hu. Fig.3 is a Corona satellite photo, showing various topography in desert environments. Fig.4 is showing traces of gravel bars developing around Tien-e-hu. Those gravel bars are preserved very well and are good evidences of the former lake shorelines. Along the survey line about 2.7 km long shown in Fig.3, mini-scale terraces (1 to 4) are found by the lakeshore 2002, showing very recent lake level change. Below the lowest terrace 1, there are three steps of lake level in 2002.

About first 1 km from the lakeshore, there are no typical gravel bars, only covered with gravelly gentle slope except Yardan mounds of lake bottom sediments. From 1.1 km to 2.7 km, 23 well-preserved gravel bars were distinguished. The interval between gravel bars ranges from 15 m to 100 m, about 70 m in average. Almost all bars are nearly parallel and surround the area of the
bottom sediments. Many blocks of the basement rocks are scattered on the gravel bars only along the survey line. But it is a good marker of each gravel bar. From the similarity in rock types, those were supplied from the low mountain area behind, maybe as rock avalanches or debris flows, and reworked by wave action.

Deposits of gravel bars were checked using pits for road construction. Small shell sample found in the sand and gravel layer from the 12th gravel bar from the highest one, was dated by AMS-method radiocarbon dating, and the result is 3290 cal.y.BP (PLD-1749). By the 2002 lakeshore, small terraces (1 to 4) are found, showing very recent lake level change. Below the lowest terrace 1, there are three steps of lake level in 2002.

Corona satellite photos processed by H.Sohma, show the distribution and alignment of these lake shorelines well (Figs. 4 and 5) not only around Tien-e-hu but also in the areas of Old Juyanhai. This suggests at least higher gravel bars may be evidence for existence of a large lake covering whole of Old Juyan lake area.

Fig.3 Corona satellite photo showing Tien-e-hu(Swan Lake) in the Old Juyan lake area and elevation based on the topographical map by Russia

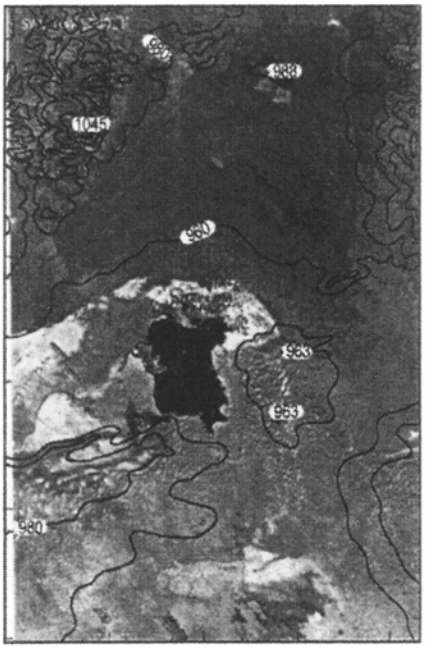

Fig.4 Corona satellite photo showing Tien-e-hu(Swan Lake) and traces of gravel bars surrounding the lake deposits

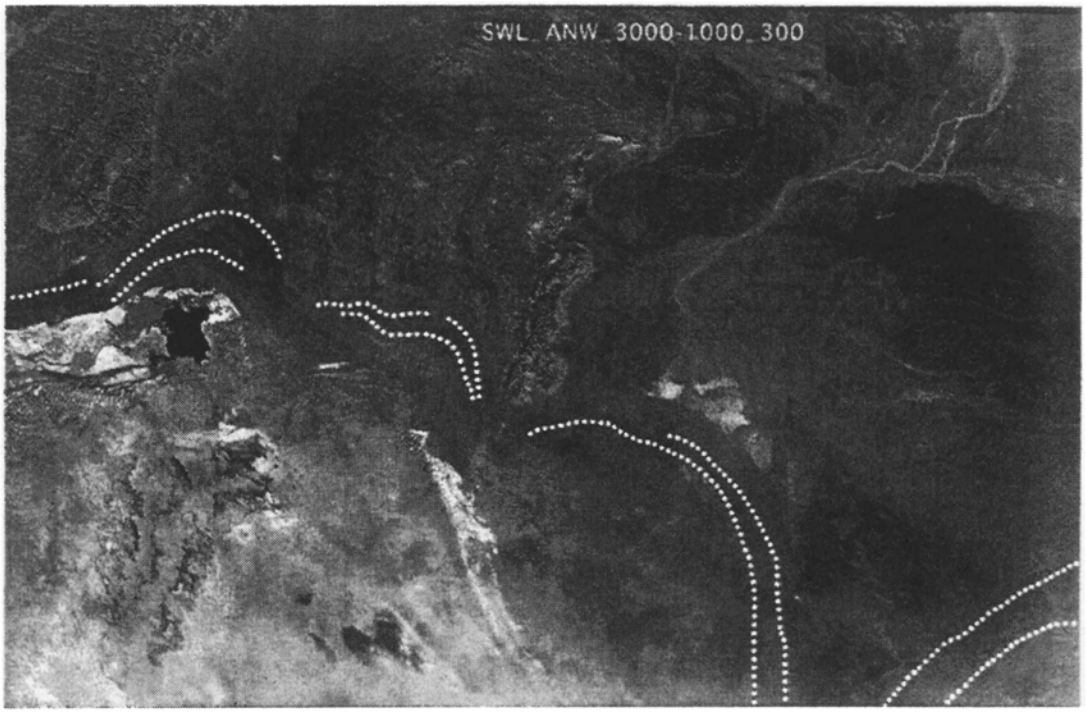

Fig.5 Corona satellite photo showing the Old Juyan Lake area and gravel bars

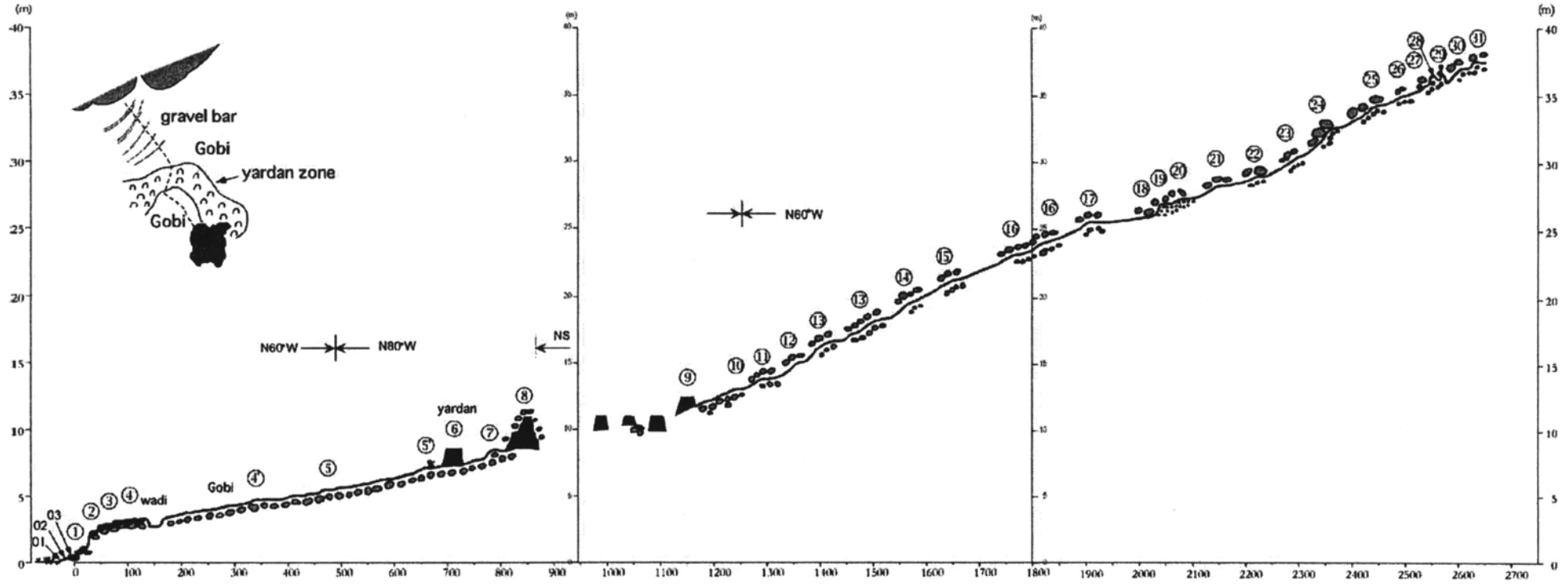

Fig.6 A profile of gravel bars of Old Juyan lake, near Tien-e-hu (Swan Lake).
Along the survey line, 2.7 km long, at least 23 gravel bars are distinguished, showing the former shoreline.

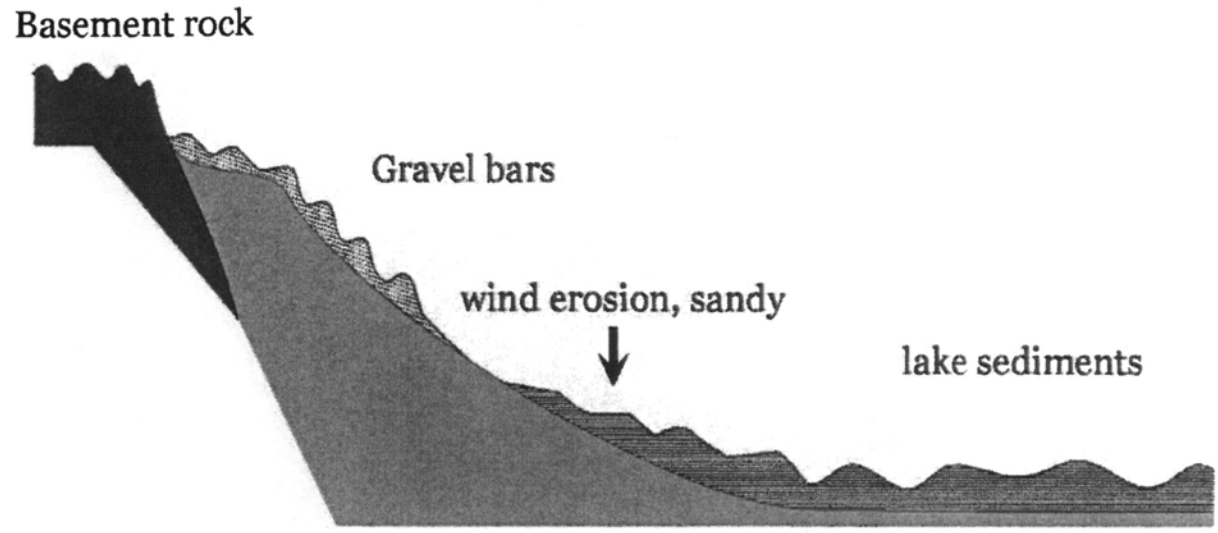

Fig.7 Schematic profile of gravel bars and lake sediments

4. Migration of Heihe and Juyan lakes

On the southwest of Old Juyan lake, some historical sites ranging from 2000 to 650 y.BP are located; for example, Black City, Green City etc. Around those historical sites, many cultivation patterns are visible on the Corona satellite photo. It suggests that the Old Juyan lake had existed not only in 5400 to 2700 cal.y.BP(Mischke et al.,2002), but also during the historical ages at least from Han to Yuan dynasties, about 2000 to 650 y.BP (Mu et al.,2003).

The elevation of the former shorelines of Old Juyan lake is about 960 to 980 m above sea level, being much higher than the lowest portion of the basin, around Gashun and Sogo lakes, about 800 to 850 m. The reason why the Old Juyan lake formed at the higher level, is a existence of the large ridge of sand dunes in the northwestern part of Old Juyan lake. This sand ridge played a role of obstacles, blocking the watercourse toward north (Fig.8). Heihe carried a great amount of clastic materials to form broad alluvial fan and terminal lowlands. Sand-rich sediments supplied by Heihe, accumulated mainly in the lower part of alluvial fan and lowland areas, are easily carried by winds eastward.

At present, a new sand dune zone separates Old Juyan lake and historical sites (Fig.8). Northwest prevailing wind carried eolian sand to make high ridges of sand dunes there. Therefore the course of Heihe was changed from NE to NNE probably by advance of the sand dune zone to east. The river water must cut and erode existed higher sand dune zones, then flow into the Juyan lake basin.

Along the north course, that of the present East River of Heihe, there are some outcrops composed of a number of flood deposits interbedded with thin weak soils, 2 km southwest of Sogonur (Fig.9, Photos 10, 11, 12 and 13). Near the lowest horizon, a thicker soil underlies the flood deposits. Its age is cal AD 1410 (540 cal.y.BP[cal.AD 1390-1440], PLD-1896). This age may support the migration model of Heihe and Juyan lakes.

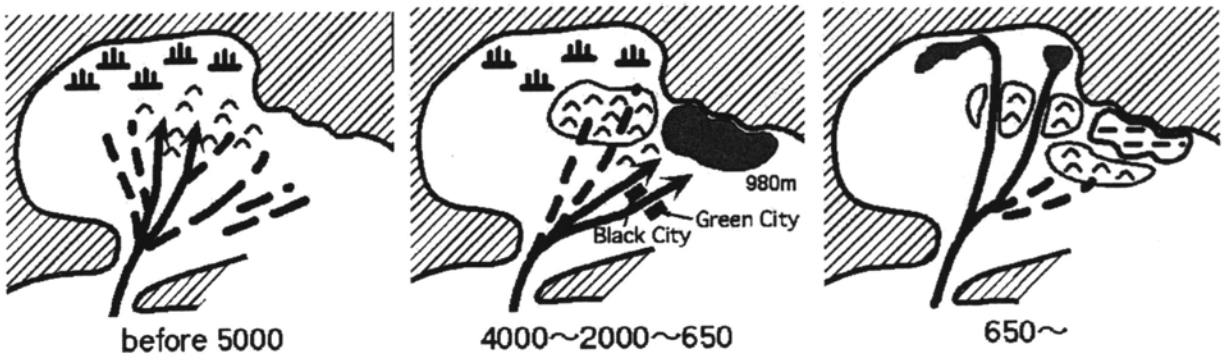

Fig.8 A model showing migration of Heihe river course, terminal lakes and sand dunes.
Old Juyan Lake formed about 5400 y.BP and existed to 2700y.BP(Mischke et al.,2002), and archeological sites of Black City and Green City suggests the lake continued to be from Han to Yuan dynasties (about 2000- 650).
After Yuan dynasty the Lake dried out and Sogo Lake and Gashun Lake formed.
These environmental changes are relating to migration of sand dunes and river course.

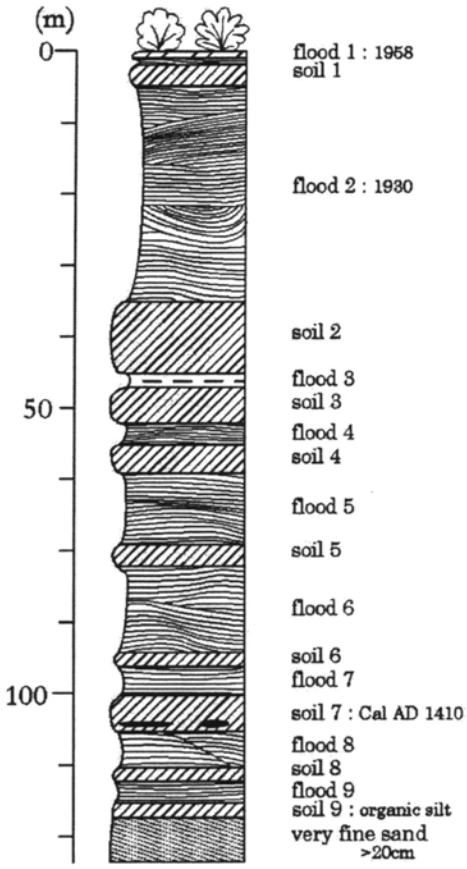

Fig.9 Columnar section showing frequent occurrence of floods and soils, south of Sogo Lake (Loc.2)

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5. Concluding remarks

The lower reaches of Heihe belonging to Inner Mongolia, are situated in almost desert to subdesert environments. The environmental condition of the area becomes worse and worse under the rapid decrease in water discharge of Heihe. The chief reason may be rapid increase in population and irrigated area in the middle reaches of Heihe. Such environmental deterioration causes the desertification, including occurrence of dust storms. The lower reaches of Heihe have been one of the most active source areas of dust storms.

In such environment, relationships between human activity and nature are much more important and serious, even in the historical ages. Old Juyan lake was located in the northeast part of the terminal areas at least 5400 to 2700 y.BP, based on lake sediments (Mischke et al., 2002) and 2000 to 650 y.BP according to archeological sites and irrigation patterns surrounded the lake. The higher lake level shown by gravel bars had lowered gradually as same as Aiby Lake in western end of Jungar Basin (Mu et al., 1999;

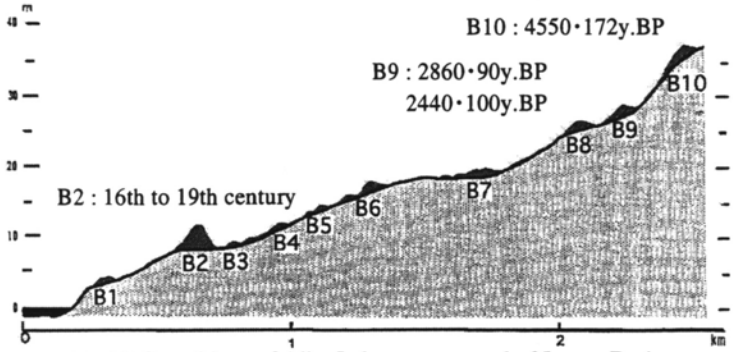

Fig.10 Gravel bars of Aiby Lake, western end of Jungar Basin (modified after Mu et al., 1999; Endo et al., 1998)

Fig.10). However, the Old Juyan Lake had dried out about 600 to 400 y.BP (Mu et al., 2003). Migration of sand dunes and river course played a big role. However the Old Juyan lake had dried up around AD 1400 probably by environmental changes including sand dune formation and migration.

Acknowledgement

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Wunnemann, B., Pashur, H. J., Li ,Jijun et al. (1998) Chronologie der pleistozanen und holozanenSeespiegelschwankungen des Gaxun Nur/ Sogo Nur und Baijian Hu, Inner Mongolei, Nordwestchina. Petermanns Geographische Mitteilungen, 142, 191-206.

Photo 1 Northern shore of Tien-e-hu (Swan Lake). Water was supplied temporarily in2002 summer.

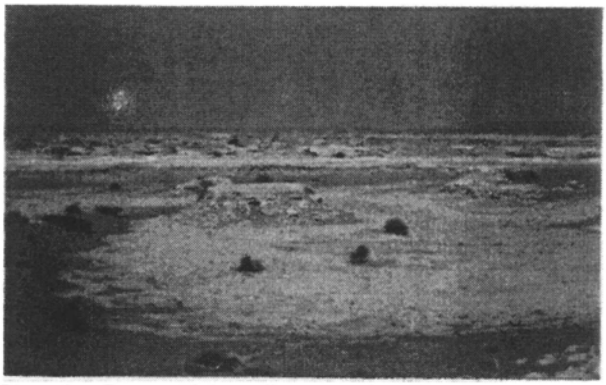

Photo 2 Exposed lake sediments and yardan topography at the northern shore of Tien-e-hu.

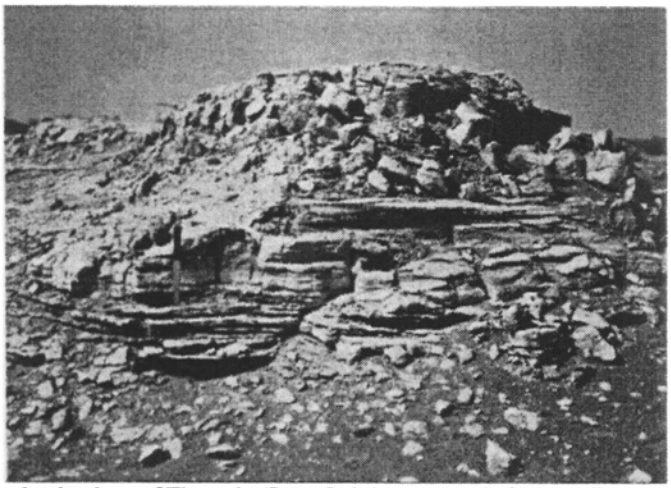

Photo 3 Yardan topography by the shore of Tien-e-hu(Swan Lake), composed of lake sediments and eolian sand.

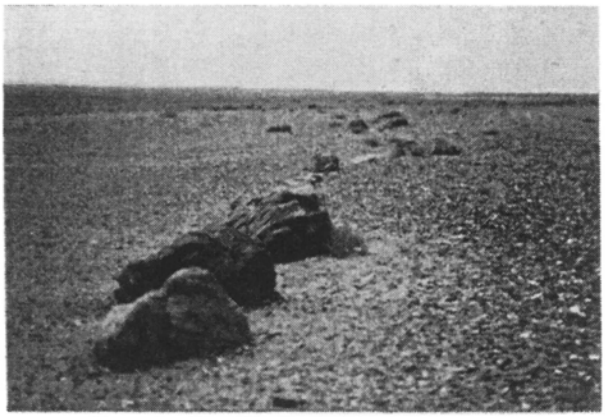

Photo 4 : Gravel bars northwest of Tien-e-hu

Photo 5 : Gravel bars northwest of Tien-e-hu

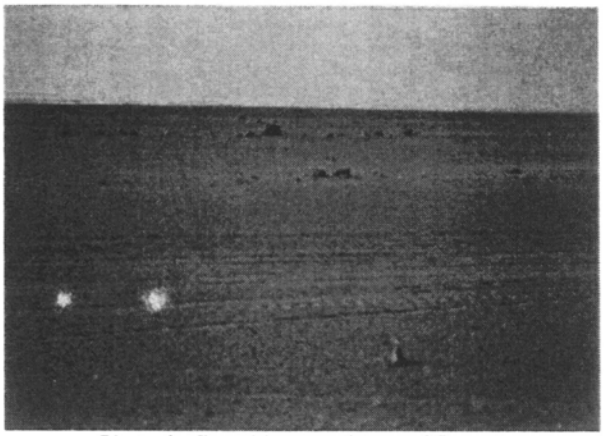

Photo 6 : Gravel bars northwest of Tien-e-hu

Photo 7 : Gravel bars northwest of Tien-e-hu

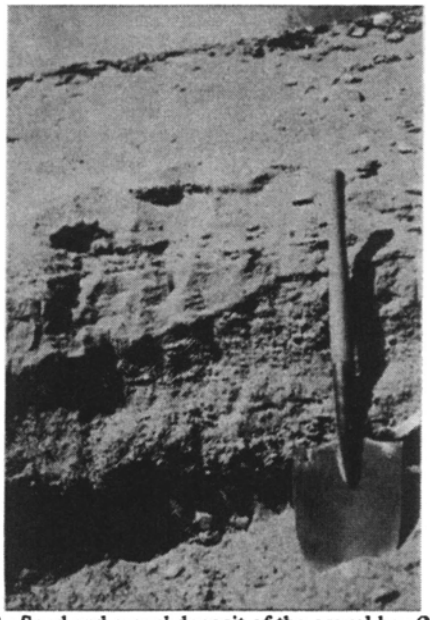

Photo 8 : Sand and gravel deposit of the gravel bar (No.19 in Fig.6) in the pit of road construction

Photo 9 : Fossil shells are included in the sand and gravel deposit of the gravel bar (No.19 in Fig.6).

Photo 10 Flood deposits at Loc.2, southwest of Sogonur

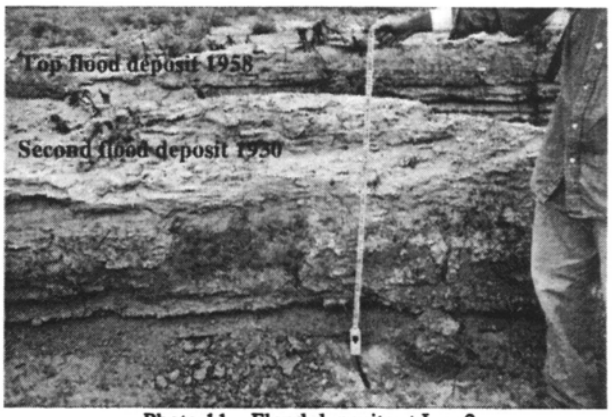

Photo 11 Flood deposits at Loc.2

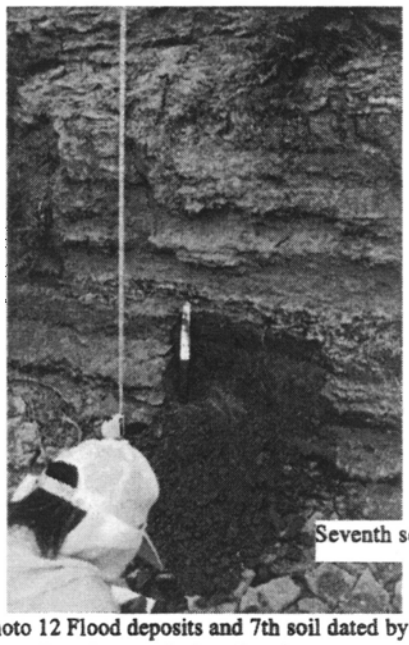

Photo 12 Flood deposits and 7th soil dated by radiocarbon method, at Loc.2

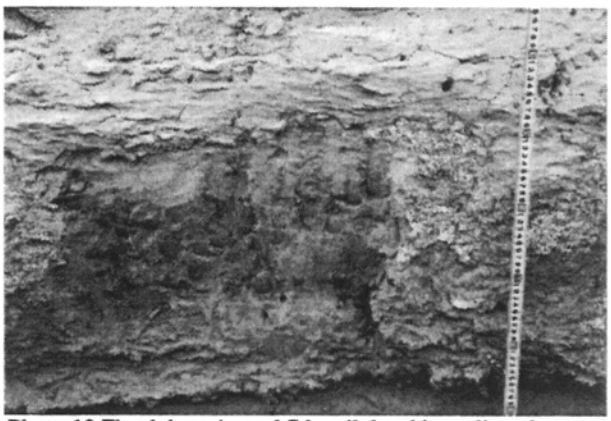

Photo 13 Flood deposits and 7th soil dated by radiocarbon method, at Loc.2