CHARACTERISTICS OF PALEOCLIMATE IN EJINA ALLUVIAL FAN INDICATED BY CROSS SECTION

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Abstract: Components, grain size, roundness and the color of the deposits can reflect the sedimentary environment. Based on fieldwork, 10 cross sections were built in the study area from 2011 to 2012. The depositional geological time was measured by the Optical Stimulated Luminescence (OSL) dating method. Lithology is determined by field lithological description, samples collected in sites and pictures taken in the field. Sedimentary facies and the change of Paleoclimate were analyzed according to the components (deposits) in the strata. Potassium content was measured by XRD spectrometer. Results indicate that from late Pleistocene to present, the sedimentary facies were composed by alluvial, lacustrine, fluvial and Aeolian deposits. Although there are small Paleoclimate changed cycles in a sedimentary environment, the change from alluvial to Aeolian sedimentary facies indicates that the Paleoclimate changed from humid into arid in overall trend which leading to the decrease of water sources.

INTRODUCTION

Ejina alluvial fan, shown in the left image of Fig.1, is located between 99°45´E, 42°30´N and 102°45´E, 40°30´N and covers an area of approximately 30,000km^2. The downstream of Hei River, the second largest inland river in China which originated on the northern side of the Qilian Mountain, flows through this area. This place was once an area with many rivers and lakes with a warm and humid climate, but now the climate here becomes to be arid which leading to the disappearance of ancient lakes, spread of desertification and degradation of Oasis. Therefore, the evolution of its environment and its driving factors are mysterious to many scientists. Wen, X.H. et al studied the grain size of sand dunes in Ejina Oasis and the results indicated that the Ejina Oasis had experienced 11.5 cycles of "Desertification" and "Oasisization" since 2.5ka BP which was mainly related to the alternating winter and summer monsoon; Fu, K.D. et al studied the change of gravel particle size in response to climate and tectonic evolution of the northern Tibetan Plateau and the results indicated that the grain size of gravels in the Jiuquan-Gebi group changed to be coarse which reflected the plateau uplifted intensely in late Quaternary; Zhang, Z.K. et al studied the change of environment in Juyan sea recorded by deposits and the results indicated that the change of Paleoclimate in Juyan sea had the characteristics that cold wet - warm wet - warm dry – cold wet since 2.6KaBP and the climate changed to be warm and dry at present. Change of the climate was the main factor leading to the environment degradation, while the human activities are the minor; Wang, X.Y. et al studied the ecological environment monitor technique by remote sensing. The results indicated that the environment degraded seriously from 1986 to 2000 and the unreasonable use of water resources was the main factor; Cao, S.K. et al previewed the vegetation and environmental factors in Ejina Oasis and indicated that the current research was focused on GSPAC system and eco-environment change in Ejina Oasis. In the future, soil water distribution in space and temporal, eco-environmental effect of transporting water in the lower Hei River and water potential in different parts of natural plant should be paid more attention; Ge, R.L. et al built a system dynamics model to estimate the Ejina Oasis land carrying capacity. The results indicated that the land carrying capacity would become 20-33% after 20 years according to present land using style. Therefore, the authors give advices to the Ejina government: Rational use water resources to build water saving agriculture and improve the ecological environment; Yang, X.P. et al investigated the geochemistry of water resources in the desert in 2003. The results indicated that there was a positive correlation between the ages of these lakes and their totally dissolved solids (TDS) and the huge enrichment of ions in the lakes and decrease of water availability originated from climatic desiccation during the last 4000 years; Yan, Z. et al studied the spatial and temporal patterns of Holocene vegetation and climate changes in arid and semi-arid China. The results indicated that the regional climate responding to large-scale climate forcing were controlled by interactions of competing factors, including the monsoons, westerlies and topography-induced regional atmospheric dynamics; Yang, X.P. studied the recharge to the inter-dune lakes and Holocene climatic changes in the Badain Jaran desert in 2010. The results suggested that local rainfall made a significant contribution to groundwater recharge and that past lake-level variations in this desert environment should reflect Palaeoclimatic changes. Wetter climates during the Holocene were likely triggered by an intensified East Asian summer monsoon associated with strong insolation; Steffen, M. et al studied the mid to late Holocene Palaeoenvironment of lake eastern Juyanze. Geochemical and palaeontological records of lake eastern Juyanze revealed the retreat of the Asian monsoon after Chinese Hypsithermal culminating in climate instability at about 3000 cal. a BP.

In this research, the characteristics of Paleocliamte in Ejina alluvial fan reflected by deposits in cross sections were presented to give the reason of Paleoclimate's formation.

CHARACTERISTICS OF PALEOCLIAMTE IN DIFFERENT CROSS SECTIONS

As shown in figure 1, based on fieldwork, 10 cross sections mainly distributed in western and north-eastern were built in the study area from 2011 to 2012. The depositional geological time was measured by the Optical Stimulated Luminescence (OSL) dating method in the Institute of Crustal Dynamics, China Seismological Bureau. According to the deposition principles, components, grain size, roundness and the color of the deposits can reflect the sedimentary environment and the geological structure.

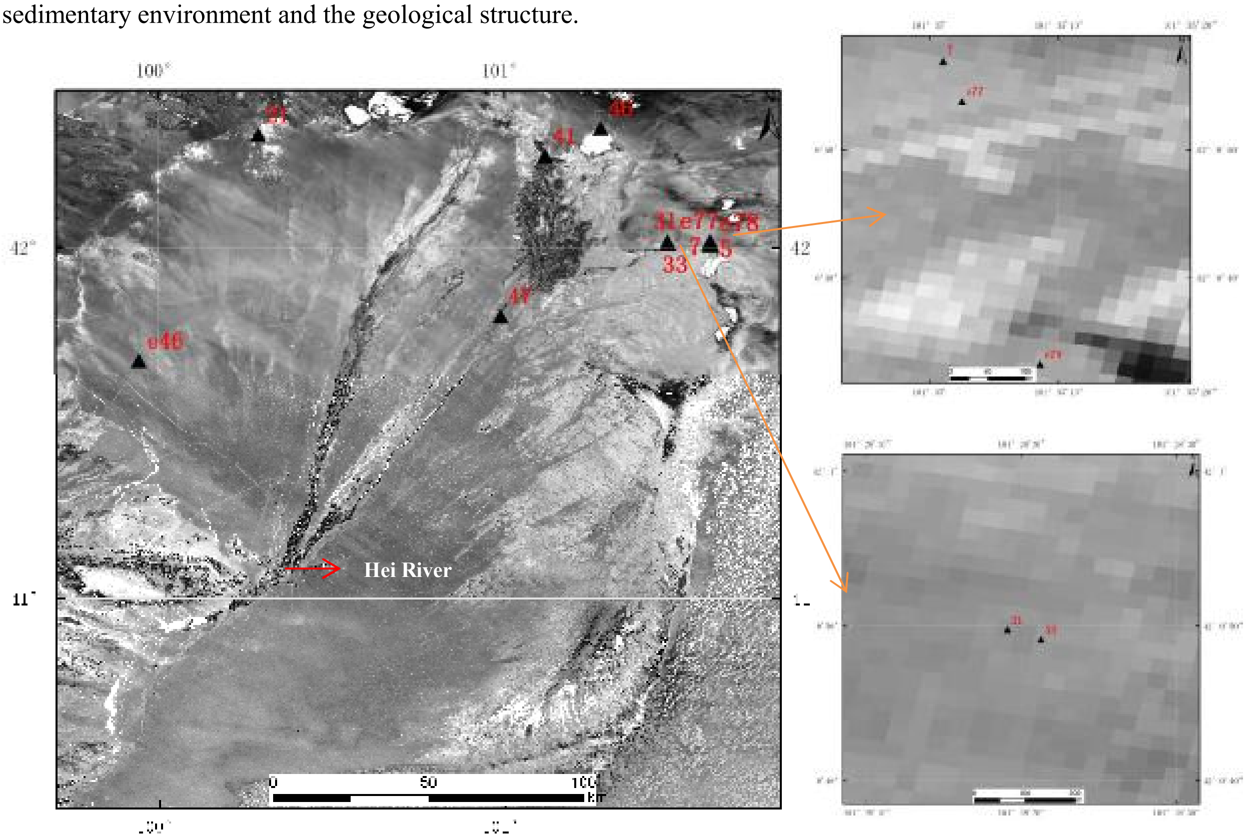


Figure1: Distribution of sections in different sites

(1) Section in point 7

As shown in figure 2(a), with about 200cm in height, this section is composed by 3 strata. The bottom is composed by caesious clay, which indicates that the deposits were under the reducing lacustrine depositional environment and the Paleoclimate was humid in middle Pleistocene; the second is 150cm in thickness and composed by black coarse gravel. Coarse grain size and poor roundness indicate that the deposits were under alluvial depositional environment with large amount of water. The depositional environment indicates that the Paleoclimate became more humid in late Pleistocene; the top stratum is composed by gray clay. Fine grain size and white color indicate that the deposits were under lacustrine depositional environment with large amount of water and low flow rate, which indicates that the Paleocliamte became less humid in early Holocene.

(2) Section in point 31

As shown in figure 2(b), with about 180cm in height, this section is composed by 3 strata. The first is composed by brick red pebbly sand. Large grain size, poor roundness and color indicate that the deposits were under the alluvial depositional environment with large amount of water and near-source components which indicated that the Paleocliamte became humid in late Pleistocene; The second stratum is composed by yellowish calcareous sand, which indicates that the deposits were under oxidizing lacustrine depositional environment and the Paleoclimate became arid in early Holocene; The third is composed by gray calcareous sand with rich calcium carbonate, which indicates that the Paleoclimate became less arid in middle Holocene; The top stratum is composed by yellowish calcareous sand, which indicates that the deposits were under oxidizing lacustrine depositional environment and the Paleoclimate became more arid in late Holocene. Therefore, the last three calcareous sand strata indicate that the paleoclimate became arid since late Pleistocene.

(3) Section in point 21

As shown in figure 2(c), with about 150cm in height, this section is distributed in the north-western site of the study area. Deposits include gray sand, gray calcareous clay, gray sand and gray pebbly sand from the bottom to top. According to correlated literatures, the first three strata were under lacustrine depositional environment in the early Holocene and the top stratum was under the Aeolian depositional environment in the late Holocene. Fine grain size of the deposits in the first three strata indicates that the deposits were under the steady stream depositional environment. The gray calcareous clay indicates that the Paleoclimate changed from humid into arid during the early Holocene and the Aeolian deposits in the top stratum indicate that the Paleoclimate became more arid in the late Holocene. Therefore, change of the depositional environment indicates that the Paleoclimate changed from humid into arid from early to late Holocene.

(4) Section in point 33

As shown in figure 2(d), with 150cm in height, this section is very near to the section in point 31 and it is composed by 2 strata. The first stratum is 20cm in thickness and composed mainly by gray calcareous sand, which indicates that the Paleoclimate became arid in middle Holocene. The second stratum is 130cm in thickness and composed by yellowish calcareous sand which indicates that the Paleoclimate became more arid in late Holocene. Therefore, the Paleoclimate changed from humid to arid since early Holocene.

(5) Section in point 41

As shown in figure 2(e), with about 180cm in height, this section is composed by gray pebbly sand, black coarse gravel, gray sand, gray-green calcareous sand and gray sand from the bottom to top. Large grain size and poor roundness of the deposits in the first two strata indicate that the components were under the near-source alluvial depositional environment with large amount of water and high water flow rate in late Pleistocene; The gray calcareous sand indicates that the deposits were under the lacustrine depositional environment with still water which reflected that the Paleoclimate became arid in the early Holocene; Gray sand in the top stratum indicates that the deposits were under the fluvial environment with little water amount and low flow rate. Therefore, change of the depositional environment indicates that the Paleoclimate changed from humid into arid since late Pleistocene.

(6) Section in point e46

As shown in figure 2(f), with about 150cm in height, this section is distributed in the western and the sediments include khaki-colored sand, black coarse gravel and khaki-colored pebbly sand from the bottom to the top. Khaki-colored sand indicates that the deposits were under oxidation of sedimentary environment. Black coarse gravel indicates that the deposits were under the alluvial environment with a large amount of water and the khaki-colored pebbly sand indicates that the deposits were under alluvial sedimentary environment with relatively small amount of water. Good roundness of the coarse gravel in the middle stratum indicates that deposits were under perennial water and transported for a long distance. Therefore, the change of the components and their grain size indicate that the Paleoclimate changed from arid to humid and then to arid in late Pleistocene.

(7) Section in point 46

As shown in figure 2(g), with about 400cm in height, this section is composed by 4 strata. The bottom stratum is composed by brick red clay interlayered by gray clay. Fine grain size of the deposits indicates that it is formed in the lacustrine depositional environment and the color indicates that it was under oxidization sedimentary environment and the Paleoclimate became arid in the early Holocene; the second stratum is composed by gray-green clay which indicates that the deposits were under the reducing lacustrine depositional environment with relatively large amount of water. The components and color indicate that the Paleoclimate became humid in middle Holocene; the third stratum is composed by gray calcareous sand. With about 200cm in height, the component and the color indicate that the Paleoclimate became arid in the early late Holocene; the top stratum is composed by gray clay. Fine grain size and the color indicate that the deposits were under lacustrine depositional environment with little amount of water, which indicates that the Paleoclimate became more arid in late Holocene.

(8) Section in point E77

As shown in figure 2(h), with 300cm in height, this section is composed by 4 strata. The bottom stratum is caesious clay with 100cm in thickness. Fine grain size and the color show that the stratum is under the reducing lacustrine depositional environment with large amount of water and the Paleoclimate became humid in early Pleistocene; the second stratum is composed by black coarse gravel. Large grain size and poor roundness indicate that this stratum was under alluvial depositional environment with large amount of water and the Paleocliamte became more humid in early Pleistocene; the third stratum is composed by gray Aeolian sand. Fine grain size, white color and the loosely cement indicate that the deposits were under the Aeolian depositional environment and the

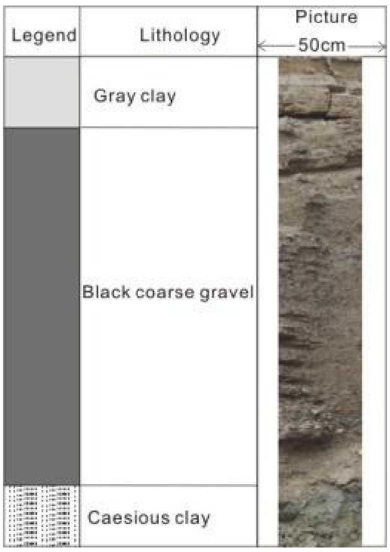
Paleoclimate became arid in middle Pleistocene; the fourth stratum is composed by black coarse gravel. With about 150cm in thickness, the coarse grain size and the poor roundness indicate that the deposits were under the alluvial depositional environment with large amount of water, which indicates that the Paleoclimate became humid in late Pleistocene.

(9) Section in point 47

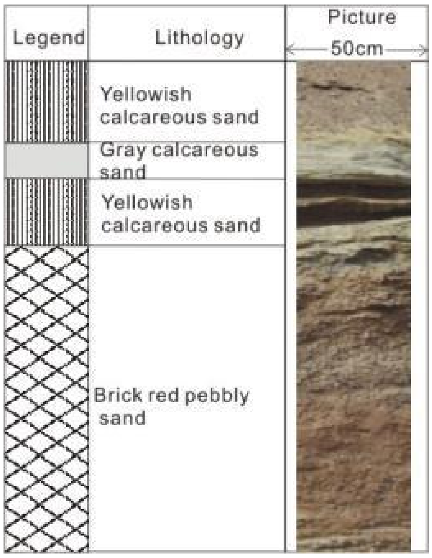
As shown in figure 2(i), with about 100cm in height, this section is located on the Hei riverside and mainly composed by gray sand. Fine grain size and the stratification of the components indicate that the deposits were mainly under the river sedimentary environment with small amount of water and low flow rate. In contrast to the lacustrine depositional environment in the early Holocene, this depositional environment indicates that the Paleoclimate changed from humid into arid in late Holocene.

(10) Section in point E78

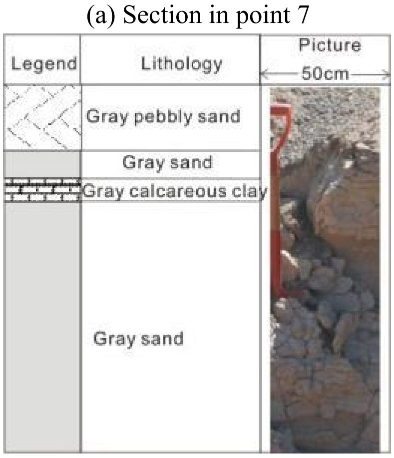
As shown in figure 2(j), with about 80cm in height, this section was composed by caesious clay and gray clay. The composition and its color indicate that the deposits are in lacustrine sedimentary environment. With about 50cm in height, the color of the first stratum indicates that the deposits were deposited in the reducing lacustrine environment and the Paleoclimate was relatively humid in the early late Holocene. The color of the second stratum indicates that the Paleoclimate became arid in the late Holocene. Therefore, the change of the deposits' color and grain size indicates that the Paleoclimate became arid from middle to late Holocene.



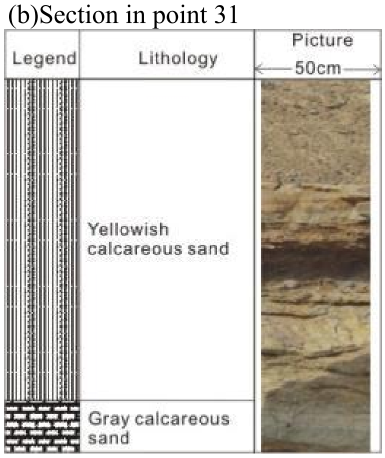
(a) Section in point 7



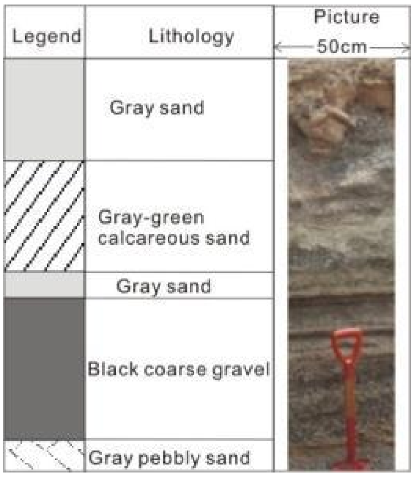
(b)Section in point 31

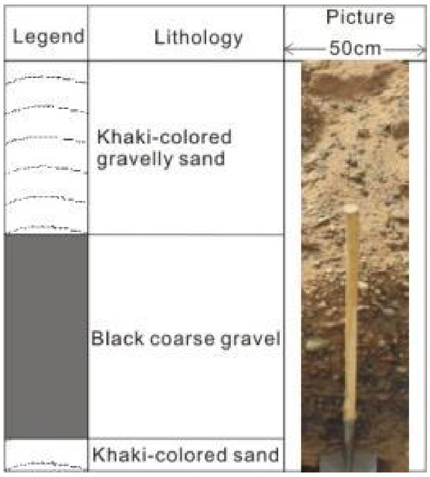


(c) Section in point 21



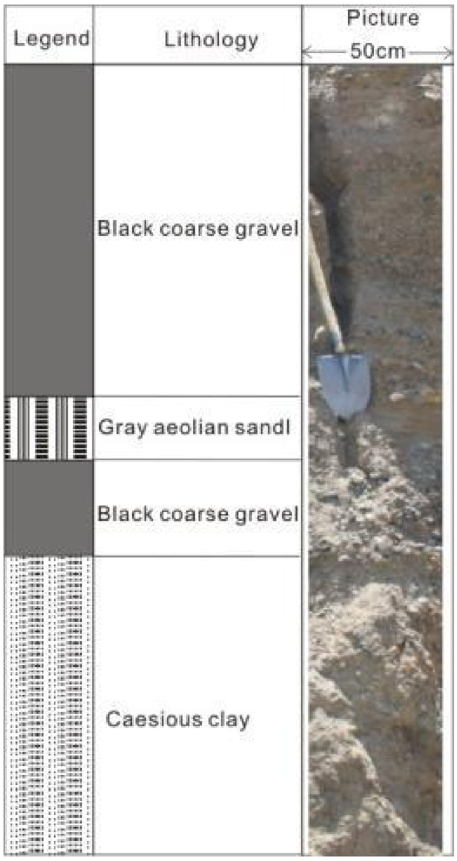
(d) Section in point 33





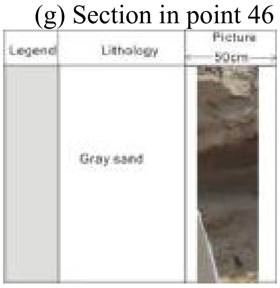
(e) Section in point 41

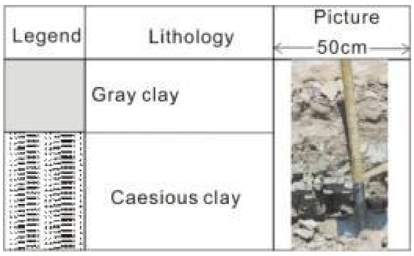
(f) Section in point e46



(g) Section in point 46

(h) Section in point e77





(i) Section in point 47

(j) Section in point e78

Figure 2: Sections in different sites

STRATIGRAPHIC SECTION

Stratigraphic section shown in figure 3 is made by the geological time's ascending order and the section is composed by 6 columns including geological time, lithology, sedimentary facies, Paleoclimate, potassium content and photograph. In which, the geological time was determined by Optical Stimulated Luminescence (OSL) dating method in the Institute of Crustal Dynamics, China Seismological Bureau. Lithology is determined by field lithological description, samples collected in different sites and pictures taken in the field. Sedimentary facies and the change of Paleoclimate were analyzed according to the components (deposits) in the strata. Potassium content was measured by XRD spectrometer in the Center of Earth Observation and Digital Earth, Chinese Academy of Sciences.

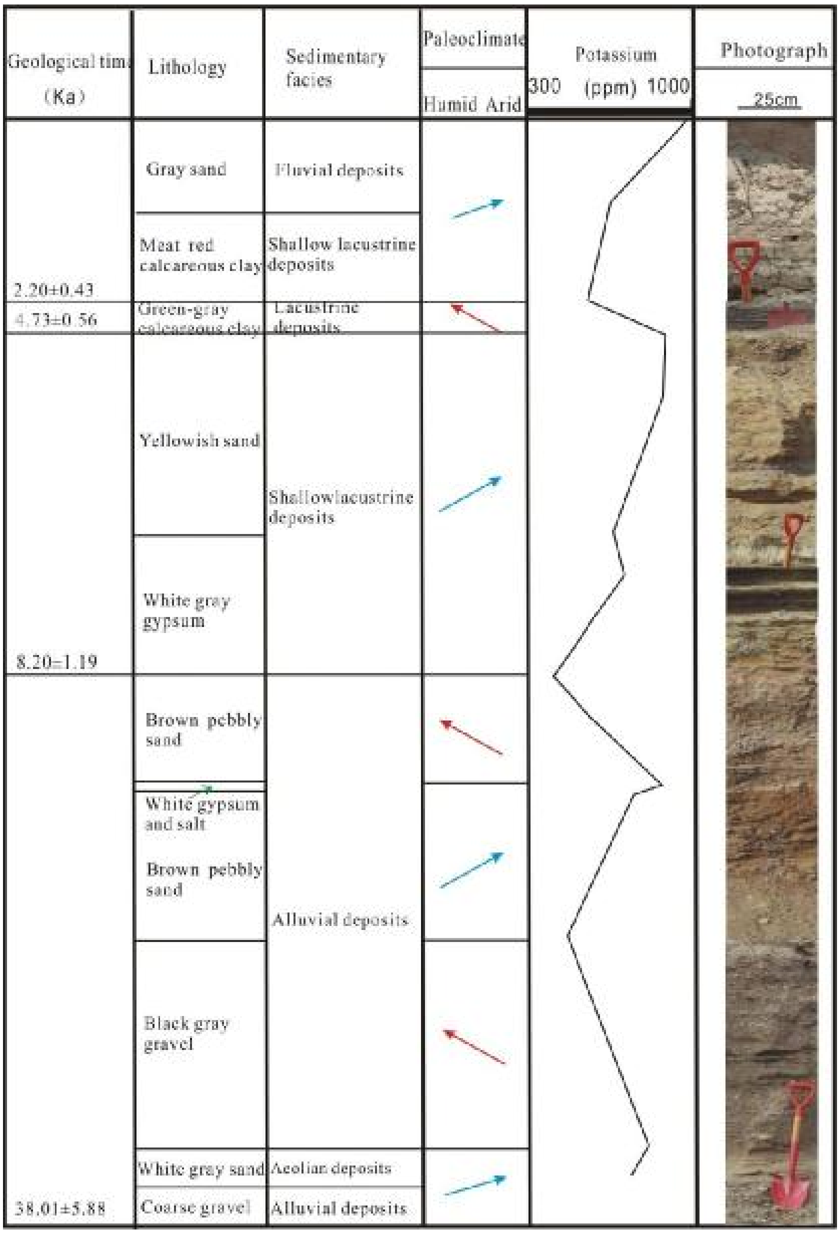


Figure 3: Stratigraphic section.

From 38.01±5.88ka to 8.20±1.19ka, the sedimentary facies were mainly composed by alluvial deposits characterized by coarse gravel to pebbly sand. Thickness of the alluvial deposits is about 4 meters and the average granularity is about 3 centimeters. These characteristics reflect that the Paleoclimate in this time was humid. According to different composition, this segment was devided into 6 strata: (1) With the composition of coarse gravel, the first stratum is 22.5 cm in thickness, 20mm in granularity, poor sorting and roundness. These characteristics indicate that the deposits were under the alluvial sedimentary environment. The deposits' granularity and color indicate that the Paleoclimate was humid in this time (Chi Zhenqing, et al, 2006). (2) With the composition of white gray fine sand, the second stratum is 15cm in thickness. The incompacted sand indicates the deposits were under the Aeolian sedimentary environment and the Paleoclimate became arid during this period; (3) With the composition of black gray gravel, the 3rd stratum is 100cm in thickness, 7.5mm in average granularity, poor sorting and roundness. These characteristics indicate that the deposits were under alluvial sedimentary environment and the Paleoclimate became relatively humid; (4) With the composition of brown sandy soil mixed with gravel, the 4th stratum is 50cm in thickness, poor sorting and roundness. These characteristics indicate that the deposits were under the alluvial sedimentary environment. In contrast to the early alluvial deposits, the amount of gravel decreased and the color changed from black gray into iron brown. These characteristics indicate that the deposits were under the oxidizing environment and the Paleoclimate became to be arid; (5) With the composition of white gypsum and salt, the 5th stratum is 5cm in thickness, which indicates that the Paleoclimate became more arid; (6) With gray pebbly sand, the sixth stratum is 25cm in thickness, poor sorting and roundness. The granularity and color indicate that the deposits were under alluvial sedimentary environment and the Paleoclimate became humid in this time.

From 8.20±1.19ka to 4.73±0.56ka, the sediment facies were mainly composed by shallow lacustrine deposits. According to different compositions, this segment can be devided into 2 strata: With 65cm in thickness, the first is composed by white gray gypsum which indicates that the Paleoclimate became to be arid in this time; With 100cm in thickness, the second is composed by yellow-brown sandy soil which indicates that the deposits were under oxidizing sedimentary environment and the Paleoclimate became to be more arid than the previous stratum. This conclusion is verified by the results of pollen analysis (Chen Fahu, etc. 2004).

From 4.73±0.56ka to 2.2±0.43ka, with 15cm in thickness, this stratum is composed by green-gray calcareous clay. The color and compositions indicate that the deposits were under reducing lacustrine sedimentary environment and the Paleoclimate became to be humid during this time.

After that, with 45cm in thickness, the top stratum was mainly composed by meat red calcareous clay which indicates that the deposits were under oxidizing lacustrine sedimentary environment and the Paleoclimate changed to be arid. Then, with about 45m in thickness, the sediment facies were mainly composed by fluvial deposits with compositions of gray sand. The change of sedimentary environment indicates that the Paleoclimate became to be arid from then on. This conclusion was proved by the grain size and elemental analysis results (Jin He-ling, 2005).

CONCLUSIONS

From late Pleistocene to present, the sedimentary facies were composed by alluvial, lacustrine, fluvial and Aeolian deposits. Components of the sedimentary facies can reflect the sedimentary environment. In commonly, gravels reflect the large flow rate, calcium carbonate reflects the arid Paleoclimate conditions and the fine sand indicates the intermittent river or Aeolian sedimentary environment. Furthermore, grain size and roundness of the components also reflect the sedimentary environment. In commonly, the larger the grain size is, the faster the flow rate becomes. The higher the roundness is, the longer the deposits stay in the fluid. From the evolution of sedimentary environment from late Pleistocene to present, although there are small Paleoclimate changed cycles in one sedimentary facies, the change from alluvial to Aeolian sedimentary environment indicates that the Paleoclimate changed from humid into arid in overall trend which leading to the decrease of water sources.

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