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CLIMATIC CHANGE AND HUMAN ACTIVITIES OF NORTHEASTERN SAHARA IN HOLOCENE ①

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ABSTRACT: Chronology establishment and dating data analyses on lacustrine deposits in northeastern Sahara show that vast fresh lakes existed over there between 9900- 2400 a B. P. Especially, great continuous lakes developed and got their maximum extent during the period from 9800 a B. P. to 6450 a B. P. From 6000 a B. P. to 3600 a B. P., the evolution of the lakes experienced a new stage with a property of drastic fluctuations and a periodicity of 600 years, which was the response to the climatic environment changes. On the aspect of the relation between natural environment and the human, the warm-humid period in the Holocene was not only a very important time for human development and evolution, but also was a moment for human reproduction and division. On the other hand, this warm-humid period was also a distinguished time to natural environment changes, the accumulation of the strong weathered debris and fine materials formed the basements for the formation of the Sahara Desert.
KEY WORDS: Sahara, Holocene, palaeo-climate

Geological records revealed that the Holocene environments had experienced drastic changes, which was closely related to human evolution and finally propelled the improvement of the mankind itself, the changes of its life styles, emergence and development of the civilizations. From this aspect, the study on the environmental changes chronology establishment and deepening the understanding of their temporal and spatial patterns are of great importance. Sahara Desert, which is 9 600 000 km^2 in area and takes up 32% of the Africa continent, is the biggest desert in the world and is the most unfavorable place for habitation. However, widely distributed lacustrine deposits in Sahara Desert indicate that some parts of this vast hyperarid area today once had been covered by fresh water and full of livings, people once wandered and settled over the area, thus abundant artifacts and various fossils of the plants and animals were

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left there. In this paper, based on the chronology establishment of the lacustrine deposits, the lake evolution, interannual climatic property, environmental change history and its relation with human activities in the geographical scope between 24°13′ – 30°17′ E, 16°13′ – 18°32′ N have been discussed.

I. CHRONOLOGY OF LACUSTRINE DEPOSITS AND CLIMATIC RECORDS

Systematic dating results on typical lake deposits, mollusks, organic matters show that the detectable lacustrine deposits occurred as earlier as 12 000 a B. P., which implied humid situation in northeastern Sahara started no later than this time(Pachur *et al*., 1996). Nevertheless, the age measurements on continuous typical lake deposits revealed that the lakes were formed between 9880 a B. P. and 2705 a B. P. Fig. 1 is an age frequency distribution curve based on 118 dating data (among them, 11 were measured by the author and others were after by Pachur, 1991) at an interval of 300 a, which not only displayed the number of the dating data, but also showed the distribution density of the lake deposits, and furthermore, the paleaolake scopes that reflected the climatic conditions. The age frequency distribution curve, therefore, can be regarded as one kind of proxy of climatic environmental changes. The curve shows three distinct features: (1) According to the measured dating data and stratigraphy correlation, it could be calculated that the successive lake facies appeared at 9900 a B. P. in northeastern Sahara, and ended at about 2400– 2520 a B. P. (2) The pattern of the curve could be divided into four parts: the earliest stage was 9900– 8550 a B. P., with a stable but high frequency; the second stage was 7800– 6450 a B. P. that characterized by some fluctuations and reached maximum lake development at the later period; between 6000 – 3600 a B. P., the curve showed a distinguished oscillation property. From 3600 a B. P. until 2400 (2520) a B. P. was the declining stage, which implied that the climate became drier and drier. (3) During the studied time scope, the age frequency curve possesses a 1650– 2100-year periodicity, especially between 6000– 3600 a B. P. was dominated by a periodicity of 600 years. All these characters reflected the history of the Holocene lake development and evolution, furthermore, represented the climatic change processes in northeastern Sahara.

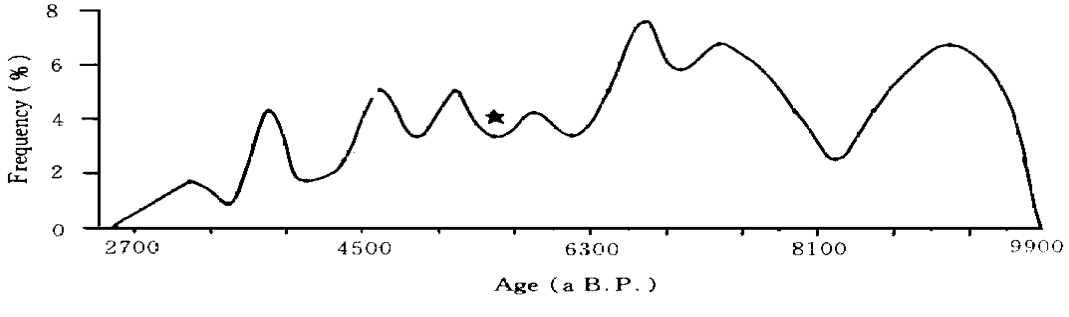

Fig. 1 Age frequency curve of paleolake deposits in northeastern Sahara

II. PALEAOLAKE EVOLUTION AND HUMAN ACTIVITIES

In order to study relationships among the lake evolution, plant and animal development, human activities, a typical closed palaeolake located at 18°26′23″N, 25°16′15″E, with an elevation of 520 m above sea level was systematically investigated (Fig. 2). Geomorphological and depositional evidences revealed that this paleaolake was not very big. A section uncovered showed that the lake was developed on dune sand in a relatively low area. The lake deposits mainly consisted of carbonate rich in microfossils. ^{14}C dating in the lower part at 32–35 cm deep on a 40-cm section was 8852±105 a B.P. (SH0048). The mollusks that deposited at the same horizon at the edge of the paleaolake deposits dated back to 5460±67 a B.P. (SH0051). The died tree root in the centeral lake dated back to 4759±80 a B.P. (SH0047, $\delta^{13}C$= –23.22‰). Fossil tree trunks which might be collected by mankind around the beach dated back to 4009±55 a B.P. (SH0050, $\delta^{13}C$= –24.405‰). The charcoal at the fireplace beside the tree trunks dated back to 3638±85 a B.P. (SH0049, $\delta^{13}C$= –24.184‰). Based on these age determination results and the sampling positions, the following order of the events happened could be deduced: the studied palaeolake occurred firstly at 9900 a B.P. and lasted till 3600 a B.P. During this period, $CaCO_3$ that enriched in microfossils deposited continuously, mollusks developed greatly in the shallow water of the lake brim, various species of plants grew around it. While the climate got drier and drier and the paleaolakes in other places gradually disappeared, human occupied this lake as the water supply source, they collected tree trunks and made fire, therefore the charcoals, fossils and artifacts remained in the area.

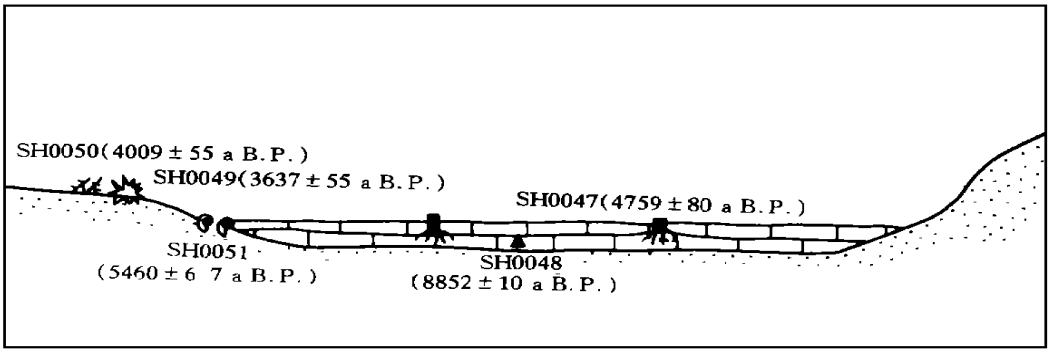

Fig. 2 Lake deposits, fossils, relics of human activities and datings

III. INTERANNUAL CLIMATIC CHANGE CHARACTERISTICS

Study on the regional and global interannual climatic fluctuation is one of the main targets of palaeoenvironmental reconstruction. In order to explore the seasonal climatic situations in the studied area, three fossil mollusks shells, which were 4.7 cm, 5.5 cm and 6.8 cm high individually from the same position (sample SH0051) were chosen to analyse their isotopic compo-

nents(Fig. 3). Based on dating results, it could be known that these mollusks were lived at 5460 a B. P. From Fig. 1, we know that during that time, the age frequency curve is relatively low, which indicates a drier climatic condition. Under this situation, the distinct isotope variations of each growth layer of three shells revealed seasonal weather differences. Study results have proved that the mollusks absorb carbonate from surroundings to form the shell through its growth procedure, in which the fractionation and equilibrium of the stable isotopes were happened and controlled by the organism physiological activities and its circumstance conditions such as the free oxygen and carbon dioxide fractional pressure(P_{CO_2}), the mineralization intensity and concentration of the water solution, all these factors were regulated by the climatic environment.

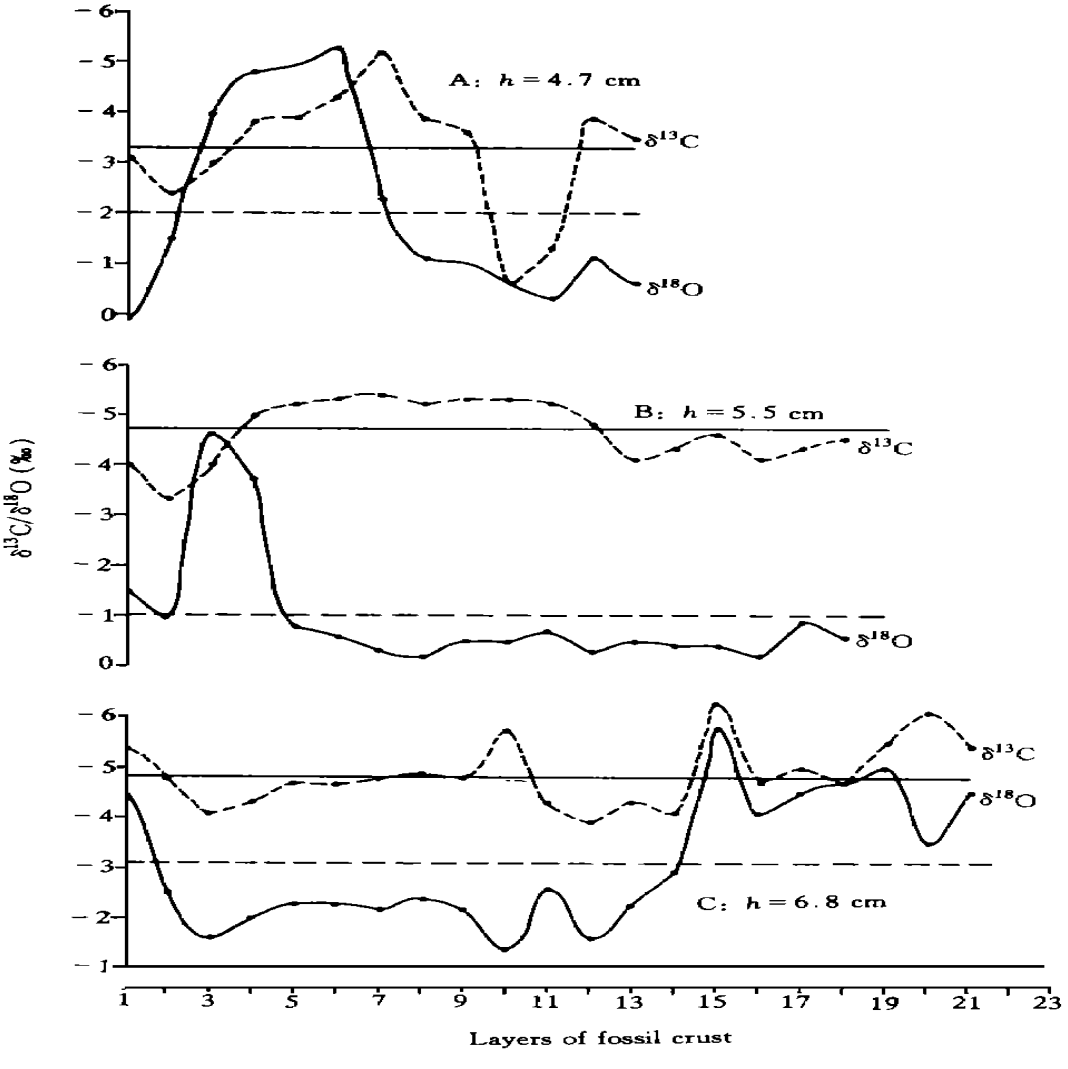

Fig. 3 The $\delta^{18}O$ and $\delta^{13}C$ curves of three shells

The isotopic records of mollusks, theoretically, are the results of the equilibrium between

the organism and its circumstances. Generally speaking, $\delta^{18}O$ is related to the temperature, $\delta^{13}C$ is related to P_{CO_2}. To the mollusks, the correlation between temperature and $\delta^{18}O$ is better than that between P_{CO_2} and $\delta^{13}C$. At the same time, it is very important to take the different regional background into account because this correlation might become very complex and different in regarding to the carbonate or noncarbonate basement rocks.

Because of the particular location of the studied area, which is a noncarbonate place, the oscillations between dry seasons and humid seasons controlled the magnitude and process of the $\delta^{18}O$ and $\delta^{13}C$ values. The obtained $\delta^{18}O$ and $\delta^{13}C$ curves of these three shells show the following features: 1) the magnitude of $\delta^{18}O$ variations are larger than that of the $\delta^{13}C$; 2) all of them died at the initial term of $\delta^{18}O$ and $\delta^{13}C$ decrease after high values. The isotopic records contain significant information on the variety of climatic environment during the interval of lake shrunk. Firstly, the divergent of the precipitation and heat, i.e. the wet season came earlier than the hot season. Secondly, the relative stable coherence of the precipitation and temperature, this situation occurred in the stage when the lake level was stable. Thirdly, the variety of the coincidence and non-coincidence between wet season and hot seasons, this induced the variety of the combination of precipitation and temperature. The situation might mostly occur when precipitation scattered through the year.

IV. CONCLUSIONS

Based on the above discussions, following conclusions can be obtained: during Holocene period, northeastern Sahara had experienced drastic climatic environmental changes, a lot of fresh water lakes formed since 9900 a B.P. and culminated in 7800– 3600 a B.P. (Parchur *et al.*, 1987), abundant organism relics and lake sediments remained. During this climatic optimum period, human activities were vigorous and widely scattered in the area of the present Sahara Desert which is the most unfavorable habitation area today. The lake evolution from 6000 a B.P. – 3000 a B.P. was characterized by fluctuations with a periodicity of 600 years. During the relatively dry period, the interannual climatic change pattern demonstrated by the isotopic records of the fossil mollusks shown a great variety. At the same time, human, animal and plant migrated around the fresh water lakes and breakdown along with climatic changes and disappearance of the lakes. It was a crucial stage for human itself development and this change climatic environment propelled the evolution of mankind and the progress of the civilization. During the period of 9900– 2400 a B.P. that was dominated by warm and humid climate, intensive weathering and denudation occurred in the area, consequently, abundant detritus formed and provided the materials for the Sahara Desert formation (Zhang, 1996). After that time, the climate deteriorated further, palaeolakes gradually disappeared completely and continuously arid climate finally came into being. Under the influence of the wind, the detritus kept on weathering, differentiation and reaccumulation, thus the modern Sahara Desert formed.

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REFERENCES

Pachur H. J., Wiirnemann B., 1996. Reconstruction of the palaeoclimate along 30°E in the eastern Sahara during the Pleistocene Holocene transition. *Palaeo-ecology of Africa*, 24: 1– 32.

Pachur H. J., Hoezmann, P. 1991. Paleaoclimatic implications of Late Quaternary lacustrine sediments in west Nubia, Sudan. *Quaternary Research*. 36: 257– 276.

Pachur H. J., Kcropelin S., 1987. Wadi Howar: paleaoclimatic evidence from an extinct river system in the northeastern Sahara. *Science*, 237: 298– 300.

Zhang Hucai, 1996. The characteristics of sand grains from northeastern Sahara and their formation mechanism and environment. *Journal of Desert Research*, 16(3): 241– 245. (in Chinese)