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THE SEQUENCE OF PALEOENVIRONMENTAL CHANGES SINCE ABOUT 4KA B. P., RECORDED BY NIYA SECTION IN SOUTHERN MARGIN OF TARIM BASIN

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ABSTRACT: Through synthetic researches of multi-index geological records of Niya section, which are of high resolution in southern margin of Tarim Basin, this paper has reconstructed the sequences of paleoclimate in this region during historical times (since about 4000a B. P.). During the last 4000 years, the area has experienced alternations of relative cold-moisture and relative warm-dry periods. Three evident cold-moisture periods and three warm-dry periods are identifing. The study shows that the human activities have an intimate relation with the evolution of paleoclimate in the southern Xinjiang. Paleoclimate has played very important role in influencing human being's agricultural activities.
KEY WORDS: southern margin of Tarim Basin; Niya section; historical times; climatic evolution;

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1 INTRODUCTION

One of the 7 key plans of IGBP (International Geo-Biosphere Project) is the PAGES (Past Global Changes), of which the relation of mutual influence of mankind and natural environmental changes during historic period has attracted great attentions over the world (CHEN, 1992; Committee of National Natural Science Foundation of China, 1995). Due to the atrocious natural conditions, study of this issues are much more backward in southern Xinjiang. So to investigate and study the inter-relation between human activities and paleoenvironmental evolution during historic period in this area is of great theoretic and practical significance to throw light on the formation and development of the extremely dry climate, to explain the processes of the historical evolution of man-land relationship in arid area, and to gain the sustainable development of environment and economy in the region.

For understanding the relation between the processes of paleoenvironmental and climatic evolution and the human activities in southern Xinjiang during historic period, we have obtained a high solution deposit section in Minfeng County (i. e. Niya area of ancient name) (Fig. 1) in October of 1999. In the article, we present some information about paleoenvironmental changes in this area.

2 RECONSTRUCTION OF THE CHRONOLOGIC SEQUENCE AND CHARACTER OF SEDIMENT

Niya section lies at the right bank of present Niya

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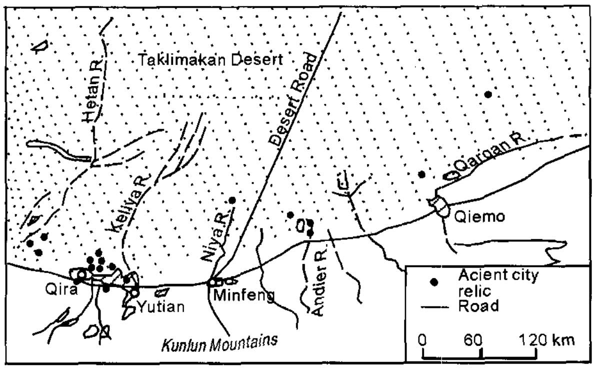

Fig. 1 The location of the research area

River, about 7 kilometers away Minfeng County, with a depth of 2. 98m. This section was originated from a lacustrine or marsh sedimentary circumstance, and appeared by newly incision decades age, due to man' s irrigation activities. By field investigation of this section, no sedimentary disconformities are found. In this section, the sediment is characterized by clay or silt or silt clay and peatfication layer with different color. Four peatfication layer samples were taken for organic ^{14}C dating measurement, the results are transferred into years in A. D. or B. C. by tree ring calibration and shown in Fig. 2 . Based on the average deposit rate of this section, the age of each sample can be obtained by age-interpolation, so that the bottom of Niya section is determined at about 4000a B. P. (before 1950 A. D.)

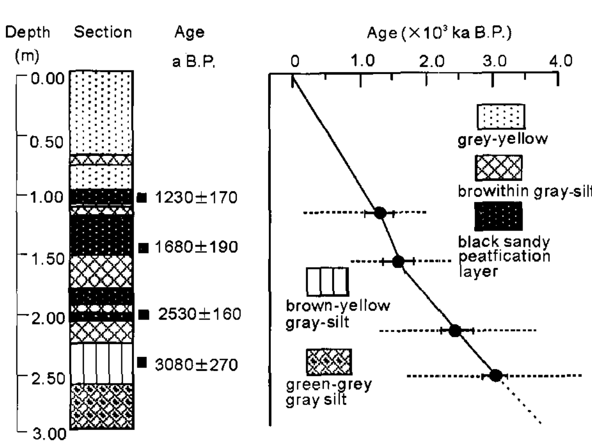

Fig. 2 The age-depth relation in Niya section, southern margin of Tarim Basin

3 RESULTS OF ANALYSIS

The article has mainly analyzed the frequency dependent susceptibility, carbonate isotope, geochemical element and pollen composition.

3. 1 Low Frequency Susceptibility of Sediment

The low frequent susceptibility has a direct relationship with the relative quantity fluctuation of the fine viscous particulate matter (OLDFIELD, 1990; ZHANG *et al.* 1998), so it can influence the intensity and type of weathering in the provenance. As a result, such fluctuations in Niya have a good relationship with climate and environmental conditions, when climate become drier and warmer, the runoff will be decreased and only fine particulate matter can be taken away, which will load to lift of Xlf's quantities directly. On the contrary, the quantity of Xlf will be descended. But the changes reflected in southern Xinjiang are different from those in closed lakes.

3. 2 $\delta^{13}C$ Fluctuation

Analyses of the content of $\delta^{13}C$ obtain very ideal results, which display a compatible relation between its fluctuations and other analytical indices. In water, the changes of carbonate $\delta^{13}C$ are controlled by below factors comprehensively: intensity of CO_2 isotope exchanging between lake water and atmosphere, demurrage of inorganic carbon in water, saltiness and frozen time of lake water, productions of lake, etc. As climate drier, water volume reduce, both of them can lead the water hardness to rise, leaving the water enrichen in $\delta^{13}C$, in contrast with it, the value of $\delta^{13}C$ is decreasing subsequently in moist climate. In addition, intensive exchange between water and atmosphere, higher water salinity and shorter freezing time lead to $\delta^{13}C$ increase (WU, 1997; HUMHREY *et al.* 1994). So the changes of $\delta^{13}C$ can reflect the changes of river' s water body deduced from the changes of climate and environmental characters(Fig. 3).

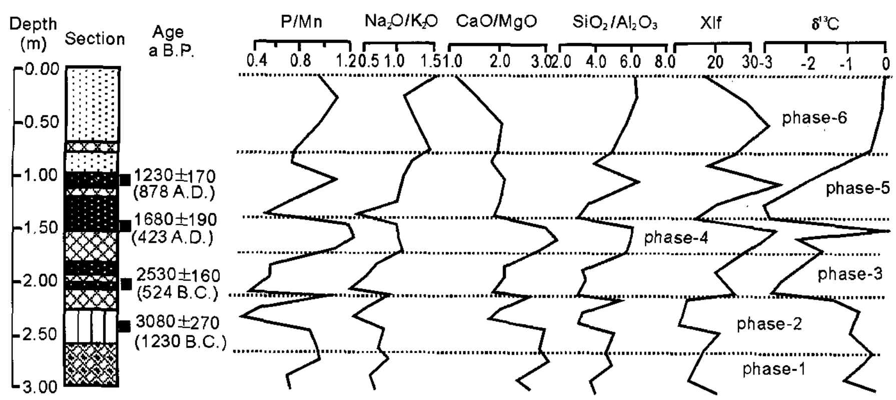

Fig. 3 Various geologic indices (Xlf, $\delta^{13}C$ and ratios of geochemical elements) indicating paleoenvironmental change since about 4000a B. P., Niya section, southern Xinjiang

3. 3 The Ratios of Geochemical Elements

The value of P/Mn can be used to distinguish oxidation-reduction environments. In Fig. 3, higher P/Mn value indicates stronger oxidative environments and warmer climate, this character is consistent with Damugou section in Qira (ZHONG *et al.* 1998a), southern Xinjiang and Holocene stratigraphy in northern Taklimakan Desert (GUAN *et al.*, 1994). The value of SiO_2/Al_2O_3 can be used to reflect the quantity relationships of some minerals, which are influenced by climatic conditions and the intensity of weathering greatly, with higher value of that, the sedimentary environment of hyporgenic geochemical elements become drier and chemical weathering force gentler. Na_2O/K_2O, CaO/MgO have the same indicating meaning as SiO_2/Al_2O_3 (LIU, 1984; LI, 1988).

3. 4 Pollen Composition

The analytical results show that the composition of spore-pollen in Niya section are mainly dominated by Chenopodiaceae, Artemisia, Ephedra and Graminea, which reflect the environment of desert and desert steppe(Fig. 4). The content of Gramineae and wood pollen closely related the human being's agricultural activities, and the value of A/C (Artermisia/Chenopodiaceae) can be used as a proxy indicator of vegetational ecology, the lower A/C value, the drier vegetational ecology (SUN *et al.*, 1994)

4 THE SEQUENCE OF PALEOENVIRONMENTAL EVOLUTION DURING LAST 4 KA B. P.

According to those geologic indices in Niya section

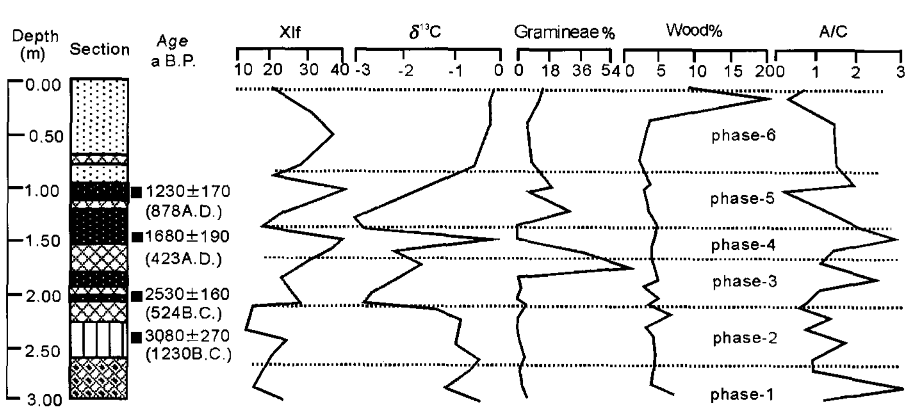

Fig. 4 Comparison of spore-pollen and $\delta^{13}C$, Xlf recorded in Niya section, southern margin of Tarim Basin since about 4000a B. P.

and the comparison between various regions, 6 possible climatic periods can be reconstructed.

(1) Relative cold-moisture period (2. 98 – 2. 60m, 4000 – 3450a B. P.)

Although the composition of spore-pollen reflect the relative arid regime in this period, other climatic indices indicate a short wet period with a peak appeared at 1820 B. C. In this period, the river runoff increased. Relative moisture characters enabled $\delta^{13}C$ and Xlf to reach lower value, but the spore-pollen A/C value to reach higher value, which implicated a relative moisture environment. In other regions, QH-14 drilling core revealed a cooling event, which ended at 3 500a B. P. in Qinghai Lake, but in eastern China, this event lagged slightly and completed at 3100a B. P. (ZHANG, 1996) . Then, climate became warmer. Painted pottery culture developed during this period in Xinjiang (YIN *et al.*, 1993).

(2) Relative warm-dry period (2. 60 – 2. 00m, 3450 – 2500a B. P.)

This period corresponded to the Zhou Dynasty in Chinese history in time. Fig. 3 shows that this period was relatively warm-dry (ZHU, 1973). Ratios of many geochmical elements and Xlf value are out of step with the $\delta^{13}C$ record, but the $\delta^{13}C$ value and lower spore-pollen value give a strong proof that this period was warm-dry. A apparent warm-dry period appearing in 1230 B. C. (3080 ± 270a B. P.) coincided with a warm peak appeared at 3000a B. P. in Bosten Lake, southern Xinjiang (ZHONG, 1998) and the second-highest temperature phase of Holocene in Dunde ice core, meanwhile, it was also in accordance with global changes (YAO *et al.*, 1992).

(3) Relative cold-moisture period (2. 00 – 1. 60m, 2500 – 1900a B. P.)

This period likely corresponded to the Qin-Han Dynasties in Chinese history. The peaks of the curves of geochmical elements, $\delta^{13}C$ and Xlf, A/C all indicate a relative wet character, and coincide with the research of Bosten Lake (Zhong *et al.*, 1998b) and Qira section (Zhong *et al.*, 1998a). They all implicated a relative cold-moisture environment. It was an optimum phase of crop in southern Xinjiang, so the value of spore-pollen of Graminea attained continuously to 56. 2% and 33. 9% in 1. 70 – 1. 60m in depth, which was likely caused by human cultivated activities. From the archaeological documents, local people began to enter the place of Niya relics in Han-Jin Dynasties, and developed argriculture. However, the highest value of spore-pollen of Graminea in this section was lagged behind the apparent cold-moisture period, perhaps due to the lag of spore-pollen records reflecting climate and environment.

(4) Relative warm-dry period (1. 60 – 1. 35m, 1900 – 1400a B. P.)

The period corresponded to the late Western Han Dynasty and the mostly part of Wei-Jin and Northern and Southern Dynasties. The changes of geochmical element ratios, $\delta^{13}C$ and Xlf all display the evident warm-dry characters. The warm-dry climatic environment caused water volume of rivers decrease, agricultural activities decline, which consist with the result of spore-pollen analysis. Based on the document found in Loulan relics (dated at 330 A. D.), we can read the records that some measures must be taken to reduce the food supply to the local officers and soldiers because it was difficult to produce enough food. Accordingly, climate became dry again during 2. 0 – 1. 5ka B. P. in Bosten Lake (ZHONG *et al.*, 1998b), the sediment of Damugou section reflected the fluctuation of water force, indicated that the warm-dry climate character in southern Xinjiang in the period. The warm-dry phase was in accordance with the fifth period of high temperature in eastern China and the sub-Atlantic period in southern Cheli (YAO *et al.*, 1997).

(5) Relative cold-moisture period(1. 35 – 0. 80m, 1400 – 1000a B. P.)

The value of $\delta^{13}C$ implied a long relatively cold-moisture period, but the fluctuation of geochmical elements ratios and Xlf indicated that there were two sub-phases in this period. At about 750 A. D., there was a short-time relative warm-dry period. The period includes the Sui-Tang Dynasties(581 – 907 A. D.) and the early Song Dynasty in Chinese history. The study shows that the climate became cold again in China since 480 A. D. (ZHANG, 1996), this event accorded to the cold-moisture period form 1. 3m (about 500 A. D.) upwards in the article. In the period, the lake of Xin jiang developed peatfication layer generally, Qinghai Lake recorded a cooling event, the $\delta^{18}O$ value in Dunde ice core discovered the low temperature event in 1.0ka B.P. (YAO *et al.*, 1992). The research of MAN Zhi-min found many proofs on cold climate from 796 A.D. to 880 A.D. In Niya section, the content of Gramineae came to the third highest value (27.4%) and the value of spore-pollen A/C to a relative high value as well at about 1060 A.D., which indicated the relative moisture environ ment and strengthened human being's activities. However, the fluctuation of geochemical elements reflected a short warm-dry phase in 1.2ka B.P., which was consistent with the warm phase of Guliya ice core in 700 A.D (YAO *et al.*, 1997).

(6) Relative warm-dry period (0.80 – 0m, 1000a B.P. to present)

In the period, the average values of P/Mn, SiO_2/Al_2O_3, Na_2O/K_2O and especially $\delta^{13}C$ were high and implied that the region has stepped into a steady relative warm-dry period. This period was from the middle Song Dynasty to present. The climate bounded up in about 910 A.D. after a cooling at 880 A.D., and stepped into the optimum period of the Middle Ages. However, the warm-dry climate show ascending tendency in the part of west China and southern Xinjiang. The grey-yellow wind-blown sand layer firstly appeared at 1.5ka B.P., and the section was filled with the accumulation of recent-wind-blown sand from 960 ± 70a B.P. to present in Damugou section (ZHONG *et al.*, 1998b). From the records of Guliya ice core in Xinjiang, there was a vital conversion of climate in 1100 A.D., before that the climate had a character of cold and little rain, but high temperature and more rain after that (YAO *et al.*, 1997). The hole of CK3 in Kunming lake of The Summer Place in Beijing discovered that the lake ever dried out caused by the dry climate in about 1050 A.D. (ZHONG *et al.*, 1997). So the boundary of about 1000a B.P. was a very important time-demarcation-line, and the proceeding of warm-dryness stepped into a new era after that. The abnormal high value of wood pollen appeared at 0.2m in the section perhaps closely related to human being's activities of tree planting.

5 CONCLUSION

Through synthetic researches of multi-index geological records of Niya section, which are of high resolution in southern margin of Tarim basin, paleoclimatic and paleoenvironmental history during 4ka B.P. has been reconstructed. During the last 4000 years, the area of the southern Tarim basin has experienced alternations of relative cold-moisture and relative warm-dry periods, three evident cold-moisture periods (i.e. 4.0 – 3.45ka B.P., 2.50 – 1.90ka B.P., about 1.40 – 1.00ka B.P.) and three warm – dry periods (3.45 – 2.50ka B.P., 1.90 – 1.40 ka B.P., 1.00 ka B.P-present) are identified, which are coincident with historic records in eastern China in temperature fluctuation. The study in this paper also shows that palaeoclimatic changes reflected from Niya section in past 4.0ka B.P. presented apparent Westlies Style model, during cold periods, relative humidity increase, but in warm periods, the dry regime aggravated. Study implied also that human activities have an intimate relation with the evolution of paleoclimate in the southern Xinjiang. Paleoclimate has played very important role in influencing the history of human being's agricultural activities evolution and human activities since 4000a B.P. recorded in this section.

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