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PRELIMINARY PALEOMAGNETIC STUDY OF LAKE SEDIMENTS FROM JIUYINGHAI, INNER MONGOLIA, NORTHWEST CHINA

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ABSTRACT

This study presents the preliminary paleomagnetic results of six lake sediment cores taken from Jiuyinghai area, Inner Mongolia, China. Four of the cores were drilled from east Jiuyinghai, one from west Jiuyinghai and one from Tien-eu Lake. The lengths of the studied portions of these cores distributed from 1 meters to1.5 meters. A C-14 dating data was obtained from the depth 2.35 m of the core JYH-D, which gives an age of 1090±90 yr B.P.

Paleomagnetic results indicate two excursions recorded in these cores, which could be used as the key beds for core correlation. The two excursions have relatively higher inclination than the other part of the cores. For the declinations, the younger excursion shows of about 180° away from most of the others, however, the older one only shows about 90° difference. The younger event could be found in all the six cores, however, the older one was only found in cores JYH-C and JYH-E. This implies that the analyzed part of cores JYH-C and JYH-E contributes longer time interval than the others. Based on the C-14 data, the younger event is proposed to appear at the age of about 1200 yr B.P. probably

Key words: Lake Jiuyinghai, northwest China, lake sediments, paleomagnetic intensity, magnetic excursion

INTRODUCTION

For the last two decades, studies of paleo-climate and paleo-environment changes became one of the hottest scientific topics in the world. Materials, which can support continuous and high-resolution records, such as lake sediments, marine sediments, loess, ice etc., were thus broadly analyzed. However, having well and precise age control is very important for such kind of study. Paleomagnetic analysis, including the investigation of the events of polarity reversal and secular variation pattern of the earth magnetic field, is one of the important methods, which can support valuable information for this purpose.

Dust storm is a very important climate feature observed in East Asia. It is originated from Central Asia, Northwest China and Mongolia. The dusts are usually strongly blown to east and south by the westerly and northeast monsoon system in spring. They could be transported as far as to the center of north Pacific and to the north of South China Sea depend major on the strength of the wind system. So, the variation of the westerly and northeast monsoon systems plays a very important role for the climate change in East Asia. Lake Jiuyinghai located at northwest China is one of the originated areas of the dust storm. Hence, to study the paleo-climate and paleo-environment changes in East Asia, it should not be got rid of studying the dust storm originated from the Jiuyinghai area.

In 2000, we began to develop a program for the study of the paleo-climate and paleo-environment changes in the Jiuyinghai area as part of an integrated project "Asian Paleo-Environment Changes (APEC)" supported by Academia Sinica of R.O.C. In the summer of 2002, seven trenching sites were dug here and six cores having the lengths of 1~ 4.4 meters were then collected. The cores are named as JYH-A, JYH-B, JYH-C, JYH-D, JYH-E and JYH-G, respectively. These cores are subjected to multiple discipline analyses, including paleomagnetic and rock magnetic studies. In this study, the preliminary paleomagnetic results of the upper portions of these six cores will be presented.

GEOLOGICAL SETTINGS

Lake Jiuyinghai is located at the Ejina-chi area in the Alaxan Plateau at the westernmost part of Inner Mongolia. It is less than 50 km south of the frontier of China and Mongolia. The Ejina-chi area is quite flat. Its mean altitude is about 1000 meters above sea level. Lake Jiuyinghai is the lowest part of the Ejina-chi, about 850-890 meters above sea level. Because it is far away from the Pacific and Indian Oceans and many high mountains located between it and the oceans, very few moisture could arrive in this area. The mean precipitation of this area is only of about 20 cm per year. Obviously, the Ejina-chi is an arid land.

Lake Jiuyinghai mainly composed of two separated lakes now. The two separated lakes are named as Sogo Nur in the east (East Lake) and Gaxun Nur in the west (West Lake). During the historical humid period, the ancient Jiuyinghai covered a relative large area, including several presently isolated small lakes, such as Lake Tien-er and Hehcherng (Fig. 1). Lake Jiuyinghai is a terminal lake of the Haiho-Ruoshui River, which is about 500 km long flowing from the northwest part of the Qilian Shan Range (Fig.1). From satellite imagery and geomorphic evidence, Lake Jiuyinghai is suggested to receive the water partly from the north, the Mongolia, in the past (Fig. 1).

The Lake Jiuyinghai was formed by the Cenozoic tectonic depression. It had had a total area more than 2,600 km^2 in maximum, but has shrunk to less than about 726 km^2 since two thousand years ago (Wang and Tou, 1997). For the last few decades, the area speeding shrank year by year due to (1) decreasing the water input which melted and discharged from mountain glaciers, (2) the evaporation rate much higher than the precipitation rate, and (3) the division of inflowing waters of the Haiho-Ruoshui River for agriculture. And it was reported that the

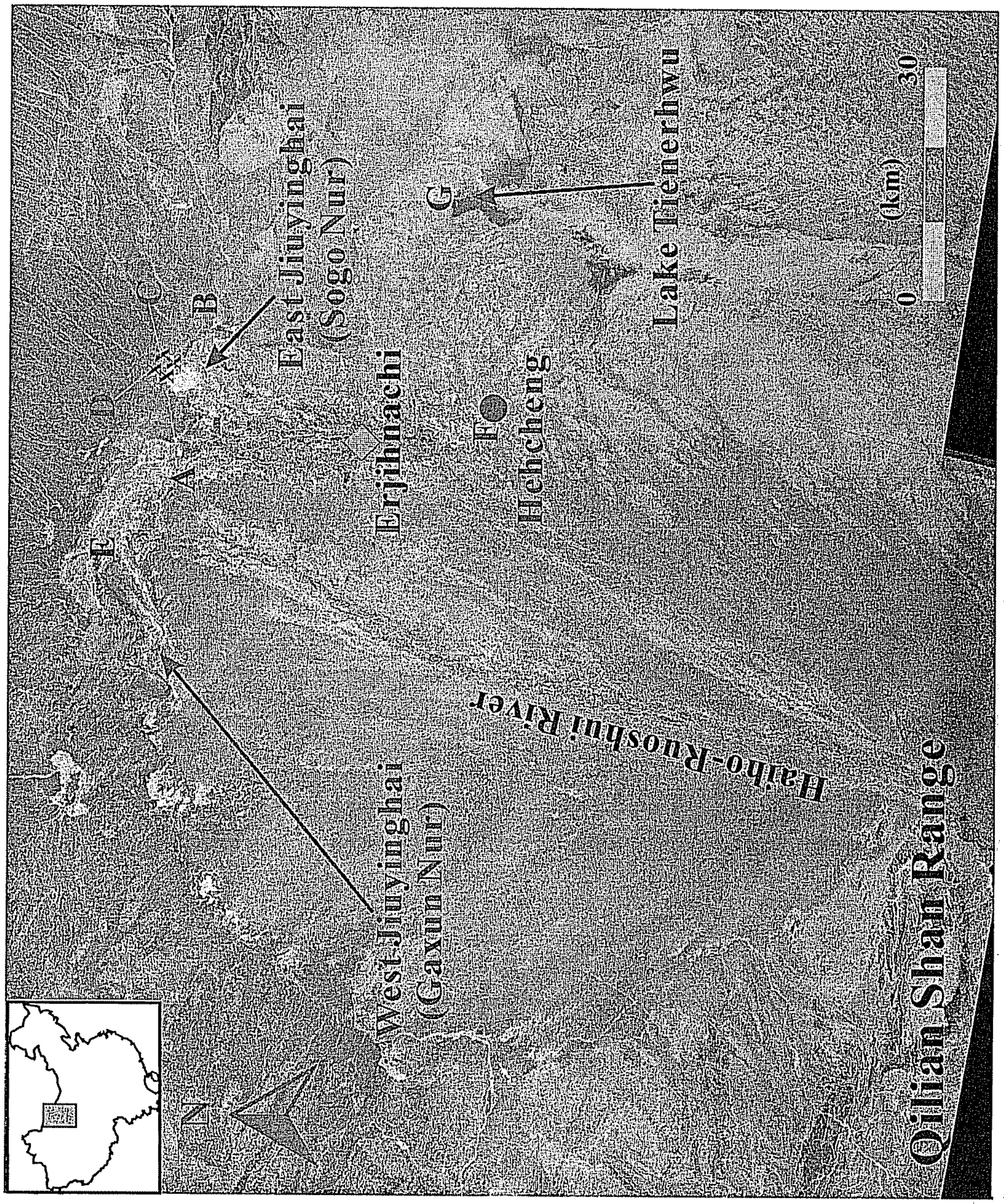

Figure 1. SPOT image and the location map of the Lake Jiuyinghai areas. The trenching sites are shown as A, B, C, D, E, F and G in the map.

west and east Lake Jiuyinghai dried up in 1961 and 1992, respectively (Wang and Tou, 1997; Gong *et al.*, 1998).

SAMPLING AND LABORATORY ANALYSIS

Samples for this paleomagnetic study were collected by u-channels from six trenching sites A, B, C, D, E and G. The lengths analyzed are 1.1 m, 1.2 m, 1.25 m, 1 m, 1.5 m and 1.15 m, respectively. Cores A, B, C, D were taken from the Sogo Nur in the east, core E was from Gaxun Nur in the west and core G was from Tien-eu Lake in the southeast of ancient Jiuyinghai. The site localities are shown in Figure 1. The lithologies of these cores are detailed described in the paper of Song *et al.* (2003) in the same volume.

Natural remanent magnetization (NRM) of the samples was measured after stepwise alternating field (AF) demagnetization from 0 mT to 100 mT with an increment of 10 mT on a cryogenic magnetometer (2G Enterprise Co., model 755 SRM). The measuring spacing is 1 cm. The original data were used to determine the characteristic remanent magnetization of the samples by employing the linear regression method. Directional secular variation patterns of these six cores were then set up. All these magnetic measurements were made in a magnetically shielding room of paleomagnetic laboratory at the Institute of Earth Sciences, Academia Sinica.

After the analysis of NRM, samples were subjected to the AF demagnetization treatment at a peak field of 100 mT simultaneously associated with a steady field of 1 Gauss on the cryogenic magnetometer to generate the anhysteresis remanent magnetization (ARM). The ARMs of samples were then measured again on the cryogenic magnetometer at the same demagnetization stages as their NRM. Finally, the NRM intensities of the samples were normalized by their ARM intensities at the same demagnetization field in order to simulate the intensity changes of the earth paleomagnetic field.

PALEOMAGNETIC RESULTS

Figure 2 shows the typical orthogonal component plots of the samples studied during stepwise AF demagnetization. Their associated normalized intensity curves are shown in Figure 3. From these figures it could be found that the secondary components of the NRMs seem to be effectively removed after the 60 mT AF demagnetization treatment for most of the samples. Hence, the directions of the characteristic remanent magnetization of the samples could be delimited. Figure 4 shows the secular variation patterns of the six cores, including declination and inclination based on the determined paleomagnetic directions. And the variation patterns of the simulated paleo- intensity curves of these cores were shown in Figure 5.

From Figure 4, it can be found that most of the samples show the normal polarities. The inclinations varied between 40° and 80° with a mean of 60° approximately, and the declinations of each cores generally varied ±30° away from their mean. However, there are two abnormal excursions could be identified. They have relative high inclinations (around 80°) and about 180° and 90° away from the mean for the declinations, respectively. The younger anomaly exists in all the cores, but the older one is only found at cores JYH-C and JYH-E. Certainly, these two excursions could be used as key beds for core correlations.

In addition, many studies have pointed out that low paleomagnetic intensities were usually observed when the short polarity reversal events and excursions occurred (Channell *et al.*,

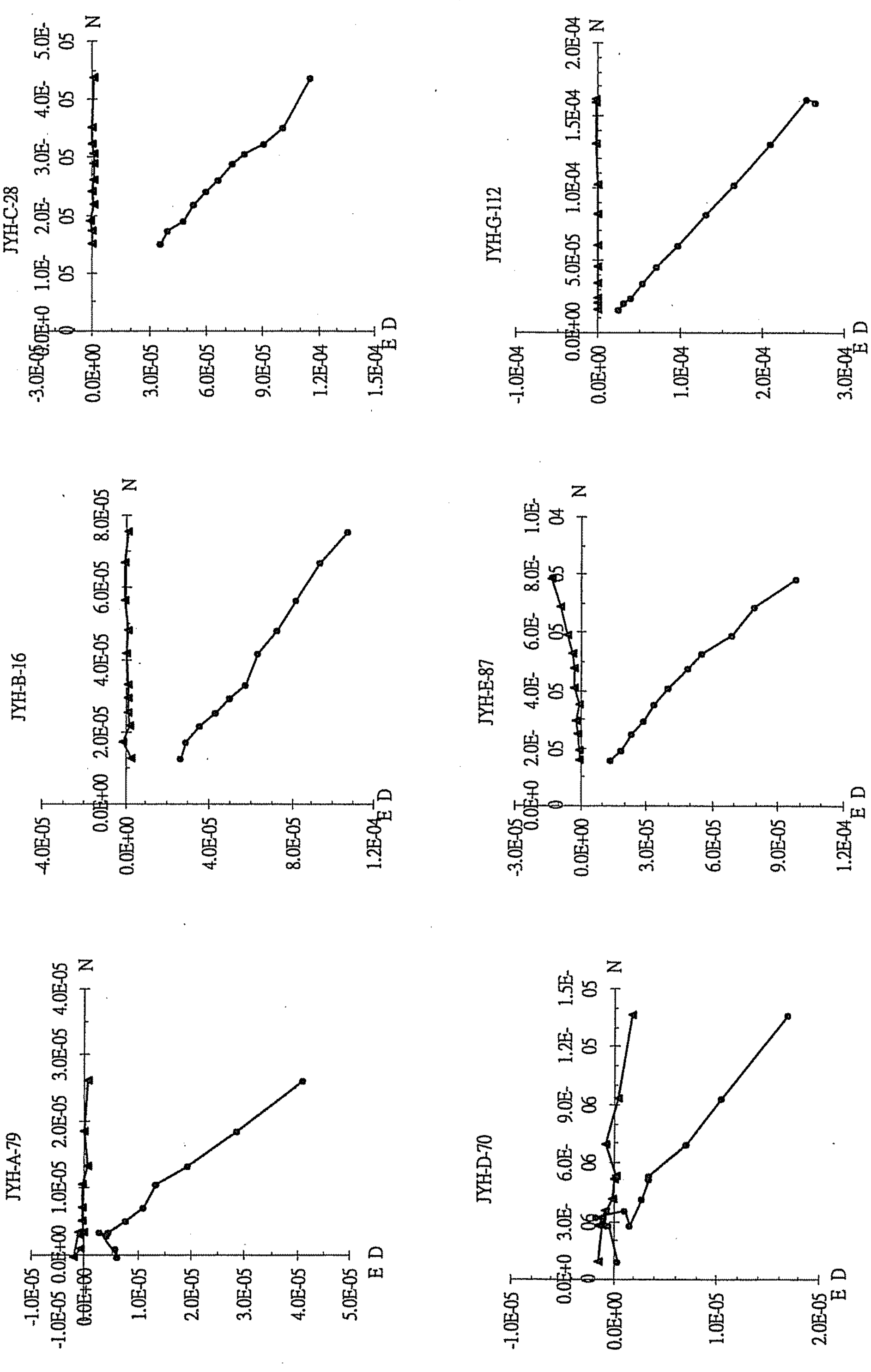

Figure 2. Typical orthogonal component plots of the samples studied showing the NRM variation during AF demagnetization treatments.

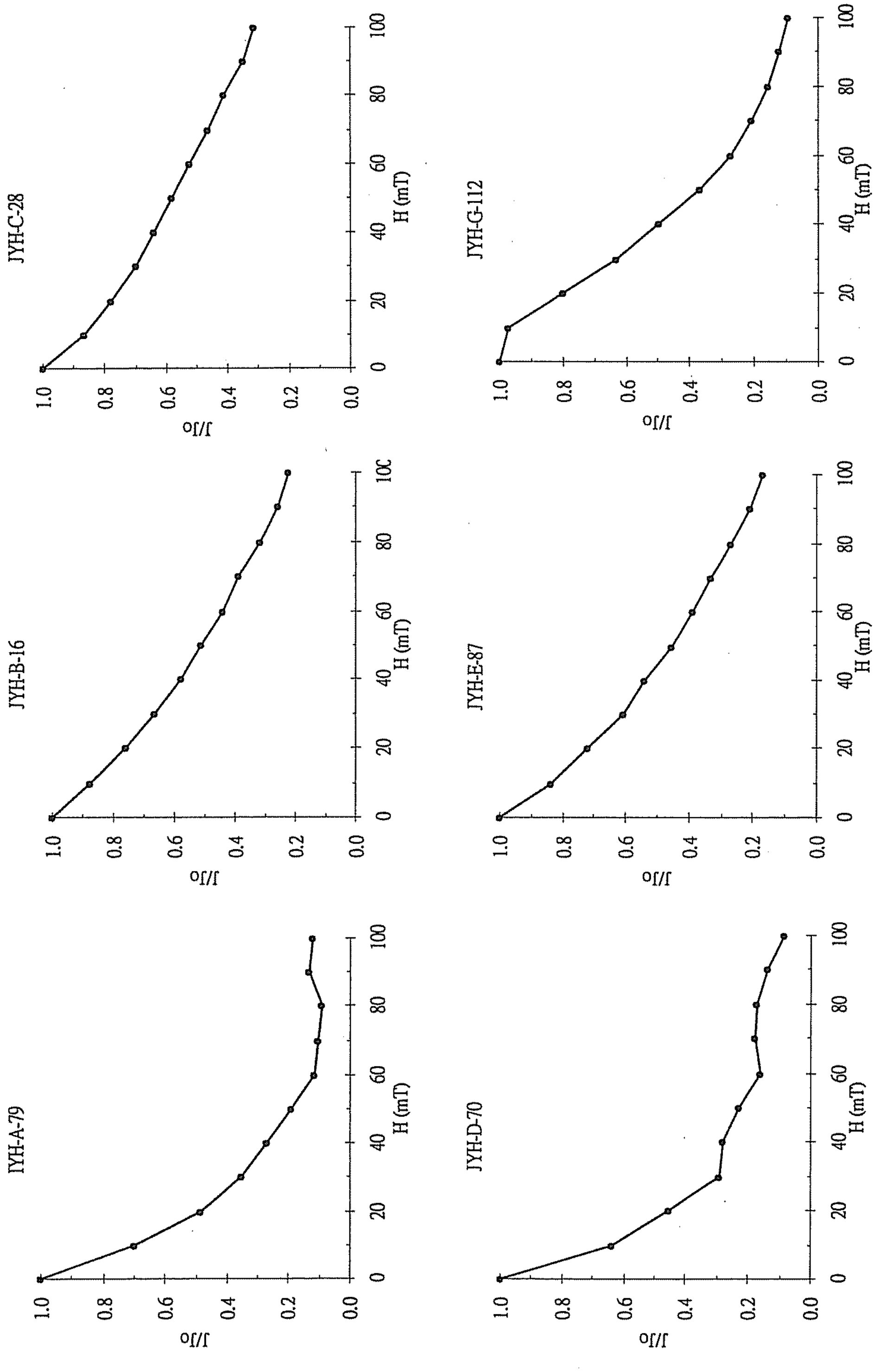

Figure 3. The associated normalized NRM intensity variation curves of the samples shown in Figure 2.

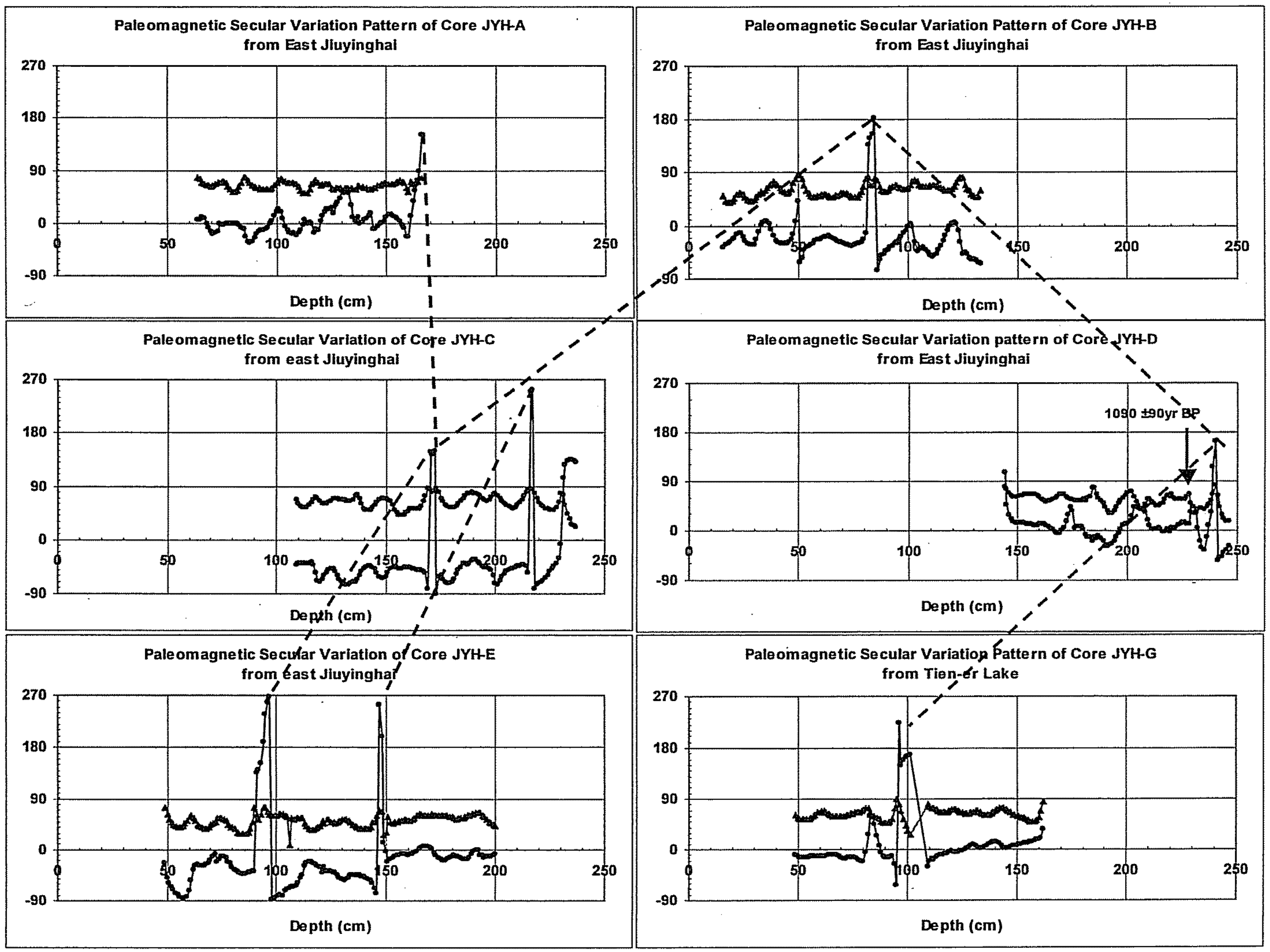

Figure 4. The directional secular variation patterns of this study show the existence of two magnetic excursions and the depth correlation between the cores.

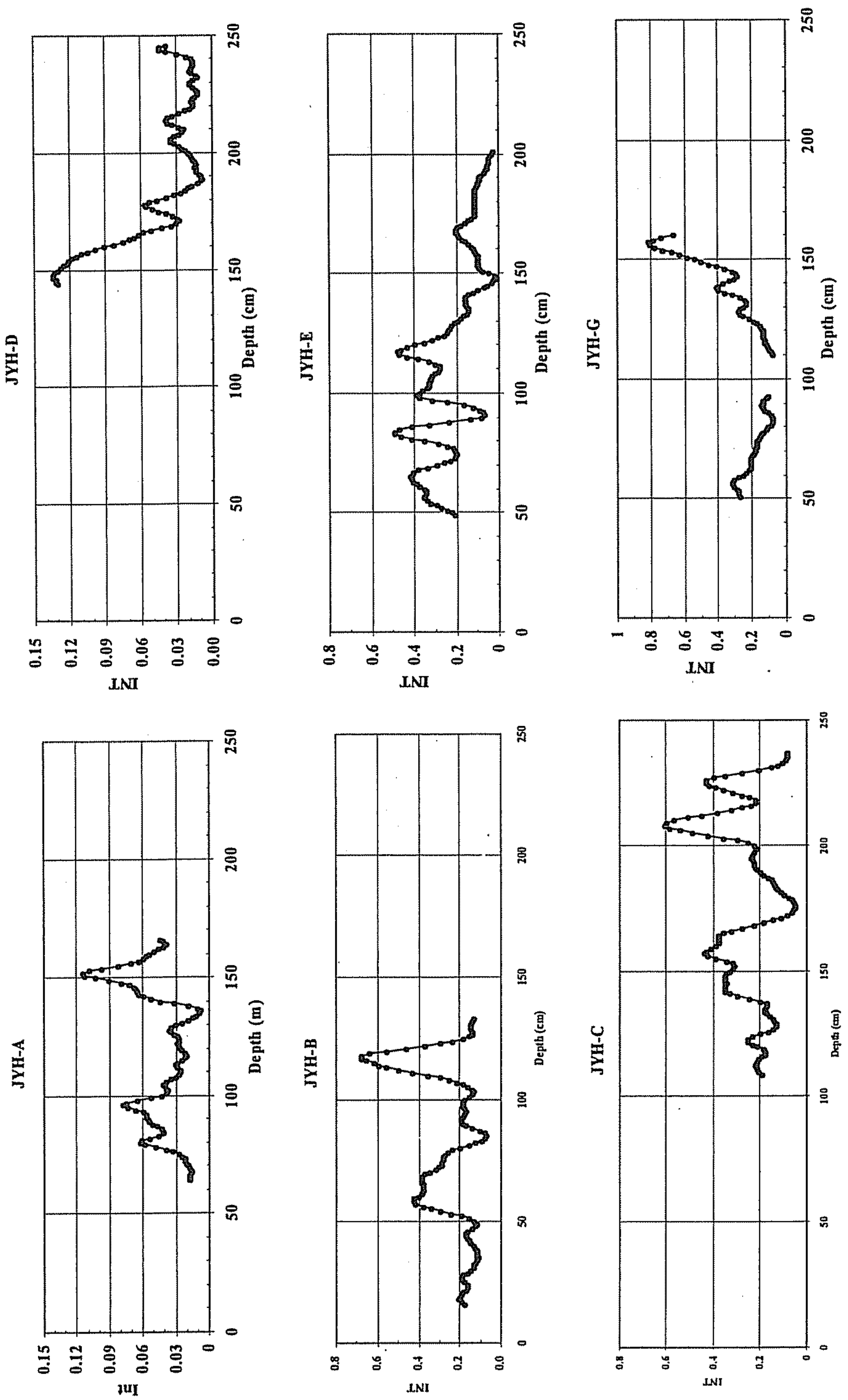

Figure 5. The simulated paleo-intensity variation patterns of the six cores studied.

1997; Guyodo and Valet, 1996, 1999; Roberts *et al.*, 1997; Schneider and Mello, 1996; Tric *et al.*, 1992; Valet and Meynadier, 1993; Williams *et al.*, 1998; Yamazaki *et al.*, 1995). From figure 5, we can find that relative low intensities did appear at the depths where the magnetic excursions were observed in each of the cores.

DISCUSSIONS

Based on the two excursions found in the cores studied, the six cores could be correlated as shown in Figure 4. The younger excursion appears at the depth 160-170 cm of core JYH-A, which is equivalent to 81-85 cm of core JYH-B, 168-172 cm of core JYH-C, 230-240 cm of core JYH-D, 90-98 cm of core E and 80-110 cm of core JYH-G. From the C-14 dating data, about 1090±90 yr B.P., obtained from the depth 225 cm of the core JYH-D, the age of this younger magnetic excursion is proposed to appear at about 1200 yr B.P. For the older excursion, it is found at the depth 215-218 cm of core JYH-C and at 145-150 cm of core JYH-E. Because no desired age datum has been determined, the appearance time of the older excursion is not known yet.

The simulated paleo-intensity trends are not so similar as those of the paleomagnetic directions except cores JYH-A, -B and -C (Figure 5). It is known that the used method, NRM/ARM pattern, depends tightly on the grain size assembly of the magnetic minerals contained in the samples. From the detailed description of the lithology of the trenching sites shown in the paper of Song *et al.* (2003), it can be found that the JYH-A, -B and -C sites have very similar sediment sequences, but the others are different. This reveals that the grain size distributions of the magnetic mineral constitutions of these cores are somehow different, which explains the difference of the simulated paleo-intensity trends. In addition, the lithological correlation data made by Song *et al.* (2003) are generally in very good consistency with the paleomagnetic directional trends of this study.

The Sogo Nur, Gaxun Nur and Lake Tien-er are all part of the paleo- Lake Jiuyinghai. Their sediments were major brought into by the Haiho-Ruoshui River. However, the different sediment sequences of the studied trenching sites pointed out that the deposition histories of these three lakes are obviously different due to quick paleo-climate and paleo-environment changes in the area studied. To investigate the detail evolution of the paleo-climate and paleo-environment changes in the Lake Jingyinghai area, more data and different studies are needed, especially the age data. Undoubtedly, it is worth of further studies.

SUMMARIES

The preliminary paleomagnetic results obtained from the cores sampled at six trenching sites in the Jiuyinghai area show the existence of two magnetic excursions. The younger event occurred slightly earlier than 1090±90 yr B.P. is proposed to appear at about 1200 yr B.P probably, and that of the older event needs to be further investigated. The unlike paleo-intensity trends of the cores reflect the different grain size assembly of their magnetic minerals contained in the sediments and point out that they are strongly lithological dependent. The different variation patterns of these sedimentary sequences might indicate the quick variation and the complexity of the environment changes in the Jiuyinghai and its neighboring areas during the past.

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