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Magnetostratigraphy of a Loess-Paleosol Sequence from Higher Terrace of the Daduhe River in the Eastern Margin of the Tibetan Plateau and Its Geological Significance

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The eolian deposits distributed in the river valleys in the eastern margin of the Tibetan Plateau (TP) are very useful in neotectonic and paleoclimatic studies. Firstly, the climate in the eastern margin of the TP is mainly controlled by the Indian summer monsoon, and detailed studies on the loess-paleosol sequences in this region can provide valuable terrestrial evidence of past changes in the Indian summer monsoon. Secondly, the river terraces in the eastern margin of the TP are considered to be a sensitive recorder of neotectonism to reflect the timing and amplitude of the TP uplift. The formation ages of these river terraces can be determined indirectly by chronological investigations of the upper loess deposits. Thirdly, much evidence suggests that the uplift of the TP play an important role in controlling changes in regional and global climates (Raymo, et al., 1988; Ruddiman and Kutzbach, 1989; Kutzbach et al., 1993; An, et al., 2001), and the eolian deposits in the eastern margin of the TP are among the best geological materials containing information about climate response to uplift of the TP.

Up to date, detailed studies have been concentrated on the loess-paleosol sequences in the Ganzi region in the Yalongjiang River valleys. Chronological investigations using magnetostratigraphic and luminescence dating methods demonstrated that the basal age of the eolian deposits in this region is about 1.15 Ma BP (Yan et al., 2001; Qiao et al., 2009). However, the formation of these eolian deposits is not only controlled by the paleoclimatic and paleoenvironmental conditions but also related to the regional evolutionary history of geomorphology. Whether the Ganzi loess is the oldest one is crucial for paleoclimatic and neotectonic studies. In order to obtain reliable information, more attention should be concentrated on the chronological investigations of these aeolian deposits with wider spatial coverage.

In the Jinchuan (JC) region of west Sichuan province, there exist at least 14th terraces of the Daduhe River. The JC loess section is on the 12th river terrace, with an altitude of 3538 m above sea level. The JC section is about 46.2 m in thickness, and contains 37 visually definable reddish paleosol layers interbedded with yellow-brown loess layers, with underlying bed of fluvial gravel deposits. In the field, 249 oriented samples were taken at 10–20 cm intervals for paleomagnetic measurements, and 2310 bulk samples were collected at 2 cm intervals for magnetic susceptibility measurements.

Magnetic susceptibility was measured using a Bartington MS2 unit. Paleomagnetic measurements were carried out in the Paleomagnetism Laboratory, Institute of Geology and Geophysics, Chinese Academy of Sciences. Stepwise thermal demagnetization up to 685 ºC was performed using an MMTD600 Thermal Demagnetizer on all 249 pilot samples with a temperature step of 20–50 ºC. Measurements were made using a 2G three-axis cryogenic magnetometer. Both the demagnetizer and magnetometer were housed in a magnetically shielded room to avoid viscous contamination. The measurement results reveal that all samples show the presence of two components. Secondary viscous remanent magnetization conforming to the present-day magnetic field direction was removed at about 250–300 ºC. After removal of the low temperature component, the direction becomes relatively stable, this component is the characteristic remanent magnetization.

Lithostratigraphy, magnetic susceptibility, inclination, declination and geomagnetic polarity of the JC section are shown in Fig. 1. Compared with the standard polarity timescale (Cande and Kent, 1995), the Brunhes/Matuyama (B/M) and Matuyama/Gilbert (M/G) magnetic reversals in

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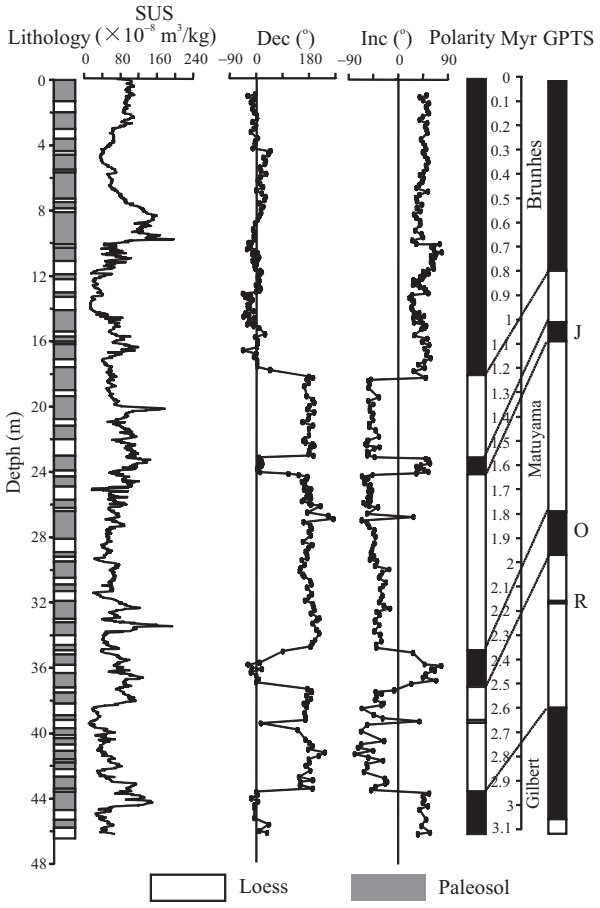

Fig. 1. Lithostratigraphy, magnetic susceptibility, inclination, declination and geomagnetic polarity of the Jinchuan section.

the JC section are found in the depths of 18.1 and 43.6 m, respectively, and the normal polarity zones at the depths of 23.2–24.2 and 35.0–37.2 m should correspond to Jaramillo (J) and Olduvai (O) subcrons in the Matuyama magnetozone. In addition, a negative magnetic sample is found at the depth of 39.3 m, which may be correlative with the subcron of Reunion (Fig. 1). The basal age of the Olduvai subcron (1.95 Ma BP) and the top age of the Gilbert magnetozone (2.581 Ma BP) suggest an average eolian accumulation rate of about 1.016 cm/ka during this period. Extrapolation based on this accumulation rate yields a basal age of about 2.84 Ma for the aeolian deposits in the JC section.

Magnetostratigraphic results of the JC loess section provide valuable information for the timing and amplitude of the TP uplift. The 12th terrace of the Daduhe River in the JC region is about 794 m in elevation above the river, which nearly represents the uplift amplitude during the past 2.84 Ma, indicating that the uplift rate in this region reaches to 27.96 cm/ka in the eastern margin of the TP during this period. Furthermore, this study provides a precise time scale for long term paleoclimatic studies, and much more information about evolutionary features of the Indian summer monsoon and climate response to the uplift of the TP can be obtained by further analyses of various paleoclimatic indictors in the JC section.

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