

Research Advances

A New Model for Correlation between the Marine Benthic Oxygen Isotope and Red Clay Magnetic Susceptibility on the Chinese Loess Plateau

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Objective

Aeolian sediments on the Chinese Loess Plateau contain some of the best continental archives of palaeoclimate change in the Late Cenozoic. The consensus that alternating MS in loess–paleosols in China was due to the strengthening and weakening of the East Asian palaeomonsoon provides an excellent climate record when correlated with global ice volume. Significantly, new basal dates from the red clay underlying the loess–paleosol sequence indicate that wind-blown dust began to accumulate on the Chinese Loess Plateau at least 22 million years ago. There are differences of opinion, however, as to the validity of using the MS record from the red clay as a proxy for palaeomonsoonal intensity or as an index of warm–cold cycling. Here we present the correlation between the magnetic susceptibility record from the pre-Quaternary aeolian red clay sediments underlying the loess, and the marine benthic oxygen isotope records for the period 8–2.6 Ma. Our main focus is on the inverse relationship between precipitation (inferred from the magnetic susceptibility record for the loess and red clay) and global ice volume. We attribute the fluctuating high and low precipitations implied in the aeolian sediments to movement of the rain belt, which penetrated deep into the interior of Asia in north-western China during interglacials and returned during periods of glaciation to central China where the Chinese Loess Plateau is located. Glacial-period rain belts stayed in south-eastern China from 2.6 Ma while the interglacial rain belts occur in CLP. Thus, we found the magnetic susceptibilities depend on the presence or absence of the rain belt.

Method

Magnetic susceptibility of red clay from Shilou, Chaona and Xunyi, MS flux from ODP site 758A, oxygen-isotope

variation from core ODP site 1148 and core ODP site 849 have been plotted on an absolute time scale in Figure 1. Simple linear interpolation has been applied on polarity boundaries for MS at Shilou section. The MS fluctuated in parallel with the oxygen-isotope oscillations in the ocean, suggesting that, the dust deposition in central China and the global ice volume were both linked to and controlled by the changes in the general circulation of the Northern Hemisphere.

Results

The MS curves from three sections on Loess Plateau apparently have a general trend in the same way while with different in more detailed comparability. Even the MS from central Loess Plateau (Xunyi and Chaona) have similar fluctuations in the intensity, the change still has some different wave propagations. Then the MS curve from Xunyi section has those different transitions (from that of Chaona section) related to that of Shilou section, which means the MS record of Shilou section has much more consistent fluctuations with Xunyi section between those two sections on central Loess Plateau. The aeolian sedimentary record on the central Loess Plateau indicates that ancient Asian monsoon activity began 8 Ma at the same time as significantly intensified uplift of the Himalayas and Tibetan Plateau and the closure of the Palaeo-Tethys Ocean. In addition, the MS record in the Shilou red clay on the eastern Loess Plateau is highly correlated with the marine benthic oxygen isotope record for the period 8–2.8 Ma, indicating a link between significant peaks in both records. The MS of the Shilou red clay also has the same trend as the benthic oxygen isotope data from ODP site 1148 for the period 6–2.6 Ma. The clearly increasing trend in MS strength indicates that the red clay may have formed in conditions of increasing monsoonal precipitation, which has important implications for the factors controlling long-term monsoonal evolution over East Asia.

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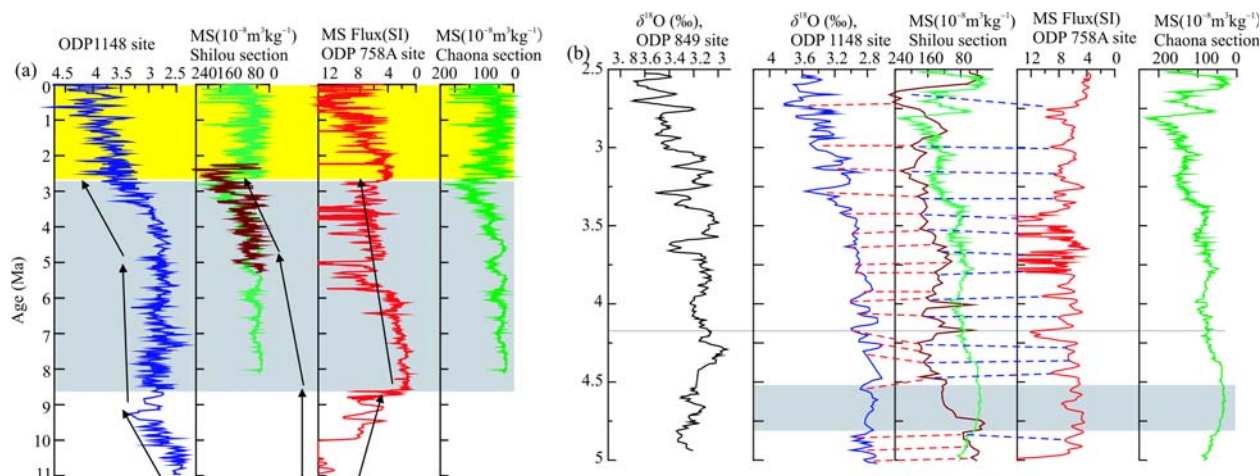


Fig. 1. Terrestrial and marine records from the Chinese Loess Plateau, northern Indian Ocean and eastern Pacific Ocean. Magnetic susceptibility of Shilou (brown), Xunyi (black) and Chaona section (green), southern China sea $\delta^{18}\text{O}$ data from ODP site 1148 (blue), MS flux from northern Indian ocean ODP site 758A (red) and eastern Equatorial Pacific $\delta^{18}\text{O}$ data from ODP site 849 (orange).

However, from 6 Ma to 2.7 Ma, MS values at Shilou correspond to low values of marine $\delta^{18}\text{O}$, indicating a relatively warm period, while high values indicate a relatively cold period.

Conclusion

Here we have deduced our model of rain belt movement to explain the relationship between the MS record in the loess and red clay sequences with the deep-sea foraminiferal $\delta^{18}\text{O}$ records. In the late Miocene to Pliocene, the palaeoclimate was warmer than in the Quaternary, with the result that the seasonal rain belts penetrated deep to the interior of Asia, reaching as far as

the Loess Plateau in glacial periods and to the present drought areas of north-western China during interglacials. Since 2.6 Ma until the present, the glacial rain belts have been located in south-eastern China and the interglacial rain belts in the Loess Plateau. This scenario explains the intensity of precipitation received by the Chinese Loess Plateau results in the observed reverse MS records in the loess and red clay sequences.

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