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High-resolution climatic signal over the last glacial-interglacial from magnetic nanoparticles in Chinese loess-paleosol

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Measurement of bulk magnetic susceptibility (MS) has been applied routinely in environmental research: for example, MS variations in Chinese loess-paleosol successions are well known for their correlation with marine oxygen-isotope records, which leads to interpretation of past Asian monsoon intensity variations in the context of global climatic change (An et al., 1997). However, MS is theoretically a function of various factors such as the concentration, grain-size and other magnetic properties inherent in magnetic particles present in a sample. In this study, we present high-resolution (millennial-scale) records of past climatic variability obtained from a loess-paleosol succession in Luochuan, central China, which have been reconstructed by applying a new method that measures MS over broadband frequencies (Kodama, 2013). This method is capable of estimating the concentration and volume fraction distribution of ultrafine magnetic particles, so-called superparamagnetic (SP) particles with volumes ranging in 10^{-24} to 10^{-25} m^3. We have investigated an upper loess-paleosol section, a profile that records climatic changes over the last glacial-interglacial cycle (An & Porter, 1997). The studied section is 13-m-thick and consists of two paleosol (S0 and S1, in Chinese loess sequence nomenclature) and two loess units (L1 and L2); the 7-m-thick L1 unit and 3-m-thick S1 unit are subdivided into subunits that are intercalated by weakly developed soil (weak paleosol) layers. Chronology for this section has been provided, based on the correlation of bulk MS values variation with marine oxygen isotope stages and linear interpolation using the control ages: 71 kyr for the L1/S1 boundary and 129 kyr for the S1/L2 boundary. An additional control age is provided for a layer within the L1 unit, which corresponds to the Laschamp geomagnetic excursion at 41 kyr (Xian et al., 2012). A total of 143 samples were collected in 10 cm intervals from the top of S0 unit to the upper part of L2 unit.

We have analyzed profiles of a series of magnetic parameters that represent the abundance of SP particles and the proportion of finer particles in their narrow distributions. Results show that high-resolution signals can be decoded from these profiles, but in a manner different from previous studies. There is no considerably enhanced signal for the paleosol units, but instead the paleosol and weak paleosol units are identical in terms of the relative abundance of SP particles. Profiles of the indices representing the proportion of finer SP particles show a common pattern that is well correlatable with the loess-paleosol stratigraphy: the weak paleosol (mostly L1SS) show high-frequency and small-amplitude fluctuations, whereas the loess units (L1LL2 and L2) are associated with large-amplitude oscillations. The high-frequency oscillations later than 70 kyr are quite similar to the D-O oscillations. Below the 70 kyr boundary, the curve tends to fluctuate at lower frequency (a few millennia scale), which resembles the contemporaneous GISP2 pattern. The close similarities between variations of these profiles and other climatic proxy variations over the last glacial-interglacial cycle demonstrates that the method in this study can be a substitution of other methods using stable isotopes, and that Chinese loess-paleosol sequences have a potential as high-resolution, millennium-scale archives of both global and local climate changes.

Reference

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