STABLE ISOTOPES OF CARBONATE: PALAEOCLIMATIC AND PALAEOENVIRONMENTAL INDICATORS IN CHINESE LOESS

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Loess in China is rich in carbonate. During palaeosol formation the original carbonate in the loess experienced a dissolution–reprecipitation cycle and might be redistributed. If this kind of pedogenic carbonate formed in isotopic equilibrium with the ambient environment, carbon and oxygen isotopic composition can act as an important palaeoclimatic and palaeoenvironmental data carrier.

Stable carbon and oxygen isotope variations in carbonate concretions related to palaeosols were examined in 14 different palaeosols (S_1–S_{14}) in the Lishi Formation of Xifeng and Luochuan loess sections, China. Our objective was to study the relationship between the stable isotopic composition of pedogenic carbonates and climate, and its application in palaeoclimatic and palaeoenvironmental reconstruction.

Our results show that the $\delta^{13}C$ values of the carbonate concretions ($\delta^{13}C_c$) in palaeosols change in an opposite direction to the $\delta^{18}O$ values ($\delta^{18}O_c$). The more developed the palaeosol is, the less negative $\delta^{18}O_c$ values and more negative $\delta^{13}C_c$ values are. The $\delta^{13}C_c$ values of these palaeosols vary within about 5.3 and 5.1 ‰ in the Luochuan and Xifeng sections, respectively, while the variation magnitudes of $\delta^{18}O_c$ between different palaeosols are 1.3 and 1.6 ‰ in the Luochuan and Xifeng sections, respectively, i.e., smaller than those of $\delta^{13}C_c$.

A good linear relationship between the oxygen isotope composition of modern soil carbonate and the mean oxygen isotopic composition of local meteoric water ($\delta^{18}O_w$) was demonstrated by Cerling (1984). The correlation between $\delta^{18}O_w$ and mean annual surface temperature first observed by Dansgaard (1964) has been substantiated by numerous measurements made over the years of modern meteoric waters from a network of the International Atomic Energy Agency (IAEA) and other sources. Using the above relationships, a semi-quantitative transfer function is established. The oxygen isotopic measurements are used to estimate the formation temperatures of the palaeosols.

The carbon isotopic composition of pedogenic carbonates is controlled by the isotopic composition of soil CO_2, which is usually well correlated with the proportion of surface plant biomass using C_3 and C_4 photosynthetic pathway in the local ecosystem (Cerling, 1984). C_3 and C_4 plants have average organic carbon $\delta^{13}C$ values of about -27 and -13 ‰, respectively (Deines, 1980). The proportions of C_3 vs C_4 relative biomass are calculated using the $\delta^{13}C$ values of each palaeosol.

The results from this study are comparable to previous conclusions obtained by different methods, indicating that the carbon and oxygen isotopic analysis of carbonate concretions in Chinese loess have great potential for reconstructing palaeoclimatic and palaeoenvironmental conditions.