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Fe isotope composition of the Quaternary Red Clay in Southeast China and its paleo-environmental implications

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Fe has four stable isotopes, 54Fe (5.84%), 56Fe (91.76%), 57Fe (2.12%) and 58Fe (0.28%). The occurrence of Fe isotopic fractionation during the weathering and pedogenic processes might have some significant paleo-environmental implications. The Quaternary Red Clay (QRC), widely distributed to the south of the Yangtze River, is regarded as a potential archive to record the paleoclimatic changes in subtropical China since the Middle Pleistocene. The composition of Fe isotopes in a profile of the QRC in Langxi County, Anhui Province, Southeast China, was analyzed by the MC-ICP-MS method in this study. The results were as follows: (1) δ56Fe of the Yellow-brown Earth (YBE), the uppermost layer of the profile, only slightly fluctuates between 0.10‰ $\sim$ 0.12‰.That of the Uniform Red Clay (URC) was stable and 0.03‰ in content. That of the Reticulate Red Clay (RRC) in the lower part of the profile, however, was instable and fluctuates between -0.06‰ $\sim$ 0.05‰.(2) The reticulate (net-like) pattern of the RRC was formed by the partial leaching of Fe in the red clay possibly due to long-term frequent fluctuations of groundwater table. The white veins of the RRC were deficiency in both total Fe (Fet) and free Fe (Fed), but the red ones were not. A significant difference of δ56Fe between the white and red veins of the RRC was found. δ56Fe of the white veins, 0.35‰ on average, was significantly higher than that of the red veins, -0.09‰ on average. This suggests that lighter Fe isotopes were preferentially removed during the formation of the reticulate pattern. (3) The content of free Fe oxides in soil is evaluated by the CBD-extracted method. δ56Fe of the CBD-extracted fraction of the red clay samples, -0.083‰ on average, is significantly lower than that of the residual fraction, 0.361‰ on average, suggesting that lighter Fe isotopes were preferentially released from primary minerals to form Fe oxides in the red clay. (4) δ56Fe of the entire profile was negatively significantly correlated with Fet and Fed contents (r2=0.3009 and 0.5105, respectively), which also suggests that Fe in the QRC becomes heavier after the preferential leaching of lighter Fe during the intensive weathering and reticulating processes. In short, the Fe isotopes were only weakly fractionated in the red clay formation under an aerobic condition. When the RRC was formed, however, a large amount of lighter Fe isotopes were preferentially removed under an anaerobic condition and heavier Fe were relatively accumulated in the residues. Therefore, heavier Fe in the red clay may imply a warm and humid climate and luxuriant vegetation during the Middle Pleistocene. The Fe isotope composition of soils or paleosols is a promising factor to interpret pedogenic processes and indicate paleo-environmental changes.