Fe isotope fractionation in paddy soils originated from lacustrine sediments and red clay

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Redox conditions in paddy soils oscillate due to regular flood and drainage cycles of rice cultivation, playing an important role in Fe cycling in these soils. Understanding the mechanism of Fe migration in these soils is critical for deciphering how paddy soils form via anthropogenic modification. Iron isotopes are a novel and promising tool to decipher the behavior of Fe in soils. To investigate how Fe is transported in the paddy soils between and within multiple genetic horizons, we measured total Fe (Fe_2O_{3T}) concentrations and Fe isotope ratios of two paddy soil profiles from Suzhou and Xuancheng, China with high-resolution sampling up to 3 cm intervals.

Suzhou paddy soils are developed from lacustrine sediment materials. In the Suzhou profile, the Fe_2O_{3T} concentrations of most soil samples are around 5 wt.% except those from two iron accumulation layers (110-128 and 220-230 cm), which have higher Fe_2O_{3T} (11-14 wt.% and ~8 wt.%, respectively). The $\delta^{56}Fe$ of the profile varies from -0.13‰ to 0.28‰, with light Fe isotope enrichment in the iron-accumulation layers.

Xuancheng paddy soils are derived from Quaternary red clay, characterized by variegated horizons. The Fe_2O_{3T} concentration and $\delta^{56}Fe$ of samples in Xuancheng profile both display small variations, ranging from 1.2 to 4.5 wt.%, and -0.09 to +0.20‰, respectively.

Sequential extraction experiments were performed to segregate iron species and determine their isotope ratios. Compared with silicate-bound iron, light Fe isotopes are significantly enriched in the poorly crystalline iron oxides and crystalline iron oxides, demonstrating that the readily-mobilized Fe is isotopically light and the residual Fe is isotopically heavy.

The Fe isotope variations along the two profiles are clearly linked to the pedogenic process, mainly caused by redox variations during the long term evolution of paddy soils, which is controlled by the alternating drainage and flood cycles, and the fluctuation of groundwater table.