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Clay-mineral extraction and purification for reconstructing silicate weathering

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Silicate weathering plays a crucial role in maintaining global climate stability over Earth's history by serving as a negative feedback mechanism against climate and carbon-cycle perturbations. However, it is currently not possible to accurately describe how silicate weathering responded to past climate changes due to the absence of direct temperature and hydrological observations during the process. It has been demonstrated that naturally occurring clays, formed during silicate weathering, have an isotopic composition that depends entirely on temperature and isotopic composition of the soil water when the mineral formed[1][2]. To reconstruct both temperature and hydrological conditions, we propose independently measuring Si-O and Al-OH site-specific oxygen-isotope compositions ($\delta'^{18}O$) of pedogenic clays.

To effectively utilize this proxy, the initial step involves extracting high-purity clay-mineral fractions from soil and sediment samples. Ensuring sample purity is essential for precise determination of $\delta'^{18}O$, as the presence of other oxygen-bearing phases, organic or inorganic, can significantly alter measured isotope compositions, potentially leading to inaccurate interpretations. To achieve this, we developed a clay purification protocol combining various chemical and physical processes. Chemical steps target the removal of organic matter, carbonates, soluble sulfates, salts, and iron oxides, while physical steps, with the aid of a dispersant, are necessary for eliminating heavier and more dense particles, where micro quartz particles are an example.

This protocol successfully isolates high-purity clay minerals from soil and sediment samples, as confirmed by a suite of various characterization techniques, encompassing both mineralogical and petrographic analyses. This accomplishment enhances the precision and accuracy of site-specific oxygen isotope analysis of natural clay samples, thereby reducing the risk of misinterpretation and improving our ability to understand the temperature and hydrological conditions driving silicate weathering events in Earth's geological past. The effectiveness of this protocol was validated through site-specific oxygen isotopic analysis on both natural and synthetic clay mineral samples. Additionally, we will present initial isotopic results from well-characterized modern soil samples.

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[2]Savin, S., & Hsieh, J. (1998), *Geoderma* 82, 227-253.