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Clay-mineral extraction and purification for reconstructing silicate weathering

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Silicate weathering is a major driver of global climate stability throughout Earth's history since it acts as a negative feedback mechanism that dampens climate and carbon-cycle perturbations. However, it is currently not possible to accurately describe silicate weathering responses to past climate change due to a lack of direct observations regarding temperature and hydrologic conditions at which the process took place. Here, we suggest that triple-oxygen isotope compositions ($\Delta'^{17}O$ and $\delta'^{18}O$) of pedogenic clays can provide such direct paleotemperature and paleohydrology constraints.

To utilize this proxy, we must first obtain high-purity clay-mineral fractions from soil and sediment samples. Indeed, sample purity is critical to the precise determination of $\Delta'^{17}O$ and $\delta'^{18}O$, since the presence of oxygen-bearing contaminants – organic and/or inorganic – may significantly shift measured isotope compositions, leading to erroneous interpretations. In this respect, we developed a clay purification protocol that combines different chemical and physical steps. Chemical steps aim to remove organic matter, carbonates, soluble sulfates, salts, and iron oxides, whereas physical steps are required to remove micro quartz. Special attention was dedicated to oxide and quartz removal; three different oxide removal methods and two quartz removal methods were performed and compared. In particular, separation with a laminar flow table led to highly enriched clay fractions.

This protocol allows for the successful separation of clays with high purity from soil and sediment samples, as confirmed by several petrographic (i.e., XRD, SEM) and geochemical (i.e., TGA) techniques. Such an achievement will contribute to more precise and accurate triple-oxygen isotope analysis of clays from natural samples, thus diminishing the possibility of erroneous interpretations and enhancing our ability to constrain temperature and hydrologic conditions of silicate weathering in the geologic past. Finally, we will present preliminary clay triple-oxygen isotope results from well-constrained modern soil samples.