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A Basalt Dissolution and Clay Precipitation Study: Using Multiple Isotope Tracers to Close Knowledge Gaps in Enhanced Rock Weathering

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Enhanced rock weathering (ERW)—the spread of rock dust into croplands for the purpose of CO_2 removal—is currently actively investigated for its feasibility as a climate change mitigation strategy. Scaling-up this option globally can potentially capture billions of tons of CO_2 from the atmosphere per year if a fast-weathering material like basalt is applied. However, predicting rock weathering at a human time scale is a new challenge; Earth scientists are used to studying weathering at geological time scales, but are now looking to know ERW effects within their lifetimes.

To meet this objective, I am conducting multiple isotope tracer experiments by dissolving crushed basalts to determine the coupling of basalt dissolution and clay precipitation reactions. We hypothesize that, with the range of fine particles present in industrial basalt feedstocks, the system is quickly driven to near equilibrium with respect to primary minerals in the basalts and becomes supersaturated with respect to many clay minerals. The precipitation of clayey phases is the rate-limiting step for further basalt weathering. In my experiments, initial solutions are doped with ^{29}Si and trace element Li. The Si release rates are precisely determined by the temporal evolution of $^{29}Si/^{28}Si$ ratios. The onset of clay precipitation is revealed by a drop of Li concentration and an increase of d^{7}Li in experimental solutions, as ^{6}Li is preferentially taken up in precipitating clays. The coprecipitation of oxidized ferrous Fe with toxic metals released from rocks is also measured.

The isotope tracer techniques used are orders of magnitude more sensitive than conventional concentration methods, which is crucial for measuring the rapid reaction rates of the wide particle size range found in ERW applications. The precise unidirectional dissolution rates will better inform us of the reactivity of basalts with widely varying mineral and chemical content, which will eventually lead to the development of a basalt reactivity index. This study will also provide a set of experimental data for calibrating geochemical models. Overall, the results of multi-mineral reaction kinetics will provide a basic science foundation and improve the fidelity of geochemical modeling predictions of CO_2 removal from months to decades.