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The factors controlling the release, transport and isotopic composition of lithium during chemical weathering

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The weathering of silicate rocks releases alkalinity and cations to the critical zone, while oceanic carbonate burial sequesters CO_2 on long timescales. These processes have been long thought to reliably regulate the composition of Earth's atmosphere, but studies are increasingly revealing greater complexity and focussing on other aspects of the weathering cycle. This includes studying processes which inhibit and modulate the silicate weathering feedback, the potential for enhanced weathering to mediate climate change, sourcing the metals needed to transition to a greener economy, and assessing the impact of anthropogenic activity on natural processes.

Measurements of novel stable isotopes to quantify fluxes is becoming more routine, and the lithium isotope system is one of the most promising tracers of silicate weathering. Lithium is found predominantly in silicate rocks, and is not majorly fractionated by primary mineral dissolution, plants, or other biological processes. The fractionation of lithium isotopes is used to assess the balance between primary silicate dissolution and secondary mineral formation, which preferentially incorporates the lighter isotope ^{6}Li, leaving waters isotopically heavier than the rocks they drain. Additionally, with the global demand for lithium predicted to quadruple by 2030, the extraction of lithium from secondary phases such as clays, and direct lithium extraction (DLE) from hydrothermal brines have become research areas of intense interest.

We have collected samples of fresh and weathered rock, surface and deep hydrothermal fluids, river waters and suspended sediments, across a range of spatial scales, in order to study the factors controlling the release, transport and isotopic composition of lithium in both natural and anthropogenically altered environments. These samples include the Cornubian granites, where there is interest in lithium extraction from hard rocks and brines, the Andes-Amazon floodplain transition, where there is a major shift in the congruency of weathering, and areas of the Amazon heavily impacted by deforestation and mining activity, where secondary clays have been re-exposed to the large rivers that drain the basin. We combine measurements of chemical and isotopic compositions to constrain the sources, processing and fractionation of lithium across a range of spatial scales in both natural and anthropogenically impacted environments.