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Lithium isotopes tracing weathering processes in a time series through soil porewaters

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Chemical weathering is a key process that controls Earth's geochemical cycles and global climate, yet at present the climate-weathering feedback is poorly understood. Lithium (Li) isotopes are sensitive to silicate weathering processes [1] and can be applied in a range of settings to improve our understanding of weathering mechanisms and timescales, and hence to quantify the role of weathering in the global carbon cycle. While marine carbonates [2] and speleothems [3] are suitable for recording changes over million year and thousand year timescales, respectively, it is equally important to assess how weathering operates over seasonal [4] and shorter [5] timescales.

In order to explore seasonal variability in a natural system, we analysed Li isotopes and major/trace elements in a time series of cave drip-water samples from Ease Gill and White Scar caves (Yorkshire Dales, U.K.). Since the drip-waters are sourced from the overlying soil porewaters, these measurements provide a record of the evolving weathering fluid chemistry at approximately monthly intervals. Our data reveal striking temporal variations in ∂^7Li of 4 to 8 permil, hinting at rapid changes in weathering processes over monthly to seasonal timescales. We assess the sources of Li using isotope measurements on local rocks and soils, which enables a first order quantification of the temporal changes in Li removal by clay formation. Comparison to records of temperature, precipitation, drip rates, and drip-water chemistry allows the local controls on weathering to be assessed and indicates that a dominant control is exerted by the fluid residence time.

These data are further complemented by batch reactor experiments, which were conducted to replicate rock weathering over timescales of hours to weeks. In combination, the time series and experiments contribute to a better understanding of weathering changes over short timescales and their influence on Li isotopes. In addition, results from the drip-waters provide key ground-truthing for interpreting our ongoing Li isotope measurements on speleothems, which will provide new records of weathering changes over longer timescales in response to regional climate forcing.

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