Glacial-interglacial weathering variations: Evidence from speleothem Li isotopes

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Chemical weathering is the main sink of atmospheric CO_2, and hence the dominant driving force of both the long-term carbon cycle, and the shorter term carbonate saturation state of the oceans. However, variations in weathering over glacial-interglacial timescales remain uncertain. This means that one of the key drivers of carbon levels in the atmosphere and oceans during time periods often used for predicting future climate change is poorly understood.

Marine weathering proxies tend to suffer from longer ocean residence times than glacial-interglacial timescales, and that expected weathering increases during warmer interglacials are balanced by increases in the continental surface area during glacials, meaning that typically ocean signals rarely see much variation in weathering during this time. Lithium isotopes are a more unambiguous weathering tracer than more traditional radiogenic isotopes (such as Sr or Os). Li is almost entirely situated in silicates, rather than carbonates, and its isotopic fractionation in rivers is demonstrably due to the intensity of silicate weathering. A number of recent studies have started to reconstruct past weathering behaviour using Li isotopes in marine carbonates. However, Li suffers from a long ocean residence time (~1 Myr) and hence cannot be used to reconstruct rapid weathering changes. One way of circumventing this is to examine speleothem carbonates. In theory, this yields more local weathering information, allowing regional weathering reconstructions not afforded by marine proxies.

We have conducted the first study of Li isotopes in speleothems, with samples from 2 well-characterised, well-dated speleothems from Israel (the caves at Soreq and Tzavoa), spanning the past 200 kyr. The data show clear variations, with interglacials having significantly lower δ^7Li than glacial periods, with average populations differing by ~6‰. We have also conducted analyses of modern speleothem carbonate, and their corresponding drip waters, allowing reconstruction of past drip water composition. Combined with analyses of overlying soils and rocks, this leads us to be able to reconstruct palaeo-weathering conditions during these climate change events.