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Lithium isotopes in Holocene speleothems from the Yorkshire Dales: testing their application as weathering regime tracers

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The chemical weathering of continental silicate rocks is a key feedback mechanism for removing atmospheric CO_2 over thousand to million-year-timescales. Measuring lithium (Li) isotopes in speleothems may provide an avenue to determine changes in local terrestrial silicate weathering processes in deglacial environments. The ^{7}Li value of drip-waters from which speleothems precipitate is hypothesised to be determined by local changes in weathering congruency: the ratio of primary mineral dissolution to secondary mineral formation. To test this idea, we analysed ^{7}Li values in speleothems LH-70s-1, LH-70s-2, and LH-70s-3 spanning 12.3 ka – 1.0 ka from Lancaster Hole in the Yorkshire Dales. These data were compared with previously measured ^{13}C, ^{18}O, Mg/Ca, and Sr/Ca records based on U-Th age models.

Over millennial timescales, our Li isotope records do not consistently replicate across speleothems, indicating that short-term fluctuations in ^{7}Li values arise from localised changes in flow pathways and epikarst residence times. Broadly correlated ^{7}Li, ^{13}C, Mg/Ca, and Sr/Ca values imply increased epikarst residence times when ^{7}Li values are elevated. This scenario reflects increased prior calcite precipitation, decreased drip rates, and extended water-rock interaction times. In this setting, the ^{7}Li values appear to be controlled by extended interaction times of water with glacial till washed into flow pathways through dolines. However, this correlation is not consistent for the entire length of the records. In LH-70s-1, an excursion to low ^{7}Li values coupled with elevated Mg/Ca, Sr/Ca, and ^{13}C values is observed prior to 11 ka, immediately succeeding the Younger Dryas. This finding may indicate that significant regional changes in weathering congruency related to the increased supply and dissolution of primary silicates following the Younger Dryas, together with increased surface runoff due to heightened permeability and climatic water surplus, may override localised hydrological controls on speleothem ^{7}Li values to drive a regional signal over longer timescales.