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Soil formation and weathering over the past 60 kyr reconstructed using lithium isotopes from Maar records

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Chemical weathering is clearly important in controlling atmospheric CO_2, but is also the critical process in soil formation. This, in turn, is important for the development and spread of vegetation, especially following on from glaciations. Furthermore, clay formation inhibits CO_2 drawdown during weathering – thus the more clay forms, the less efficient the CO_2 drawdown is.

We have examined records from a Maar lake in the Eifel region of Germany (known as ELSA – Eifel Laminated Sediment Archive), which provide a high-resolution palaeoclimate record across the past ~60 kyr. These include both the last glacial maximum and shift into the Holocene, but also multiple abrupt climate change events during the last glacial, such as Dansgaard-Oeschger (interstadial) events. Hence, these records provide the opportunity for an examination of a local weathering record response to global changes, and how they contributed to soil formation across millennial-scale and shorter climate warming and cooling timescales.

We use lithium isotopes in both bulk sediment and separated clays as a tracer of secondary mineral formation. Our d^7Li values of the sediments range between -5.5 and +0.4‰, with data from warmer interstadials being ubiquitously lower than values from cold stadials. This implies that soil formation and accumulation was higher during the colder time periods, and less during the warmer interstadials. The likely reason is an accelerated hydrological cycle, plus increased solubility of primary and (non-oxide) secondary minerals, leading to less clay formation during warming. These effects can be seen both across the changes from the last glacial to the Holocene (1000s of years), but also across much more rapid Dansgaard-Oeschger events (less than ~100 years).