Fingerprinting the temperature and fluid source of fracture-filling calcite in geothermal systems using clumped isotopes

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Precipitation of minerals, such as calcite, in fractures can modify and reduce fluid flow in geothermal energy systems. Such mineral deposition can be a key limiting factor in viable geothermal energy production.

Clumped isotopes offer a new way of characterising the temperature and fluid source of fracture-filling calcite. This technique is based on the thermodynamic relationship between carbonate mineral growth temperature and the abundance of chemical bonding (“clumping”) between ^{13}C and ^{18}O isotopes (expressed as Δ_{47}) within single carbonate ions (e.g. Eiler, 2007). In the gas phase, isotopic exchange between CO_2 molecules and water is continuous and so CO_2 gas will record the ambient fluid temperature. When the CO_2 is trapped in a solid mineral phase, the isotope ratio is fixed. As a result, clumped isotopes will record the temperature of crystallisation, enabling the application of clumped isotope palaeothermometry to a range of geological problems.

Samples from active geothermal fields (the Kawerau geothermal field, New Zealand (McNamara et al., 2017)) and analogues to basaltic geothermal systems in Western Scotland have been analysed with clumped isotopes. We present petrography, $\delta^{13}C$ and $\delta^{18}O$, and clumped isotope data from these samples to show how clumped isotopes can fingerprint the temperature and fluid source of fracture-filling calcite in geothermal systems. Having this understanding of fracture filling conditions can lead to focused development of remediation measures.

References
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