

A multi-proxy approach to characterizing calcite fracture-filling processes, and the implications for geothermal energy

JACOB VANDERWAL¹, JOHN MACDONALD², AND OWEN SHERWOOD¹

1. *Department of Earth Sciences, Dalhousie University, Halifax, Nova Scotia B3H 4R2, Canada*

<jacobtvanderwal@dal.ca>

2. *School of Geographic and Earth Sciences, University of Glasgow, Glasgow G12 8QQ UK*

Geothermal energy has emerged as a reliable, cost-effective, and sustainable energy resource in areas of tectonic activity where hot sub-surface fluid circulation is common. Precipitation of carbonates within fractures that act as fluid conduits can act to modify and reduce flow, acting as a limiting factor to geothermal energy production. It is therefore important to understand the relationship between mineral precipitation, fluid source, and precipitation temperatures when assessing the economic potential of a geothermal locality. Here we present cathodoluminescence (CL) petrography, $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ stable isotope data, and minor element analyses for six carbonate veins collected from a 'fossil' analogue (easily accessible) basalt-hosted geothermal system in Lunan Bay Scotland, in order to determine the timing and conditions of fracture filling with regards to active geothermal circulation. Carbonate veins, predominantly composed of calcite with minor dolomite and quartz co-precipitates, range from a few mm to tens of cm in width. Carbonate growths are observed as stretched and bladed crystals likely formed during active fracturing, and blocky, altered crystals indicative of post-fracture precipitation. CL signatures, suggestive of changes in Fe/ Mn, exhibit relatively constant signatures across smaller veins (<1 cm) and gradual unidirectional variation across larger veins (>1 cm). However, minor element (FeO, MnO, MgO, Na₂O, and K₂O) transects across the larger veins suggest more erratic fluctuation, decoupled from trends expected based upon the CL signatures. The $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ (VPBD) values also fluctuate in comparison to CL, with end values varying from -9.9 to -1.9 ‰ and -13.2 to -1.4 ‰ respectively. Several reasons for these variations will be discussed, including changing fluid sources, degrees of fluid-host rock interaction, as well as changes in carbonate crystallization temperature. Furthering our understanding of fracture filling conditions using these methods will help to recognize and avoid systems that may be prone to fracture filling, thereby determining the economic potential of a geothermal locale.