Ti-in-quartz thermometry of hydrothermal veins in ocean crust

A.K. BARKER[1], L. COOGAN[1], K. GILLIS[1] AND D. WEIS[2]

[1]SEOS, University of Victoria, B.C. (akbarker@uvic.ca)
[2]PCIGR, University of British Columbia, Vancouver, B.C.

Ocean crust is cut by axial faults that provide high permeability pathways and consequently focus fluid flow forming an integral part of axial hydrothermal systems. Quartz is associated with upwelling hydrothermal fluids and is concentrated in hydrothermal stockworks and fault zones.

The thermal evolution of hydrothermal systems is important in understanding the heat and chemical fluxes during hydrothermal alteration of ocean crust. Previous estimates of the temperature of alteration in the sheeted dyke complex are not well constrained. The TitaniQ thermometer [1] is applied to investigate the temperature of quartz precipitation as a function of Ti concentration in quartz. These data are integrated with whole rock trace element and Sr isotope data to investigate the coupled thermal and chemical properties of focused fluid flow through an axial fault.

EPR crust (ca. 3 Ma) exposed at Pito Deep is the site of a detailed ALVIN transect across a 25 m wide high angle axial fault, ~100 m below the lava-dike transition. Fault zone wall rocks are altered to amphibole dominated assemblages typical of the sheeted dyke complex at Pito Deep. The alteration in the fault zone ranges from amphibole dominated basalts with limited veining to highly brecciated samples dominated by quartz and chlorite. Quartz occurs as veins with sulphides, minor titanite and rare epidote. Additionally quartz is found in the clasts and matrix of cataclasites, along with chlorite and sulphides.

Ti concentrations in quartz were determined by LA-ICP-MS, with a detection limit of 0.6 ppm. Quartz from 6 samples in the fault zone at Pito Deep have Ti concentrations ranging from <0.6 – 2.2 ppm. Applying the TitaniQ thermometer[1] (assuming αTiO_2 of close to 1) Ti concentrations in quartz from this fault zone indicate maximum temperatures of 400 ±30°C and extend to lower than 360°C (~40% of analyses) at Ti concentrations below the detection level.

Breccia compositions (e.g. $^{87}Sr/^{86}Sr$) suggest high permeability fault zones facilitate mixing of seawater below the lava-dike transition with upwelling high-temperature hydrothermal fluids providing a large temperature gradient leading to precipitation of quartz and sulphides.

[1] Wark and Watson (2006) *Contrib Min Pet.* **152**, 743-754.

Sm-Nd, Sr, C and O systematics in hydrothermal calcite-fluorite veins: Implications for fluid-rock reaction and geochronology

S.L.L. BARKER[1,2]* AND S.F. COX[1]

[1]Research School of Earth Sciences, The Australian National University, Canberra, ACT 0200, Australia
[2]Present address: Department of Earth and Ocean Sciences, University of British Columbia, BC V6T 1Z4, Canada (correspondence: sbarker@eos.ubc.ca)

The Sm-Nd isochron technique has shown promise to determine the age of hydrothermal mineral deposition for fluorite [1] and calcite [2]. The Sr and Nd isotope composition of a hydrothermal fluid will be dependent on the Sr and Nd isotope values of the rocks with which that fluid has equilibrated, and the extent of isotopic exchange along fluid flow pathways. In this study, the Sm-Nd isotopic composition of nine calcite and /or fluorite veins (comprising 12 samples in total) were measured for veins that form part of a low-temperature (100–200 °C) fault-fracture hosted hydrothermal system, in the eastern Lachlan Fold Belt, Australia [3, 4]. These samples were carefully selected on the basis of structural relationships, and similarity in $\delta^{18}O$, $\delta^{13}C$ and $^{87}Sr/^{86}Sr$ compositions of the veins [4]. Previous work suggests that the vein swarm is hosted in mid-Devonian limestones, which were folded around 350 - 325 Ma [5]. Field relationships demonstrate that vein growth occurred during folding.

Four Sm-Nd isochrons from distinct sample sets were determined; an isochron from six calcite veins found in the same outcrop (317±330 Ma), and three isochrons from individual calcite-fluorite veins (1510 ± 87 Ma, 671 ± 68 Ma and 265 ± 40 Ma). Three of these four ages are unreasonable, while one (265 ± 40 Ma) significantly postdates the proposed age for deformation. The erroneous isochron ages are attributed to vein minerals precipitating from multiple fluids, which had distinct $^{143}Nd/^{144}Nd$ compositions. $^{143}Nd/^{144}Nd$ variations are attributd to either far field changes in fluid source and/or changes in fluid flow pathways. This study indicates that despite careful sample collection, veins which formed in apparent synchrony may be deposited from solutions which have a diverse range of initial isotope ratios. This study calls into question the applicability of isochron techniques to fracture-hosted hydrothermal systems.

[1] Chesley *et al*. (1991) *Science* **252,** 949-951. [2] Peng *et al.* (2003) *Chemical Geology* **200**, 129-136 [3] Cox (2007) *JGR* **112**, doi,10.1029/2006JB004734 [4] Barker (2006) EPSL **250**, 331-344 [5] Hood and Durney (2002) *AJES* **49,** 291-309