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Tracking deep fluid infiltration along major detachment fault using a multi-mineral in-situ oxygen isotopes approach, a case study from the Buckskin-Rawhide complex

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Fluid infiltration along major detachment faults and the associated mineral alteration can affect the stability of the continental crust by significantly modifying the rheology of the infiltrated rocks. Although several tools (i.e, stable isotopes, minor and major elements, REEs, Cl and F in hydrous minerals) have been developed to track fluid infiltration, fluid imprints may still be quite cryptic or subtle when total fluid quantities are small and/or strongly channelized. Here we present new SIMS in-situ oxygen isotopes data for quartz, K-feldspar, plagioclase and biotite in a deformed granitoid located in the immediate footwall of the Buckskin-Rawhide metamorphic core complex (Arizona, USA) main detachment.

Most K-feldspar and plagioclase grains are porphyroclastic and show zoning in oxygen isotopes with ^{18}O values gradually decreasing from ~6-6.5‰ in their core to ~3-4‰ at their rims. One plagioclase grain shows no zonation and only low values (3-4‰), whereas two large K-feldspar grains (>2 mm) have complex oscillatory d^{18}O zoning. Quartz (6.5-8.5‰) and trace biotite (-2 to 0‰) show limited d^{18}O variations without any correlation between their textural positions and their oxygen isotopes. Using the average d^{18}O compositions of biotite (-1‰) and plagioclase (3‰) and K-feldspar rims (4‰), which are inferred to have formed in isotopic equilibrium, gives temperatures of 400-450 ºC and requires an infiltrating fluid ^{18}O of ~1‰. In contrast, quartz-mineral pairs give temperatures that are below 250 ºC, suggesting that quartz most likely continued to re-crystalize until much later in the exhumation history of the rock.

A fluid d^{18}O of 1‰ indicates an originally meteoric fluid that has undergone partial exchange with a rock oxygen reservoir. Whereas whole-rock ^{18}O values for Buckskin footwall samples (~ 7 ± 1‰) would effectively obscure an external fluid history, targeted and texturally resolved in-situ SIMS measurements reveal that meteoric fluids, in fact, infiltrated to midcrustal depths (≥ 9 km depending on geothermal gradient). This example highlights the need to perform in-situ measurements to accurately study fluid-rock interactions, especially when the amount of fluid may be small and does not induce major retrogression of the primary minerals.