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Intragrain oxygen isotope zoning in feldspar porphyroclasts to understand fluid histories in the Whipple Mountain metamorphic core complex.

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Fluids can drive both mass flux and thermal flux along detachment faults. Given that oxygen isotopes are sensitive to variation in temperature, time, and water composition during water-rock interactions, patterns in $\delta^{18}O$ within extensional detachment fault systems can record details of fault-controlled hydrothermal activity and fluid-assisted deformation. This study applies *in situ* measurements of $\delta^{18}O$ by SIMS in K-feldspar and plagioclase from three quartzofeldspathic mylonites collected from different structural depths below the Whipple Mountain metamorphic core complex detachment fault (WDF). These samples possess a range of brittle and ductile deformation microstructures, and secondary mineral alteration.

Generally, feldspar SIMS profiles show significant $\delta^{18}O$ zoning with intragrain oscillations of several permil. Immediately below the detachment fault (<1 m), feldspar $\delta^{18}O$ profiles are dominated by oscillations between 2 – 4 ‰. Deeper beneath the WDF (40 m), feldspar profiles show muted $\delta^{18}O$ oscillations superimposed on a systematic core-to-rim $\delta^{18}O$ zoning from. In both cases, the $\delta^{18}O$ patterns in feldspar are too large to be explained by closed-system diffusive exchange during cooling alone. Feldspar porphyroclast microstructures are consistent with a combination of dissolution-precipitation recrystallization, which facilitated crack-seal style deformation, and subgrain rotation recrystallization, both of which could enable oxygen isotope exchange and diffusion driven by external low-$\delta^{18}O$ fluids. Epidote porphyroclasts in samples near the WDF record low $\delta^{18}O$ values and quartz-epidote $\delta^{18}O$ fractionations are widely scattered, but quartz-epidote $\delta^{18}O$ pairs converge towards consistent equilibration temperatures of ~410°C in the structurally deepest sample. Combining intragrain $\delta^{18}O$ data from feldspars with quartz-epidote $\delta^{18}O$ systematics suggests that low-$\delta^{18}O$ fluid infiltration extended to midcrustal depths and occurred during reactivation of existing mylonitic footwall fabrics. These SIMS oxygen isotope analyses provide a novel means to correlate microstructures to fluid signatures and thermometry that would be inaccessible by bulk analysis, and thus are an essential method for investigating the combined hydromechanical and rheological evolution of detachment fault systems.