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ISOTOPE AND TRACE ELEMENT MOBILITY IN TITANITE DURING "LOW-TEMPERATURE" CRYSTAL-PLASTIC DEFORMATION

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Determining the real-world mobility of isotopes and trace elements in chronometer phases over a wide range of P-T conditions is paramount for interpreting ages from isotopic dates, especially when trace elements are measured in concert for petrochronology purposes. Titanite has become a popular petrochronometer due to its presence in a variety of bulk compositions and participation in many mineral reactions. More recently U-Pb in titanite has shown promise for directly dating crystal plastic deformation. However complications such as recovery and fluid-aided recrystallization often make dates equivocal and difficult to interpret. The Wasatch Fault bounds the eastern Basin and Range province and has exhumed the Little Cottonwood stock from ~11 km depth. Remnant portions of the ductile shear zone crop out in the footwall and contain titanite porphyroclasts. Previous thermochronology and thermobarometry, and new microstructural observations and quartz opening-angle thermometry limit the temperature of deformation to 300–350 ºC—conditions much cooler than most titanite-involved metamorphic reactions (~500–800 ºC) and the experimental (~650 ºC) and empirical (>750 ºC) titanite Pb closure temperatures. Titanite porphyroclasts, relative to a non-deformed control sample ~10 m away, have both chemically and isotopically re-equilibrated during deformation. EBSD maps of the porphyroclasts show twin boundary migration and subgrain rotation recrystallization fabrics within the crystals and minimal organization of dislocations that might suggest recovery. When normalized to the control titanite and compared to REE abundances measured in other phases, spider-plot patterns show titanite reacted with amphibole (M & HREE), plagioclase (Sr), apatite (P & LREE), and fluids (Mg, Al, Fe). Importantly Zr was unchanged between samples. Areas of high twin density and misorientation tend to have younger dates with some 12 Myr younger than the control sample mode (Z-test = 22) but were likely not completely reset. Isotopic and element mobility in titanite was mediated by crystal plastic deformation possibly by fast diffusion at twin boundaries and dislocations. These data demonstrate that titanite was reactive at greenschist-grade temperatures and expand the possibilities for building P-T-D-t paths with titanite.

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