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Dating polymetamorphism using titanite: Linking trace elements, textures, and ages

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Here we present titanite U-Pb dates from two banded calc silicate gneisses (SSP18-1A and 1B) from western Maine. Mineral textures and compositions display multiple phases of metamorphism. The peak lower granulite facies assemblage is Di + Kfs + Pl + Ttn, with little to no calcite present. Late Czo + Tr replaces Di + Pl, suggesting an influx of $X_{\text{H}_2\text{O}} > 0.90$ fluids. Nearby metapelites show the transition from sillimanite-bearing to muscovite-bearing assemblages, indicating that fluid infiltration may be widespread. Compositional maps of clinopyroxene in SSP18-1B show fracturing and rehealing of early Fe-rich diopside with late Mg-rich diopside. Both samples exhibit overprinting of An-rich plagioclase by increasingly Ab-rich plagioclase. Titanite grains in both samples exhibit BSE textures and compositional variation consistent with multiple phases of growth and dissolution-precipitation reactions.

Titanite trace element and U-Pb data were collected by LA-ICP-MS at the University of Maine using an ESI NWR193^{UC} excimer laser ablation system coupled to an Agilent 8900 ICP-MS. Single spot ages range from 280 to 400 Ma with 12-20 Ma propagated 2SE. Four composition-date domains are identified in SSP18-1B: A. 400 ± 8 Ma (dark BSE cores), B. 372 ± 4 Ma (bright BSE cores), C. 342 ± 6 Ma (bright BSE cores, no Eu anomaly), and D. 302 ± 3 Ma (dark BSE rims, low LREE). Titanite Fe and Y concentrations increase with decreasing date, whereas Sr concentrations decrease. In clinopyroxene, Fe and Y decrease between high Fe-diopside and late Mg-diopside, placing the fracturing and rehealing events between 400 and 372 Ma. Strontium concentrations in titanite decrease between subsequent generations of plagioclase, diopside, and titanite, suggesting a continual fractionation of Sr from the reactive bulk composition. Low LREE in ca. 300 Ma titanite domains in both samples are consistent with the formation of texturally late allanite and clinozoisite, thus constraining the timing of the high $X_{\text{H}_2\text{O}}$ fluid infiltration event. Zr-in-titanite temperatures for rims in the quartz-bearing SSP18-1B give a weighted mean T of 764 °C at 4.5 GPa, consistent with the muscovite-absent sillimanite-bearing assemblage in garnet cores from metapelite samples. However, the 100-150 °C lower Grt-Bt temperatures for metapelites are not consistent with peak metamorphic phase equilibria. Our data demonstrate the utility of linking titanite textures and trace element concentrations with those of other minerals to reveal past

metamorphic and deformational events. Additionally, we show that titanite may reliably preserve U and Pb isotopic ratios, trace elements, and textures over subsequent high-T metamorphic events.