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Low-temperature, fluid-driven resetting of titanite following ultrahigh-temperature metamorphism in Madagascar

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LA-ICP-MS U-Pb dates and EPMA trace-element maps of titanite were collected from granulite-facies calc-silicate gneisses of southern Madagascar (peak *T*: 750–950°C) to evaluate how titanite responds to high-temperature metamorphism, cooling, and retrogression. Fluid-mediated replacement of precursor titanite by titanite of different composition (interface-coupled dissolution-precipitation, ICDR)—not diffusion—was the primary mechanism by which titanite was reset following high-grade metamorphism. Comparison of titanite U-Pb dates (530–490 Ma) with independent petrology and thermochronology indicates that the alteration occurred at temperatures as low as 300–500 °C. Apparent Zr temperatures (temperatures calculated assuming titanite–quartz–zircon equilibrium) in altered titanite are less than or equal to the metamorphic peak, but higher than the inferred alteration temperature, implying that Zr was removed, but that titanite–quartz–zircon equilibrium was not achieved during alteration. Although evidence for ICDR was observed over a region of ~100 km, differences in U-Pb dates among samples, and even among titanite grains in the same thin section suggest that alteration was highly localized at any given time.