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Recrystallisation and subgrain formation in metamorphic-hydrothermal titanite

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Titanite is a useful petrochronometer in metamorphic rocks, and typically crystallises at intermediate pressure and temperature conditions (~ 400 – 800 °C, 0.5 – 2 GPa) in a wide range of lithologies. However, it is widely recognised that titanite is susceptible to recrystallisation in the presence of fluids. Here, we examine several stages of metasomatic (re)crystallisation of titanite from deformed calc-silicate rocks of the Glenelg Metamorphic Complex, Victoria, Australia, in the presence of a saline fluid. These stages are: (1) equilibrium metamorphic growth textures such as sector or oscillatory zoning; (2) development of fractures within the grain, providing pathways for fluid ingress and transport of major and trace elements; (3) fluid-mediated recrystallisation moving inwards from fractures and grain boundaries, leading to the recrystallisation of single titanite crystals as numerous subgrains, the development of patchy internal zoning in BSE imaging, and/or the development of internal porosity. Textural evidence also suggests metasomatic titanite may have formed from reactions involving the replacement of ilmenite or apatite, via mechanisms (2) and (3). LA-ICPMS analysis shows that titanite recrystallisation was accompanied by partial to complete resetting of U-Pb ages, but trace elements were largely inherited from the precursor mineral, leading to a decoupling of age and trace element composition.

Additional petrographic evidence suggests the fluid was a saline (Cl-rich) brine enriched in LREE. Evidence includes the crystallisation of LREE-rich titanite at the boundaries between titanite subgrains, partial dissolution of apatite and precipitation of monazite rims, and the presence of Cl-rich scapolite veins or thin (< 5um) monazite veins within different samples. Titanite recrystallisation was accomplished by coupled dissolution-reprecipitation processes in the presence of these highly reactive saline brines. However, the preservation of equilibrium metamorphic textures in clinopyroxene, hornblende, plagioclase and quartz implies that the fluid was in equilibrium with the primary assemblage of the rock. The fluid was therefore likely sourced internally, such as from the breakdown of hydrous minerals during prograde metamorphism, rather than introduced from an external source, such as the nearby emplacement of post-metamorphic granites.