# Textural development of monazite during high-grade metamorphism: Hydrothermal growth kinetics, with implications for U,Th-Pb geochronology

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## ABSTRACT

Monazite has become an important tool for geochronology, but it commonly exhibits complex internal zoning of composition and age. Experiments were conducted to characterize the textural development and the rate and mechanism of growth of finely powdered (<3 μm) natural monazite in quartzite $\pm$ $H_2O$ at 1.0 GPa and 1000 °C. Coarsely crushed quartz crystals <1 to >500 μm in diameter grew rapidly and progressively engulfed monazite crystals to form arrays of monazite inclusions. The mean diameter of all monazite crystals decreased in the first 24 h, then increased at a constant rate consistent with growth by grain boundary diffusion-controlled Ostwald ripening with a minimum rate constant $K_{1/4} = 4.41 \times 10^{-2}$ μm/s$^4$. Using small quartz crystals of uniform diameter (~0.5 μm) in the starting material reduced quartz grain boundary mobility and limited the development of inclusions. Monazite grew by matrix volume diffusion-controlled Ostwald ripening with $K_{1/3} = 1.02 \times 10^{-2}$ μm/s$^3$. In all run products, matrix coarsening produced linear crystal-size distributions that reflect continuous recrystallization and nucleation. Textural evidence suggests that matrix coarsening-induced coalescence was also an important growth mechanism.

During annealing of fluid-filled rock, growing host crystals may occlude small monazite crystals, preserving their isotopic composition. Large monazite crystals may pin grain boundaries, while smaller crystals may move with grain boundaries by recrystallizing, a process that resets isotopic systems. Monazite crystals on grain boundaries may grow by Ostwald ripening to form rims and by coalescence. Accurate interpretations of monazite ages therefore require knowledge of the texture/growth history of the rock and its dated grains.