

Rapid development of spiral garnets during subduction zone metamorphism revealed from high-resolution Sm-Nd garnet geochronology

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The physical and chemical resistance of garnet to syn- and postgrowth alteration has made it a primary phase for investigating tectonometamorphic processes. Often exhibiting both compositional and textural zoning, garnet can provide a near-continuous history of evolving pressure-temperature-deformational conditions. A spectacular example of textural zoning is the development of spiral inclusion trails, which form when garnet overgrows an actively evolving matrix foliation during deformation. Multiple studies have applied zoned garnet geochronology to place temporal constraints on the rates of metamorphism and deformation during orogenesis. We report new high-resolution isotope dilution-thermal ionization mass spectrometry Sm-Nd isochron dates on concentric growth zones from microstructurally and thermodynamically characterized garnets from the Betic Cordillera, southern Spain, that grew during subduction at ~1.5–2.0 GPa and 570–600 °C. Our crystallization ages for the garnet core (13.64 ± 0.31 Ma), mantle (13.41 ± 0.37 Ma), and rim (13.34 ± 0.45 Ma) indicate rapid garnet growth and are consistent with published garnet ages interpreted to reflect high-pressure metamorphism in the region [1]. Implementing a Bayesian resampling technique, the duration of spiral garnet growth was constrained to 0.46 (+0.46/-0.34) Myr [2]. While other zoned garnet geochronology has shown similar rapid growth in subduction zone settings, this is the first documentation of such rapid growth of a spiral garnet. Combining this garnet growth duration with the magnitude of spiral inclusion trail curvature, we compute a strain rate of $\sim 10^{-13}$ s⁻¹, an order of magnitude faster than all previous spiral garnet studies. We interpret that these spiral garnets recorded a rapid pulse of deformation and strain during the final stages of subduction and incipient exhumation.

[1] Early Miocene continental subduction and rapid exhumation in the western Mediterranean, Platt et al. (2006), *Geology* 34, 981–984

[2] Rapid development of spiral garnets during subduction zone metamorphism revealed from high-resolution Sm-Nd garnet geochronology, Farrell, et al. (2024), *Geology* 52