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Rapid, paced garnet growth in blueschists from Lu-Hf dating of laser-cut domains combined with trace-element mapping

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Unravelling the timing and rate of subduction-zone metamorphism requires linking the composition of petrogenetic indicator minerals in blueschists and eclogites to time. Garnet is a key mineral in this regard, not in the least because it best records P-T conditions and changes therein and can be dated, using either Lu-Hf or Sm-Nd chronology. Bulk-grain garnet ages are the norm and can provide important and precise time constraints on reactions across both facies. Domain dating, i.e., dating of individual growth zones, moves beyond that in constraining the precise timing of garnet growth reactions. We combined a low-loss micro-sampling technique in laser cutting with a refined Lu-Hf routine to precisely date multiple growth zones of a sub-cm-sized garnet in a blueschist. The targeted garnet grain from a glaucophane-bearing micaschist from Syros Island, Greece, was chemically characterized by major- and trace-element mapping (EPMA, LA-ICPMS) and five zones were extracted using a laser mill. The three core and inner mantle zones are chemically comparable and identical in age within a 0.1 Myr precision (2σ). The outer two zones are chemically distinct and are resolvably younger (0.2-0.8 Myr). The timing of these two major garnet-growth episodes, together with the variations in trace-element chemistry, constrain important fluid-release reactions, such as chloritoid-breakdown. The data show that the integral history of garnet growth in subduction zones may be extremely short (<1 Myr), but may, even in that short timeframe, consist of multiple short pulses. Garnet-forming reactions clearly are localized and, thus, associated with focussed fluid flow. Beyond subduction-zone processes, our new protocol for Lu-Hf domain geochronology of "common-sized" garnet opens possibilities for constraining the causes and rates of garnet growth and the pace of tectonic processes in general.