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Shear heating along a nascent subduction interface

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Metamorphic soles of ophiolites record the initiation of intraoceanic thrusting that may eventually lead to self-sustained subduction. Age differences between sole metamorphism and ophiolite crystallization have been used to study the dynamics of subduction initiation (SI), including its generation by vertical ("spontaneous") or horizontal forcing ("induced"). In the archetypal Samail Ophiolite, the timing and duration of metamorphism in the sole have been controversial, because different methods yield divergent results. For example, zircon U-Pb TIMS dates suggest that granulite-facies sole metamorphism beneath the ophiolite occurred over ≤1 Myr [Rioux et al., *in press*, JMG] and was roughly synchronous with ophiolite crystallization, consistent with spontaneous or rapidly induced SI. In contrast, garnet Lu-Hf isochron dates suggest that sole metamorphism was lengthier (~8–10 Myr) and initiated well-prior to ophiolite crystallization [Guilmette et al., 2018, Nat. Geosci.], favoring induced SI. These differing results lead to considerable ambiguity in the tectonic mechanisms of SI in the Samail system.

To characterize the duration of metamorphism in the Samail sole independently of isotopic dates, we analyzed granulite-facies garnet using EPMA and LA-ICPMS chemical mapping, coupled to thermobarometry and diffusion speedometry. These results were further tested with zircon U-Pb and garnet Lu-Hf dates from the same rocks. The garnet mapping data shows preserved prograde major and trace-element zoning through 750–800°C peak temperatures, with subsolidus, concentric REE zoning in rare garnet cores transitioning to suprasolidus, oscillatory-zoned, cauliflorous rims and new grains. There are several examples of sharp, step-function, growth- and resorption-related zoning retained in major and trace elements. Using published experimental diffusion parameters, such sharp elemental discontinuities suggest abrupt high-T metamorphism (0.1–1.0 My at >700°C). These short durations are supported by the zircon dates from the same rocks, providing internally consistent evidence for rapid peak metamorphism. (Garnet dates are forthcoming and will be presented at the conference.) Such transient heating is incompletely explained by conductive equilibration between slab and mantle wedge, and implies that dissipative heating strongly influenced sole metamorphism. The similarity in absolute timing between sole and ophiolite formation suggests spontaneous SI driven by slab sinking, analogous to SI in the Izu-Bonin-Mariana system.