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Timescales of subduction initiation in the Samail ophiolite: High-precision U-Pb zircon petrochronology of the metamorphic sole

MATTHEW RIOUX[1], JOSHUA M GARBER[2], MICHAEL P SEARLE[3], JAMES L. CROWLEY[4], SALLY M. STEVENS[5], MARK D SCHMITZ[4], ANDREW KYLANDER-CLARK[1], TYLER K. AMBROSE[6] AND ANDREW J SMYE[2]

[1]UC Santa Barbara
[2]Pennsylvania State University
[3]Oxford University
[4]Boise State University
[5]University of Wisconsin
[6]Yukon Geological Survey

Presenting Author: rioux@eri.ucsb.edu

Geochemical, geochronological, and thermobarometric data suggest that the Samail ophiolite formed in a subduction zone setting, likely during subduction initiation. Metamorphic rocks below the ophiolite are interpreted to be preserved remnants of the subducted slab and provide a unique opportunity to study the temporal progression of subduction initiation. Here we present coupled zircon trace-element and high-precision U-Pb dates from granulite-facies, garnet- and clinopyroxene-bearing amphibolite samples from metamorphic sole localities along the length of the ophiolite (n = 18). Zircon grains show systematic trends of decreasing heavy rare earth element slope (HREE) with decreasing Yb concentration, reflecting progressive depletion of the HREE during prograde garnet growth. Combined zircon U-Pb dates, HREE slope, and Ti-in-zircon temperatures record prograde-to-peak zircon and garnet crystallization between 96.7–95.2 Ma, immediately predating and overlapping the crystallization of the overlying ophiolite crust (96.1–95.2 Ma). Our new dates contrast with previously published geochronology suggesting earlier (>100 Ma) prograde metamorphism and—if the preserved rock record reflects the full duration of metamorphism—are consistent with either spontaneous subduction initiation or an abbreviated period of initial thrusting during forced subduction initiation. Garnet-free amphibolites from lower-grade portions of the sole and leucocratic pods that occur within sole amphibolites are uniformly HREE enriched and are ~0.5–1.3 Myr younger than the highest-grade rocks from the same localities, constraining the temporal offset between metamorphism and juxtaposition of the higher- and lower-grade units. A gradient in the initiation of high-grade metamorphism from the northwest (96.7 Ma) to southeast (96.0–95.7 Ma) may record propagation of the nascent subduction zone and/or variations in subduction rate beneath the length of the ophiolite.