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Subduction shear zone morphology and exhumation style: Insights from peak Pressure-Temperature conditions and timing of subduction in the Cycladic Blueschist Unit (Syros, Greece)

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High-pressure/low-temperature (HP/LT) metamorphic rocks may be exhumed via forced return flow in a heterogeneous melange and/or coherent underplating and unroofing, depending on factors such as rock rheology and temperature. These end-member models lead to a chaotic mixture or a characteristic trend, respectively, in regional and outcrop-scale structure, metamorphic grade, and metamorphic age. A systematic investigation into the structural evolution, peak pressure-temperature (PT) conditions, and timing of metamorphism in HP/LT terranes can help to distinguish the relative contributions of each end-member mechanism to rock exhumation. The Cycladic Blueschist Unit (CBU) on Syros Island (Greece) is one of the world's best examples of an exhumed subduction shear zone, and the structurally highest section is classically described as a "melange"; however, across the island, peak PT (12-22 kbar, 450-580˚C) and timing of the subduction-exhumation transition (50-30 Ma) are poorly constrained. To refine the CBU's P-T-t path and shed light on potential exhumation mechanisms, we investigate Syros rocks via (micro) structural analyses, quartz-in-garnet solid inclusion barometry (QuiG), Ti-in-Quartz (TitaniQ) thermobarometry, and multi-mineral Rb-Sr geochronology.

We first combined field observations and petrology to distinguish prograde from retrograde deformation and metamorphism; we find (consistent with previous studies) that Syros preserves relicts of prograde subduction in blueschists and eclogites in specific structural domains within variably retrogressed rocks. We targeted prograde microstructural domains to determine peak PT conditions. We find remarkable consistency in P from the QuiG barometer in different rock types across the island, ∼14-16 kbar (n=86, 17 samples). TitaniQ of inclusion trails in prograde-zoned garnet and epidote porphyroblasts reveal homogeneity in [Ti] between 0.2-0.6 ppm (n=28, 4 samples) corresponding to T ∼420-480˚C. We targeted prograde domains in one mafic and one meta-sedimentary blueschist to constrain timing of peak subduction with Rb-Sr geochronology; results are in progress.

Our island- and outcrop-scale structural observations suggest that Syros represents progressive, coherent subduction and underplating of oceanic and continental lithospheric slices, as opposed to island-scale mixing in a melange. Interestingly, however, the QuiG barometry indicates that all slivers of oceanic crust and sediments reached the same peak PT conditions corresponding to a depth of ∼45-55 km prior to being exhumed back to the surface. This apparent "subduction depth limit" may reflect the depth (and temperature) at which the subducting slivers achieve favorable viscosities such that buoyancy of the subducting material and the shear forces exerted by the down-going slab balance, effectively halting sliver subduction.