Metamorphically-induced rheological heterogeneity and the deep tremor source in subduction zones

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We present data from an exhumed subduction interface that closely resembles the geologic environment of modern deep episodic tremor and slow slip (ETS). We focus on Eocene high pressure metamorphic rocks from the Cycladic Blueschist Unit on Syros Island in Greece. Metabasalts on Syros consist of intercalated blueschists and eclogites that record prograde deformation at 12-16 kbar (35-50 km) and 450-550 C-- PT conditions that overlap with the deep ETS source in warm subduction zones such as Cascadia. Textural observations, Si-in-phengite concentrations, and quartz-inclusion-in-garnet barometry indicate that all of the mineral assemblages are in equilibrium, suggesting that variations in metamorphic facies reflect protolith bulk compositions rather than significant differences in PT conditions. Furthermore, field observations reveal that the coexistence of blueschists and eclogites sets up an important rheological contrast between the two metamorphic assemblages. The blueschists exhibit planar ductile deformation fabrics, whereas eclogites distributed within the blueschist matrix exhibit boudinage, brittle shear fracturing, and veins commonly filled with quartz and high pressure minerals. We interpret the high pressure brittle deformation and veining in eclogites to reflect fluid sealing and overpressurization: the high fluid-pressures drive brittle shear and extension in strong eclogitic layers that is dampened viscously into the weaker blueschist matrix. Our observations are inconsistent with models of deep ETS that invoke changes in rate-and-state friction parameters along a narrow planar fault zone, but are consistent with the inferred prominent role of high fluid pressures from geophysical and modeling studies. We suggest a conceptual model in which ETS is controlled by coupled brittle-viscous deformation in partially eclogitized basalts embedded within high-fluid-pressure patches along the plate interface.

Keywords: episodic tremor and slow slip, subduction interface deformation, high pressure metamorphic rocks

