Links between slab mantle dehydration and forearc seismogenic zone structure in the Shumagin Gap, Alaska using magnetotelluric imaging

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SUMMARY

Fluids in subduction zones influence many important geological processes as the hydrated incoming plate lithosphere (i.e. slab) releases pore-bound and chemically-bound water into the over-riding crust and mantle wedge. In particular, fluids released from the slab beneath the forearc seismogenic zone are thought to create conditionally-stable regions which have strain-dependent slip behavior and may control megathrust rupture. The Shumagin Gap is unique along the Aleutian arc for its paucity of historical megathrust (>8 Mw) rupture nucleating in the gap. Geodetic data suggest that gap is weakly-coupled relative to adjacent segments. The reasons for the weak coupling and lack of megathrust rupture are unclear. Furthermore, the adjacent Semidi segment ruptured in July 2020 with Mw 7.6 and propagated into the Shumagin Gap. To examine the role of fluids, marine magnetotelluric (MT) data were collected along a 250 km trench-perpendicular profile in 2019 as part of the Electromagnetic Alaskan GeoPRISMS Experiment. The resulting 2-D resistivity model contains a conductor near the plate interface and is correlated with a wide-band of reflectors from seismic studies, seismicity, and the July 2020 rupture patch. This suggests that fluids play an important role in controlling the slip behavior in the Shumagin Gap. The source of the fluids at the plate interface is commonly thought to come from the downgoing slab crust. However, the MT results indicate a significant slab mantle conductor >15 km below the slab Moho, directly beneath (and connected to) the conductor at the plate interface. This suggests that deeper slab mantle serpentinization may reach pressure-temperature conditions conducive to dehydration beneath the forearc seismogenic zone. This provides an additional source of forearc fluids not previously considered in subduction zone water budgets which can modulate slip behaviour.

Keywords: magnetotellurics, subduction zone, seismogenic zone, dehydration, Alaska