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Seismic Constraints on Water and Melt Pathways and Fluxes Through Western Pacific Island Arcs

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We use arrays of ocean bottom seismographs (OBS) as well as land seismographs on islands to image velocity anomalies resulting from the presence of melt, fluids, and hydrated minerals in the Tonga/Lau and Mariana arc systems. Studies in the Lau basin use data from 50 OBSs and 17 land seismic stations deployed for one year during 2009-2010, and focus on the interaction of the arc and backarc melt production system with water given off from the slab. Rayleigh wave tomography reveals that the slow velocity anomaly beneath the spreading center is displaced westward with greater depths, suggesting that partial melting occurs along an upwelling limb of mantle flow originating west of the backarc [Wei et al., 2015]. Variations in basalt chemistry along the spreading center result from interplay between this western source and mantle near the slab containing more water. The observed Lau backarc anomalies vary inversely with the inferred mantle water content, suggesting that water reduces the melt porosity. Water may increase the efficiency of melt transport and reduce porosity by lowering the melt viscosity, increasing grain size through faster grain growth, or by causing a different topology of melt within the mantle rock.

The goal of the Mariana experiment is to better constrain the water cycle in subduction zones by determining the degree of mantle hydration in the downgoing slab and the overriding mantle forearc. 20 broadband OBSs were deployed around the Northern Mariana trench, and in addition 5 hydrophones were suspended in the water column in the deepest part of the trench to partially overcome limitations on OBS locations due to water depth greater than 6 km. Initial results show plate bending earthquakes in the incoming plate, thought to be associated with water flow into the mantle and serpentinization, occur in the upper 15 km of the subducting mantle and are most numerous within 20-30 km laterally from the trench axis. Analysis of Rayleigh wave phase and group velocities from seismic noise correlation shows strong effects of variable water depth, but indicates slow mantle shear velocities in both the subducting and overriding mantle, probably due to serpentinization.