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Seismological Imaging of Melt Production Regions Beneath the Backarc Spreading Center and Volcanic Arc, Mariana Islands

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We image the seismic velocity and attenuation structure of the mantle melt production regions associated with the Mariana Backarc Spreading Center and Mariana Volcanic Arc using data from the Mariana Subduction Factory Imaging Experiment. The passive component of this experiment consisted of 20 broadband seismographs deployed on the island chain and 58 ocean-bottom seismographs from June, 2003 until April, 2004. We obtained the 3D P and S wave velocity structure of the Mariana mantle wedge from a tomographic inversion of body wave arrivals from local earthquakes as well as P and S arrival times from large teleseismic earthquakes determined by multi-channel cross correlation. We also determine the 2-D attenuation structure of the mantle wedge using attenuation tomography based on local and regional earthquake spectra, and a broader-scale, lower resolution 3-D shear velocity structure from inversion of Rayleigh wave phase velocities using a two plane wave array analysis approach.

We observe low velocity, high attenuation anomalies in the upper mantle beneath both the arc and backarc spreading center. These anomalies are separated by a higher velocity, lower attenuation region at shallow depths (< 80 km), implying distinct magma production regions for the arc and backarc in the uppermost mantle. The largest magnitude anomaly beneath the backarc spreading center is found at shallower depth (25-50 km) compared to the arc (50-100 km), consistent with melting depths estimated from the geochemistry of arc and backarc basalts (K. Kelley, pers. communication). The velocity and attenuation signature of the backarc spreading center is narrower than the corresponding anomaly found beneath the East Pacific Rise by the MELT experiment, perhaps implying a component of focused upwelling beneath the spreading center. The strong velocity and attenuation anomaly beneath the spreading center contrasts strongly with preliminary MT inversion results showing no conductivity anomaly in the same region (Matsuno and Seama, pers. communication). This suggests that the seismic anomalies may result from very small in-situ melt fractions that are not electrically connected with the surface. The larger-scale surface wave inversion shows three regions of slow upper mantle velocities coincident with gravity lows along the spreading center and separated by about 200 km along strike; these anomalies may correspond to regions of strong upwelling in the arc-backarc system.