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Estimating bend-faulting and mantle hydration at the Marianas trench from seismic anisotropy

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Bend faults formed in oceanic lithosphere approaching deep ocean trenches promote water circulation and the formation of hydrous minerals. As the plate subducts, these minerals can dehydrate into the mantle wedge, generating the melts that feed arc volcanoes, or subduct fully into the deeper mantle. Balancing the global water budget requires an estimate of the amount of water recycled to the mantle by subduction, but current estimates for water fluxes at subduction zones span several orders of magnitude, mainly because of large uncertainties in the amount of water carried in the lithospheric mantle of the incoming plate.

We use active source seismic refraction data collected on the incoming plate at the Marianas trench to measure azimuthal seismic anisotropy in the uppermost mantle, and assess the degree of faulting and associated serpentinization of the uppermost mantle based on spatial variations in the observed anisotropy. We find that the fast direction of anisotropy varies with distance from the trench, rotating from APM-parallel at the eastern side of the study area to approximately fault-parallel near the trench. The fast direction orientations suggest that a coherent set of bend-faults are beginning to form at least 200 km out from the trench, although the extrinsic anisotropy signal from the faults does not substantially overprint the signal from preexisting mineral fabrics until the plate is ~100 km from the trench. The average (isotropic) mantle velocity decreases slightly as the plate nears the trench. Preliminary interpretation suggests that the observed spatial variations in anisotropy can be explained by serpentinization localized along pervasive, trench-parallel faults or joints.