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The effects of 3D slab geometry on deformation in the mantle wedge

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Convergence-perpendicular fast S-wave polarization is commonly observed above the hot arc and back-arc mantle in subduction zones. Hypotheses which provide an explanation for this pattern of anisotropy typically invoke either melt-preferred orientation or olivine lattice-preferred orientation controlled by 3D flow. These hypotheses lead to different interpretations of shear-wave splitting observations. The melt-preferred orientation hypothesis suggests that flow is simple and 2D while the 3D flow hypothesis suggests a strong trench-parallel component of flow. Although melt-preferred orientation might play an important role in localized regions with large melt content, 3D flow may explain widespread convergence-perpendicular anisotropy. Candidate mechanisms for 3D flow include buoyancy driven flow, rollback, slab deformation, variable slab and trench geometry, oblique subduction, and slab edges. A limited amount of work has been done on investigating these mechanisms. This work includes analogue experiments, which have addressed slab edges and rollback for simple cases with restricted boundary conditions, and numerical experiments investigating 3D buoyancy driven flow in models with 2D geometry. Here we investigate the deformation field associated with slab-edges, oblique subduction, and variable slab dip using 3D thermal and fluid dynamic finite-element models of subduction zones. We implement a kinematic-dynamic approach where flow is driven by velocity boundary conditions parallel to the slab surface and geometry is steady-state. These models also include olivine rheology and high-resolution in the nose of the wedge. Finite strain ellipses are calculated in steady-state velocity fields and used as a proxy for olivine lattice-preferred orientation. Our models show that the best candidate mechanism for generating trench-parallel flow and fast S-wave polarization involves a strong transition to shallow dip over 500 km of trench. Shallow dipping slabs induce a strong component of flow in the mantle wedge above adjacent more steeply dipping slabs. Our models

suggest that the pattern of shear-wave splitting observed in the Andean system where flat-slab subduction occurs may be explained by 3D flow within the mantle wedge instead of trench-parallel flow occurring beneath the subducting Nazca plate.