Arc-parallel flow beneath the TUCAN Broadband Seismic Experiment in Central America

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Resolving the geometry of flow in subduction zones is essential in understanding mantle wedge thermal structure, slab dehydration, melting and melt transport in the wedge, and subduction zone dynamics. In three-dimensional models of anisotropy obtained by tomographically inverting shear-wave splitting measurements from local events recorded by the TUCAN array, olivine a-axes are predominantly arc-parallel in the mantle wedge beneath the arc and back-arc at depths of 50 to 150 km (except in northern Nicaragua). The arc-parallel a-axes extend into mantle wedge well beyond the cold, shallow wedge corner where B-type olivine fabric may occur. The observed anisotropy cannot be explained by simple two-dimensional arc-normal corner flow, and instead suggests significant arc-parallel flow. This hypothesis is confirmed by the trend of a distinct Pb and Nd isotopic signature in arc lavas associated with subducting seamounts offshore of Costa Rica. The anomalous signature systematically decreases for nearly 400 km from a maximum in central Costa Rica, directly inboard of the seamounts, down to background levels in northwestern Nicaragua. As the timing of the initial input of the isotopic signature beneath Costa Rica can be constrained and its transport distance is known, northwestward flow rates can be estimated (~63–190 mm/y) and are comparable to the magnitude of subducting Cocos plate motion (~85 mm/y). These results indicate flow in the mantle wedge can be significantly three-dimensional.

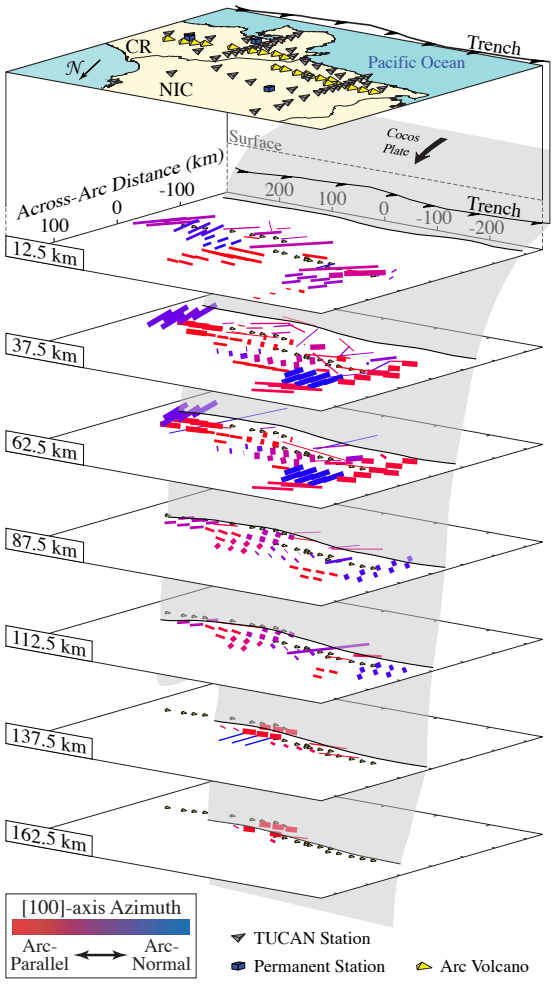

Figure: Model of anisotropy in the Nicaragua-Costa Rica subduction zone. Vectors represent well-resolved olivine a-axes in an olivine-orthopyroxene model. Vector orientation and color indicate horizontal azimuth, length corresponds to the strength of anisotropy relative to single-crystal values, and thickness corresponds to model parameter resolution. The TUCAN seismic array and volcanic arc are shown at the surface, and the volcanic arc position is plotted on each slice through the model. The slab–wedge interface is shown by grey shading. The mantle wedge is located in front of the slab in the layers spanning 50–175 km depth. Roughly arc-parallel a-axes dominate well-resolved wedge regions beneath the arc and the rear- and back-arc at depths of 50–150 km.

Abt, D. L., and K. M. Fischer, Resolving three-dimensional anisotropic structure with shear-wave splitting tomography, Geophys. J. Int., 173, 859-886, doi: 10.1111/j.1365-246X.2008.03757.x, 2008.

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