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Dynamics of flat slab subduction beneath Peru: Insights from seismic anisotropy

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Around 10% of subduction zones worldwide today exhibit shallow or flat subduction, but we have yet to fully understand how and why some slabs flatten. The largest flat slab segment that exists in the world today lies beneath much of Peru extending 1500 km in length from 3 °S to 15 °S. At the southern end of the Peruvian flat slab region the Nazca Ridge, an aseismic ridge feature with ∼18 km thick oceanic crust, is presently being subducted. By utilising seismic anisotropy we investigate the role of this ridge in terms of the deformation of the surrounding mantle, as well as the dynamics of the broader flat slab region. To achieve this we conduct shear wave splitting analyses at 49 stations distributed across southern Peru, primarily from the PerU Lithosphere and Slab Experiment (PULSE). We present detailed shear wave splitting results for both teleseismic events (SKS, PKS, sSKS) that sample the upper mantle column beneath the stations, as well as direct S from local events that constrain anisotropy above the flat slab.

Teleseismic results reveal distinct spatial variations in anisotropic structure along strike, most notably a sharp transition from coherent splitting in the north to pervasive null (non-split) arrivals in the south, with the transition coinciding with the northern limit of the Nazca Ridge. For both anisotropic domains there is evidence for complex and multi-layered anisotropy. It appears likely that the *KS splitting measurements reflect trench-normal mantle flow beneath the flat slab, but that shallower layers of anisotropy modify the splitting signal.

The local S results, which are sensitive to the supra-slab anisotropy, reveal that the thin mantle layer between the flat slab and the overriding continental crust is likely the main source of shallower anisotropy. The local S splitting measurements again show dramatic variability along strike. North of the Nazca Ridge we observe consistent trench-parallel splitting, while south of the ridge fast directions are relatively scattered, and yet delay times are very similar between both the sub-regions. Directly over the ridge itself the splitting is weakest and nulls most prevalent. Overall this pattern is consistent with deformation of the mantle above induced by the ongoing migration of the Nazca Ridge through the flat slab system.

In summary we find the regional anisotropic structure, and thus the pattern of deformation, appears to be closely tied to the location of the Nazca Ridge. Consequently this suggests that the ridge is not a passive feature but that instead it plays a key role in the mantle dynamics of the Peruvian flat slab system.