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3D seismic tomography and seismotectonics of the Ecuadorian margin inferred from the 2016 Mw 7.8 Pedernales aftershock sequence

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Based on seismicity recorded by the permanent Ecuadorian seismic network and our large emergency array installed shortly after the Pedernales earthquake, we derived a 3D velocity model of central coastal Ecuador using a local earthquake tomography. We manually analysed seismic waveform recorded on the amphibious array to determine high quality P- and S-wave arrival times. Events with ML 3.5, gap < 200°, a minimum of 10 observed onsets and a location rms < 0.5 based on our 1D velocity model were included in the inversion processes.

Joined inversions for earthquake locations, velocity structure (Vp and Vp/Vs) and, if applicable, station correction terms were carried out with increasing complexity from 1D to 3D. Taking advantage of our station in-between-spacing of ~20 km, we set a minimum horizontal node spacing of 15 km in the trench-perpendicular direction. To obtain a detailed image of the lateral velocity fluctuations we applied a smoothing technique by inverting two more times with the original node locations shifted by 5 km and 10 km, respectively. Finally, the best model was obtained by calculating the average velocity of these inversions.

From the tomography we imaged the subducting oceanic Nazca plate down to 50 km depth inferred by a high Vp feature dipping eastward. The distribution of the relocated seismicity is mostly distributed along the plate interface and allow us to identify the boundaries between the subducting and overriding plate. We also observe variations in the Vp/Vs along strike that can be correlated with a larger presence of sediments and/or fluids in the northern section. These changes are consistent with the north-south transition from an accretionary to erosive regime. To the north, in the marine forearc section we image areas with high Vp/Vs contrast where seismicity close to the trench is located. This finding might suggest the presence of eroded or fractured wedge capable to trigger seismicity after a large megathrust earthquake. Also, we observe a low Vp region which might co-locate to areas where slow slip events have been identified. The southern section shows a wider zone of seismicity suggesting a thicker crust subducting beneath the continental plate that can be associated with the influence of the incoming Carnegie Ridge. The presence of this large bathymetric feature also adds buoyancy to the incoming oceanic crust and might affect the way how stress is released in this area. In the overlying continental crust, we observed clustered shallow seismicity in both northern and southern profiles which is located at the limits of high Vp/Vs bodies. Moreover, our results show how the Bahia Caraquez and Manta cluster, both registered after the Pedernales earthquake, surround a body that might correspond to a less consolidated area in the marine forearc. Finally, we can co-locate a high Vp/Vs body located in the east part of the southern section to areas that recorded high PGA during the Pedernales earthquake. Our results presented here highlight the heterogeneities of the subduction zone that might influence different stress release behavior over time and can coexist and interact even in a local to regional scale along the central coastal Ecuadorian margin.