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Subduction zone guided waves in Northern Chile

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Guided wave dispersion is observed in subduction zones as high frequency energy is retained and delayed by low velocity structure in the subducting slab, while lower frequency energy is able to travel at the faster velocities associated with the surrounding mantle material. As subduction zone guided waves spend longer interacting with the low velocity structure of the slab than any other seismic phase, they have a unique capability to resolve these low velocity structures.

In Northern Chile, guided wave arrivals are clearly observed on two stations in the Chilean fore-arc on permanent stations of the IPOC network. High frequency (> 5 Hz) P-wave arrivals are delayed by approximately 2 seconds compared to the low frequency (< 2 Hz) P-wave arrivals. Full waveform finite difference modelling is used to test the low velocity slab structure that cause this P-wave dispersion. The synthetic waveforms produced by these models are compared to the recorded waveforms. Spectrograms are used to compare the relative arrival times of different frequencies, while the velocity spectra is used to constrain the relative amplitude of the arrivals. Constraining the waveform in these two ways means that the full waveform is also matched, and the low pass filtered observed and synthetic waveforms can be compared. A combined misfit between synthetic and observed waveforms is then calculated following Garth & Rietbrock (2014). Based on this misfit criterion we constrain the velocity model by using a grid search approach.

Modelling the guided wave arrivals suggest that the observed dispersion cannot be solely accounted for by a single low velocity layer as suggested by previous guided wave studies. Including dipping low velocity normal fault structures in the synthetic model not only accounts for the observed strong P-wave coda, but also produces a clear first motion dispersion. We therefore propose that the lithospheric mantle of the subducting Nazca plate is highly hydrated at intermediate depths by dipping low velocity normal faults. Additionally, we show that the low velocity oceanic crust persists to depths of up to 200 km, well beyond the depth range where the eclogite transition is expected to have occurred. Our results suggest that young subducting lithosphere also has the potential to carry much larger amounts of water to the mantle than has previously been appreciated.