Geophysical Research Abstracts
Vol. 18, EGU2016-9894-2, 2016
EGU General Assembly 2016

Modelling guided waves in the Alaskan-Aleutian subduction zone

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Subduction zone guided wave arrivals from intermediate depth earthquakes (70-300 km depth) have a huge potential to tell us about the velocity structure of the subducting oceanic crust as it dehydrates at these depths. We see guided waves as the oceanic crust has a slower seismic velocity than the surrounding material, and so high frequency energy is retained and delayed in the crustal material. Lower frequency energy is not retained in this crustal waveguide and so travels at faster velocities of the surrounding material. This gives a unique observation at the surface with low frequency energy arriving before the higher frequencies.

We constrain this guided wave dispersion by comparing the waveforms recorded in real subduction zones with simulated waveforms, produced using finite difference full waveform modelling techniques. This method has been used to show that hydrated minerals in the oceanic crust persist to much greater depths than accepted thermal petrological subduction zone models would suggest in Northern Japan (Garth & Rietbrock, 2014a), and South America (Garth & Rietbrock, in prep). These observations also suggest that the subducting oceanic mantle may be highly hydrated at intermediate depth by dipping normal faults (Garth & Rietbrock 2014b).

We use this guided wave analysis technique to constrain the velocity structure of the down going ∼45 Ma Pacific plate beneath Alaska. Dispersion analysis is primarily carried out on guided wave arrivals recorded on the Alaskan regional seismic network. Earthquake locations from global earthquake catalogues (ISC and PDE) and regional earthquake locations from the AEIC (Alaskan Earthquake Information Centre) catalogue are used to constrain the slab geometry and to identify potentially dispersive events. Dispersed arrivals are seen at stations close to the trench, with high frequency (>2 Hz) arrivals delayed by 2 – 4 seconds. This dispersion is analysed to constrain the velocity and width of the proposed waveguide.

The velocity structure of this relatively young subducting plate is compared to the velocity structure resolved in the older oceanic lithosphere subducted beneath Northern Japan. We also use guided wave observations to investigate the thickness and low velocity structure of the subducting Yakutat terrain. Additionally we discuss the dependence of the inferred slab geometry on the earthquake catalogues that are used.