Three-dimensional seismic structure of the shallow plate boundary in the northern Hikurangi margin from NZ3D OBS data

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Slow earthquakes occur around the seismogenic zones of the plate boundary faults and they have so far been largely studied on the deep portions of the plate interface based on land-based geophysical observations. On the other hand, recent marine studies reveal that shallow slow earthquakes at the up-dip portions of seismogenic zones are also common in subduction zones. These shallow slow earthquakes have been found to occur from near the trench to ~10 km depth of the plate interface and their genesis is thought to be closely linked to fluid pressures and effective stresses at the fault. However, primary controls on seismogenesis at these depths, such as fault structures and stratigraphic/hydrogeologic properties around the subduction megathrust faults, are highly complex in three dimensions and poorly understood.

In order to refine our understanding of structural characteristics regulating slow earthquakes occurring at shallow plate boundaries, we collected 3-D seismic refraction/wide-angle reflection data from offshore Gisborne at the northern Hikurangi subduction margin, New Zealand, as part of an international collaborative project, NZ3D. The dataset covers an area of 60 km x 14 km ranging from the northern Tuaheni landslide complex and the easterly forearc slope to the subduction trench and was recorded on 97 ocean bottom seismographs deployed with an average spacing of 2 km on 4 parallel lines with over 140,000 airgun sources. In the study area, shallow slow slip events and tectonic tremor have been well documented (Wallace et al., 2016; Todd et al., 2018). Previous 2-D seismic reflection studies also show that the subduction of large-scale seamounts facilitates the transport of fluid-rich sediments deep into the subduction zone and produces conditions of high fluid pressures along the plate interface and pathways for fluid migration into the overriding plate (Bell et al., 2010; Barker et al., 2018).

Using the very dense airgun-OBS data, we constructed a preliminary three-dimensional P-wave velocity structure model of the accretionary forearc and the plate boundary from first arrival tomography. The velocity images from over 250,000 first arrivals revealed a thick low-velocity ($V_p < 5.0$ km/s) volume along the plate interface down to a depth of at least ~10 km. This velocity structure may represent a thick subduction channel filled with fluid-rich sediments associated with seamount subduction.

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