Mantle Hydrothermal Circulation System Identified by Seismic Full Waveform Inversion of OBS Data

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A previous study by Park et al. (2021) has shown that the Japan Trench bend faults play a key role in developing a hydrothermal system for hydration of the oceanic crust and upper mantle with a subsequent dehydration of the oceanic lithospheric mantle. Fujie et al. (2020) showed that P-wave velocity models resulting from traveltime tomography of an Ocean Bottom Seismograph (OBS) dataset have anomalously lower values around the bend faults in the outer slope of Japan Trench. Despite these observations, there has not been any high resolution seismic velocity model which could clearly explain the hydrothermal fluid circulation paths near the bend faults. Here we use a subset of the OBS data from Fujie et al. (2020) and apply acoustic full waveform inversion (FWI) to develop high resolution velocity models by starting from a smooth initial model obtained by traveltime tomography. A multi-scale FWI approach in frequency domain is conducted for the frequencies between 2-7.5 Hz, arranged in three groups, with 50 iterations per group. Reciprocal principle is used to invert the data from hydrophone components of 14 OBS instruments, to efficiently reduce the calculation time. The very large shot to receiver offset in OBS data allows us to update the velocity models as deep as Moho discontinuity. In the resulting P-wave velocity model, a clear velocity reduction in the bend fault fracture zone is found, which reaches down to the Moho discontinuity. Reverse time migration depth images of a multichannel seismic reflection dataset from the same survey line show fluctuations in the Moho depth, with the bend faults penetrating down to the oceanic mantle. Our FWI resulting velocity model shows those faults reaching to the mantle and disturbing the Moho reflection. This is, by our knowledge, the first time that a high resolution velocity structure of such bend fault is developed in this area.

Keywords: Full Waveform Inversion, Bend fault, Mantle dehydration, OBS

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