Seismicity in the trench-outer rise region along the Japan Trench based on repeated OBS observations: Implications for large outer-rise earthquakes

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In subduction zone environments, intraplate normal-faulting earthquakes in the trench-outer rise region, so-called outer-rise earthquakes, are source of hazardous tsunami as well as interplate megathrust earthquakes. However, intraplate normal-faulting events are less frequent than interplate megathrust earthquakes and occurred far away from the land-seismic network. Therefore, accurate distribution of the intraplate normal-faulting earthquakes has not been clear. After the 2011 Tohoku-oki earthquake, seismicity in the trench-outer rise region, which includes several large M7-class earthquakes, has become active. We have conducted earthquake observations repeatedly in the trench-outer rise region along the Japan Trench by using ocean bottom seismographs (OBSs) since the 2011 earthquake. In these observations, we used ultra-deep type OBSs which can be deployed in the trench-axis area where the maximum water depth is more than 7000 m. We used these data to investigate hypocenter distribution and focal mechanisms of the earthquake in the trench-outer rise region and their spatial relations to the bending-related normal-faults and crustal structure heterogeneities in the incoming Pacific plate subducting into the Japan Trench.

The earthquakes observed by the repeated OBS observations were characterized by the shallow normal-faulting earthquakes. Most of the earthquakes occurred at depths shallower than 20 km, which corresponds to the oceanic crust and uppermost part of the oceanic mantle, although some events with normal-faulting focal mechanisms were observed at depths of 40 to 50 km below the sea surface. These observations suggest that the extensional stress regime extends down to a depth of 40 km within the Pacific plate. The shallow earthquakes within the oceanic crust and the uppermost part of the oceanic mantle generally showed trench-parallel linear trends along the horst-and-graben structures even though the horst-and-graben structures can be divided into small segments, both parallel and oblique to the trench. Therefore, large normal-faulting earthquakes might have complicated rupture process along the segmented normal-faults. Compared to the earthquakes at depths shallower than 20 km, earthquakes at depths of about 40 km occurred in the limited area. The seismicity at deeper depths generally coincide with areas of low Vp, which may suggest the localized hydration along the normal-faults extending into the oceanic mantle. Spatial heterogeneity of the seismic velocity structure might be an indicator of potential faults of large outer-rise normal-faulting earthquakes.

