

Seismicity near the trench axis and in the outer rise region of southern Japan Trench: Results from ocean bottom seismograph observations

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The 2011 Mw 9.0 Tohoku-oki earthquake ruptured the subduction mega-thrust fault in the central Japan Trench. The 2011 Tohoku-oki earthquake is characterized by large coseismic slip along the plate boundary fault reaching the trench axis. Based on the seismic and geodetic observations, main rupture area with the coseismic slip over 50 m occurred on the shallow subduction plate interface in the central Japan Trench. The post-seismic deformation following the 2011 earthquake shows along-trench variations. Westward post-seismic deformations were observed by seafloor geodetic measurements in the central Japan Trench, which can be explained by the viscoelastic relaxation. On the other hand, eastward post-seismic deformations were observed in the southern Japan Trench, south of the main rupture area. The eastward deformations suggest the afterslip on the shallow subduction zone near the trench. In contrast, normal-faulting earthquakes in the trench-outer rise region occurred in both central and southern Japan Trench. We investigate the aftershock activity in the southern Japan Trench to the south of the main rupture area by using ocean bottom seismographs deployed both landward and seaward of the trench. In the trench-outer rise region seaward of the trench axis, several ~100 km long linear earthquake trends both parallel and oblique to the southern Japan Trench have been identified. The trench-strike changes from N-S to NNE-SSW to the south of the main rupture area of the 2011 Tohoku-oki earthquake. The earthquake trend oblique to the southern Japan Trench is a southern extension of the trench-parallel linear earthquake trend in central to northern Japan Trench. This suggests that faults of large outer-trench normal-faulting earthquakes can extend linearly beyond the bend of the trench. The trench-oblique faults should be considered as a substantial part of the outer-rise earthquakes and related tsunamis. In the trench landward slope, we found regular earthquakes along the shallow plate interface near the trench of the southern Japan Trench, where the afterslip of the 2011 Tohoku-oki earthquake is expected from the eastward post-seismic deformations. The near-trench shallow earthquakes locate seaward of the episodic tremor activities reported by Ohta et al. (2019). Temporal correlations between the near-trench earthquakes and the tremor activities suggest that the slow-slip on the shallow subduction plate interface extends close to the trench axis. As indicated by the proximity of the regular earthquakes and slow slips, the diverse slip behavior in the shallow subduction zone is a distinct feature of the southern Japan Trench. The diverse slip behavior in the shallow subduction zone of the southern Japan Trench could be related to smaller scale structure heterogeneity, such as the thickness variation in the low-velocity interplate sedimentary unit imaged by seismic reflection surveys (Tsuru et al. 2002).

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