Heterogeneous structure around a region of slow earthquake activity off Ibaraki prefecture along the Japan Trench

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Large earthquakes of magnitude (M) ~7 have repeatedly occurred in the Ibaraki-oki region, about 100 km offshore of the Ibaraki prefecture along the Japan Trench, at a constant interval of ~20 years. Mochizuki et al. (2008) conducted a marine seismic survey and revealed that there exists a subducted seamount in the region. They also conducted an offshore seismic observation using ocean bottom seismometers (OBSs) to show that the seismicity in the region can be seen off of the subducted seamount, but not along the plate interface over it. They found that the location of the subducted seamount did not agree with the focal region of the repeating M7 earthquakes. From these results, they argued that the plate interface over the subducted seamount does not constitute an asperity of the repeating M7 earthquakes. Wang and Bilek (2011) introduced an idea that the seamount subduction causes formation of a fracture network within the overriding plate, and such a fracture network would prevent accumulation of large strain energy along the plate interface over the subducted seamount to generate large earthquakes. In addition to the repeating M7 earthquakes, recent studies (e.g. Matsuzawa et al., 2015; Nishikawa and Ide, 2018) have reported activity of slow earthquakes in the region. Relationship between activity of various types of earthquakes and structural features around the plate interface is one of the key topics to better understand controlling factors over earthquake types to be generated.

Recent studies in the Hikurangi subduction margin off the North Island of New Zealand show spatial relationship between variety of fault slips and topographic features of the plate interface. Wallace et al. (2016) successfully observed a large slow slip event just beneath an offshore array of ocean bottom pressure gauges, and precisely determined its slip distribution. They revealed that its slip propagation appeared to have circumvented subducted seamounts that have been imaged by magnetic anomalies as well as seismic reflection sections. Todd et al. (2018), for the first time, detected offshore tremor activity in the Hikurangi margin. The activity appears to have started just after the cessation of the slow slip, and its spatial distribution is only limited within regions of subducted seamounts. These results show that distributions of slow slip and tremor activity do not appear coincident, and thus the physical properties of the plate interface may be different. Further seismic surveys are supposed to provide vital information on structural variations that control physical characteristics of the plate interface.

In February, 2011, we acquired wide-angle reflection and refraction seismic data using 21 OBSs along a 150 km transect in the Ibaraki-oki region during the KH11-2 R/V Hakuho-maru cruise. We also included data from an OBS array that had already been deployed for a long-term seismic observation above the subduction front of the subducted seamount. Thus, we could construct a dense OBS profile above the subducted seamount with a receiver interval of ~3 km to achieve a high spatial resolution, whereas the largest interval is 10 km near both ends of the profile. First arrivals from the airgun sources can be traced up to ~95 km on most of the OBSs. The OBS record sections show significant heterogeneity that may include very rough structural features of the subducting oceanic crust along strike. Such heterogeneity may control seismic activity in the region.

Keywords: Ibaraki-oki, Active source seismic survey, Heterogeneous structure

