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The Po/So waves propagating in the Philippine Sea

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The Po/So waves which have high-frequency content, large amplitude, and long-duration propagate for large distance (up to 3000 km) across the oceanic lithosphere. In our previous study, we analyzed Po/So waves from deep-focus earthquakes occurring in the subducting slab beneath Japan, recorded by broadband ocean bottom seismometers (BBOBSs) at northwestern Pacific [Shito et al., 2013]. We demonstrated that the Po/So waves are developed by multiple forward scattering of P and S waves due to laterally elongated heterogeneities in both the subducting and laterally extending oceanic lithosphere. Following this study, the question when and where do the small-scale heterogeneities form in the oceanic lithosphere comes about. In order to answer this question, the Po/So waves in younger oceanic lithosphere need to be analyzed. Therefore in this study, we investigate the Po/So waves in the Philippine Sea plate (15-60 Ma), which is much younger than the Pacific Plate (130 Ma).

The Philippine Sea is one of the marginal seas of the Pacific Ocean. It is fundamentally divided into two regions bounded by the Kyushu-Palau Ridge. It is thought that these two regions were formed in different episodes of back-arc spreading and that western part (45-60 Ma) is older than eastern part (15-30 Ma) [e.g., Seno and Maruyama, 1984]. The comparison of Po/So waves propagation in the different ages of the oceanic lithosphere is expected to reveal the origin of the small-scale heterogeneities.

Seismological observations using BBOBSs was conducted in the Philippine Sea from 2005 to 2008, and high-quality Po/So waves from earthquakes in subducting Philippine Sea plate were recorded very clearly. The findings from the observed Po/So waves in the Philippine Sea plate are summarized as follows. (1) The Po/So waves propagate much effectively in western part than eastern part of the Philippine Sea. (2) The Po/So waves propagate even in youngest oceanic lithosphere (15 Ma) near the past spreading center of the Shikoku Basin.

In order to reveal the structure of the oceanic lithosphere and propagation efficiency in the Po/So waves, we performed numerical FDM simulations of 2-D seismic wave propagation in a realistic oceanic lithosphere model. The model is developed in the same procedure as the case of the Pacific plate [Shito et al., 2013]. In the oceanic lithosphere, we introduce laterally elongated small-scale heterogeneities, which are described by von Karman type stochastic random distribution function. Because the thickness of the oceanic lithosphere is considered to correlate with the age [e.g., Kawakatsu, et al. 2009], we vary the thickness of the oceanic lithosphere from 80 km to 20 km. To evaluate the fit of the computed waveforms to the data, we use the spatial attenuation of the seismic wave energy along the record section (up to 1500 km). The seismic wave energy is defined as integrated squares of amplitudes in a certain tine window (25 s from the Po/So wave onset). The model with the thickness of the oceanic lithosphere of 60 km and 30 km successfully explain the spatial attenuation of the Po/So waves record section observed at western and eastern parts of the Philippine Sea, respectively. The thicknesses are consistent with those obtained by previous studies [Kawakatsu et al., 2009]

This result suggests that the oceanic lithosphere including small-scale heterogeneities grow as it ages and develop large-amplitude and long-duration of high-frequency Po/So waves. The small-scale heterogeneities may form at the bottom of the lithosphere as it cools. They suggest that small-scale melts in the asthenosphere are frozen and attached at the bottom of the lithosphere, which remain even after the lithosphere is subducted into the mantle.

Keywords: Po/So waves, Philippine Sea plate, oceanic lithosphere