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Origin of the oceanic lithosphere inferred from Po/So waves

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It has long been recognized that the oceanic P and S waves (Po and So waves) have signal with high frequency, large amplitude, and long duration and propagate for large distance up to 3000 km across the ocean. The Po/So waves are developed by multiple forward scattering of P and S waves due to small-scale heterogeneities in the oceanic lithosphere and scattering and capturing of P wave in seawater layer [e.g., Shito et al., 2013; Kennett and Furumura, 2013]. In order to study the origin of the small-scale heterogeneities, the Po/So waves travelling in the Philippine Sea are analyzed.

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, each is considered to be 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 the 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 as a part of the Stagnant Slab Project [Fukao et al., 2009], 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 [Shito et al., 2014]. (1) The Po/So waves propagate even in youngest oceanic lithosphere (15 Ma) near the past spreading center of the Shikoku Basin. (2) The Po/So waves propagate much more effectively in older western part than younger eastern part of the Philippine Sea.

We investigate the mechanism of this propagation efficiency using numerical a Finite Difference Method simulations of 2-D seismic wave propagation. The comparison of the observed and calculated Po/So waves indicates that the age-dependence can be explained by the thickness of the heterogeneous lithosphere. The estimated thicknesses of the oceanic lithosphere are consistent with those obtained by a previous study based on receiver function analysis [Kawakatsu et al., 2009]. The expected depth of the lithosphere asthenosphere boundary corresponds to the top of partial melting region calculated on the basis of the model defined by the water solubility of 1000 parts per million H2O [Mierdel et al. 2007].

The results suggest that the oceanic lithosphere including the small-scale heterogeneities thicken with age. These small-scale heterogeneities may form continuously in oceanic lithosphere from the time of its formation at a spreading ridge, via the solidification of melts distributed in the asthenosphere.

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