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Seismic properties in the lithosphere and asthenosphere beneath the petit-spot region inferred from BBOBS data

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The petit-spot volcanoes were first reported by Hirano et al. [2006]. They are young (0-10 Ma) volcanic micro-knolls on very old (130 Ma) NW Pacific plate (about 500 km offshore from the Japan Trench). Although the estimated activity distributes widely in time (0-10 Ma) and in space (over 600 km), the volume of each volcanic edifice is small (several orders of magnitude less than the previously known seamounts and knolls). Hirano et al. [2006] proposed the hypothesis that small fraction of melt came from the asthenosphere through fractures in the lithosphere which were induced by flexure around the outer-rise. However, the mechanisms of the melt production and magma eruption process of this new type of volcanism are still unknown.

In order to investigate the melt source of the petit-spot, seismological observation using Broad-Band Ocean Bottom Seismometers (BBOBSs) was conducted. We measure seismic attenuation and travel-time anomalies in the lithosphere and asthenosphere beneath petit-spot region to infer physical properties of the region. The path-averaged attenuation of P waves and travel-time anomalies of both P and S waves are measured using waveform data from 10 regional earthquakes within the Pacific slab in Tohoku subduction zone. The data which sample beneath the petit-spot show from low to moderate attenuation anomalies and negative or absent travel-time anomalies. The observed relation between the attenuation and travel-time anomalies is quantitatively evaluated based on mineral physics. Theoretical and experimental studies in mineral physics predict the relation between seismic attenuation and travel time anomalies due to thermal effect in terms of anharmonicity and anelasticity. The observed relation between the attenuation and travel-time anomalies is consistent with predictions based on the thermal (cold) effect. The observed low attenuation and negative travel-time anomaly indicate that temperature beneath the petit-spot is lower than the global average. This is consistent with the fact that the petit-spot region is relatively old oceanic plate. These suggest that the present asthenosphere beneath the petit-spot is under normal condition. An alternative possibility is that (if any) anomalies in attenuation and velocity are too small or too thin to be resolved by this analysis.

Keywords: llithosphere, asthenosphere, petit-spot