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

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The petit-spot is a term for submarine volcanoes recently discovered by Hirano et al. [2006]. They are young (0-10 Ma) volcanic micro-knolls in 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). The mechanisms of melt production and magma eruption process of the new type of volcanism are still unknown. Hirano et al. [2006] proposed that small fraction of melt came from the asthenosphere through fractures in the lithosphere which were induced by flexure around the outer-rise. Local seismicity located in petit-spot region may relate to the magma eruption process. In order to investigate nature of the petit-spot, we promote a comprehensive survey based on geophysics, geochemistry, geology, and numerical modeling, which is called petit-spot multidisciplinary project.

As a part of the petit-spot multidisciplinary project, seismological observation using Broad-Band Ocean Bottom Seismometers (BBOBSs) is conducted. We deploy three BBOBSs in the petit-spot region with about 100 km spacing. We arrange BBOBS array to enclose both Yukawa-kaikyu and recent seismicity around the petit-spot. The sites are equipped with Guralp CMG-3T sensors recorded at 100 Hz. The BBOBSs were deployed in May 2007 by R/V KAIREI (JAMSTEC) and were recovered July 2008 by R/V YOKOSUKA (JAMSTEC). All the BBOBSs were successfully recovered with high quality data. We establish two main goals of the observation, precise earthquake location of local events, and estimation of seismic properties in the asthenosphere beneath the petit-spot. The first and second one will constrain the mechanism of the magma eruption and the melt production, respectively. In this study, we focus on the melt production process.

We measure seismic attenuation and travel-time anomalies in the 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. The results are expected to constraint especially on the melt production process of the petit-spot.