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Physical properties of subducted slab and surrounding mantle in the Izu-Bonin subduction zone inferred from BBOBS data

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Subduction zones are one of the most active sites of volcanism on Earth, where primary processes of physical and chemical evolution occur. To understand the dynamics of subduction zones, it is important to estimate the various parameters (e.g., temperature, chemical composition, and melt fraction) that control magmatism. For this purpose, a key approach is quantitative interpretations of seismological observations based on a knowledge of mineral physics.

In this study, we use BBOBS experimental data, in combination with the results of recent theoretical and experimental studies in mineral physics, to quantitatively investigate the relations between (1) P-wave attenuation and P-wave travel-time anomaly, and (2) P-wave and S-wave travel-time anomalies, with the overall aim of exploring the spatial distributions of temperature and partial melt, which control subduction-zone magmatism.

As part of the Stagnant Slab Project, 12 Broad-Band Ocean Bottom Seismometers (BBOBSs) are deployed in the Philippine Sea region from October 2005 to October 2006. The BBOBSs were deployed and were recovered by R/V KAIREI (JAMSTEC). The sites were equipped with three-component Guralp CMG-3T sensors (24-bit recording, 200 Hz sampling). We also obtain waveform data from the land station OSW, part of the Japanese F-net broad-band seismograph network.

We measure the path-averaged attenuation of P waves and travel-time anomalies of both P and S waves using waveform data from 10 regional earthquakes in the Izu-Bonin slab. The observed relation between the attenuation and travel-time anomalies is quantitatively evaluated based on mineral physics. The relations of the data which sample the slab and the Pacific mantle beneath the slab are consistent with the prediction according to the thermal effect. On the other hand, the relation of the data which sample mantle wedge has pronounced positive travel-time anomalies which are not accompanied by comparable high attenuation. The travel time anomalies are too intense to be explained only by the temperature effect. The temperature anomalies estimated from attenuation suggest that the temperature in the mantle wedge reaches the dry solidus of peridotite. The relative intensity of S- to P-wave travel-time anomalies of the mantle wedge data, after correction for the thermal effect, is relatively small ($R = 0.5$-1.2). Similar low velocity anomalies without comparable high attenuation and with relatively small R are reported in previous studies of subduction zones at Tonga, in the southwest Pacific, and Tohoku, Japan. Recent results of theoretical and experimental studies indicate that there exist texturally equilibrated partial molten rocks in these regions.