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Three-dimensional shear wave structures of the upper mantle beneath the Philippine Sea and the French Polynesia region

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We have operated many seafloor observations by using newly developed long-term broadband ocean bottom seismometers (BBOBSs) to reveal the mantle dynamics beneath the oceanic region in the Pacific Ocean. We have conducted array observations by BBOBS in and around the Philippine sea plate to analyze the structure of the subduction zone and in the French Polynesian region characterized by a topographic high of 700 m (called Pacific superswell), a concentration of hotspot chains, and large scale low-velocity anomalies in the lower mantle to analyze the whole mantle structures in this region.

We have analyzed the three-dimensional shear wave structures of the upper mantle beneath these regions by using surface wave tomography technique.

In the Philippine sea region, we analyzed the isotropic and anisotropic shear wave velocity structure by using Rayleigh and Love waves recorded by land and seafloor broadband seismometers. We obtained high spatial resolution (about 300km) shear wave structure model in the Philippine Sea region. Along the Izu-Bonin(Ogasawara)-Mariana arc, we have detected three separate slow anomalies in the mantle wedge at depths shallower than 100 km beneath the rear arc. Each anomaly has a width of about 500 km. We suggest that each of the anomalies is a site of large scale flow of deep mantle into the mantle wedge, and that each already contains a component from the adjacent subducting slab.

Our anisotropic structure model suggests that the fast directions of azimuthal anisotropy are parallel to the directions of ancient seafloor spreading in the lithosphere of the Shikoku and West Philippine Basins and Pacific Ocean, whereas they are parallel to the direction of the present-day absolute plate motion (APM) in the asthenosphere of the Shikoku Basin, and oblique to the direction of the APM in the Pacific Ocean (by about 30 degree) and in the northern part of the West Philippine Basin (by about 55 degree). In the subduction zones around the Philippine Sea plate, the fast direction of azimuthal anisotropy is trench-parallel in the Ryukyu arc, and oriented NW-SE in the Izu-Ogasawara island arc. The Philippine Sea plate, which is a single plate, shows very large lateral variations in azimuthal and radial anisotropies compared with the Pacific plate.

Beneath the superswell in the French Polynesian region, we determined three-dimensional shear wave speed model down to a depth of 200 km by using fundamental mode of Rayleigh waves. The temporary observation by seafloor and islands enables us to study the upper mantle structure beneath the superswell with an unprecedented high resolution. Resolution analyses indicate that these temporary observations locally improve the lateral resolution to about 400 km. We observe superficial slow anomalies associated to the spreading ridges such as the Lau Basin and two kinds of hotspot signatures: We found pronounced and continuous slow anomalies down to at least 200 km depth near the Society, McDonald, Marquesas, and Pitcairn hotspots whereas the slow anomalies beneath the Samoa, Rarotonga and Arago hotspots are only present at depths shallower than 80 km.

Keywords: seafloor observation, upper mantle structure, surface wave analysis