Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SCG065-12 Room:301B Time:May 23 17:30-17:45

Origin of small-scale heterogeneity at the shallowest lower mantle

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Data from short-period seismic network reveal anomalous later phases for deep and intermediate-depth earthquakes in circum-Pacific subduction zones (Kaneshima, 2003, 2009). The anomalous phases are best interpreted as S-to-P scattered waves (wavelengths of ˜10 km) from heterogeneities in the shallow lower mantle (depths <950 km). Several S-to-P scatterers where elastic properties of the rocks must substantially change within several kilometers are detected in the shallowest 300 km of the lower mantle beneath the circum-Pacific region. Around most of the observed scatterers the seismic tomography models have delineated high seismic velocity anomalies which are associated with recently subducted slabs. The majority of the scatterers are located near the bottom boundaries of the slabs (Kaneshima, 2009). The most likely origin of the scatterers would be basalt which used to form the oceanic crust, but the existence of the oceanic crust associated with the most recent slab subduction at the scattering sites is unlikely. Alternative explanations include: the presence of ancient basaltic rocks, phase transformation of garnet, localized dehydration of hydrous minerals, or a sharp boundary between different rock fabrics such as isotropic and anisotropic lower mantle rocks associated with mantle flow dragged by the slab subduction. Elastic properties of mantle minerals under the lower mantle conditions obtained by recent development of high pressure laboratory experiments, combined with the improved knowledge of rheology of mantle rocks, and numerical simulations of slab subduction should be essential for understanding the origin of the small scale heterogeneities.

References:

Kaneshima, S., Small-scale heterogeneity at the top of the lower mantle around the Mariana slab, Earth Planet. Sci. Lett., 209, 85-101, 2003.

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Keywords: shallowest lower mantle, seismic scatterer, base of slab, compositional heterogeneity