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Anisotropy of S wave velocity in the lowermost mantle using data recorded at Syowa in Antarctica

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Abstruct

We investigate the velocity structure of the lowermost mantle (D double prime layer) beneath the Antarctic Ocean. We analyze seismograms from 16 deep earthquakes in south Pacific subduction zones from 1990 to 2001 recorded by STS-1 broad-band seismographs at Syowa station in Antarctica. The epicentral distances range 85 - 95 degree. In this range S waves pass through D double prime layer beneath the Antarctic Ocean. Deep (127-565km) events reduces the effects of any source side anisotropy in the upper mantle and largeous (M6.1-M7.6) events provide good quality shear wave signals. After corrections for the effects of upper-mantle anisotropy using SKS wave splitting, differential travel times of split S waves are estimated to be up to 6s, and show that longitudinal components (SV) energy arrives earlier than transverse components (SH) energy. The absence of significant splitting for S waves with turning points more than a few hundred kilometers above the core-mantle boundary (CMB) indicates that anisotropy is localized within the D double prime region. We estimate that thickness of the anisotropic zone is about 350km. This case of SH leading SV is consistent with transverse isotropy with a vertical axis of symmetry.

Differential travel times among S, ScS and SKS phases and waveform modeling are used to construct the velocity structure in D double prime layer. SH shows a double arrival at the epicentral distance near 89 (deg). However SV in this range remains a single arrival. Isotropic model never explaines these observations. We calculate synthetic waveforms using the Direct Solution Method (DSM: Geller and Ohminato, 1994; Geller and Takeuchi, 1995). We find that synthetics for transverse isotropic models explain well the observed differential travel times and waveform. This transverse isotropic model, called SYYM, shows faster S wave velocity than PREM on average in the lowermost mantle. For SV, SYYM-SV has no discontinuity and is identical to PREM above 2000km and has lower velocity below 2300km. At CMB, SYYM-SV is 0.5% faster than PREM. For SH, SYYM-SH has the discontinuity with a 1.5-2.0% velocity increase about 340km above CMB and negative velocity gradient within the D double prime layer.

This study region corresponds to the high velocity region at the lowermost mantle by tomographic studies (Kuo et al., 2000; Masters et al., 2000). This kind of transverse isotropy is considered to be correlated with high velocity regions where paleo-slabs may descend into the lower mantle (Kendall and Silver, 1996; Garnero and Lay, 1997). We suggest that anisotropic D double prime layer in this region attributes to the paleo-slab material.