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A low S-wave velocity region at the base of the mantle under the South Pacific Superswell from SKKS-SKS and S-SKS data

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Fine scale heterogeneity of S-wave velocity at the base of the mantle under the South Pacific Superswell is examined using SKKS-SKS and SV-SKS differential travel time. Broadband seismograms of 4 deep earthquakes in the South America were recorded at the station belonging to a new seismic network of SPANET [Ishida et al., 1999], the previous temporary network of SPASE [Wiens et al., 1995] by IRIS/PASSCAL program, and IRIS/GSN stations. The differential travel times were measured by the cross-correlation method from the radial component of the seismograms. We adopted the measurement value with the correlation coefficient larger than 0.7. Additionally, old SKKS-SKS measurements are used [Souriau and Poupinet, 1990; Tanaka and Hamaguchi, 1993; Sylvander and Souriau, 1996]. The residuals of SKKS-SKS and SV-SKS with respect to PREM [Dziewonski and Anderson, 1981] were corrected using the recent three-dimensional S-wave velocity models of S16U6L8 [Liu and Dziewonski, 1998], S362D1 [Gu et al., 2001], SAW24B16 [Megnin and Romanowicz, 2000], SB4L18 [Masters et al., 2000], S20RTS [Ritsema et al, 1999]. S16U6L8 was the best model for the reduction of the residuals of S-SKS among the models listed in the above, while all the models could not reduce sufficiently the SKKS-SKS residuals. Based on the SKKS-SKS residuals corrected using S16U6L8, the positive residuals become larger with closing to the South Pacific superswell.

We conducted forward modeling to explain the large positive residuals by modifying the S-wave velocity structure at the base of the mantle. Through the forward modeling, the maximum thickness of the modified region is determined as 200 km to avoid the change of S-SKS residuals as possible. Forward modeling reveals that the residuals are explained by 5 to 6 % low velocity region with lateral extent of about 500 km in the lowermost 200km of the mantle. Although the magnitude of the velocity reduction and thickness of the anomaly region strongly depend on the three-dimensional model and do not unique due to a trade-off between the thickness and velocity anomaly, a very low S-wave velocity region at the base of the mantle is a robust feature.

Another constraint is the amplitude ratio of SKKS/SKS. We obtained the SKKS/SKS ratios in epicentral distance range between 95 and 107 degrees. The ratio has a local peak value of about 0.6 at a distance of 98 degrees. Then it abruptly reduces to 0.2 at a distance of 99 degrees and rapidly increases to 1.0 at a distance of 105 degrees. The rapid variations of the ratio at a distance of 98 and 105 degrees are both abnormal because PREM predicts a gradual increase the ratio from 0.15 at 95 degrees to 0.6 at 110 degrees. This anomaly may be caused from focusing of SKKS phases by a strong lateral velocity gradient associated with the low S-wave velocity region. Further waveform modeling is required.

The low S-wave velocity region is close to the ULVZ of P-velocity beneath the southwestern Pacific. And it locates under the low S-velocity body in the lower mantle at depths of 2500 to 2800 km beneath the south Pacific superswell seen in many tomographic images of shear waves. These features suggest that a superplume under the south Pacific superswell is generated at the core-mantle boundary and elongates in the lower mantle.