Analysis of mantle structure beneath subduction zones using a ray summation method for ScS reverberations

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Kato et al. (2001) determined the mantle structure beneath the subduction zone in Japan by modeling time-domain seismograms of multiple ScS and sScS reverberation in a ray summation method. The method synthesizes waveforms of not only ScSn and sScSn but also arrivals reflected at discontinuities in the mantle. They obtained Q values separately for the upper and lower mantle, updating S-wave speed of the mantle from iasp91. Depths and reflection coefficients of the Moho, 410-km and 660-km discontinuities were also determined. These parameters led to new understanding of the mantle structure related to the subducting slab beneath Japan (e.g. Kato and Kawakatsu, 2001).

In this study, we applied the method of Kato et al. (2001) to the other subduction zones to compare results with the mantle structure beneath Japan. Using broadband data archived by IRIS-DMC, we examined record sections including arrivals of ScSn and sScSn from large deep-focus earthquakes, which are greater than Mw7.0 and deeper than 500 km, all over the world during the period between 1990 and 2004. The present method is most effective for waveforms at small epicentral distances. Deep-focus earthquakes in Tonga and Bolivia recorded at nearby broadband stations satisfy this condition, and in fact observed waveforms we collected are in a good quality for our analysis. Kato et al. (2001) stacked broadband records of Japanese dense array for a deep focus-earthquake in order to improve S/N ratio. In Tonga, no array data are available for ScSn and sScSn. We attempted to stack two transverse-component waveforms recorded at the station AFI from two deep-focus earthquakes which occurred approximately at the same location. Before the stacking procedure, velocity seismograms were bandpass-filtered between 0.01 and 0.05 Hz. Using the stacked waveforms as observations, we determined parameters of mantle structure in the same way to Kato et al. (2001) by maximizing cross correlation between observed and synthetic waveforms. The Q value in the upper mantle is estimated to be around 100, whereas Q in the lower mantle is larger than 300. These values for Tonga are similar to those obtained beneath Japan Sea by Kato et al. (2001). Our Q value in the upper mantle is also in good agreement with the one estimated by Flanagan and Wiens (1998) using depth phases in Tonga. The 660-km discontinuity is about 20 km deeper in our analysis, which is consistent with previous results in Tonga (Niu and Kawakatsu, 1995; Suetsugu et al., 2004). The 410-km discontinuity is estimated around a depth of 410 km, which is almost at the same depth as that in Japan. The uncertainty is, however, larger than that of the 660-km discontinuity. We could not estimate reflection coefficients at the 410- and 660-km discontinuities because of high background noises in the observed waveforms. The average S-wave velocity in the upper mantle is within a few percent of iasp91, whereas the velocity in the lower mantle tends to be a few percent slower. We will also show the mantle structure determined beneath Bolivia.