I222-P017 **Room: Poster Session Hall** **Time: May 15**

Comparison of the structure beneath three subduction zones from waveform modeling of ScS reverberations

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We investigated what similarities and differences exist in the characteristics of the crust and the mantle structures beneath Bolivia, Tonga, and Japan subduction zones. Our aim is to find and understand factors affecting the nature of slab subduction processes. We obtained models of the crust and mantle structure by modeling waveforms of deep focus events in these three subduction zones. Using the ray summation method (Kato et al., 2001), we modeled waveforms of multiple ScS and sScS reflections and their reflected waves at the discontinuities in the mantle, all of which consist a suite of ScS reverberation waveform (Revenaugh and Jordan, 1987). ScS reverberation waveforms are sensitive to such structural parameters as the average attenuation factors (Q) and S-wave speeds in the upper and lower mantle, depths and reflection coefficients of the Moho, 410-km and 660-km discontinuities. It is characteristics of these three subduction zones to have large deep earthquakes and high quality broadband seismographic stations within small epicentral distances, and when such conditions are met, the present method works most effectively. Two major improvements are made on our methodology; use of displacement waveforms and use of source time functions. We used displacement waveforms rather than velocity in order to impose more weight on low frequency oscillations which can be less affected by source effects. Source duration is added to model parameters, which improves match between observed and synthetic waveforms. The effect of the source duration is especially significant for the great Bolivian earthquake (Mw8.2), whose duration was estimated to be 50 seconds in this study.

Waveforms of multiple ScS and sScS reflections are affected by the Moho structure which varies among the subduction zones. The Moho related parameters are stably determined in this study. The Moho related parameters in Bolivia are different from those in Tonga and Japan. The depth of the Moho is 50 km in Bolivia, which is deeper than 20 km in Tonga and 13 km in Japan. The reflection coefficient at the Moho in Bolivia, which is twice as large as those of Tonga and Japan, is derived as 0.20. By properly modeling variation of the Moho parameters and source effects, we are now able to see and discuss variation of the attenuation structure. In Tonga, Japan, and Bolivia, the Q values for upper mantle are 120, 130, and at least 500, respectively. For the lower mantle, we derive approximately 350, 150, and 450, respectively. Q in the upper mantle beneath Bolivia is notably higher than in the other two subduction zones, Tonga and Japan in which Q values are close to PREM. Differences in the reflection coefficients of 410-km and 660-km discontinuities and thickness of the transition zone are not large between Japan and Bolivia, whereas the low S/N ratio prevented us from determining these parameters precisely in Tonga. Also considering the deep Moho depth in our results, it seems that the distinct characteristics of subduction structure in Bolivia tend to be explained by a shallow anomaly, so it is possible that they are due to the characteristics of the South America continent.