S-wave travel time anomalies by the Izu-Bonin stagnant slab

Daisuke Suetsugu[1]; Masayuki Obayashi[2]; Hiroko Sugioka[3]

[1] IFREE; [2] IFREE, JAMSTEC; [3] JAMSTEC

P-wave travel time data, mostly based on the ISC bulletin, have been extensively used for seismi tomography to investigate P-velocity models in the mantle, which have provided strong evidence for stagnant slabs in the mantle transition zone beneath various subduction zones. On the other hand, S-wave tomographic studies with the bulletin data have not given a clear image of stagnant slabs. Widiyantoro et al. (1999) performed P- and S-wave tomography using arrival time data reprocessed from the ISC data by Engdahl et al. (1998). Tey concluded that the stagnant part of the Izu-Bonin slab is clearly visible in the P-wave tomogram, but not clear in the S-wave tomogram. However, the weak S-velocity signature of the stagnant slab may be caused by relatively noisy S-wave travel time data based on the ISC bulletin, since an S-wave onset is relatively hard to pick precisely as compared with a P-wave onset.

In the present study, we analyzed P- and S-waves from deep earthquakes beneath the Izu-Bonin region to obtain direct evidence for or against P- and S-wave signature of the stagnant Izu-Bonin slab. We used Hinet records of the two deep earthquakes: One is beneath the southern Izu-Bonin region (2002/06/03; 27.51N, 139.87E, h=504km by Engdahl et al.); the other is beneath the Shikoku basin (2004/10/11; 31.16N, 135.42E, h=504km by Engdahl et al.). We manually picked P-wave arrival times on vertical component and S-wave arrival times on transverse component. If seismic velocity anomalies associated with the Izu-Bonin stagnant slab are present, the southern Izu-Bonin event should give greater negative travel time anomalies in southwestern Japan than the Shikoku basin event, since the body waves from the former event should be propagated in the cold stagnant slab than those from the latter event.

We computed travel time residuals of P and S waves for the two events and subtracted the residuals of the Shikoku basin event from those of the southern Izu-Bonin event using hypocenter coordinates determined by Engdahl et al. to obtain the differential travel time residuals of the two events. The calculation of the differential residuals should reduce effects of the upper mantle heterogeneities under the Hinet stations and relatively enhance effects of lateral heterogeneities in the mantle transition zone between the two events, where the stagnant slab is present. The P and S differential residuals range from -2.0 to -0.5 s and from -4.0 to -1.0 s, respectively, in southwest Japan, indicating that the stagnant slab has high velocity anomalies for both P and S waves. In order to study possible effect of event mislocation on the differential residuals, we computed the differential residuals using hypocenters relocated with a 3D whole mantle P-velocity model (Obayashi and Fukao, 2001), which gave the similar pattern. The weak S-velocity signature in the previous studies may be caused by noisy S-wave data in the ISC bulletin.

We calculated theoretical differential residuals using 1D ray tracing and Obayashi and Fukao (2001)'s P-velocity model to compare with the observed P differential residuals. The theoretical one has a lateral variation of the differential residuals similar to that of the observed one, while the amplitude of the observed variation is larger than the theoretical variation. We need to account for a damping effect of the P-wave tomogram and ray bending by 3D velocity variation to explain the observed differential residuals quantitatively.