Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SCG65-P15 Room:Convention Hall Time:May 20 17:15-18:30

Shear wave polarization anisotropy induced by C-type olivine LPO and fluid distribution beneath southern Kyushu

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A high Vp/Vs region detected by seismic tomography suggests the existence of fluid and serpentinized peridotite near the slab surface beneath the southern Kyushu region, Japan (Matsubara and Obara, 2011). The existence of fluid and serpentinite plays an important role for volcanism and seismicity in subduction zones. The distribution of fluid and serpentinite are, therefore, significant for considering the dynamics of subduction zones.

In this study, we perform the shear wave splitting analysis to detect the seismic anisotropy near the slab surface beneath the southern Kyushu region using shear wave splitting. In this study, we compare observations with theoretical values calculated from mineral elastic constants, discuss the cause of seismic anisotropy and infer the distribution of fluid and serpentinite beneath the southern Kyushu region.

We use events, whose source depth is greater than 30 km and magnitude is greater than 2.5, from 2004 to 2010 recorded at Hi-net stations in the southern Kyushu region. The observed polarization direction and delay time are NEE-SWW to NWW-SEE and 0.04-0.63 s, respectively. Previous works showed that the delay time is less than 0.3 s fro shear wave splitting induced by the crustal anisotropy. The observed shear wave splitting whose time delay is greater than 0.3 s, therefore, originates from the seismic anisotropy in the mantle.

In the southern Kyushu region, a lot of split shear waves whose delay time is greater than 0.3 s pass through the high VP/VS region at the depth of 100-150 km. From the comparison of other ray paths, seismic anisotropy can be restricted in this region. The theoretical calculation shows that the Lattice Preferred Orientation (LPO) of C-type olivine fabric with the trench parallel b-axis and the trench normal c-axis inclined 60 degrees from the horizontal can reproduce the observations. We, therefore, suggest that C-type olivine fabric LPO causes the seismic anisotropy beneath the southern Kyushu and the thickness of the anisotropic layer is estimated to be about 13-30 km. This result suggests also that the existence of fluid in this region. We, thus, consider that the migration of interstitial fluid in peridotite is activated due to a decrease of the dihedral angle of olivine fluid interface (Mibe et al., 1999) at the depth below 100 km beneath the southern Kyushu region.

In this study, we observe no shear wave splitting induced by serpentine in the forearc mantle wedge. This result does not contradict the existence of a thin serpentine layer (1~3 km) proposed by Hilairet and Reynard (2009).

Keywords: shear wave polarization anisotropy, C-type olivine, LPO, fluid, serpentine