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Fluid distribution in the mantle wedge of the northeastern Japan arc inferred from seismic velocity and anisotropy structures

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A recent tomographic work by Nakajima et al. [2001] revealed a detailed P- and S-wave velocity structure beneath the northeastern (NE) Japan arc. Their results showed that seismic low-velocity zones in parallel to the down-dip direction of the subducting slab are widely distributed in the mantle wedge of the NE Japan arc. They corresponded to seismic high attenuation zones estimated by Tsumura et al. [2000]. They have been interpreted as the ascending flow from deeper portion of the back-arc side, which perhaps contains large amount of fluids.

Using the results of Nakajima et al. [2001] we calculated the values of dlnVs/dlnVp, which enable us to know whether or not melt or aqueous fluid in the low-velocity zones are in the state of textural equilibrium [Takei, 2002]. As a result, it is found that the fluid phase existing in the low-velocity zones of the mantle wedge in NE Japan has a crack-like configuration which is far from textural equilibrium. When we assume H2O for fluids filling the cracks, their aspect ratio and volume fraction are approximately 0.001 and 0.1 %, respectively. Aspect ratio and volume fraction are approximately 0.01 and 1 %, respectively, assuming melt for fluids. It is expected that the development of such thin crack-like pores involves some structural anisotropy. We calculated the theoretical delay times of shear wave anisotropy corresponding to the fluid-filled pores obtained above, by using the formulation of Hudson [1981].

We investigated shear-wave polarization anisotropy in the central part of NE Japan. We used waveform data recorded at the stations of Tohoku University and JMA and temporary stations installed by Joint Seismic Observations. We obtained 1834 anisotropy data from 607 intermediate-depth earthquakes. Cross-correlation method was used. The delay times obtained at the stations located to the west of the volcanic front (~0.15 s) are generally larger than those (~0.05 s) obtained at the stations to the east of it. Leading shear-waves mainly polarize in E-W direction at the stations in the western part and in N-S direction at the stations in the eastern part. We compared these observations with the theoretically predicted anisotropy. If we assume that all crack-like pores are filled with melt and align in E-W direction, the observed delay times agree well with the theoretical predictions.

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