Japan Geoscience Union Meeting 2010
(May 23-28 2010 at Makuhari, Chiba, Japan)
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SSS018-12 Room: IC Time: May 25 15:00-15:15

Seismic velocity anisotropy inherent to phyllosilicate-rich rocks

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Seismic velocity anisotropy of biotite schist (30 %-mode biotite) was measured under confining pressures up to 150 MPa. The rock shows weak orthotropy which was altered from transverse isotropy (TI) generated by biotite preferred orientation. The orthotropy was caused by micro folding in the rock. The velocity increase under confining pressure indicates that most crack planes are aligned parallel to the cleavage planes (silicate-sheet) of the oriented biotite minerals. The anisotropy of the rock is basically TI due to both the aligned biotite minerals and cracks, which have a common symmetry axis. We found that other sheet-silicate-rich rocks have a similar anisotropy with the biotite schist, in which the TI-type anisotropy is characterized by the slow P- and S-wave velocities along the symmetry axis. This is caused by the preferred orientation of sheet-silicate minerals and the extremely slow P- and S-wave velocities along the axis perpendicular to the silicate sheet compared to the directions along the silicate-sheet. When rock contains a large percentage of highly oriented sheet silicates, the fast and slow shear waves exchange their polarities at some off-symmetry axis directions, indicating that the qS-wave (quasi-S wave) velocity exceeds the SH-wave velocity. The phase velocity distribution of qS-wave shows an asymmetry with respect to the angle from the symmetry axis, which is characterized by a bulge in this distribution located near the symmetric axis. This is inherent to most sheet-silicate minerals. When crack density of aligned cracks increases, the P-wave velocity along the symmetry axis decreases considerably. The qS-wave phase velocity in the off-axis directions also decreases, in accordance with the decrease of the P velocity along the symmetry axis.
The asymmetry of the qS-wave phase velocity distribution increases as the P-wave velocity decreases along the symmetry axis.

Keywords: velocity anisotropy, phyllosilicate, preferred orientation, transverse isotropy