Seismic velocity anisotropy of mica-containing rocks

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We measured elastic wave anisotropy of mica-rich rocks and compared the measured anisotropy with the model calculation. Anisotropy measurements suggest that anisotropy of mica-rich rock is controlled by preferred orientation of mica minerals. The model calculation suggests that mica mineral mostly affects S-wave anisotropy than P-wave anisotropy. The measured anisotropy of biotite-rich rocks is well explained by preferred orientation of biotite. It is interesting that P-wave anisotropy is controlled mostly by cracks whereas S-wave anisotropy is controlled mostly by preferred orientation of mica.

We calculated seismic wave velocity anisotropy caused by preferred orientation of mica minerals by using the differential effective medium method (DEM).

Spheroidal biotite crystals having their c-axes coincide with the symmetry axis of the spheroid are embedded into an isotropic matrix up to a volume ratio 30

All crystals are aligned with their c-axis parallel to the symmetry axis of the effective homogeneous medium, which is transversely isotropic.

The effect of crystal shape on anisotropy was studied by changing the aspect ratio (the ratio between minor-axis and major-axis of the spheroid) range from 0.01 (flat spheroid) to 1 (sphere).

The S-velocity anisotropy becomes large as the crystal shape becomes flat, whereas P-velocity anisotropy shows only small changes with changes in the crystal shape.

Especially, biotite generates large S-wave anisotropy of the rock, and the anisotropy becomes stronger as the aspect ratio of the biotite crystal becomes smaller.

When the volume ratio of mica mineral is large, the P-wave phase velocity surfaces show considerable deviations from ellipse, and the SV-wave phase velocity surfaces forms a large bulge which crosses the SH-wave phase velocity surface (singularity) in the plane including the symmetry axis.

Those results indicate an interesting contrast when compared with the effect of crack or pore shape on seismic velocity anisotropy; crack (or pore) shape affects the P-velocity more than the S-velocity.

We also calculated Thomsen's anisotropic parameters as functions of crystal aspect ratio and of the mica volume ratio.

Since biotite is one of the common rock forming minerals in the crust and sometimes shows strong preferred orientations, our calculation is useful for understanding seismic wave propagation in the crust.