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Seismic velocity anisotropy in a rock containing preferred orientations of biotite and cracks

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Seismic velocity anisotropy of biotite-rich schist was measured under confining pressures up to 150 MPa and compared with the calculated velocity anisotropy based on a crack model. The lattice preferred orientation of biotite and the velocities at 150 MPa confining pressure indicate that the rock is basically a transverse isotropy (TI) having the unique axis perpendicular to the foliation plane. The TI anisotropy is slightly disturbed by crenulation of which axis is along the lineartion on the foliation plane and cracks. The change of velocity under confining pressure was modelled by putting oblate-spheroidal cracks in an initially TI matrix with all crack normals aligned parallel to the unique axis. When increasing the confining pressure, seismic velocities in some particular directions change in a manner that can be interpreted as closure of aligned microcracks. The rock anisotropy is more affected by the anisotropy of biotite mineral in the higher confining pressures. Using a combined model of crack anisotropy and a TI matrix, we calculated velocity change as a fuction on crack density. We also examined Thomsen's approximations with exact calculations of the phase velocities. Thomsen's approximations show mostly good agreement with the exact calculations for qP- and SH-waves, but considerable discrepancies appear for qS-wave in the case of large crack density and gas-filled cracks. Directional plot of the group velocity forms a cusp. The magnitude of cusp depends on crack density and the bulk modulus of crack-filling fluid. Since the anisotropy is strongly related to crack density and crack-filling fluid, the changes in seismic anisotropy may be useful for underground monitoring when the target site has TI-type intrinsic anisotropy.