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Transport, elastic properties and anisotropy of the rocks from the Kola superdeep borehole (experimental data)

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Permeability and elastic wave velocities (Vp,Vs) of rock samples collected from the Kola SG-3 superdeep borehole and from surface outcrops were studied at high temperatures and pressures.

Vp and Vs and their directional dependence were found to be largely controlled by the modal composition of the rocks and the LPO of major minerals. Velocities are significantly higher in amphibolite than in gneisses. Besides the lithologic control, a marked pressure sensitivity of wave velocities and anisotropy is observed in both rock types, in particular at low pressure. Differences in velocities and anisotropy between core samples and surface analogues in the low pressure range are due to drilling effects and rapid core retrieval. As pressure is increased, the effect of microcracks is more and more eliminated and velocities and anisotropy of the compacted core and surface samples are very similar. The experimentally determined velocities simulating in situ conditions compare fairly well with the VSP data, in particular, when anisotropy is included in the determination.

In contrast, permeability is not significantly affected by the mineral composition of the rocks. It is exclusively controlled by the state of microfracturing, which in turn is strongly dependent on concurrent effect of pressure and temperature. Increase in confining pressure leads to a decrease of rock permeability. Increase in temperature may lead to permeability increase, decrease or inversions. Microscopic inspection of the microstructure reveals two families of microcracks: low aspect ratio cracks, crossing several mineral grains, and high aspect ratio cracks, localized at grain boundaries. The effect of these microcracks on rock permeability changes with temperature. On sample heating, the microcracks with low aspect ratio close, and microcracks with high aspect ratio open. As a result, the total effect is reflected by an inversion on the permeability-temperature trends. At conditions simulating PT increase with depth, permeability decreases, whereas permeability anisotropy increases. Under PT conditions of deep parts of the Kola SG-3 permeability anisotropy is largely controlled by preferred orientation of main rock-forming minerals. Hence, at such conditions the nature of anisotropy of elastic wave velocities and permeability is similar.

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