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Properties and state of rocks in the section of the Kola (SG-3), Ural (SG-4), German (KTB) and Finnish (OKU) research boreholes: similarity and distinctions

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The Russian (USSR) superdeep boreholes drilling programme included drilling deep and superdeep boreholes both in sedimentary and crystalline rocks. Among the programmes aimed at the study of the properties and state of the earth crystalline crust the most interesting results were obtained when drilling the Kola SG-3 (12261 m) and Ural SG-4 ($\sim$6010 m) boreholes. Among foreign scientific projects also aimed at the study of the deep crystalline crust, Gravberg-1 (Sweden) and KTB (Germany) are best known. At the moment the investigation of the drill hole Outokumpu (OKU) located in SE Finland near the worked-out deposit bearing the same name is carried out. It reached a depth of 2516 m.

The analysis of structural-textural peculiarities of rocks composing the crystalline massifs of SG-3 and SG-4 indicated the presence of two characteristic blocks in these geological-geophysical sections. One of them is mainly composed of homogenous, as a rule, volcanic rocks united by one or several close stages of formation. In this block, isotropic or weakly anisotropic rocks dominate. Within the second block, the consequences of intense deformation, a high degree of recrystallization and rock anisotropy, interbedding of rocks are observed. Crystalline-schistose structures dominate. These structures are typical of deeply deformed and metamorphosed sedimentary, volcanic and igneous rocks that experienced dislocation metamorphism under inequilateral pressure (stress). Such structures are typical of the lower SG-3 and SG-4 sections and virtually of the entire KTB and OKU sections.

By the obtained vertical velocity sections of the crystalline massifs it may be inferred that the difference in the velocity characteristics determined by VSP, acoustic logging and simulating PT-conditions of the massif is slight. Virtually no depth dependence of the velocity determined by these methods has been observed at SG-3 and SG-4. Compression wave velocities are 4.5-6.4 km/s, those of shear waves - 2.5-3.7 km/s. The calculation method for determining compression and shear wave velocities by the mineral composition allows obtaining the results close to real ones, at least to a depth of 15-20 km. The rock density is mainly determined by mineral composition.

As follows from the analysis of petrographical determinations, compression wave velocities are more sensitive to compositional variations and PT-conditions than those of shear waves. Accordingly, compression waves can be more useful for distinguishing the boundaries between rocks with different composition, fault dislocations, the boundaries between the decompaction zones filled, for instance, with fluids. At the same time, the use of shear waves, especially the VSP polarization method, is rather efficient for distinguishing strongly anisotropic areas of the massif under study.

A significant result of the investigations is a discovery of highly anisotropic rocks in the SG-3, SG-4, KTB and OKU sections. The presence of velocity anisotropy as well as a complex structure of the rocks composing crystalline metamorphosed units greatly hampers interpretation of the results of seismic investigations conducted at the earth surface. It should be noted that deep and superdeep boreholes drilled in crystalline metamorphosed massifs are the only tool suitable for checking of the information obtained at the surface.

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