Impact of water cut on the distribution of seismic event magnitudes in the Khibiny mountains

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The change in the geodynamic regime of the Khibiny mountains is significantly affected by large-scale mining operations carried out for more than 90 years. The specifics of the deposits in the Khibiny are a high horizontal tectonic stress, the presence of brittle high-strength rocks, as well as fault structures filled mainly with loose rocks, the depth of development and the volume of annually extracted rock mass, which determines their seismic hazard.

Most of the tectonic disturbances are exposed on the surface by mining, which contributes to the unhindered penetration of atmospheric water deep into the rock mass. In this regard, the physical and mechanical properties of the massif sections change, and the probability of block movement along geological structures increases. In general, the combination of all factors leads to an increase in seismic activity, however, a powerful seismic event can be triggered by one of them, for example, an increase in water cut in a rock mass.

Based on the data of long-term seismological observations and long-term monitoring of water courses carried out at the deposits of the Khibiny mountains, the dependence of the distribution of magnitudes of mining-induced seismic events on the level of water cut in the environment was revealed. A significant decrease in the b-value (the slope of the frequency-magnitude graph) of the Gutenberg-Richter magnitude distribution was found during the period of high watering in May-June, which is due to the melting of snow that fell during the winter. In the autumn months, the value of parameter b increases to the level of the beginning of snowmelt. The physical mechanism that explains this phenomenon is the growth of Coulomb stress due to a decrease in the effective normal stress and a decrease in the friction coefficient at the contact of the geological structure - a block of the rock mass due to an increase in pore pressure caused by an increase in the water content of the medium. The b-value determines the proportion of strong and weak seismic events. As b decreases (increases), the proportion of strong events increases (decreases). Thus, the dependence of the slope of the recurrence curve on the level of water cut must be considered when assessing the rockburst hazard at the fields of the Khibiny massif. The study was supported by the Russian Science Foundation, project No. 22-27-20125.