Spatial-temporal variations of seismicity at the Saamsky fault area (Khibiny rock massif)

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The apatite-nepheline deposits located at the Kola Peninsula are mined under rockburst-hazardous conditions. The open-pit mining of the deposits began in 1929.

The Saamsky open pit (mining operations have been completed) separate the Kukisvumchorr and Yukspor deposits of the Kirovsk mine. Nowadays, the deposits are being developed by underground mining. Underground mining operations have almost reached the final contour of the open pit, and driving operations have already crossed the Saamsky fault, which was stripped by the open pit excavation.

The Kirovsk mine area is controlled by an automated monitoring system for rock mass state. The seismic mode of the deposits is affected by a combination of several factors such as high tectonic stresses, blocky fractured host rocks, geological hard inclusions in the rock mass, stoping operations, impact of blasts, water inflows, etc. Despite the obvious particularities of the seismicity occurrences associated with a particular or several influencing factors, a systematization of seismic data by the cluster analysis is necessary for conducting detailed studies, for greater reliability of seismicity analysis.

The authors have analyzed seismicity using spatial-temporal clustering to identify potential impacting factors and mechanisms of rock massif failure.

The paper analyses the seismicity at the Saamsky fault area for 2008-2018 years. 50 strong seismic events occurred in this area during the period studied, including 46 events of energy class K=6 and 4 events with class K=7. Some underground shocks were felt on the Kirovsk mine industrial site.

Taking into account the clustering of seismicity in both time and space, the authors have analyzed the location of clusters and possible causes of their occurrence.

It has been found that near the fault, the seismic activity mainly occurs in the footwall of the ore body, but strong events also occur in other parts of the fault, which may indicate the activity of the fault as a whole. Moreover, the analysis of the seismicity's dynamics allows determining the deposits' areas with a constant long-term occurrence of seismic events and areas with a relatively short-term increase of seismic activity, often in the presence of additional triggers (for example, increased watering or blast impact). In addition, the authors have revealed areas where seismic events have been absent for a long time.

The studies have identified clusters in the console part of the rock massif: in the Kukisvumchorr and Yukspor deposits.

The authors have revealed a correlation between the time of seismic events occurrence and the time of blasting during driving operations. Directly in the fault zone, driving operations and intersection of the fault structure has evidently been a trigger for fault activation, because seismic events occurred not only at the horizon of the operations performed, but also above. An additional factor in the activation of the fault was the seasonal factor and the associated increase in water inflows.

Thus, application of the presented approach has allowed authors to identify possible causes of formation of clusters or groups of clusters of seismic events, and to reveal both permanently acting and short-term trigger factors.