

The analysis of the Tectonics – SSS – Seismicity System in the 3D-model of the Rasvumchorr Mine – Central Open Pit Natural and Technical System (Khibiny)

Dmitry Zhiron (1), Sergey Klimov (), Anzhela Zhirona (), Alexey Panteleev (), and Vadim Rybin ()

(1) Geological Institute KSC RAS, Apatity, Russian Federation (zhiron@geoksc.apatity.ru), (2) Geological Institute KSC RAS, Apatity, Russian Federation (klim-sa@yandex.ru), (3) Geological Institute KSC RAS, Apatity, Russian Federation (anzhelaz@geoksc.apatity.ru), (4) Mining Institute KSC RAS, Apatity, Russian Federation (PanteleevAV@szfk.biz), (5) Mining Institute KSC RAS, Apatity, Russian Federation (rybin@goi.kolasc.net.ru)

Main hazardous factors during the operation of deposits represent tectonics (structural dislocation), strain and stress state (SSS), and seismicity. The cause and effect relationships in the Fault Tectonics – SSS – Seismicity system were analyzed using a 3D geological and structural Rasvumchorr Mine – Central Open Pit model. This natural and technical system (NTS) has resulted from the development of the world-class apatite-nepheline deposits the Apatite Circus and Rasvumchorr Plateau. The 3D model integrates various spatial data on the earth's surface topography before and after mining, geometry of mines and dumps, SSS measurements and rock pressure, seismicity, fault tectonics and etc.

The analysis of the 3D model has clearly demonstrated the localization of three main seismic emanation zones in the areas of maximum anthropogenic variation of the initial rock state, and namely: ore pass zone under the Southern edge of the Central open pit, collapse and joining zone of the Rasvumchorr Mine and NW edge of the open pit, and zone under the Apatite Circus plate – collapse console. And, on the contrary, in the area of a large dump under the underground mine, a perennial seismic minimum zone was identified. The relation of the seismicity and fault tectonics was revealed only in three local sectors near come certain echelon fissures of the Main Fault(MF). No confinement of increased seismicity areas to the MF and other numerous echelon fissures is observed. The same picture occurs towards manifestations of rock pressure. Only an insignificant part of echelon fissures (including low rank of hierarchy) controls hazardous manifestations of rock pressure (dumps, strong deformations of the mine contour, etc.). It is shown that the anthropogenic factor (explosive, geometry and arrangement of mined spaces and collapse console), as well as the time factor significantly change orientation and structure (contrast and heterogeneity) of the stress fields.

Time series of natural geophysical field fluctuations were additionally analyzed in order to find relationships with the seismicity. A sustainable regular relationship between the seismicity and solar and lunar tides has been observed; though, medium (classes 3 to 6) and high (class 7 and above) energy values of the events reveal various symmetry towards the Lunar cycle phases. The relationship of seismicity with other geophysical fields, e.g., geomagnetic disturbances, is defined as weak to very weak.

The anthropogenic (man-induced) factor mostly influences the seismicity in the NTS rock masses. A law for shifting of maximum seismicity zones following the advance of the mining front has been found. The 3D model integrates various spatial data on the earth's surface topography before and after mining, geometry of mines and dumps, SSS measurements, and rock pressure, seismicity, fault tectonics, and other manifestations.

The study is made within R&D topic No. 0231-2015-0013. The collection, processing, and analysis of data for natural stress fields became possible due to the support from RSF grant 14-17-00751.