AP23489856 «Resource-saving technologies development for mining mineral deposits that ensure the mining facilities safety in regions with high tectonic activity» sc.s. – Mussin A.A.

The relevance

The relevance of the problem lies in the need to improve resource efficiency in the development of mineral deposits and to ensure the safety of mining industry facilities located in regions characterized by high levels of modern tectonic activity. The greatest risks are faced by mining facilities situated in mountainous areas, where seismic energy release processes are still ongoing. Therefore, when designing new structural elements of mining enterprises, areas within interblock zones—at the boundaries of blocks and lithospheric plates—are deliberately avoided, as these zones are typically associated with the highest levels of seismic activity. By applying a methodology for identifying interblock zones and estimating the seismic energy released within them, it is possible to calculate the energy volumes in the zones where mining facilities are located or planned for construction.

The intensive development of mineral deposits, which in recent years has led to a continuous expansion of excavated space within rock masses and increasing depths of extraction, contributes to the activation of geodynamic processes and phenomena both within the subsurface and at the Earth's surface. The most critical of these include: sudden failure of rock and collapse of mine roofs and sidewalls due to the release of elastic energy accumulated in the blocky rock mass; the destruction of aquifers resulting in disruption of the hydrogeological regime of groundwater and subsurface water; and loss of stability of the Earth's surface.

With the increasing depth of mineral extraction and the expansion of mined-out voids within rock masses, conditions arise that lead to the loading of large-amplitude tectonic fault displacements. These conditions are sufficient to induce extensive shear-type movements of rock along well-developed slip planes, facilitating the release of significant amounts of stored elastic seismic energy.

Ensuring geodynamic safety during the construction and operation of mining enterprises requires the forecasting and identification of key geohazards that contribute to the manifestation of hazardous mining-geological processes. Although the widely recognized method of geodynamic zoning of the subsurface (as developed by Prof. I.M. Petukhov and Prof. I.M. Batugina) is applied in geodynamic studies, the issue remains only partially resolved and retains its relevance. This is largely due to the necessity of considering a broad spectrum of natural and technogenic conditions, including the characteristics of accumulated voids specific to each major deposit, which contribute to dynamic loading within the blocky rock mass.

Therefore, the identification of patterns and the classification of geodynamic process research results—within the context of the natural-technogenic system associated with mineral deposit development—enable a more comprehensive assessment of the adverse consequences resulting from the combined impact of natural geodynamic activity in the blocky rock mass and ongoing mining operations.

Research Results in the first half of 2025:

The influence of mining-geological, mining-technical, and geodynamic conditions on the development of mineral deposits has been comprehensively studied, leading to the identification of patterns in how these factors affect the fundamental elements of mining structures. Investigations have been carried out to determine the regularities governing the formation of stress concentration zones within rock masses and their impact on the design parameters of underground excavations.The effects of dynamic factors—such as rockbursts and seismic loading resulting from blasting operations—on the stability of underground openings have been analyzed. Particular attention has been paid to the relationship between the stress–strain state of the rock mass and changes in the parameters of mining structures.

Furthermore, the mechanisms of deformation and failure of mining structures and excavations under the influence of both natural and anthropogenic factors have been examined. The study also revealed the patterns by which various factors influence the load-bearing capacity of mining structures and the stability of the surrounding rock mass. As a result of the analysis, parameter combinations have

been identified that lead to reduced stability of mine workings, as well as to deformation and failure of structural elements.

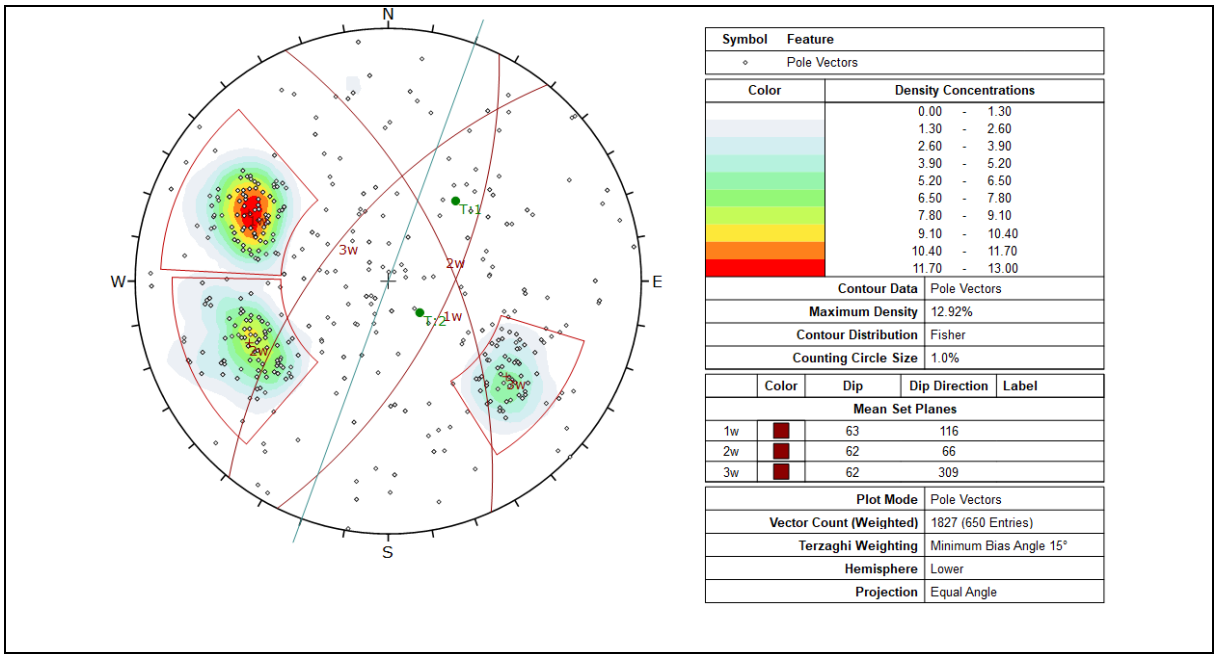

Figure 1 – Stereographic projection generated in Dips software based on the orientation of jointing in the rock mass

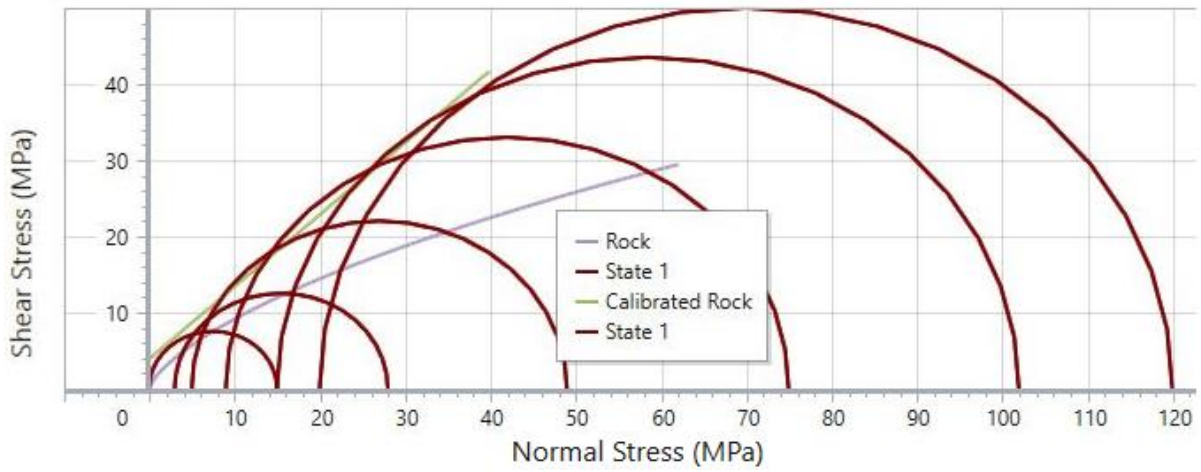

Figure 2 – Rock mass strength diagram

List of publications for the first half of 2025

1) The article has been prepared and submitted to a journal indexed in the Scopus database with a CiteScore percentile of 81:

A. Mussin, A. Imashev, G. Yeskenova, A. Matayev, A.Suimbayeva, G. Zhunusbekova, N. Shaike. Justification of a Resource-Saving Technology for the Development of Inclined Ore Bodies While Ensuring the Preservation of Mining Infrastructure // Civil Engineering Journal.

The article is currently under peer review.

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Information for Potential Users

As a result of the project implementation, a resource-saving mining technology will be developed for the extraction of deposits with horizontal and gently dipping ore bodies. This technology will ensure the preservation and stability of mining infrastructure, taking into account the mining-geological, mining-technical, and rockburst-prone conditions of the mine, as well as the dynamics of mining operations. The research results are expected to be applied in the future in the development of underground ore deposit extraction technologies.

Area of Application

Applicable to the design of underground mining excavations in regions characterized by high tectonic activity.

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