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Research of the mechanism of destruction of a block mass in the evaluation of the slopes stability in open cast mining

Recherche du mécanisme de destruction d'une masse de blocs dans l'évaluation de la stabilité des pentes dans l'exploitation minière à ciel ouvert

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ABSTRACT: Assessment of the impact of the block-hierarchical structure of the rock mass on the development of geomechanical processes is a new approach to solving the problems of ensuring the safety of mining operations in the development of upland mineral deposits and highways on mountain slopes and in areas affected by tectonic disturbances is relevant, since it is not possible to apply traditional methods of calculating stability for an isotropic array for a block array.

KEYWORDS: stability, blockiness, fracturing, rock formation, estimation, calculations

1 INTRODUCTION

Kyrgyzstan is located in the north-east of Central Asia and belongs to the mountain-folding system of the Southwest Tien Shan. Four mega-complexes and four mega-stages corresponding to them in the development of the lithosphere are distinguished in the geological structure of the territory of the republic, which differ sharply from each other in the composition, structure and conditions of their formation. Almost 95% of the territory is occupied by mountains at an altitude of more than 1000m above sea level, in connection with which almost all mineral deposits are mined in high altitude conditions on complex massifs with block structure. Predicting the state of a block massif and ensuring its stability is an urgent task, since it is not possible to use traditional methods for calculating stability for an isotropic rock mass for a block mass.

The exploited gold ore deposits of Kyrgyzstan are mountainous, located in the zone of influence of discontinuous tectonic disturbances. The host rocks are represented by intrusive and effusive rocks subjected to hydrothermal-metasomatic changes. In rock massifs, up to 5 systems of cracks of different orientations are clearly expressed, which determines the block structure of the rock mass.

In recent years, unplanned collapses of rock blocks of the onboard massif have become more frequent at mining enterprises in Kyrgyzstan. To date, due attention has not been paid to ensuring the safety of mining operations in such fields. The stability assessment for such arrays is carried out according to the existing methods acceptable for isotropic media.

Therefore, the assessment of the impact of the block-hierarchical structure of the rock mass on the development of geomechanical processes is a new approach to solving the problems of ensuring the safety of mining operations in the development of upland deposits in the zones of influence of tectonic disturbances.

Based on the analysis of the literature, it is established that the assessment of the block-hierarchical structure and fracturing of the rock mass is a priority in mining geomechanics. However, the issues of influence on the development and management of geomechanical processes in the development of upland deposits and roads on mountain slopes in the mountain-folded regions, which include Kyrgyzstan, have not been given due attention to date.

The main purpose of managing geomechanical processes in the development of upland deposits is to determine the optimal design of the sides of quarries, determine the angles of slopes and the height of ledges, the parameters of safety and transport berms.

1.1 *Analytical review of scientific and practical literature*

The development of deposits is invariably accompanied by changes in the geological and, accordingly, geomechanical environment: the deformation and strength characteristics of rocks change, vertical and horizontal stresses increase with depth, the stress concentration zone on the contour of the quarry side increases, and the environment becomes blocky.

The geological environment of a block structure, being subjected to man-made impact, changes its state: fracturing from explosions is superimposed on the formed blockiness of the massif, the properties of rocks and the massif change, i.e. the geomechanical environment changes.

Geomechanical processes occurring in the rock mass during mining operations depend on the properties of the geological environment and the parameters of the technogenic impact. The main geomechanical processes in the instrument array of upland quarries that affect the stability and safety of mining operations are deformation, which are manifested in the form of additional stresses on the contour of the quarry, the development of the process of moving not only the side of the quarry, but also the slope on which the quarry is built.

A distinctive feature of upland mineral deposits is that the size of the blocks in the weathering zone have different parameters and slight adhesion, and the blocks are kept in equilibrium only due to the action of gravity.

With the development of irreversible deformations of the sides of the quarry, the rocks directly on the slope are involved in the displacement process and the volumes of displaced rocks reach millions of cubic meters. The side of the quarry on slope b is usually located in a rock mass with low strength characteristics. When opened, natural cracks are exposed, which

contributes to the intensive penetration of water through the cracks deep into the massif.

In the instrument array of upland quarries, structural inhomogeneities are clearly expressed, which are structural blocks of various sizes. According to the size of the blocks, several orders of inhomogeneities are distinguished: structural disturbances at the level of mineral grains; microfractures forming blocks up to tens of centimeters in size; macrofractures (blocks up to several meters in size) and large geological disturbances commensurate with the scale of the deposits as a whole (Medvedev R. V. 1972, Kazikaev D. M. 1981, Fisenko G. L. 1976, Dzevomsky Ya. 1971).

The element of heterogeneity can be a tectonic block, brachiosclad, a separate block bounded by faults, crack systems, or intense fracturing. The schematic hierarchy of the block array is shown in Figure 1.

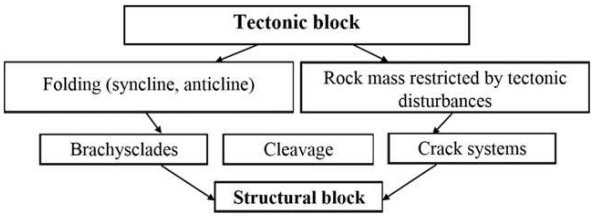

Figure 1. Schematic hierarchy of a block array

Such a structure of an array determines the anisotropic nature of the distribution of its physical and mechanical properties in space, since the internal structure and composition of neighboring structural blocks can be completely different, as well as the intensity of fracturing, opening and filling material between block cracks, water content of crack systems and strength.

In most cases, when calculating the stability of slopes in massifs of a block structure, the slope can be stable, but when one or two blocks fall out, the entire array collapses, which makes it very difficult to ensure the safety of such areas and complicates the prediction of the stability of such slopes (see Figure 2).

The conducted studies [Golodkovskaya G. A. 1989, Trofimov V. T. 1994] of the geological environment allowe d us to establish that it is a discrete, hierarchical-block str ucture, which is characterized by such properties as:

- non-equilibrium state;
- differentiated non-uniform stability;

In the development of upland deposits, such a geologi cal environment is:

- directly slopes on which gravitational slope proce sses develop,
- geological structure of the rock mass, occurrence of ore bodies
- tectonics and tectonic disturbances, both discontin uous and folded,
- physical and mechanical properties of host rocks and
- ores
- natural stress state of the rock mass,
- ground water level

These properties have an impact on the safety of cons truction and operation of upland quarries and mountain roa ds.

Figure 2. Blockiness of the rock mass on the slopes

1.1.1 *Research methodology*

To study the mechanism of destruction of a block array, we conducted laboratory studies based on the separation of individual blocks, by physical and geomechanical modeling of this process.

The purpose of the research was to evaluate the effect of the filler on the block separation resistance during its volumetric compression. And considered the following two tasks:

1. create a methodology for laboratory studies to determine the resistance to the separation of the block under volumetric compression

2. determine the dependence of the resistance to separation of the block array under volumetric compression on the filler.

For the experiment in laboratory conditions, a methodology for conducting studies of the resistance of a separate block to separation was developed and a simple model of a block array was created, where a single movable block was considered as the main "block" under conditions of volumetric compression (see Figure 3).

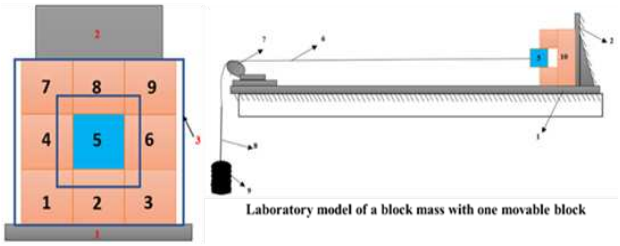

Figure 3. Studying the resistance of a block mass to separate

1 – construction base, **2** – vertical support wall **3** – plexiglass support wall, **1,2,3,4,6,7,8,9** – cubic fixed rock blocks, **5** – the only movable block of rock, **6** - cable for detaching the block, **7** - cable reel, **8** - cargo stand, **9** - cargo (100g), **10** – fixed block of rock

The main part of the structure is a horizontal fixed wooden frame. There is a vertical support wall, a drum for the cable and a device for applying the load. Also, to secure the nine blocks of rock built vertically, a retaining wall of Plexiglass is made, bent along the vertical edges. In the middle of the wall, a hole is made with a size larger than one block, at the place where the movable block is located, so that the movable block can freely come off. All the blocks were made of rocky rocks (Figure 4).

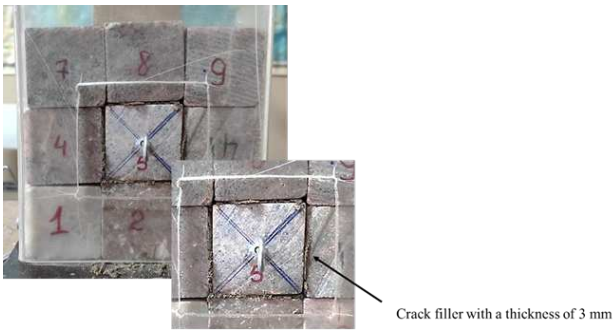

Figure 4. Prepared rock blocks with filler for testing

When studying interblock cracks on slopes and on cores, the following types of aggregates were identified. There are empty cracks without aggregate, cracks with solid aggregate are identified, which firmly cement the blocks with each other and provide greater load-bearing capacity of the array and the stability of the slope as a whole for a long time, until the weathering process weakens them. Also, weak clay aggregates were found, which, when they give a weak connection to the blocks and when wet, practically lose their adhesion and present a greater probability of disruption in quarries.

Based on this, for the laboratory test experiment, sand-clay aggregates were taken in different ratios, as shown in Table 1. The internal friction angle and adhesion for each type of aggregate were determined in advance.

The filler was applied only around the movable block, which should come off.

Table 1. Types of cracks fillers used in the experiment

#	**The ratio of clay and sand**	**Angle of internal friction ϕ, deg**	**Cohesion C, Mpa**
1	Without filler (dry contact)	-	-
2	With water (wet contact)	-	-
3	Clay 100%	27	0,009
4	Sand 100%	26	0,004
5	Sand 50% и Clay 50%	20	**0,033**
6	Sand 30%, Clay 70%	20	0,013
7	Sand 70%, Clay 30%	25	0,01

The purpose of this simple laboratory experiment was to establish the dependence of the block separation resistance on the type of filler.

Based on the data obtained, simple graphs were constructed (see Figure 5).

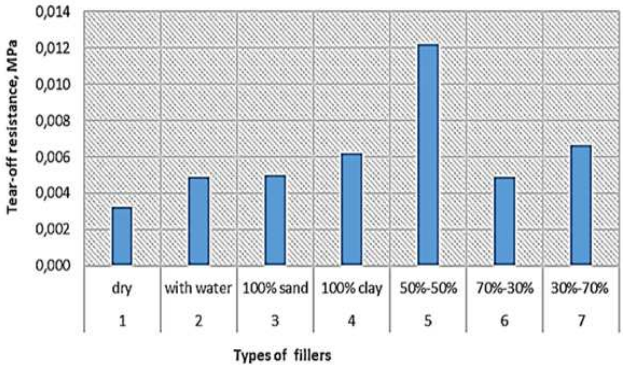

Figure 5. Dependence of the block's resistance to separation from different fillers

The graph shows that the block's resistance to separation d epends on the type of aggregate, with the greatest resistan ce being provided by the aggregate, where the ratio is 50 % sand to 50% clay.

2 CONCLUSIONS

According to the results of the work carried out, it was found that:

1. The resistance to separation of rock blocks depends on the type of inter block aggregate, with the greatest resistance to separation of clay aggregates in the ratio of 70% x30%to sand.
2. The break-off resistance of rock blocks depends on the break-off point. The greatest resistance to separation is provided by the lower point.

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