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ON THE FEATURES OF CHANGES IN MINING AND GEOLOGICAL CONDITIONS IN CONNECTION WITH THE DEVELOPMENT OF THE YOSHLIK PORPHYRY COPPER DEPOSIT

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Annotation.

The article presents data on the possible deformation of rock masses in the Yoshlik deposit based on the results of studying the geological-tectonic structure of the deposit and the engineering-geological properties of the rocks, as well as based on the analysis of similar masses in the depleted Kyrgashinkan mine and in the Kalmakyr and Sary-Cheku deposits, where the extraction process is nearing completion. The possibility of occurrence of deformations of various nature and volume, as well as the development of other mining and geological processes and phenomena, due to the expansion of the quarry field, an increase in the depth of development, and the opening of waterlogged tectonic faults, leading to a decrease in the stability of the benches during the development of the deposit, has been substantiated.

Key words

stability, slope, deposit, deformation, geology, open-pit, tectonic fractures, magmatic rock, rocks, hydrogeology.

Introduction.

The Yoshlik porphyry copper deposit is located in the northern block of the Almalyksay River basin, which is a left tributary of the Akhangaran River. It borders the Kalmakyr deposit to the east, the Karamazor Mountains to the south, and the Barakali deposit to the northwest.

As a result of the analysis of the geological and tectonic structure of the Yoshlik deposit, it can be noted that the history of the geological development of the territory covers periods from the Lower Paleozoic to the Mesozoic-Cenozoic. The deposit is located in a tectonic wedge, bounded to the north by the latitudinal Karabulak fault and to the south by the Kalmakyr fault.

The area of the deposit is composed mainly of intrusive igneous rocks: syenite -diorite (71%), diorite (22%) and granodiorite -porphyry of the Almalyk type breaking through them (about 1%). The enclosing sand-carbonate deposits (0.5%), effusive quartz porphyry (4%) and andesite-dacitic porphyry are insignificant [1,2,3].

Main part.

The development of a solid mineral deposit leads to a significant change in all elements of engineering and geological conditions. The primary natural stress state and equilibrium conditions of rocks in the massif are violated. This leads to a redistribution of stresses, leading to the appearance of stress concentration centers in some places and to weakening in others.

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The stability of mine workings, i.e. the slopes of benches and sides, was assessed on the basis of an analysis of the geological-tectonic structure and engineering-geological characteristics of rocks. Mining-geological processes and phenomena associated with the development of the deposit were assessed on the basis of a study of the deformations formed in the exploited Yoshlik quarry and a comparison with other deformations formed during development in the operating quarries of Kalmakyr, Sary-Cheku and the exhausted quarry of Kurgashinkan.

The geological and structural structure of the deposit area is determined by the development of two fault systems here, with which mining and geological processes are associated. The first system is represented by several faults of north - northwest strike located between the Karabulak and Kalmakyr faults, which do not have a clear expression on the modern erosion section.

The second system includes sublatitudinal faults - Karabulak, Kalmakyr and Burgundinsky. All of them are well expressed in the modern erosion section by zones of crushing (cataclasis) that captured various rocks (including many metasomatic ones). These are long-lived faults that were renewed during the Alpine orogeny [1.2.3].

Due to the development of two systems of ore-controlling faults, the area of the Yoshlik deposit will be divided into sections (blocks) Karabulak, Central and North -Western.

As noted above, the tectonic structure of the described deposit is determined by two large sublatitudinal faults: Karabulak and Kalmakyr. As a result, the edge is divided into a number of tectonic blocks. The Karabulak fault limits the ore stockwork of the deposit from the north and is represented by a thick (50-60 m) crushing zone composed of heavily altered, flared quartz-sericite rocks, within which bands of clayey material are distinguished, clearly limited by tectonic surfaces - seams. The thickness of such bands varies from 1 to 14 m. The dip of the Karabulak fault is steep, to the north at an angle of 75-80°. The Kalmakyr fault dips to the south at an angle of 65-75° and is characterized by a smaller thickness (15-20 m) of the zone of sheared , sericitized and chloritized rocks and their more intense crushing. In the hanging wall of the fault, a zone of increased fracturing and crushing of rocks with a thickness of 70-80 m is recorded. Between the Kalmakyr and Karabulak faults, a number of smaller tectonic faults of steep dip (intermediate faults 1,2,3,4) were recorded during the development of the deposit. The thickness of the crushing zones of these faults exceeds 15-17 m. Apparently, small ore or barren tectonic cracks and numerous zones of crushing and fracturing were renewed as a result of tectonic movements along the Karabulak, Kalmakyr and other faults not only in the pre-ore but also in the process of ore formation. Smaller intermediate rupture faults supporting the listed faults are predominantly faults with steep (70-80°) dips to the southwest and southeast. In addition to tectonic cracks, crack formation is detected in rocks along the quarry wall and it is possible that they are related to the dynamic conditions of the quarry, in particular, seismic stresses. Under the action of a blast wave, the stress state of the massif changes, which reduces the friction forces along the weakest surface and, with a small reserve/stability, leads to sudden collapses of the wall.

In the massif of host intrusive rocks, the density varies slightly from 2.55 to 2.67 g/sm^3. For sulphide ores it is 2.60 g/sm^3, mixed 2.56 g/sm^3, and oxidized 2.51 g/sm^3. The compressive strength varies from 111.6 MPa for syenite -diorites to 48 MPa for quartz porphyry; in a water-saturated state it decreases by an average of 25%.

From the above data it is evident that the wide range of strength indicators is associated with different rock fracturing and crack filler compositions.

The pattern of change in strength properties with depth has not been established. However, a dependence on the structural features of the rock mass is undoubtedly visible. The strength of rocks drops sharply (7-8 times) in zones of tectonic disturbances and 4-5 times in highly fractured rocks. The loss of strength when moistened reaches 6-5 %. The rocks of the deposit were classified as medium and strong in strength, the strength of which varies within the range of 29.6 - 153.6 MPa. The strongest are quartz porphyry and diorite, the strength of which on the southwestern side reaches 123-155.0 MPa. Granodiorite porphyry has an average strength of 49.6 - 106.6 MPa.

The weakest rocks in the deposit were syenite-diorites, especially on the north-eastern side. The strength of syenite-diorites fluctuates within the range of 35-66 MPa. In fault zones and tectonic disturbances, their strength noticeably decreases to 6.6-38 MPa.

It has been established that an increase in humidity leads to a decrease in both the angle of internal friction and cohesion. This explains the increase in the speed of massif displacement during periods of intense precipitation.

Tectonic cracks develop in igneous rocks within the zone of influence of tectonic faults under the influence of tectonic compressive and tensile forces exceeding the ultimate strength of igneous rocks. Such cracks are found everywhere, they are very diverse in space.

In addition, within the Yoshlik quarry, a small number of gaping (reversible) cracks have been discovered , the formation of which is associated with blasting operations and unloading of rocks during mining. They are especially observed on stationary slopes.

Shear tectonic faults of sublatitudinal strike with crushing zones from 30 to 90 m in combination with large faults divide the massif into a number of blocks of various sizes.

The most unfavorable in terms of the stability of benches and sides are faults located parallel to the sides and directed towards the excavation, for which the angle of incidence of faults is close to the angle of inclination of the side. Such faults usually serve as a sliding plane for large collapses and other deformations. With the deepening and widening of the quarry, deformations of various natures are expected to occur.

The faults in the central part of the quarry extend perpendicularly to the edge and their influence on the formation of deformations in the same lithological differences of rocks is significantly less; when developing deep horizons in such places, only collapses with insignificant volumes and sloughs are expected. On the northern edge, a number of faults of sublatitudinal strike (part of the Karabulak and Kalmakyr faults) steeply dipping (60°-70°) towards the excavation may be a factor in weakening the massif and forming a landslide with an estimated volume of possible displacement of about 0.1-0.2 million m^3 .

It should be noted that the developed Kurgashinkan deposit and the developed Yoshlik and Kalmakyr deposits are similar in geological and structural terms, however, landslides, collapses, and rock falls have occurred and are highly developed on the sides of the developed Kurgashinkan quarry, while in the Yoshlik quarry they are still insignificant. The main reason is the difference in the mining and technical conditions of their operation. The Kurgashinkan deposit was developed with steep sides: northern, southern and southwestern more than 45°. Faults (steeply dipping) are mostly located parallel to the sides of the quarry and directed towards the mined-out space. More than 50% of the quarry field area is flooded (status - 2024). The sides of the Yoshlik deposit are flatter (by 5-6°) than those of Kurgashinkan. The faults are located in the outcrop of the sides, mainly perpendicular, less often obliquely.

Hydrogeological conditions of the Yoshlik deposit are quite favorable for development . At present, the length is 2700 m, the width is 2500 m and the depth of the quarry is 175 m, and the bottom of the quarry is located 155 m below the water level of the Almalyksay River. In the future, the quarry will open up both the main faults - Karabulak, Kalmakyr, and other intermediate 1,2,3,4 accompanied by a series of small disturbances. As the quarry deepens, the main factor in the accumulation of groundwater, the factor of formation of water inflows, their entry into the quarry will occur by filtration through Paleozoic rocks. Actual water inflows help to identify the main patterns of the relationship between river and fissure waters. The regime of fissure-groundwater is formed under the influence of precipitation and evaporation. Groundwater is fed from the southern highland part of the region, the level fluctuation follows directly the change in the amount of precipitation. The main water inflow comes from the zone of faults and through large cracks in the form of seepage; during the development of the Yoshlik deposit to the design level, the predicted water inflow may increase by 12-15 times and, accordingly, the area of moisture in the quarry field will increase.

With the expansion of the quarry field area and the increase in the depth of quarry development, the quarry configuration, the location of faults in relation to the sides change. In connection with this (the opening of watered faults and the change in their direction in relation to the sides), the possibility of more intensive development of mining and geological processes during the development of deep horizons is not excluded.

Results and Discussions.

The Yoshlik deposit as a whole, in zones of disturbances and highly fractured, as indicated above, areas change sharply, but insignificantly in terms of lithology. As for the change in the physical and mechanical properties of rocks with depth, no pattern has been established in this matter.

But there is a tendency for the density index to increase or the porosity of water absorption and the coefficient of fracture emptiness to decrease with depth. Quantitative assessment of rock fracturing shows that with increasing depth the parameters of fracturing hardly change, their increase is observed near tectonic faults at rock contacts, except for cracks associated with blasting operations to unload rock, which can change over time (in width and length).

The results of direct measurements of crack parameters at the sites, the study of fracturing on the stationary sides of the Yoshlik and Kalmakyr deposits show that in the existing cracks, expansions and extensions or increases in their width and length are noted, as well as the appearance of new cracks, their opening in places reached 2-3 mm. The depth of propagation is small at 2.5-3.0 m. In these zones, the strength indicators fall to 20% [2]. The smallest calculated angle of inclination of the quarry side is recommended for the north-eastern flank of the quarry, where intense disturbance of the rocks is observed, passing here by the Karabulak and Kalmakyr faults.

Based on the results of studying the fracturing of rocks in the deposit area, three genetic types of cracks were identified: tectonic, exogenous and artificial. The direction of tectonic cracks is associated with the direction of the fault. The formation of exogenous cracks is associated with processes occurring in the weathering crust. Artificial cracks arise under the influence of unloading and explosions in the Yoshlik quarry. The largest of them are tectonic: a) Kalmakirsky a normal- slip fault with a latitudinal strike and a steep (80°) dip to the south, the thickness of the crushing zone varies from 10 to 35 tons; b) a central fault, traced in the quarry workings at an angle of 80-90°, the thickness of the crushing zone reaches 5-10 m; c) intermediate faults located between the Kalmakyr and Karabulak faults, having an almost north-eastern strike (45°) and a southern dip with an angle reaching vertical, a zone of rock crushing with a thickness of 2-4 m. All faults are accompanied by zones of intense fine fracturing.

Analysis of the fracturing of the main varieties of quarry rocks to a depth of 500 m and according to the materials of geological exploration wells shows that no regular changes in the intensity of fracturing with depth have been established. The rocks throughout the studied depth outside the zones of faults and intensive fracturing have a uniform spread of the values of the sizes of structural blocks.

In terms of stability, the most unfavorable are cracks with dip angles of 40°-60° and conformably dipping with the slope. When analyzing crack systems by rock types, it was found that in slopes, longitudinal cracks (parallel and subparallel to the slope strike) make up 6.5%, diagonal cracks 58.0%, and transverse cracks 26.0%. Of these, longitudinal and diagonal cracks, conformably dipping, make up 12% and 43.0% and are the most unfavorable in terms of slope rock stability. Analysis of small collapses developed in the Yoshlik quarry shows that they all formed along systems of conjugated large cracks of falling slopes of benches. For example, on the southern side (horizon 40-625 m), the collapse occurred along cracks with a dip azimuth of 10° and 120° and dip angles of 63° and 64 ^{0}. On the northern side, the collapse occurred along cracks with an azimuth of fall of 178°-76° and an azimuth of fall of 286°-62°.

Thus, the analysis of the results of the study of fracturing of rocks of the Yoshlik deposit shows that the intensity of fracturing, the nature of cracks and the degree of disturbance of the massif depend on the presence and proximity of large tectonic faults by crushing zones and large tectonic disturbances. Near the fault zones, the intensity of fracturing is maximum, reaching 60-70 crack/track meter (by core), the coefficient of fracture porosity reaches 4.2-5.2%. At a distance of 10-13 m and more from the faults, a zone of highly fractured rocks is distinguished, characterized by a specific fracturing of 30-40 crack/track meter and a coefficient of fracture porosity of 1.37-4.27. Rocks outside the zones of influence of tectonic faults are characterized as massive, with moderate and weak fracturing. The intensity of cracking is from 10-30 crack/track meter (moderately cracked) to 5-10 crack/track meter (weakly cracked), respectively, the coefficient of crack porosity is less than 1.5%.

Thus, the analysis of the physical and mechanical properties of rocks revealed that in some varieties of rocks the strength indices increase with depth, in particular, in diorites and granodiorite porphyries, in syenite-diorites and quartz - porphyries no regular increase or decrease is observed; the main changes in the physical and mechanical properties of rocks are associated with fracturing, especially in strength indices. The maximum values of strength indices correspond to massive, weakly fractured rocks, and the average values correspond to moderately fractured rocks located closer to faults, the minimum values correspond to strongly fractured rocks, directly in the zones of influence of faults.

Conclusion

In general, the deposit area is characterized by increased fracturing of the upper horizon rocks. This is due to tectonic disturbance of the massif, weathering of rocks, blasting operations and unloading of rocks, the radius of influence of which in the massif reaches 50-70 m. Landslides and large-scale collapses will mainly form on the southwestern and northeastern sides of the quarry, where Kalmakirsky The upthrust -slip fault and the Karabulak fault intersect the sides almost perpendicularly and have a steep dip (60°-90°). At the same time, atmospheric waters do not saturate the fractured crushed weathered loose rocks, reducing their strength properties in the slopes.

In the future, talus is the most common type of deformation on quarry benches and has a cone- shaped form. The cause of talus is weathering (natural crushing of rock) and blasting operations.

The long term of quarry operation requires solving the issue of ensuring long-term stability of bench slopes in the ultimate position. To solve this problem, it is necessary to conduct experimental work to clarify the parameters and technology of bench slopes when setting their final position.

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