Rating assessment of rocks and ores in the conditions of the Kyzyl-alma deposit of Angren mine department

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Abstract. A comparative analysis of assessing the stability of rock masses was carried out based on rating indicators that are used at foreign underground mining enterprises. An assessment of the state of the rock mass at the Razvedochnaya and Kyzyl Alma mines of the Angren mine was carried out. The method for determining the category of disturbance of an ore and rock massif is effective, gives a quick assessment of the state of the massif - the international Barton rating system is recommended to be used in problem areas (unstable, stressed, weakened, fractured, disturbed (tectonic faults), watered massif, etc.) during excavation, fastening and maintaining workings, for qualitative and quantitative assessment of the state of the ore and rock mass.

1 Introduction

The article presents a comparative analysis of the current methods for evaluation of rock mass quality based on various rating systems in use in underground mines abroad and at the Polar Division of Norilsk Nickel. Rock mass quality has been evaluated in mines the underground mines of the Angren Mining Administration (Razvedochnaya, Kyzyl Alma). The method used in the mines for assessment of damage degree in ore body and rock mass is efficient, and produces qualitative and operational evaluation of rock mass quality; therefore, Barton's Rock Mass Classification is recommended for quantitative evaluation of ore and rock mass under difficult ground conditions in mines (unstable, high-stress, weakened, jointed, faulted, wet rock mass, etc.) in the time of drivage, reinforcement and support of underground openings [1-8].

Rock mass classification systems are the tool suitable for assessment of necessity for support installation in mine openings at mine planning stage, especially when mining is carried out in hard and jointed rock mass subjected to high vertical and horizontal tectonic stresses.

It is advised to avoid changing between different rock mass classification systems, it is better to use alternative systems for checking and improvement of the results.

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It is important to bear in mind that rock mass classification systems are based on empirical relations that should be cross-checked in the course of actual mining by geologists and geomechanics using appropriate techniques of field investigation and engineering evaluation [9-14].

It is worth mentioning that the process of rock mass classification allows distinguishing between the effects exerted by different geological factors on rock mass behavior and, therethrough, estimating hazards likely to emerge during reinforcement and support of mine workings. Engineering decisions made on this basis are more reasonable. Rock mass quality evaluation using two or more systems offers a deeper insight on a rock mass. The rock mass classifications are not a substitution for field studies, characterization of geomaterials and geological analyses. They are the supplement and play a specific part in rock mass investigations and in geotechnical studies based on empirical knowledge.

2 Experimental research

A review of modern methods for assessing the stability of rock masses made it possible, based on rating indicators, to establish that systems and methods for assessing (classifying) rock masses are both qualitative and quantitative in nature. In world practice, at the design stage, when there is no practical data on the stability of rocks during excavations, rating classifications of rock masses are used, in which the stability of the rock mass is assessed in points.

Rock mass classification systems are often used by mining engineers, geologists and geomechanics for both mass description and empirical analysis. Classification systems - provide a high-quality and reliable assessment of massifs and are an excellent means of communication between specialists from various departments of mining production.

The main classification systems for rock masses abroad are as follows:

• *RQD* (Dikre et al., 1967) - based on the strength of the rock mass;

• System *Q* (Barton et al , 1974; Grmstadt and Barton, 1993; Barton, 2000) - for the stability of workings;

• *RMR* (Benyavsky , 1973, 1976, 1979 and 1989), *MRMR* (Laubscher , 1990; Jakubek and Laubscher , 2001) - for the stability of workings;

• *GSI* (Hoek , 1994) - geological strength index;

• *RMI* (Palmström , 1995) - rock strength index, etc.

When designing mining operations, the presented rock mass classification systems are used for various design directions (systems). For example, the design of excavation support is carried out mainly on the basis of the *Q system* (Gramstadt and Barton, 1993) [2, 3].

The analysis of modern international methods for assessing the stability of rock masses based on rating indicators made it possible to determine that, from the point of view of an alternative to the method used in the mines of the Angren mining administration (Kyzyl Alma mine and Razvedochnaya mine), the method of determining the category of disturbance of the ore and rock massif is the most corresponds to the international Barton rating system (calculation of the *Q index*) [2, 3], which, based on established evaluation criteria, allows you to design the parameters of support for capital , preparatory, cutting and production workings.

Since the method used in mines for determining the category of disturbance of an ore and rock massif is effective, it gives a quick assessment of the state of the massif if all the required measures are completed, the Barton international rating system is recommended to be used in problem areas (unstable, stressed, weakened, fractured, disturbed (tectonic faults), flooded massif, etc.) during excavation, securing and maintaining workings, for qualitative and quantitative assessment of the state of the ore and rock massif. At the same time, the most

effective and safe systems for supporting workings are designed for these conditions (problem areas), incl . using modern types of fastening [5].

When conducting research in mines, the quality of the massif was determined by *Q* - an index that takes into account the main parameters of the massif: *RQD* - characterizing the quality of the massif (structural damage) ; J_n is the number of crack systems; J_r — crack surface roughness; J_a — weathering and change in the state of cracks; J_w is the water content of the massif and fractures; *SRF* is the stress state of the massif.

Q index value was calculated based on 6 established parameters using the formula [2, 3]:

$$Q = \frac{RQD}{J_n} \text{x} \frac{J_r}{J_a} \text{x} \frac{J_w}{SRF}$$

In pairs, the parameters characterize three main factors that determine the stability of workings:

RQD / J_n - degree of disturbance of the array (relative size of the structural block);

J_r / J_a - relative friction resistance along cracks;

J_w / SRF - effective stresses (influence of water and disturbance).

Assessment of the quality of the massif (structural damage) was carried out using the determination of *RQD* at the outcrops of workings, in the zone and outside the zone of mining work.

RQD was calculated using the formula:

$RQD = L_z / L \text{ x } 100\%$,

where L_z is the sum of the lengths of the distances between natural cracks in the studied area of outcrops with a length of more than 10 cm, m;

L is the total length of the study area, m.

3 Research results

The Q index was calculated for the worst and best scenarios (table 1, 2, 3).

Table 1. For host rocks (outside the zone of influence of geological disturbance):

RQD	76.2%
J_n	4
Jr	from 2 to 3
Ja	from 0.75 to 3
J_w	1.0
SRF	from 3 to 9

After the calculations, the *Q index* amounted to values from 4.7 to 8.0, which characterizes the stability of the rock mass as medium stability.

Using the nomogram for determining the type of fastening based on Barton's Q rating (Figure 1), we establish the type of fastening of workings: systematic fastening with anchors + shot -concrete 4-10 cm, or anchors + metal mesh + shot -concrete 5-9 cm, or frame flexible support.

Table 2. For the ore-bearing zone and the contact zone

RQD	65.0%
J_n	3
Jr	from 2 to 3
Ja	0.75
Jw	1.0
SRF	from 2 to 8

After the calculations, the *Q index* amounted to values from 8.7 to 22.0, which characterizes the stability of the rock mass in the ore-bearing zone as average and above average stability.

Using the nomogram for determining the type of fastening based on Barton's Q rating, we establish the type of fastening of excavations: systematic fastening with anchors, or systematic fastening with anchors + shot concrete 4-10 cm.

Q index in the contact zone ranged from 3.2 to 8.1, which characterizes the stability of the rock mass as low and medium stability.

Using the nomogram for determining the type of fastening based on Barton's Q rating, we establish the type of fastening of excavations: anchors + metal mesh + sprayed concrete 5-9 cm, or systematic fastening with anchors + sprayed concrete 4-10 cm.

Table 3. For the Kyzylalmasay fault zone

RQD	thirty%
J_n	4
Jr	from 1 to 3
Ja	from 0.75 to 3
J_w	1.0
SRF	from 6 to 13

After the calculations, the *Q index* ranged from 0.25 to 3.0, which characterizes the stability of the rock mass in the fault zone as low and very low stability.

Using the nomogram for determining the type of fastening based on Barton's Q rating, we establish the type of fastening of workings: anchors + metal mesh + shot -concrete 9-12 cm, or anchors + metal mesh + shot -concrete 12-15 cm.

4 Conclusion

Classifications of rock masses are a tool for assessing the need to install excavation support at the design stage, especially for excavation in strong and fractured rock masses under

conditions of vertical and horizontal tectonic stresses. However, the capabilities of systems for assessing rocks occurring in complex geological conditions should be limited . In this case, it is necessary to clarify the estimated parameters under natural conditions.

You should avoid switching from one system to another - it is better to use them to check and get a more accurate result. It is important to understand the possible mechanisms of destruction of a rock mass when its continuity is violated ; one cannot fully rely only on the classification of the rock mass.

It must be remembered that classification systems are usually based on empirical relationships that require cross-checking by geologists and geomechanics during mining operations using appropriate field studies and engineering assessment.

It should be noted that the very process of classifying rock masses makes it possible to determine the influence of various geological parameters on the overall behavior of the rock mass and thus better assess all the factors that create problems in securing and maintaining mine workings. This allows you to make more informed engineering decisions.

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