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ASSESSMENT OF THE IMPACT O* KOCK MASS DISCONTINUITIES ON THE STABILITY IN ROOMS AND PILLARS

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ABSTRACT Investigations have been earned out to determine the quantitative and qualitative indices of the discontinuities under the conditions of Chelopech Mme The influence of the separate joint sets on the stability of rooms and pillars is analysed It has been found that there are différent assessments for the choice of optimal orientation of the rooms and pillars In these cases the final decision in determining the parameters of open-stope methods depends on the overhead costs for pillar strengthening and roof support

1 INTRODUCTION

Fault structures, tectonic joints and bedding are the factors which determine largely the behaviour of the real rock mass Under stress conditions the following most typical features are manifested

-the indices determining the mechanical properties under laboratory and in-situ conditions differ considerably,

- there are anomalies in the distribution of primary stresses (stresses in the undisturbed rock mass),
- a field of mechanical and structural amsotropy is formed depending on the number of joint sets

These characteristics have an immediate impact on the stability of underground structures, particularly of open slopes, ı e rooms and pillars The stability evaluation necessarily involves the quantitative and qualitative indices of the rock mass discontinuity Its systematic study is an integral part of the production activity of any mining enterprise

This paper discusses the main quantitative and qualitative indices of the rock mass discontinuity and its effect on the orientation of rooms and pillars al Chelopech Mme wheTe a gold-copper deposit is being exploited

2 QUANTITATIVE AND QUAIHA11VL INDICES 01- ÎHE ROCK MASS DISCONTINUITY

The study of the rock mass discontinuity at Chelopech Mme is determined by the need to evaluate the stability of rooms and pillars in relation with the forthcoming change in the mining technology The deposit consists of individual stock-like orebodies mined until now by sublevel caving The development workings in orebody No 9 were used to study the rock mass discontinuity The five measuring stations are located in blocks Nos 17, 18, 19 Over 50 joints were recorded The processing, analysing and interpreting of the data obtained were based on the recommendations of the International Society for Rock Mechanics, Commision of Standardization of Laboratory and Field Tests [6] The investigations involve the determination of the following parameters of jointing orientation, spacing persistence roughness, wall strength, aperture, filling seepage number of sets and block size

Special attention was paid to the different types of joints

x-high persistence |0ints spreading outside the mine working,

d joints traced and ending in another discontinuity

r-low persistence joints spreading over a relatively short distance and disappearing *m* the rock mass,

The data processing was performed by the DIPS sofiwaie pavkage [2] fig I shows the hemispherical piojection of Ihc it corded joints and their grouping into separate systems for the conditions ol ılıt measuring station 19-460 The analysis shows lii.il five joint sets can hi. observed in the study Hit ı 1 able I presents the mean values of orientation ol iln identified joint sets and the frequency of their occurrence at each measuring station The geometnc-mean values Xr, were used in the data processing They were preferred to the weighted mean values Xw because of their greater representativeness.

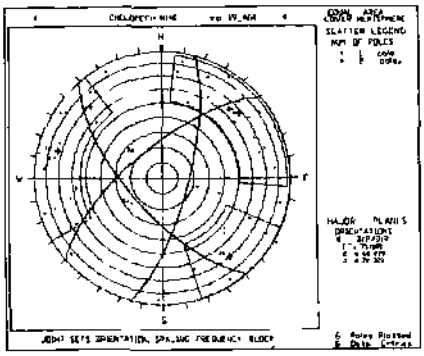

Fig 1 Hemispherical projection of joints at measuring station 19-460

It is important to note the dispersion of data charactenzing the onentation of jointing. The analysis shows that the r-jomts have a higher degree of vanabılıty At the same time their onentation corresponds to the definite joint sets However, in most cases their taking into account leads to a change in the rank of ordenng of the given set.

The results have shown that for each measuring •tation there are three joint sets (out of the total five s *ts recorded in the whole study area) This means th it there is a block structure and its linear dimensions influence the size of blasted material and the stability of the open stope spaces (rooms and pillars)

Table 2 presents the average spacings between the joints for each measuring station.

The data processing showed that at this stage it is difficult to assess the probability character of the joint spacings and the joint persistence because the number of measurements available does not meet the requirements for obtaining sufficiently representative data. Here it is necessary to point out the deep meaning of B Sander's well-known recommendation [4], who says' ".. in all cases where the regularity of a given phenomenon has not yet been established, it is necessary to make the maximum possible quantity of measurements "

As to the aperture, roughness, filling and alteration of the joints, the measurements have shown far more stable results The latter makes it possible to accept this part of quantitative and qualitative indices of jointing as sufficiently representative not only for the study area but also for the whole deposit

Table 1 Angle of dip DIP and azimuth of dip DIP DIRECTION for the separate joint sets

joint set	mean values of orientation		frequency of occurrence
	DIP°	DIP DIRECTION°	
SA	66+ 10	212 ± 17	5
SR	72 ±7	023 + 16	4
Sr	58+11	140 ± 11	3
SD	68 ±3	308 ± 12	2
S_F	73	105	1

Table 2 Average spacing between the joints of each set for each measunng station

measuring station	[1] of joint sets, N	index of joint sets	average spacing between loınts, d„ m		
			d,	àj	d.
18-435	3	SR, Sr, S_a	1 57	0 995	1 86
19-455	3	S_r, S_F., S 4	0 932	1 66	1 75
19-460	3	S_p; S_A, S_n	081	t 7	1 08
17-465	3	SR, SA, Sr	0 86	0 879	1.2
19-475	3	SA, SR, Sn	0 78	1 665	2 624

NOTE ı=],2, N

The integral quantitative indices of the rock mass discontinuity, which are used in the further assessment of the stability of open stopes (rooms and pillars) are given in Table 3.

Table 3. Integral quantitative indices of the rock mass discontinuity

measuring station	mean size of elementary structural block L, m	volume of elementary structural block V_n,m3	relative portion of non-systematic joints T„,%	volumetric intensity of jointing J_v, m-3
18-435	1 471	2,87	17	4.14
19-455	1.447	2.7	13	3 16
19-460	1 196	1.48	13	441
17-465	0.979	0.907	11	4,39
19-475	1.689	3.4	10	3.81

Without underestimating the existing difference in the quantitative values for each measuring station, it should be pointed out that this difference ts within limited boundaries. At the same time the attempt to interpret the probability character of the joint spacings and persistence, as well as the considerable variation in the orientation showed highly complex tectonics of the area and the deposit as a whole. This requires the use of individual approaches to the evaluation of the stabihty of open stopes (rooms and pillars) for both the individual orebodies and the individual levels of the ore field,

3. IMPACT OF THE ROCK MASS DISCONTINUITY ON THE STABILITY IN ROOMS AND PILLARS

The presence of several joint sets and their position in relation to the applied stress determine the rock mass mobility coefficient. When the real rock mass is considered as a discrete medium, the angle of break 2 a depends largely on the angle of dip (DIP) of the existing tectonic joints. It should be noted that for all cases analysed in Section 2 this angle is found in the interval characterizing its most unfavourable position [45 + (p/2] Here the angle <p is an arbitrary designation Its value is determined on the basis of the quantitative characteristics of the joint system under study persistent set, subpersistcm sel, non-persistent set, intact bndges, friction angle, wavmess (if present)

From the point of view of the precondition for maximum safety in mining operations, the moms and pillars should be oriented in such a way ihai the expected cases of disturbed stability in the chosen direction should have minimum probability

The index S[characterizing the rock mass mobility in the given direction is convenient to be used in the assessment of pillar stability The necessary parameters for determining S_t are as follows [4]'

- orientation of the separate joint sets, DIP, DIP DIRECTION;
- saturation coefficient characterizing the statistical structure of the joints, b,
- the mean friction coefficient along the weakness planes, Fi ;

The saturation coefficient characterizing the statistical structure of the joints is determined on • thebasis of the hemispherical projection of the jointing (see Fig 1)

b = (n/N)g,

where

n is the number of points located within the boundaries of the peak under study,

N is the total number of points on the hemispherical projections,

g ıs the number of peaks

The index S, is determined by the expression

S, – (tg DIP x b)/Fi

The mean friction coefficient Fi is determined as a weighted mean value of the friction coefficients for each joint /5\

The rock mass mobility coefficient is determined for Block No 19 at Chelopech Mine As output data are used the quantitative and qualitative indices of discontinuity determined at measuring stations 19-475 and 19-460

These stations are located at different sublevels but arc pıaclıcaüy positioned one above the other thus allowing to consider lhem together

Table 4 Determination of index S, characterizing the rock mass mobility in Block No. 19 at Chelopech Mine

measuring station	joint sets			saturation coefficient	friction coefficient					mean fraction coefTtcteüt Fi	rock mass mobility coeffic'ent S,
	index	DIP°	DIP DIR^0	b	«1	$x_?$	x_1	X_4	x_i		
					0.6	05	0.4	03	0 1		
19460	S F	73	105	108		5	3	13		0.36	9.808
	SA	66	212	0.83		6	1	13		0 365	5.093
	Sn	68	308	0.63		4	2	14		0.35	4 44
19-47;	S_A	66	212	1.21		5	3	7		0.38	7,13
	SR	72	023	0 97		3	1	6		0.37	8.04
	SR	68	308	0.56		3	2	7		0.366	3.77

NOTE X| - highly rough; x_2 - rough, x_3 - slightly rough, X4 - smooth; x_s- smoothed

Table 4 presents the calculations for determining index S_t. Fig 2 shows the character of alteration of index S_t on the horizontal plane The directions m which the rock mass has the highest mobility, i e S_t - max, can be clearly seen. In case of considering rib pillars, they should be oriented in such a way that the long axis should coincide with the direction of highest mobility. In this case the weakness planes of sliding are closed in the rock mass and the probability of pillar failure is minimum. Fig. 2 shows that there are two directions in which the rock mass mobility S, has clearly expressed peaks. The direction 023° - 212° should be taken as preferable for the pillar orientation since m this range two planes of weakness are concentrated. The direction 105°- 308° has only one clearly expressed peak but its coincides with the absolute maximum *of* rock mass mobility From a technological point of view the final choice of pillar orientation should be made after calculating the costs for their possible strengthening using various rock bolt designs

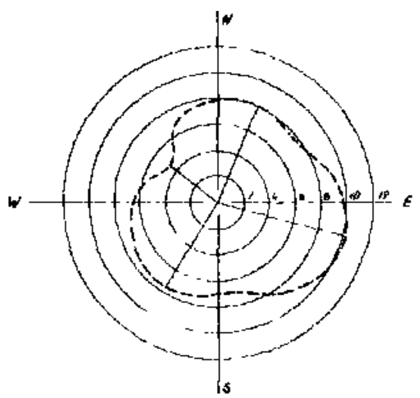

Fig 2 Diagram of index Si characterizing the rock mass mobility

When studying the room-pillar system the approach to choose only the optimal pillar orientation would be one-sided. Therefore it is necessary to assess also the impact of rock mass discontinuity on the roof • stability in stopes. In this case it is normal to use an approach similar to the well-known Mathew's Stability Graph [3]. The assessment of the effect of jointing on the roof and wall stability is made by means of a suitable quantitative index. For the purpose factor B, introduced by Mathew, is used. The numerical values of factor B are determined on the basis of the size of the angles obtained as a difference between the onentation of a given joint set (angle of dip DIP and azimuth of dip DIP DIRECTION) and the onentation of the planes of the stope under study In this case only the stope roof is considered The direction will be optimal when factor B - max The character of alteration of factor B in the horizontal plane has been studied in order to determine the optimal onentation of the stope axis Its value is determined by a 45° pitch but it is possible *to* decrease this pitch Fig. 3 shows the character of alteration of factor B using the output data on the jointing at measuring station 19-460. Since there are three joint sets at every point of the investigated horizontal plane, the result with the lowest value of factor B is accepted to be representative Though slightly expressed, the maximum of factor B can be obseivcd in the direction of 90^ü - 270° This result does not coincide with the determined optimal direction of the long axis of pillars (see Fig.2) The final choice of optimal orientation of rooms and pillars will depend on the analysis of the overhead costs for pillar strengthening and stope roof support Of particular importance, along with operational' safety, is the mineral extraction coefficient whose values have a direct impact on the final economic indices of the mining technology

4. CONCLUSION

One of the natural factors which have a considerable impact on the effectiveness of the mining technology is the rock mass discontinuity. The quantitative and qualitative indices, characterizing the jointing, allow to make an impartial assessment of the rock mass state in different parts of the ore field In open stoping methods it is absolutely necessary to assess the impact of rock mass discontinuity on the orientation of rooms and pillars. Often there are cases when the assessments for choosing the optimal direction of rooms and pillars differ considerably In such situations the overhead costs for pillar strengthening and stope roof support play a decisive role.

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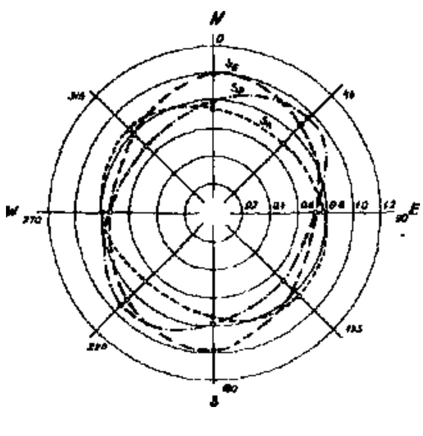

Fig 3 Character of alteration of factor B for the open stope roof at measuring station 19-460

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