

Assessment of the Stress State of Mine Workings in Shock-Hazardous Fields

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Abstract. The article presents the results of experimental data obtained by the method of slotted unloading, the presence of subhorizontal stresses in the array of gold deposits of Uzbekistan. It is shown that as a result of the study it was found that the structural structure of the array at a certain ratio of the elastic properties of the intermediate layer can make correlations in the obtained dependences. The analytical method determined the critical depth of rock-bump hazard for Kochbulak and Kyzyl-Almatin fields.

1 Introduction

The problem of impact hazard in the mines of Uzbekistan has existed since the end of the XX century. First dynamic rock pressure manifestations were observed in 1990 during the sinking of development workings in deep horizons Inpicking field. At this mine, the problem of impact hazard did not arise immediately, it increased in stages with the increase in the depth of mining. When working out the upper part of the field up to 275 m, there were no signs of the manifestation of the mountain pressure in the dynamic form. The first signs of rockbursts were observed in between chambers of the pillars in the panels developed without leaving a barrier pillar.

2 Materials and Methods

Individual features of rockbursts in the form of peeling was beginning in the depths of 300 meters or more, with the sinking of preparatory workings, there was outward signs of the rockburst hazard was widespread "chatroomresource" workings, submeridional stretch, which indicates actions in the array of subhorizontal compressive stresses. The height of the collapse in the roof of the tent in some cases reached 1-1.2 m.

Experience in the development of foreign rockburst-hazardous deposits Tashtagol ore management, Norilsk mining and metallurgical complex, the mines of the Far East etc. also shows that the first signs of rockburst hazard (shelling, shooting, heavy decolouration) initially observed in the driving of horizontal mine workings. Then, as the further deepening of mining, these manifestations of mining pressure are observed in the roof of the treatment chambers, pillars and in the preparatory workings. Based on this, to determine the critical depth of the manifestation of mountain shocks, it is advisable to first assess the

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stress – strain state of the mass of mine workings, and then give a forecast - at what depths the manifestations of mountain shocks in the workings, the roof of the chambers and in totally during the treatment workings are possible.

3 Results and Discussion

Analytical, engineering and experimental methods for determining the stress-strain state of underground mining structures are widely used in solving geomechanics problems by calculation. There are many engineering solutions for the calculation of stresses in mine workings. In the development of shock-hazardous ore deposits with complex mining and geological conditions at the first stage of engineering solutions will take the method of IGD, as the most widespread method, characterized by sufficient simplicity and reliability. According to the method of IGD [1,3] the voltage at the *i*-th point of the output circuit should be determined from the expression.

$$\sigma_i = \sigma_v K_{Z_i} + \sigma_h K_{X_i} \tag{1}$$

where is the σ_v voltage at the *i*-th point of the output circuit, MPa;

σ_v, σ_h - initial vertical and horizontal stresses of the rock mass, MPa;

K_{Z_i} - the concentration coefficient of the vertical voltage from the unit load at the *i*-th point of the output circuit;

K_{X_i} - the concentration coefficient of the horizontal stress from the unit load at the *i*-th point of the output circuit.

Values it is σ_v, σ_h possible to define analytical calculations or make according to in situ stresses. Values K_{Z_i} and K_{X_i} are determined by the value of the calculated angle (fig.1) in table 1.

Table 1. The stress concentration factor along the contour of the development production.

θ	30	40	50	60	70	80	90	100	110
K_{Z_i}	-0.64	0.45	2.96	3.44	2.44	2.10	1.91	1.64	1.95
K_{X_i}	1.20	2.97	1.66	-0.35	-0.61	-0.91	-0.87	-0.61	-0.62
θ	120	125	135	140	150	160	170	180	
K_{Z_i}	2.10	1.96	1.71	1.24	0.06	-0.58	-0.80	-0.85	
K_{X_i}	-0.38	-0.06	1.23	1.80	2.62	2.53	2.33	2.37	

The sign (-) in the tables corresponds to the tension (the acting loads were applied by compressive ones). In the case of tensile stresses, the signs of the concentration coefficients are reversed. As can be seen from the table, depending on the ratio of stress loads on the circuit workings can be very different.

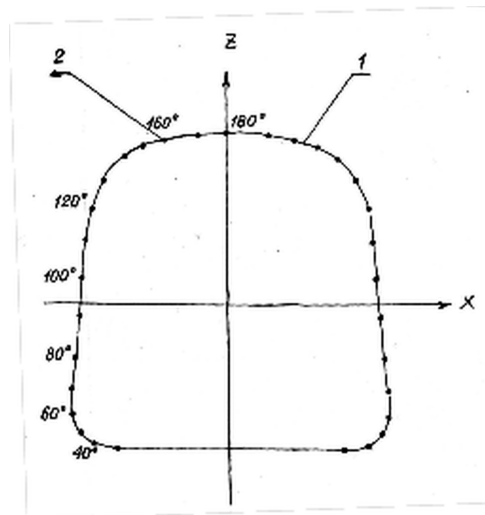


Fig. 1. The estimated development production outline: 1 - circuit output, 2 – point contour generation and the size of the estimated angle θ in degrees.

By value it is σ_i possible to define category of shock hazard of development on the basis of expression.

$$\sigma_i \leq \sigma_{sq} \cdot K_{imh} \quad (2)$$

where σ_{sq} - the tensile strength of the rocks in the sample, but the compression, MPa;
 K_{imh} - coefficient of shock hazard.

The coefficient K_{imh} is adopted in accordance with the requirements of the instructions [2]:

Category I (high impact hazard) is more than 0.8;

Category II (shock hazard) – 0.7 – 0.8;

Category III (non-hazardous) - 0.6-0.7.

Visual signs of these categories of impact hazard can be conditionally:

Category I - microdry actually rock bump;

Category II - intensive decolouration, shooting, jolts;

Category III - decolouration, peeling.

Taking into account the above, obviously, to determine the critical depth of the dynamic manifestations of mountain pressure should be consistently for each horizon to calculate the stress in the most dangerous areas of workings (angle, roof and wall) and compare them with the permissible. Permissible voltages are recommended to be taken into K_{imh} account characterizing the II category of shock hazard according to the formula

$$\sigma_{add} = \sigma_{sq} \cdot 0,7 \quad (3)$$

Then the formula (3) is transformed into:

$$\sigma_v \cdot K_{Z_i} + \sigma_h \cdot K_{X_i} \leq \sigma_{sq} \cdot 0,7 \quad (4)$$

The magnitude of the vertical stresses is σ_v determined by the expression:

$$\sigma_v = \gamma H \quad (5)$$

where γ - the volumetric weight of rocks, MP/MZ ;

H - depth of development, m.

And the horizontal stress can be calculated from the equation.

$$\sigma_h = C_p \cdot \gamma H \quad (6)$$

Where C_p is the ratio of horizontal and vertical measured stresses. Then substituting in the formula (3) the above expressions (5, 6) we obtain.

$$\gamma H \cdot K_{Z_i} + C_p \gamma H \cdot K_{X_i} \leq \sigma_{sq} \cdot 0.7 \quad (7)$$

Based on the formula (7), we find the critical depth of the mountain shocks.

$$H_{cr} \leq \frac{0.7 \cdot \sigma_{sq}}{K_s \gamma (K_{Z_i} + C_p \cdot K_{X_i})} \quad (8)$$

where H_{cr} - the critical depth of the dynamic manifestations of mountain pressure, m;
 K_s - factor of safety, taking into account the uneven distribution of stresses in the array.

The value is K_s recommended to take 1.4 - 1.5, based on the average error of measurement of stresses of rocks by modern methods, equal to 40 - 50 %.

The formula (8) can be used to estimate critical depths for workings that are outside the zone of influence of treatment works. In order to take into account the impact of underground chambers, it is necessary to know their additional stress concentration in the excavation area. Convert the formula (8).

$$H_{cr} \leq \frac{0.7 \cdot \sigma_{sq}}{K_s \gamma [(K'_{Z_i} + K'_{X_i}) + C_p (K_{X_i} + K'_{X_i})]} \quad (9)$$

where K'_{Z_i} , K'_{X_i} - the concentration coefficients of the stress of underground chambers in the area of workings, respectively, from vertical and horizontal unit loads.

The values of the coefficients can be K'_{Z_i} , K'_{X_i} determined from the graphs fig. 2, which are defined for different ratios of the chamber height h to its width $[4,5]$.

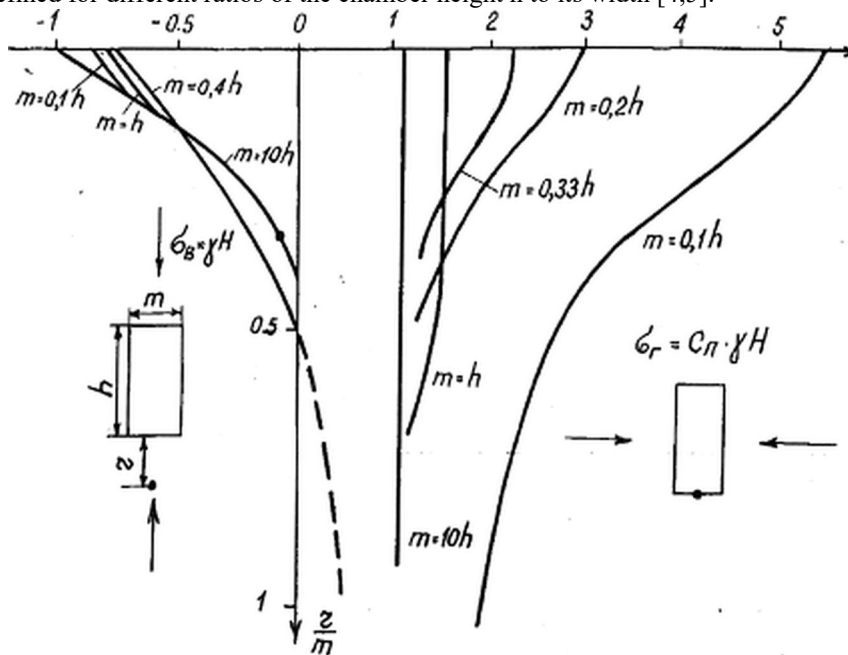


Fig. 2. The coefficients of stress concentration in underground mines: horizontal load - to the right of the r/m axis; from vertical loads on the left of the axis r/m

Table 2. Results of calculations of VAT and impact hazard of single horizontal mine workings.

Name of rocks and ores	Critical Voltage around the city, impacts 0.7 (σ_{sq}) MPa	The critical depth for a single mining, m			
		Wall	Roof	Corner clearings	Min.extra.kr ethnic depth
Kochbulak field					
Andesitic porphyry	48.8	1386	590	349	349
Lawarence	74.4	2212	900	531	531
Syenite-diorite porphyry	120.1	3313	1412	834	483
Carbonate metasomatite	44.4	1257	535	316	316
Quartz sericite metasomatite	55.3	1537	655	386	386
Average					415-450
Kyzylalmasay field					
Quartz (ore)	57.0	1709	713	423	423
Shale, quartz	69.0	2069	863	513	513
Slantsy metamorphosed	63.6	1914	798	474	474
Felsites	60.5	1728	721	428	428
Syenite-diorite porphyry	120.1	3507	1463	869	541
Average					480-510

Using the above method, the VAT assessment of mine workings outside the zone of influence of treatment works in the three most dangerous areas on the sides, the roof and the angles of workings was carried out (Fig.1). The initial data for the calculations were the result of determining the initial stresses of mountain ranges and the physical and mechanical properties of rocks and ores. In this case, the following stress concentration coefficients were adopted (table.1) [7,8].

In the wall of production $\theta = 100^{\circ}$, $K_v = 1.84$, $K_h = -0.81$.

In the roof of the mine working $\theta = 180^{\circ}$, $Q = -0.85$, $K_h = 2.37$.

In the angle of production $\theta = 140^{\circ}$, $K_v = 1.24$, $K_h = 1.80$.

4 Conclusion

Calculations are given for the condition of passage of workings along the strike of ore bodies, since in this case they are vertical (σ_v) and maximum horizontal stresses (σ_h). How to find the results of calculations (tab.2) the most intense and rockburst-hazardous corners of excavations. Due to the different rock strength, the critical depth varies widely. To assess the critical depth, their average values obtained for different rocks in the most dangerous areas (excavation angles) were taken. The critical depth was in the range of 450 m to Nicaragua and 510 m for Kyzyl-Almatin fields [6–9].

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