Modelling of rock massifs tension at underground ore mining

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Abstract
Obtained by photoelastic method on the models made of optically active materials research findings of ore – hosting massif behavior where anthropogenic tension develops under the exploitation influence are given in the article. Conditions of massif elements action with tension arranging on hazard level of its deformability depending on critical tension are considered separately.
Key words: DEPOSIT, ORE, TENSION, DEFORMATIONS, PHOTOELASTICITY, DESTRUCTION.

During the process of mineral deposits exploitation large volumes of relocatable rocks and concentration of output on restricted areas of the Earth crust form tension and deformations of the crust up to the critical values. Complex of induced geomechanical processes with natural geodynamical processes disturbs a geodynamical balance in the upper part of the Earth crust, which activates catastrophic phenomena on the ground surface [1]. At underground mining the ore extraction from pillars of the stope of rocks deformation leads to the ore dilution by stowage material and pillar buckling failure is in danger of massif destruction and ground surface above it. Stability of ore – hosting rock massifs is determined by the level of tension on the boundaries of stope ore, which is provided by filling the voids by consolidating concrete mixtures that requires high expenses on consolidating stowing mixtures production. Validation of the parameters of consolidating stowing requires geomechanical verification with the proof of stowing effectiveness in comparison with the technology of open worked-out area. One of the methods that solve the problem is the modelling of massif behavior at tension parameters' changing by photoelastic method [2]. The most complex is the mining of ore deposits concentrated in the large deposits which often are developed with the usage of open and underground mining methods. The main criterion of such combining is critical tension exclusion in massifs [3]. The method of research organization includes selection of optically active materials; designing of the equipment that allows loading the models at various slope angles of main direction and magnitude of force with taking horizontal thrust into account; providing of photorecording of the modelling results [4].

The models were made of optically active material polyurethane with 1 fringe value equal to 7.6 MPa for the following conditions: the depth of excavation location from the day surface is 350 m, volume weight of the overlying rocks 3.02 t/m^3. For the determination of stability of the given contour point the strength condition is analyzed

$$\sigma_1 - \sigma_2 \geq sin\delta(\sigma_1 + \sigma_2) + \sigma_{сж} + (1 - sin\delta), \quad (1)$$

where σ_1, σ_2 are tension in the contour point; δ is an angle of an inner friction, 30^0; $\sigma_{сж}$ is the rock rigidity, 1400-1600 MPa. In-situ tension

$$G_н = \gamma H \frac{G_м}{\sigma_в}, \quad (2)$$

where γ is ore density and host rocks density, t/m^3, H is the depth of point location from the day surface, m.; $\sigma_в$ is the tension in a model.

For the tension determination in a model the following equation is used

$$\sigma_м = \sigma^{1.0} \times n, \quad (3)$$

where $\sigma^{1.0}$ = 0,1 kgf/sm^2 for one strip; n - is a strip number in the model point of interest.

For tension determination in a model and in-situ the following equation is used:

$$G_н = \gamma H \frac{G_м}{k}, \quad (4)$$

where $G_н$ is in-situ tension, MPa; $G_м$ is a tension in a model, MPa; k is similarity coefficient; γ is the density of ores and rocks, kg/m^3; H is the depth of point location from the day surface.

Massif state was investigated under the following conditions: horizontal thrust 0.5; 1.0; 1.5; slope angle of main direction and magnitude of force to the vertical axis α = 0 at each value of horizontal thrust; stowing module E = 0.1 MPa, module of host rocks 1.4 MPa; chambers without and with stowing. Maximum values of tension for safety exploitation providing were determined at the modelling of extraction chambers without cavities stowing. Investigated variants of massif managing are characterized by tension value measured in two directions: chambers and interchamber pillar of experiment block and in chamber cross section. At the coefficient of the horizontal thrust λ = 0.5 (Fig.1) maximum tension in the zones of arch keystones and in chambers' walls are equal to

7.6 x 7.5 = 57 MPa and in the arch apex of ceiling it is 7.6 x 2 = 15 MPa. In the interchamber pillar maximum pressure tension: 7.6 x 6.5 = 49 MPa.At the coefficient of the horizontal thrust λ = 1.0 in the zones of arch keystones, ceiling and chamber walls (Fig. 2) the tension is 7.6 x 6.5 = 49 MPa. The same tension is in the chamber ceiling arch. In a interchamber pillar the maximum tension decrease: 7.6 x 5.5 = 42 MPa. At the coefficient of the horizontal thrust λ = 1.5 in the zones of arch keystones of ceiling and the chambers' wall (Fig.3) tension is 7.6 x 6.5 = 49 MPa and in the ceiling arch up to 7.6 x 8.5 = 64 MPa in contrast to 15 at the coefficient of the horizontal thrust 0.5. Characteristic zones of maximum tension are the ceiling arch and the bottom. The measured tension in the ceiling was: at the coefficient of horizontal thrust λ = 0.5 7.6 x 5.5 = 41 MPa; at the coefficient of horizontal thrust λ = 1.0 7.6 x 13.5 = 102 MPa; at the coefficient of horizontal thrust λ = 1.5 7.6 x 18.5 = 140 MPa. Maximum tension develops at the coefficient of horizontal thrust 1.5.

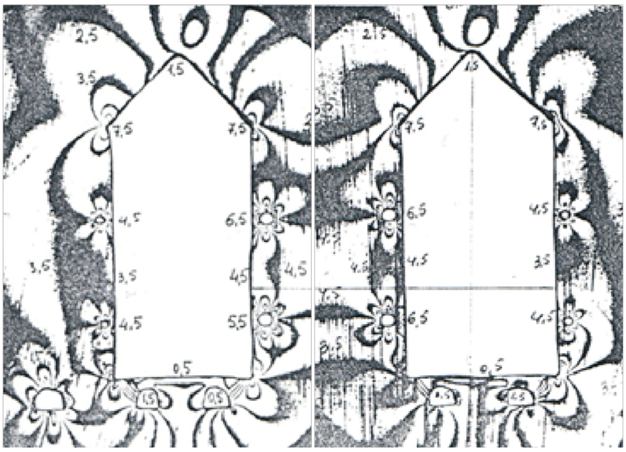

Figure 1. Isochrome fields at the coefficient of horizontal thrust 0.5: on the left – open chamber; on the right – filled chamber

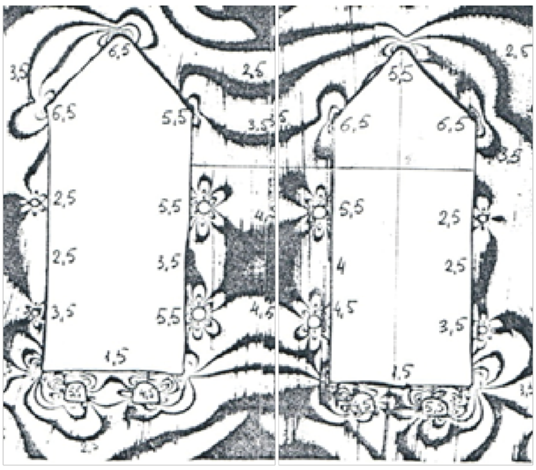

Figure 2. Isochrome fields at the coefficient of horizontal thrust 1.0: on the left – open chamber; on the right – filled chamber

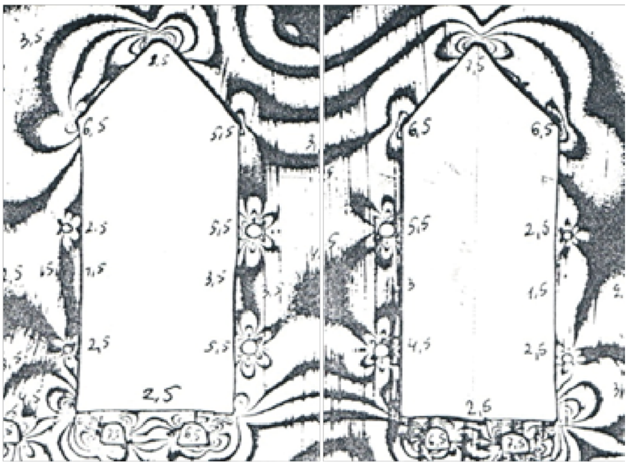

Figure 3. Isochrome fields at the coefficient of horizontal thrust 1.5: on the left – open chamber; on the right – filled chamber

Tension fields in the massif in the zone of rocks arch above the stope are illustrated in the Fig.4.

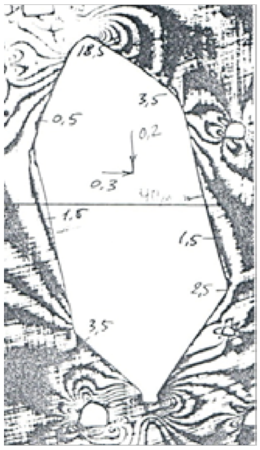

Figure 4. Isochrome tension in the arch of the stope

Investigation of the models from low-molecular materials with photorecording of modelling results allows assessing the level of anthropogenic tension. Optimization of the parameters of massif condition management is an important factor of the providing of exploitation economic effectiveness [5-13].

Conclusions

Investigation of the models from low-molecular materials with photorecording of modelling results allows assessing the level of anthropogenic tension and optimizing parameters of mining on the factor of earth surface preserving from destruction. It is possible to range tension in the surroundings of stope ores excavations and ore-hosting massif on the level of destruction hazard: 1) The highest tension is in chamber ceiling; 2) Chamber stowing decreases tension level up to 2 times; 3) Tension concentration is close to critical in case of stowing absence in the zone of interchamber pillar that's why pillar extraction is dangerous, it can lead to massif destruction.

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