The problem of controlling the mountain pressure when underground developing of ore deposits

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ABSTRACT
Here the problem of rock mass controlling when exploring the sloping ore deposits is considered. The method of determination of stresses, deformations and displacements of thick mass under the sagging roofing over the worked out space is given.

RÉSUMÉ
Ici le problème de contrôle de masse de roche en explorant les gisements de minerai étant en pente est considéré. La méthode pour la détermination de tensions, les déformations et les déplacements de masse épaisse sous la toiture sagging sur l'espace calculé est donnée.

Keywords: Sandstone; Aleurolit; Sliding; Barrier pillars; Interchamber pillars

1 INTRODUCTION

The increasing development of mining industry in the region, huge prospects of its further development, connected with the increase of depth of mining works and exploitation of more and more complex deposits put forward to the first priority the problem of rock masses mechanics. The proper record–keeping of geo-mechanical processes that take place in rock masses, and finding the reliable scientific methods of its controlling have great importance because of constant complication the geological and technical conditions of ore deposits exploitation. In particular it is related to underground mining of huge ore deposits in stable capacious rocks. The high stability of latters made possible applying the method of open worked out space. Its economic effectiveness to the large extent depends on the well–grounded ways of calculation of stability and strength of underground excavations and on defining the optimal parameters of the mining system.

Applying the system of open worked out space mining supposes the keeping up rocks' balance during its exploitation and after completion if the failure of rocks is impossible for some reasons. That is why the necessary conditions for the use of these systems are high requirements for the stability of worked out area.

2 PROBLEM STATEMENT

One of the main technological problems in the process of minerals exploitation is worked out area's supporting. There is a variant of natural supporting of worked out space with high technical and economical factors – the chamber–and–pillar system. It is characterized with small volume of the preparatory workings and the good possibility for self–propelling equipment for drilling, loading and transporting the extracted ore. In the case of rather firm rocks and high strength ore mining the chamber–and–pillar system with leaving wide barrier pillars is used. The main task especially in the case of deep horizons exploitation is ensuring the stability of worked out area at maximum mining extraction.

During the works in rock mass in some areas the support for overlying stratum is liquidated. This breaks the balance that was in untouched mass. The balance is recovered by proper load distribution between pillars supporting the overlying stratum by forming the natural balance arch (Aitaliyev and Takishov 1999; Takishov 2000). Under these conditions the main mass load will be on the barrier–support pillars (Fig.1a) and interchamber pillars will support only the under arch part of the mass (Fig.1b). The natural balance arch is formed when sagging of overlying stratum over the worked out space. Depending on the size of sagging of overlying stratum the stressed–deformed condition of rock mass is formed, which determines its stability or instability.

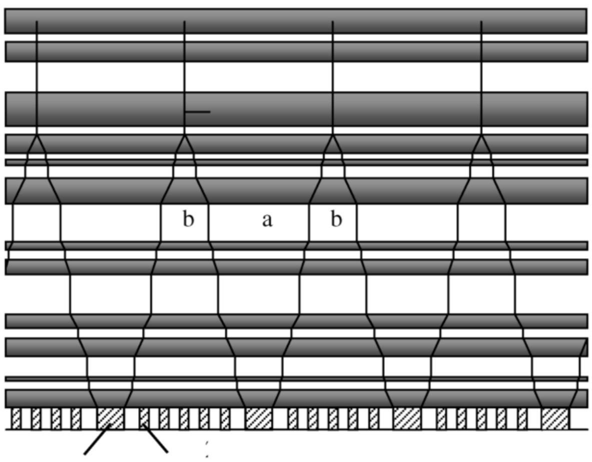

Figure 1. – Barriers pillar; 2 – Inter cameras pillar

Thus, the problem of defining the stressed–deformed condition of rock mass above the worked out area in the range of elastic arch sagging is stated. Mountain-geological and physics–mechanical properties of rocks are taken into account.

3 SOLUTION OF THE PROBLEM

The research objects are ore deposits in which the hard rock layers are alternated with low strength capacious rocks. The research is being conducted on the Zhezkazgan ore deposit which is known as sedimentary sandy–alevrolitum rocks with

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copper – containing sand stones (Satpaev 1967). Ore–containing stratum is represented by sloping layers of low strength red and strong grey sand stones. Rock mass stability is connected with formation of natural balance arch and grey bends condition. As for red sandstone it is somewhat lower the depth of vertical breaking off (y_{90}) under the overlying stratum sagging over the worked out area. And it is cut by glide lines.

Mathematical modeling of geological conditions of red and grey sandstone bends' natural bedding over the sloping ore body is being conducted. The idealized form of geological cross-section of Zlotaust bedding (Zhezkazgan ore–deposit) is shown on Fig.1 the red –colored bends are painted.

The stressed–deformed condition of every strip between the displacement boundaries and contact lines of rock mass types over barrier and interchamber pillars is being researched simulated in the form of rectangular strips, which interaction with rock mass is defined by the following loads: $q_{11i} - i^{th}$ bend over the barrier pillars with overlying; $q_{12i} - i^{th}$ bend over barrier pillars with under lying; $q_{21i} - i^{th}$ bend over interchamber pillars with over lying; $q_{22i} - i^{th}$ bend over interchamber pillars with bottom lying; $q_i -$ horizontal component and $Q_i -$ with the crossed interaction force $i^{th} -$ neighboring bends over the barrier and interchamber pillars.

The crossed component Q_i for the strips over interchamber pillars characterizes the part of the load supporting it at the ends, under the sagging of overlying stratum over the worked out area, resulting in some additional load on the barrier pillars.

The problem of defining stress, deformation and displacement of carrier elements is solved using the methods of deforming firm bodies mechanics. The horizontal component of strips interaction over interchamber and barrier pillars is found. The equations for defining the overlying stratum's stress over the interchamber pillars are as following:

$$\sigma_{2xi} = \frac{6Q_i}{h_i^3 l_{2i}} \left\{ \left(l_{2i}^2 - x^2 \right) y - \frac{2}{3} \left[\left(\frac{h_i}{2} \right)^2 - y^2 \right] y \right\} - q_i$$

$$\sigma_{2yi} = \frac{2Q_i}{h_i^3 l_{2i}} \left[\left(\frac{h_i}{2} \right)^2 - y^2 \right] y + \frac{q_{21i} - q_{22i}}{h_i} y - \frac{q_{21i} + q_{22i}}{2}$$

$$\tau_{2i} = -\frac{6Q_i}{l_{2i} h_i^3} \left[\left(\frac{h_i}{2} \right)^2 - y^2 \right] x \qquad (1)$$

where $h_i -$ is the height of i^{th} grey strip of overlying stratum; $l_{2i} -$ half of the i^{th} grey strip over interchamber pillars.

Here the horizontal component of strips' interaction over the interchamber and barrier pillars is defined as following:

$$q_i = -\frac{\nu}{2(1-\nu)} \left(\frac{q_{11i} - q_{12i} + q_{21i} - q_{22i}}{h_i} y - \frac{q_{11i} + q_{12i} + q_{21i} + q_{22i}}{2} \right) \qquad (2)$$

where ν - the crossed deformations coefficient

In particular case, if in (2) consider $q_{11i} = q_{12i} = q_{21i} = q_{22i}$ then the relation between horizontal and vertical stresses is expressed by outward pressure by Dinnik A.N.

e have the following equation to define the displacement of overlying stratum over the interchamber pillars:

$$u_{2i} = \frac{1-\nu^2}{E} \Bigg\{ \frac{2Q_i}{h_i^3 l_{2i}} \Bigg\{ \Bigg\{ \left(3l_{2i}^2 - x^2 \right) - 2 \left[\left(\frac{h_i}{2} \right)^2 - y^2 \right] \Bigg\} x + \left[2\left(l_{2i}^2 + l_{1i}^2 \right) - h_i^2 \right] l_{2i} \Bigg\} y -$$
$$- q_i x - \left(\frac{\nu}{1-\nu} \right) \Bigg\{ \Bigg\{ \frac{2Q_i}{h_i^2 l_{2i}} \left[\left(\frac{h_i}{2} \right)^2 - y^2 \right] x - (q_{21i} - q_{22i})(l_{2i} - x) - \frac{q_{2i}}{2} (l_{2i} - l_{1i}) - Q_i +$$
$$+ (q_{11i} - q_{12i}) l_{1i} \Big\} \frac{y}{h_i} - \frac{(q_{21i} + q_{22i})}{2} x - \frac{q_{4i}}{4} (l_{1i} + l_{2i}) \Bigg\} \Bigg\} + \frac{6(1+\nu)}{Eh_i} Q_i y;$$

$$\upsilon_{2i} = \left(\frac{1-\nu^2}{E} \right) \Bigg\{ \frac{2Q_i}{h_i^3 l_{2i}} \Bigg\{ \left[\left(\frac{h_i}{2} \right)^2 - \frac{y^2}{2} \right] \frac{y^2}{2} + \Big\{ \Big\{ \Big[h_i^2 - 2\left(l_{2i}^2 + l_{1i}^2 \right) \Big] \left(x + l_{2i} \right) +$$
$$+ \frac{1}{4} \Big[5\left(l_{2i}^3 - l_{1i}^3 \right) - h_i^2 \left(l_{2i} - l_{1i} \right) \Big] \Big\} l_{2i} \Bigg\} \Bigg\} + \left[\frac{1}{h_i} (q_{21i} - q_{22i}) y - (q_{21i} + q_{22i}) \right] \frac{y}{2} -$$
$$- \left(\frac{\nu}{1-\nu} \right) \Bigg\{ \frac{6Q_i}{h_i^3 l_{2i}} \Bigg\{ \left(l_{2i}^2 - x^2 \right) - \frac{2}{3} \left[\left(\frac{h_i}{2} \right)^2 - \frac{y^2}{2} \right] \Bigg\} \frac{y^2}{2} + \Bigg\{ \Bigg[\frac{q_{2i}}{2} \left(l_{2i} - l_{1i} \right) + Q_i +$$
$$+ (q_{21i} - q_{22i}) l_{2i} - (q_{11i} - q_{12i}) l_{1i} \Big] (x + l_{2i}) - \frac{1}{4} (l_{2i} - l_{1i}) \left[q_{1i} (l_{2i} + l_{1i}) + Q_i \right] \Bigg\} \frac{1}{h_i} +$$
$$+ \frac{1}{4} \left(\frac{\nu}{1-\nu} \right) \left(\frac{q_{2i}}{h_i} y - q_{3i} \right) y \Bigg\} - \left[\frac{6Q_i}{h_i^2 l_{2i}} \left(l_{2i}^2 - \frac{x^2}{6} \right) - \frac{Q_i}{l_{2i}} + \frac{\nu}{2(1+\nu)} \left(q_{1i} - \frac{Q_i}{l_{2i}} \right) \right] \frac{x^2}{2h_i} \Bigg\} -$$
$$- \frac{3(1+\nu)}{2E} \frac{Q_i}{l_{2i} h_i} \left\{ x^2 + \left[\left(l_{1i} + 3l_{2i} \right) + 4x \right] l_{2i} \right\}, \qquad (3)$$

where $q_{2i} = q_{11i} - q_{12i} + q_{21i} - q_{22i}$,

$q_{4i} = q_{11i} + q_{12i} - q_{21i} - q_{22i}$,

$q_{1i} = q_{11i} - q_{12i} - q_{21i} + q_{22i}$,

$q_{3i} = q_{11i} + q_{12i} + q_{21i} + q_{22i}$.

By similar researches the relations for defining the overlying stratum's stress and displacement over the barrier pillars are defined.

The calculations of stress component and displacement of every grey bend if $h_i = 7m$, $q_{11i} = 21{,}66MPa$, $q_{12i} = 21{,}87MPa$, $q_{21i} = 1{,}45MPa$, $q_{22i} = 1{,}62MPa$, $Q_i = 0{,}604MN$, $\nu = 0{,}22$, $E = 20000MPa$, $\gamma = 0{,}026MN/m^3$, $l_{1i} = 19m$, $l_{2i} = 46m$ have been done. Here in Fig.1 the bottom grey bend's mass (Fig.1) stresses and deformations are given and their conditions determine the worked out area's roofing stability.

Stress distribution epures and curved axis are shown in Fig. 2. Tangential stresses are shown on the strips joints at $x = \pm l$, where it accepts maximum value. Horizontal stress epures are introduced "a" at $y = -h_i/2$, "b" at y = 0, "c" at $y = +h_i/2$. Though the strip over the barrier and interchamber pillars was studied separately on the account of observing the boundary conditions, the stress distribution of the overlying stratum over the worked out area still has its logic link and the flexed axis (Fig.2d) has smooth transitions. Vertical stresses σ_{yi} reach their maximum value over the barrier and horizontal σ_{xi} under the arch part over the interchamber pillars where the sagging also reaches its maximum value.

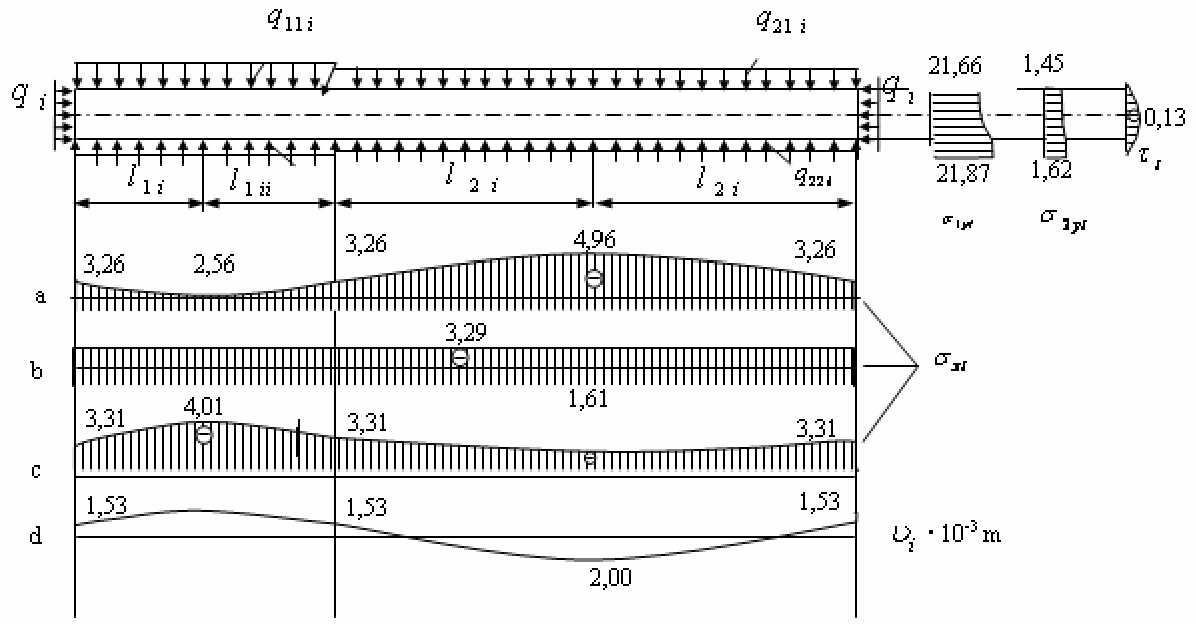

Figure 2.

4 CONCLUSION

1. The analytical method of the stresses, deformations and rock mass displacements over the worked out area has been developed.
2. The suggested approach makes it possible to determine the condition of every i^{th} strip and in general to estimate the stability of overlying stratum.

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