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A TECHNOLOGY FOR MINING ORE VEINS UNDER COMPLEX MINING CONDITIONS

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ABSTRACT: The factors characterizing the concept of complex mining conditions during the exploitation of vein-type ore deposits in Bulgaria are formulated. A study was made to determine the type of packing material and the sequence of mining operations during the exploitation of the reserves in the protective pillar of the Metlivko shaft at Goroubso Mining Company. The method of finite elements was used for the purpose. The character of displacements around the stopes, on the surface terrain and in the Metlivko shaft has been analyzed. The results obtained served as a basis for developing a project for mining the reserves, which is being implemented.

1. INTRODUCTION

Some ore deposits in Bulgaria can be classified as thick ore veins. These veins, together with the host rocks, form a low strength rock mass. The deposits are characterized by a relatively low ore-mineral content. In many cases the exploitation of these deposits necessitates the protection of surface equipment and development workings. This combination of factors can be termed complex mining conditions.

This paper presents a study on the choice and practical implementation of a technology for mining the reserves in the protective pillar of the Metlivko shaft at Goroubso Mining Company. The reserves are being mined on level 500 and level 450. The preliminary studies have shown that because of the low assay grade, the use of a hardening packing technology cannot ensure positive economic results. The only applicable methods of mining at present seem to be dry packing and hydraulic filling. Following the tendency for achieving high rates of mining as well as bearing in mind the narrow specialization of the personnel in using shrinkage stoping, we also had to consider the possibilities of applying the shrinkage- stoping-with-waste-filling method. The latter means that at a gfven moment, . before the packing starts, the working chamber is in a state of empty space. Therefore, three technologies are applicable in mining the reserves in the protective pillar: dry packing (s.zap.), hydraulic filling (h.zap.) and shrinkage-stoping-with-waste-filling (pr.prostr).

2. FORMULATION OF THE TASK

The three technologies presented above are obviously unequal" regarding costs and economic effect. But in this case the primary criterion for choosing the mining method should be the evaluation of the state of the Metlivko shaft and surface equipment. For the purpose we have used a solution based on the method of finite elements (MFE). A calculation scheme, consisting of 530 units (N_u = 530) and 500 quadrangular elements (N_e = 500), has been constructed. A plane problem is posed, the approximation displacement being of the type:

$$U = aj + 0l2X + ct3y + o\hat{}xy$$

The problem can be solved provided the rock mass is assumed to be an elastic medium. The character of displacements, i.e. their magnitude and direction, was studied. The evaluation of the mining operations in the Metlivko shaft was made in compliance with the operative Instructions. Table 1 shows the data on the characteristics of the medium, which are used in the calculation scheme for determining the displacements around the stopes and on the surface by the MFE.

Index 1 in the table corresponds to the properties of the packing material during stowing, and index 2 shows the change in the properties as a result of compaction.

Table 1

Type of medium	Density γ kN/m³	Modulus of deformation E,MPa	Poisson's ratio u
Lead-zinc ore	28	2800	0 28
Host rocks (gneisses)	26 7	5000	0 25
Dry packing -1	192	25	0 38
Dry packing - 2	215	40	0 33
Hydraulic filling -1	16 0	20	0 41
Hydraulic filling - 2	18 0	50	0 32

The study for determining the displacements around the stopes and on the surface aims to evaluate the effect of the proposed mining technologies on the state of the Metlivko shaft and the industrial site on the surface The following mining conditions are accepted as basic and determining the choice of the technological solution for the exploitation of the reserves within the boundaries of the protective pillar

- ore vein thickness
- type of packing material
- sequence of mining the reserves on level 500
- development sequence of mining operations on level 500 and level 450

First a study was made to determine the displacements around the stopes and on the surface during exploitation of the reserves only on level 500 The calculation scheme allows to determine the vertical displacements U_y and the horizontal displacements U_x. They are represented in the form of maps with isolines On each map are plotted the coordinates of the points determining the boundary conditions, the position of the ore vein, the earth's surface and the Metlivko shaft

Metlivko Uy (pr prostr)

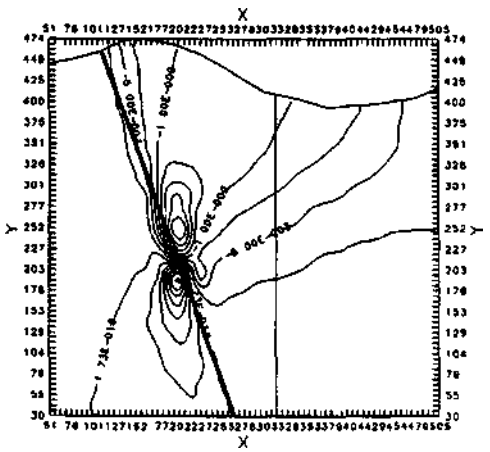

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Figure 1 shows a map with the distribution of the vertical displacements U_y during exploitation of the reserves only on level 500 by shrinkage-stoping-with-waste-filling (pr prostr.)

Metlivko Uy (pr prostr. - pr.prostr.)

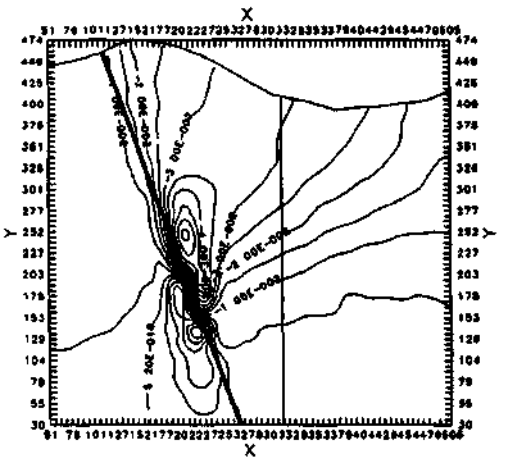

Fig 2

Figure 2 shows the character of distribution of the vertical displacements U_y when using shrinkage-stoping-with-waste-filling on level 500 and level 450 (pr prostr -pr prostr)

It is interesting to note that the three mining technologies considered have the same character of distribution of the vertical and horizontal displacements In the three cases a distinct maximum can be observed both for the horizontal and the vertical displacements, which is directly related to the way of development of the mining operations

In order to evaluate the effect of the mining operations during exploitation of the reserves on level 450 as well, a study was conducted to determine the displacements around the stopes and on the surface during simultaneous operations on level 450 and level 500 A preliminary assumption was made that the mining operations on level 450 will start after stopping the mining operations on level 500 Thus the packing material will compact at the expense of its compression properties and the displacements of the host rocks, which is taken into account by introducing new characteristics of the medium given in Table 1 This enabled us to consider a total of seven combinations of mining technologies on level 500 and level 450 We should point out that the distribution of the displacements around the stopes and on the surface has the same character for all seven combinations With respect to quality, a

certain similarity with the maps characterizing the displacements during exploitation of the reserves **only on level 500 is observed. With** respect **to quantity, however, there is a** considerable difference, **which is easy to explain bearing in mind the large mining area. Of special significance are the data obtained about the character of the** distribution of **displacements in relation to the choice of a** place for **driving the development workings. An important economic effect is achieved with regard** to their **maintenance, especially during the last** stage when **the mining operations are performed in the** immediate **proximity to the respective level. The** character of **the displacements around the** stope during the **exploitation of the reserves on level** 500 is shown in **Figure 3.**

Metlivko - h.500, pr. prostr.

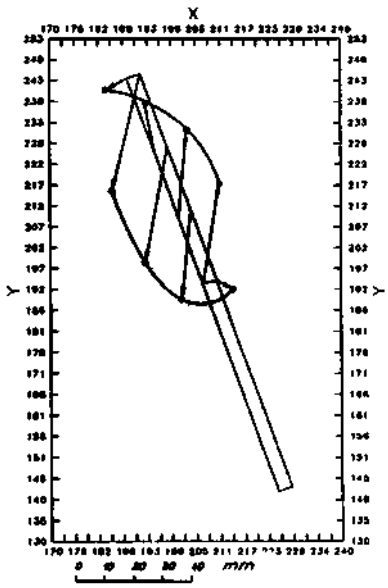

Fig 3

3. DISCUSSION

The investigation carried out to determine the displacements around the stopes and on the surface **enabled us to draw** some important conclusions about the way of development of the mining operations during the practical implementation of the project for mining the reserves within the boundaries of the protective pillar of the Metlivko shaft

The type of packing material does not affect considerably the magnitude of displacements around the stope and on the surface provided that only the reserves on level 500 are mined

When mining the reserves on level 450 as **well,** the magnitude of displacements reaches considerably higher values thus having an effect on the Metlivko shaft and surface equipment. The calculations have shown that the combinations dry packing on level 500 - dry packing on level 450, as well as hydraulic filling on level 500 - dry packing on level 450 are of equal value. It is inadmissible to use shrinkage-stoping-with-waste-filling during simultaneous exploitation of the reserves on level 500 and level 450.

In sections where the ore vein is over 3 m thick the only possible mining technology is hydraulic filling-with-descending-slicing This method is characterized by high consumption of timber so that the authors are faced with the pressing need to develop an alternative technology for supporting the roof rocks in the extraction workings

CONCLUSION

The program system developed by applying the method of finite elements for determining the displacements around the stopes and on the surface allows to obtain data about the magnitude of displacements and their orientation during the whole stage of development of the mining operations. The graphic materials obtained are constantly enriched with new data which, if combined with in-situ measurements of the studied variables (displacements, deformations, stresses), can be adopted as a complete technology On the basis of the results obtained a project was developed for the exploitation of the reserves, which is being implemented in mining the protective pillar of the Metlivko shaft at Goroubso Mining Company

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