MODERN METHODS OF SOFTWARE MODELING ON TECHNOGENIC DEPOSIT - OLD FLOTATION TAILING PIT - BOR

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Abstract:
Technogenic deposit of copper from the old flotation tailings pit - Bor was created by the deposition of flotation tailings that was created by processing ore from several ore bodies of the Bor copper deposits. The deposit of copper was explored with drilling from the surface. Modeling of the distribution of copper and gold in the man-made deposit Old flotation tailing pit - Bor was carried out using computer technology. It included a detailed geological and statistical analysis of copper and gold content data. Modeling of the distribution of copper and gold was also carried out using a block model of the deposit, as the most illustrative representation, of which the previously mentioned elements are an integral part. In the case of 'mini-blocks' that are crossed by the boundary contour, the "GEMS" program uses a calculated percentage of the block that enters the contour, that is, it takes only the part of the block that is inside the contour as reserves.

Keywords:
Geological exploration, Geomodel, Gemcom, 3D.

INTRODUCTION

The old flotation tailing pit - Bor is located in the area of the city of Bor, which is the administrative seat of the Bor district and, at the same time, the environment where various economic activities related to the exploitation of copper and gold deposits are carried out in the mines of the former economic giant RTB Bor, now Serbia ZiJin Copper, doo Bor, and Serbia ZiJin mining doo Bor (formerly Rakita exploration Bor). The processing of copper and gold ore created tailings that have a negative impact on the environment and that must be rehabilitated. Created tailings were formed over a long period, since the beginning of the exploitation and processing of copper and gold ore, using different technological procedures, with different utilization of useful components, which means that a significant amount of copper and gold remained in them, which is probably possible to valorize.

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Technogenic copper deposit The old flotation tailings pit in Bor was created by depositing the material that remained after the flotation processing of the ore from the old Bor open pit and from the ore bodies that were excavated underground (Figure 1). The deposited material is predominantly made of silt, dust, and sand and contains different concentrations of copper, gold, and accompanying ore elements. Their quantity is considerable, because due to the imperfection of the technological procedures of ore processing, its complex mineralogical and petrological characteristics, and other factors, only about 85% of the copper from the primary ore was separated into the copper concentrate, while the rest of about 15% was separated into the flotation tailings. It is similar to other useful components. Gold flotation recovery ranged between 20% and 30%.

The general physical characteristics and internal structure of the man-made deposit Old flotation tailings (Field 1 and Field 2) are determined by the characteristics of its immediate substrate and the way the landfill was formed.

Based on geological documentation and profiles, the apparent thickness of man-made material ranges from 25 m to 65 m.

Field 1 has an oval shape in plan. The dimension of the longer axis of Field 1 of the old Bor flotation tailings, in the direction NW - SE, is about 400 m, and the shorter (SW - NE) about 300 m.

Field 2 has an oval shape in plan. The dimension of the longer axis of Field 2 of the old Bor flotation tailings, in the direction NW - SE, is about 800 m, and the shorter (SW - NE) about 600 m.

The entire area (Field 1 and Field 2) has an elliptical shape, and its area is about 0.6 km^2.

2. MODELING OF THE DISTRIBUTION OF COPPER AND GOLD IN THE TECHNOGENIC DEPOSIT OLD FLOTATION TAILINGS - BOR

Modeling of the distribution of copper and gold in the man-made deposit Old flotation tailings - Bor was carried out using computer technology. It included a detailed geological and statistical analysis of data on copper and gold content in analyzed samples from explorational drill holes from Field 1 and Field 2, their mutual connection in space, statistical analysis through the coefficient of variation, graphical interpretation in the form of transverse and longitudinal vertical sections, as well as an analysis of spatial distribution by profiles and levels. Modeling of the distribution of copper and gold was also carried out using a block model of the deposit, as the most illustrative representation, of which the previously mentioned elements are an integral part.

Modeling of the man-made deposit The old flotation tailings pit Bor was carried out using computer technology for the calculation of ore reserves, which enables the formation of a digital block model of the deposit and the creation of appropriate, computer-generated, graphic documentation.

The volume of each small (mini) block was calculated by multiplying the interpolated value of the thickness of the ore (in the specific case, flotation tailings) in its center with the cross-sectional area equal for all small blocks.

Figure 1. Old flotation tailing pit - Bor.

In the case of mini-blocks that are crossed by the boundary contour, the "GEMS" program (Figure 2) used calculates the percentage of the block that enters the contour, that is, it takes only the part of the block that is inside the separated contour as reserves.

Computer processing of analytical and other geological data collected during geological and accompanying research in the man-made deposit Old flotation tailings pit Bor was started by entering data into the appropriate "acQuire" database from completed drill holes.

All individual drill holes displayed in the database have name tags and contain data on the height of the drill hole, coordinates and length, data on the measured deviation of the drill hole, and the results of chemical analyses of individual samples.

Basic statistical data on the distribution of analyzed elements for all individual samples that were entered into the block model of the deposit Old Flotation Tailings Pond Bor are shown in Table 1.

From Table 1, it is possible to see that the coefficient of variation of the copper content in the man-made deposit Old flotation tailings pit Bor is 57.02%, which indicates its even distribution. The coefficient of variation of gold content is 241.99%, which indicates a very uneven distribution of gold in the man-made deposit.

After forming a solid model (closed 3D models) of the man-made deposit Old flotation tailings pit Bor and defining the reference surface, interpretation of the deposit was performed on vertical and horizontal parallel sections. The interpretation of the deposit and its immediate surroundings through the corresponding block model implies their division into blocks of regular dimensions (Figure 3).

Figure 2. Gemcom GEMS.

Table 1. Basic statistical data on composite samples from the man-made deposit Old flotation tailings pit Bor.

Element	Cu_{uk}, % (Copper)	Au, g/t (Gold)	Ag, g/t (Silver)
Number of data	2,987	1,599	1,350
Minimum value	0.005	0.010	0.200
Maximum value	2,800	41,500	151,947
Median	0.260	0.330	1,192
Coefficient of variation	57.026	241,991	333,604

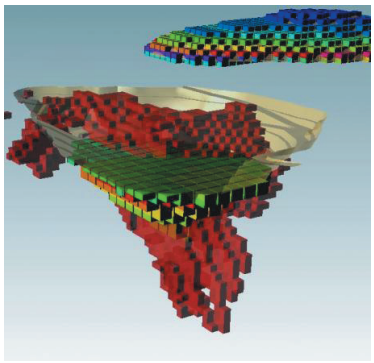

Figure 3. 3D Block model.

Considering the above, the block size of 5x5x5 m was adopted for both Field 1 and Field 2. The block model covers the space with the geodetic coordinates, with approximate dimensions of 1,240x700 m.

The formed block model contained:

- 260 lines
- 150 columns and
- 30 levels (+400 to +250).

In the formed block model, a 45° rotation of the blocks was applied to orient the blocks in the direction of providing the technogenic deposit.

By creating the block model, the following values were defined for each block:

- Rock type;
- Volume mass;
- Content of useful and harmful components: Cu (%), Au (g/t), Ag (g/t), and S (%).
- The economic value of the block, that is, the amount of useful components in the block or the profit that is achieved by mining that block.

The determination of the content of the mentioned components (Cu, Au, Ag, and S) in the blocks was started with the creation of variograms, which represent the basis for the calculation ("estimation") of the content (Figure 4).

Legend:

- variogram from data

- theoretical variogram

1. spherical – variogram type; - Spherical, variogram range; variogram threshold ;
2. "nugget effect" – a grouping of data-compaction as a function of distance between samples;

Gamma (H) – variogram value.

3. RESERVE CALCULATION PROCEDURE

The amount of ore reserves is calculated by adding the amount of ore calculated in mini-blocks. The average copper content was calculated as the average weighted value of the content of all mini-blocks above the limit content. Weighted content values were calculated since some blocks captured a smaller amount of ore, compared to blocks of "normal" size. These are the blocks that are:

- Localized in peripheral, boundary parts of mined rocks and tailings;
- Located in border areas of certain categories of reserves;
- Located in border areas of blocks with preliminarily determined balance reserves.

The calculation of ore quantities and average content within geological and balance reserves, by category of reserves, was calculated by first making closed models ("SOLID" models), and then the calculation was made within the formed three-dimensional spaces.

The analyzed area was explored by drilling on an irregular square and rectangular grid, at approximate distances of 20x40 m, 40x40 m, 50x100 m, and 100x100 m. The measurement of the deviation of the drill holes was not carried out since they are relatively shallow with a length of no more than 80 m. The data that was analyzed and included in the geological, i.e. "geological-computer" interpretation for the man-made deposit Old flotation tailings Bor originate only from drill holes, they have not been verified by mining exploration works, as a result of which the risk of reserve estimation is somewhat higher. Geological reserves and their quality are shown in Tables 2 and 3.

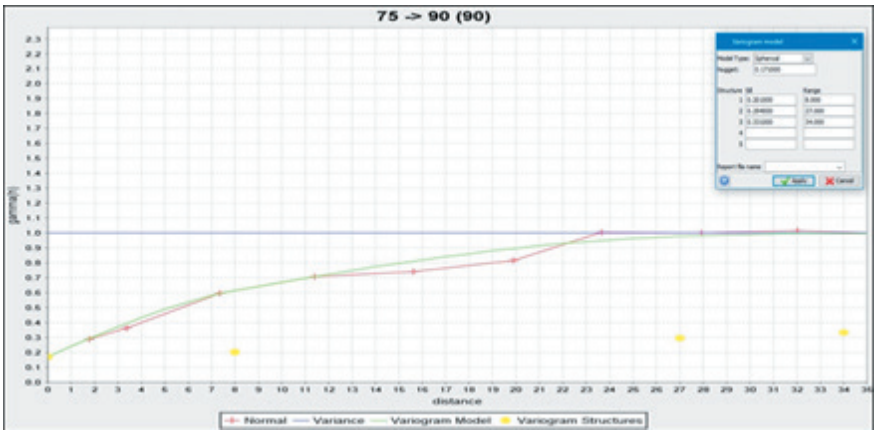

Figure 4. Variogram.

Table 2. Geological reserves by category and total in the man-made deposit of copper and gold Old flotation tailing pit - Bor.

Reserves	Volume (m^2)	Mass (t/m3)	Reserves (t)
B	10.194.993	1,70	17.331.488
C1	4.385.845	1,70	7.455.937
B+C1	14.580.838	1,70	24.787.425

Table 3. Contents and quantities of copper, gold, and silver in the geological reserves of man-made deposit Old flotation tailing pit Bor.

Reserves	Cu_{uk}, % (Copper)	Cu (t)	Au, g/t (Gold)	Au (kg)	Ag, g/t (Silver)
B	0,230	39.818,9	0,420	7.287,2	2,776
C1	0,205	15.257,0	0,286	2.133,1	1,102
B+C1	0,222	55.075,9	0,380	9.420,2	2,273

4. CONCLUSION

Technogenic deposit of copper and gold Old flotation tailings pit - Bor was created as a result of the disposal of flotation tailings after the processing of a large number of ore bodies from the Bor deposit of copper and gold, which differ in terms of genesis, textural-structural characteristics, mineral composition and content of copper and gold. A smaller part of the flotation tailings was created as a result of the processing of copper and gold ore from the Lipa deposit.

Modeling of the distribution of copper and gold in the man-made deposit Old flotation tailing pit - Bor was carried out using computer technology. It included a detailed geological and statistical analysis of data on copper and gold content in analyzed samples from exploratory wells from Field 1 and Field 2, their mutual connection in space, statistical analysis through the coefficient of variation, graphical interpretation in the form of transverse and longitudinal vertical sections, as well as an analysis of spatial distribution by profiles and levels. Modeling of the distribution of copper and gold was also carried out using a block model of the deposit, as the most illustrative representation, of which the previously mentioned elements are an integral part. The assessment of copper and gold content in the man-made deposit Old flotation tailing pit - Bor was carried out using the kriging method (cross-validation method - confirmation), and by determining the limits of data interpretation and evaluating the blocks in the deposit.

5. ACKNOWLEDGMENTS

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