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## MICROMINE CALCULATIONS OF ORE RESERVES IN THE BOROV DOL PORPHYRY COPPER DEPOSIT, REPUBLIC OF NORTH MACEDONIA

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**A b s t r a c t:** The calculations of ore reserves in the Borov Dol deposit were mainly carried out with the support of the AutoCAD software package, and those results received official confirmation in the Republic of North Macedonia. The latest calculation using MICROMINE provides a wider range of use of source data from detailed geological surveys and rapid correlation between metals and associated elements in the deposit. The MICROMINE procedure for the calculation of ore reserves in the Borov Dol deposit consists of several stages starting from: creation of new project and related data base (Excel and Micromine), Micromine database validation process, building and creating wireframe, creation of the particular block model as well as calculation of ore reserves by MICROMINE software package. The obtained results are highly correlative and compatible with the same obtained through the method of vertical parallel profiles calculated using the AutoCAD software package (difference 1.21%).

**Key words:** ore reserves; MICROMINE; copper ore; procedure; comparison

### INTRODUCTION

The porphyry copper deposit Borov Dol today represents a important object of porphyry copper ores that are exploited in the mine Borov Dol. Its historical connections reach back to the middle of the last century when the research practically started, while with certain interruptions the detailed geological investigations continue until today. The first calculations of ore reserves were performed in 1984 (Culev et al., 1984), while the second official cross-sections of the potentiality of the Borov Dol deposit were performed in the 2014 (Petrov et al., 2015) after more extensive detailed geological surveys, mainly with exploratory geological drilling. That calculation was based mainly on AutoCAD. Exploration of the Borov Dol deposit continued even after 2015, but intensified especially in period 2020 and 2021, where as a result of those explorations, another elaborate was prepared in 2022 (Serafimovski,

2022). In the calculation of ore reserves and within the framework of that elaborate, AutoCAD was mainly used, but for the first time an attempt was made to use the Micromine software package as an supplemental method, which as such have not been used in our country. This was also the occasion for the production of this paper, in which we want to animate this software support for the calculation of ore reserves, which provides wide opportunities both for the preparation and input of research data, as well as for the formation of models of ore bodies through which then the qualitative-quantitative characteristics of the ore mineralization are calculated and a quick correlation is made on the basic and accompanying metals in the ore deposit. The results of the calculation of ore reserves in the Borov Dol ore deposit, by extensive use of MICROMINE software, are shown in this paper.

### GENERAL FEATURES OF THE BOROV DOL ORE DEPOSIT

The Borov Dol copper deposit is located in the southeastern part of the Republic of North Macedonia, about 120 km southeast of Skopje and 15 km

northwest of Radoviš. The fact that the area of the Borov Dol ore deposit and the Borov Dol mine represents part of the contact zone between the Vardar

zone and the Serbian-Macedonian mass indicates the complexity of the structure and the complexity of the relationships between all the lithological units in it (Veličković and Tudžarov, 1978)).

In the metallogenetic regards it belongs to the Serbian-Macedonian metallogenetic province as a regional metallogenetic unit. Within the Bučim-Damjan-Borov Dol mining area, the Borov Dol mining field belongs to the Damjan block, which is a very heterogeneous geological structure. Namely, this block is made of geological formations of the Precambrian metamorphic complex, Old Paleozoic metamorphic rocks, Jurassic ultrabasic rocks and granite, Albion-Cenomanian sediments and Upper Eocene sediments, volcanogenic-sedimentary formations, Tertiary andesite, as well as Pliocene and Quaternary formations. Within the framework of the Precambrian metamorphic rocks, fine-grained two-mica gneisses (Gmb), yellow to yellow-gray thin bands of mica (Sm) with clearly defined schistosity, as well as amphibole schist (A), that are characterized by a greenish color and occur in smaller layers or lenses.

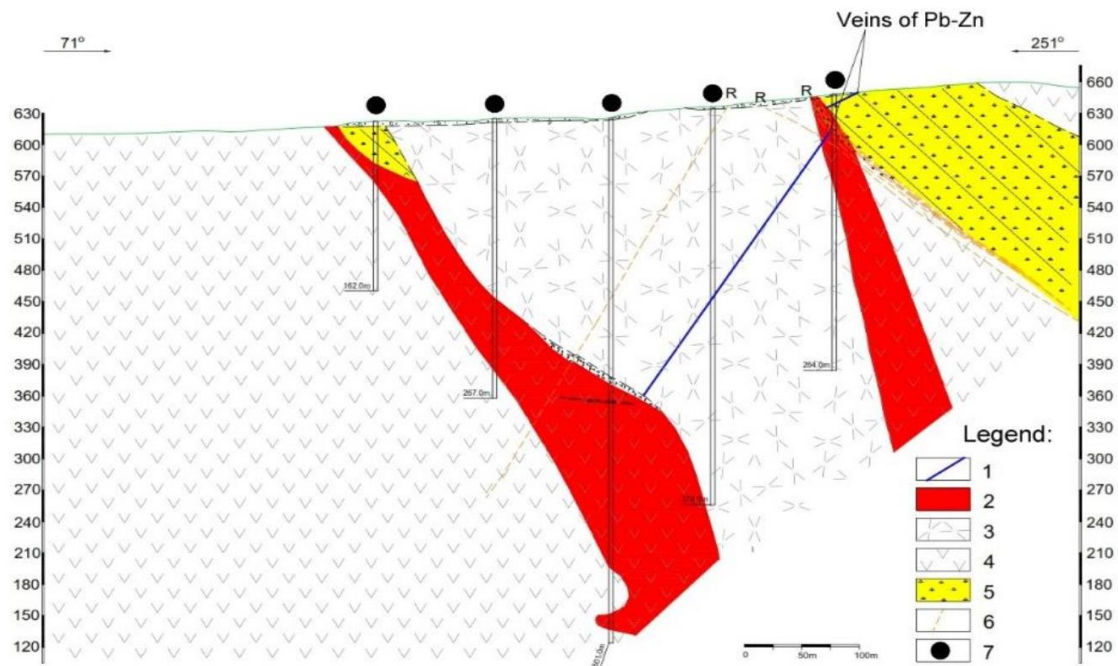
Old Paleozoic metamorphic rocks are represented with chlorite-sericite and amphibolic schist, with thin strips of marble, while ultrabasic occurs in the form of strips, following the regional fault structures along the valley of the Kriva Lakavica river. Schist-carbonate serie (FM) is characterized by gray, light-grey to yellowish and white color. Marble (M) appears in the form of long, narrow bands or smaller lenses, with weak or clearly pronounced layers. Serpentinite (Se) occurs in the form of smaller bodies in more localities, such as amphibolite (schist or enclosures in granites). By color they are characterized as green to light colored.

Jurassic magmatic activity is represented by granite ( $\gamma$ ), covered by Cretaceous and Eocene sediments in the western part of the block. The Alb-Cenomanian sediments are present as facies of basal conglomerates ( $^1K_{1,2}$ ) and facies of sandstones, clays and marls ( $^2K_{1,2}$ ). The Alb-Cenomanian sediments were intruded by the Tertiary andesite-latite and occur in the form of elongated bodies, embedded between the intruding bodies, or as a non-eroded cover, above the intruding bodies. Upper Eocene sediments are represented by conglomerate, limestone and flysch formations ( $^4E_3$ ). Tertiary volcanics are mainly andesite masses, which cut-through and covered Cretaceous and Eocene sediments. Gray-whitish andesite cut-through sediments while gray-black andesite cut-through coarse-grained grey-white andesite. Pyroclast ( $\Theta$ ), presented as andesitic tuffs and tuffs, spatially occupy the lower

parts of the volcanic massif. Andesite rocks ( $\alpha$ ) are of NW-SE direction. By color, andesite is gray, light-gray to gray-green with a distinctly porphyry structure and massive texture.

Pliocene-Quaternary geological units are present in a large area of the the Damjan block. They represent weakly stratified and heterogeneous materials, both in composition and size, and covered by the carbonatite complex rocks. Those units are brackish-water lake coarse-clastic sediments represented by poorly processed gravel mixed with sandy-clay material ( $^3Pl$ ). Modern Quaternary sediments (placers) are usually represented by deluvial-proluvial (d) and alluvial (al) layers and do not have a greater distribution.

In the Borov Dol locality, the morphostructural analysis included the study of the morphological forms of the ore bodies with special reference to the relations with the volcanic bodies. Based on that, a morphostructural classification of the ore bodies and a genetic interpretation of the obtained data were carried out (Serafimovski et al., 2010; Petrov et al., 2014; Serafimovski, 2022). Structural-morphological characteristics and scale of the ore mineralization determine the spatial position of the ore body in the Borov Dol deposit, which is controlled by fault structures with a NW-SE stretching direction, circular-elliptical Neogene structures (typical of the structures of volcanic apparatus) and subvolcanic-volcanic facies of Tertiary intrusive-effusive volcanism and its volcanogenic activity, where andesitic formations, using the labile zones were intruded, sometimes cutting through, creating predisposed conditions for the circulation of hydrothermal solutions and deposition of copper ore mineralization (Tudžarov and Serafimovski, 1994; Serafimovski et al., 1996; Lehmann et al., 2013). The mineralization itself is localized in the domain of the volcanic apparatus, that is, within the circular-elliptical depression Borov-Dol volcanic structure, which represents a segment of the large Brest-Borov Dol ring-ellipsoidal structure (volcanic caldera). Namely, the sulphide copper-bearing mineralization is deposited in porphy-like gray-white coarse-grained andesite, intruded by gray-black fine-grained andesites (Tudžarov, 1993; Gjorgiev, 2020a). Based on the degree of exploration, the density of exploration works – drillholes in a grid layout, a complex form of ore deposit is indicated in the form of a cone around the sterile gray-black andesite with a irregular ellipsoidal shape, which changes in depth. Simply, it can be said that the ore body of a conical character morphologically follows the shape of the andesite neck in a disproportional relationship (Figure 1).



**Fig. 1.** Cross section of the Borov Dol ore deposit (Petrov et al., 2014; Gjorgjiev et al., 2020b)  
 1. Pb-Zn veins. 2. Ore body. 3. Dark gray fine-grained porphyry andesite. 4. Gray-white coarse-grained andesite.  
 5. Volcanic tuff. 6. Faults. 7. Exploration drill holes

The ore mineralization is of stockwork-impregnation pyrite-chalcopyrite-hydrothermal genetic type, where impregnations dominate over the mineralized pyrite-chalcopyrite strings and veins, quartz-pyrite chalcopyrite strings, as well as over independent pyrite and chalcopyrite thin strings and veins (Tudjarov and Serafimovski, 1995).

Based on the detailed ore-microscopic studies (Atanasov, 1977; Ivanov and Serafimovski, 1984; Serafimovski et al., 1992), as well as electron microprobe study (Serafimovski, 1993), the following ore minerals were confirmed in the Borov Dol ore deposit: pyrrhotite, chalcopyrite, pyrite, native gold, pecite, magnetite, rutile, sphene, anatase, hematite, specularite, martite, molybdenite, cubanite, vallerrite, bornite, sphalerite, galena, tetrahedrite, tennantite, covellite, digenite, proustite, chalcocite, siderite, tenorite and limonite. Of the non-metallic minerals that accompany ore minerals paragenesis were quartz and calcite. Microscopic study carried out in the phase of the detailed geological research of the

Borov Dol ore deposit by Serafimovski and Tasev (2014), confirmed presence of seligmannite, luzonite, famatinite, Ag-telluride (petzite), digenite, cubanite and sylvanite. Those findings were confirmed few years later by Gjorgjiev et al. (2019).

Chalcopyrite, as the main ore mineral, occurs in the form of granular aggregates, injected into the andesite mass, and in the fissure network in the form of pyrite-chalcopyrite strings - veins or self-staged chalcopyrite thin strings-strings. Pyrite, as the most abundant accompanying mineral, also occurs in the form of granular aggregates and in association with chalcopyrite in the constructed stockwork network.

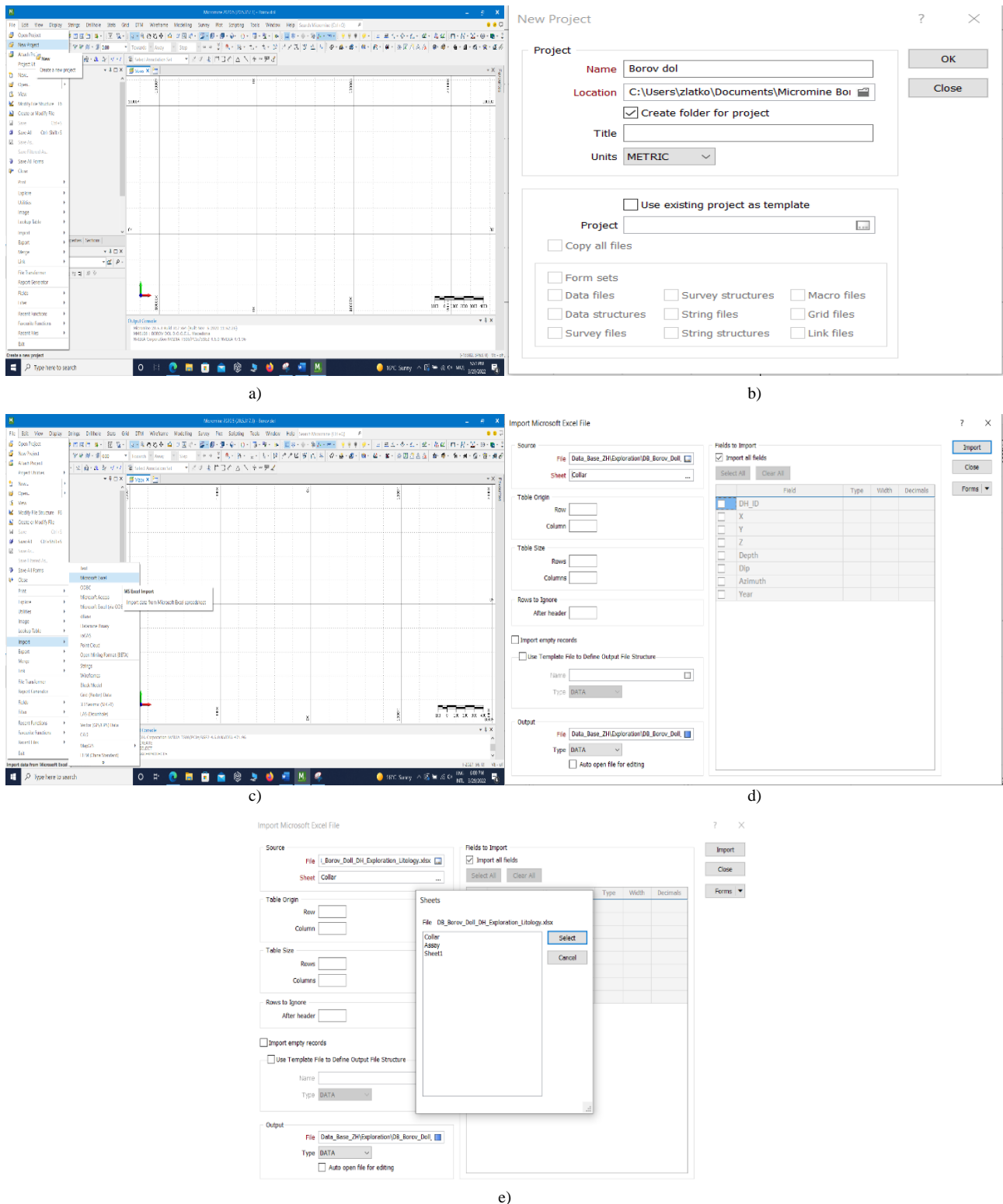
Sulphide copper-bearing mineralization is characterized by extensive mineralization of the space with a weaker and scattered concentration of useful components. The intensity of mineralization is weak, it belongs to the domain of low-percentage copper-bearing minerals in the class of 0.23 – 0.27% Cu. Within the deposit, there are sterile parties, which define the degree of continuous ore bearing.

## METHODOLOGY AND DATA INPUT

The calculation of ore reserves with the Micromine software is a complex and extensive data demanding process. There is an array of complex, logical and interrelated steps that need to be performed sequentially in the Micromine software

package. The entire process starts with creation of a new project (see Figures 2a and 2b), followed by creation of a database in Excel based in general of data on Collars and Assays (see Figures 2c, 2d and 2e).

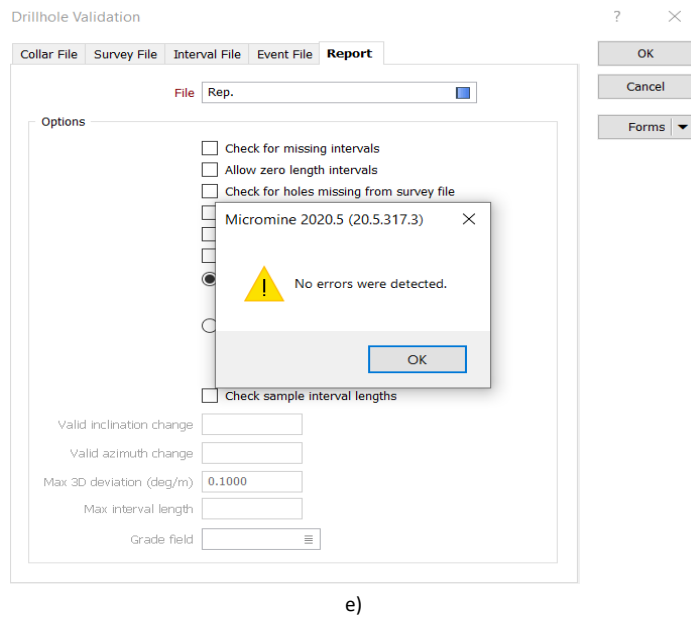
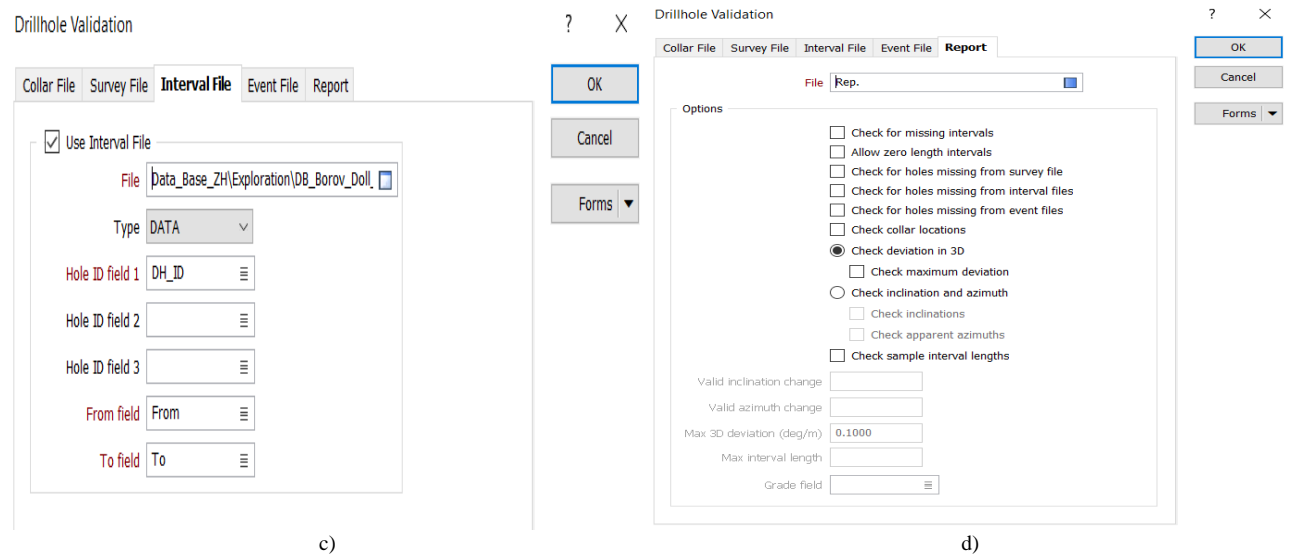
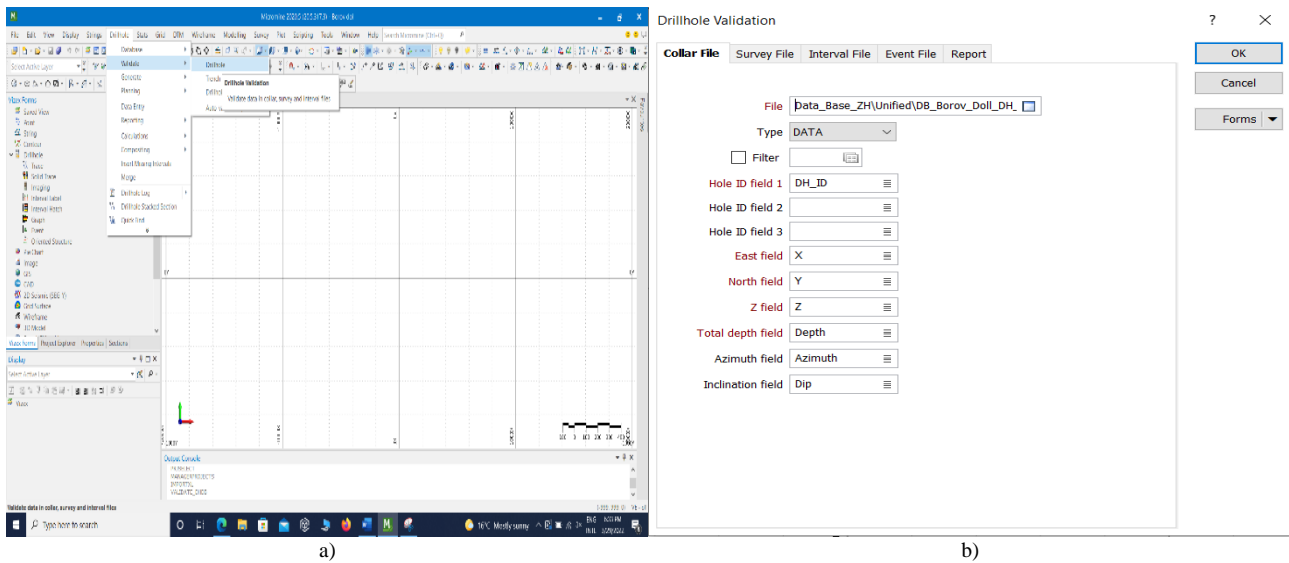




**Fig. 2.** Creation of new project and related database (Excel and Micromine)  
a-b) New project. c-d-e) Related database creation

As it can be seen, the creation of database in Micromine is strongly based on Excel constructed database, which brings extensive data on Collars and Assays. Then follows the validation of the data-

base created in Micromine that is done through the Drillholes icon and Validation dropdown menu and associated steps as shown in Figures 3a, 3b, 3c, 3d and 3e.



**Fig. 3.** Micromine database validation process.  
 a) Start of verification process. b, c, d and e) Error correction process

After receiving a message that no errors were detected (Figure 2e) we may proceed with the further steps, such as creation of the Drillhole database, through several consecutive steps *Create Drillhole database* (based on *Collars* and *Assays*, naming that particular database), followed by checking process through the so called *Vizex forms*, where we choose the *Point* icon and within the field options, we choose our *Collars database* and we may check the respective coordinates. Also, successive to *Vizex forms* is the use of the *Interval Hatch* where drillholes intervals through several consecutive steps (*Import Data*, *Interval Files Assays*, *Hatching-Hatch Field*, *Hatch Set* and *Edit*) can be imported. In that very same manner is edited interval *Label*, where can be checked values and

concentrations of particular drillholes, while in the same *Drillholes* menu can be checked and/or generated exact coordinates through a series of commands such as *Downhole coordinate*, *Create new coordinate file* as well as *Interval File*. Creation of strings-polylines can be performed in several ways. Namely, through the *Vizex forms* drawing can be imported from *AutoCAD*, as well as drawn in the *Vizex forms* as *New String*, by entering required data.

The very next stage or step in the process is building of the wireframe solids based on the previously constructed strings. This particular procedure is performed through the *Build Wireframe* icon (maximal volume should be selected always) and *Create Wireframe* (see Figure 4a and Figure 4b).

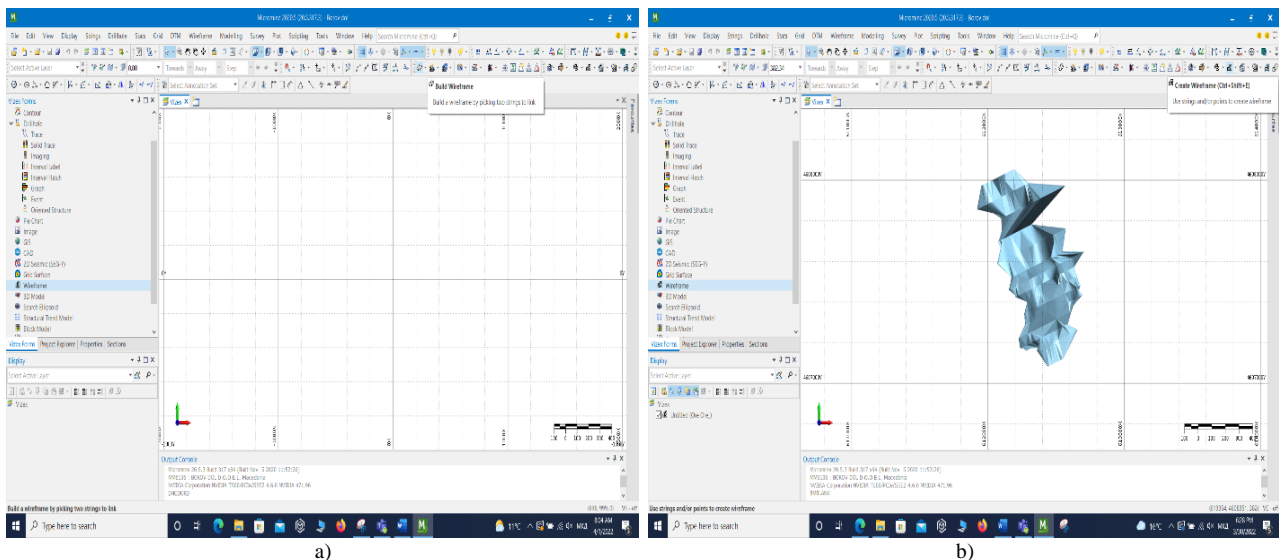


Fig. 4. a) Starting window in the process of building Wireframe and b) created Wireframe

## CREATION OF THE BLOCK MODEL

The creation of the particular Block Model (BM) always starts with creation of the Empty Block Model. That particular step is performed again through the *Vizex forms* and choosing *Wireframe* icon where for the type of solid is selected *Ore* for which we are entering *X*, *Y* and *Z* data in the *Metadata* window. After these steps in the *Menu Bar* we select *Modeling* icon and in the dropdown menu we choose *Block Model Tools* to *Create Blank*. If required we may control what we just created with selecting *Menu Bar-Define Section* and proceeding with *Vizex forms* and selecting *Draw style – 2D slice*. With the completion of this procedure, we now have the BM filled with data from the

investigated boreholes of the first phase of the assessment. To check what we have done go to the left side of the monitor in *Vizex forms* and double click on the *Block Model* icon.

Immediately after creating an empty Block Model it is time to proceed with creation of an Empty Block Model of the Ore Body itself. Since, the aforementioned Empty Block Model is already constructed, the procedure is straight-forward by selecting *Menu Bar – Modeling* and from the dropdown menu is chosen *Block Model Tools > Create Blank Block Model* (Figure 5a) where further details are defined (*Restrictions*, *Output*, *Extents*, etc.; Figure 5b).

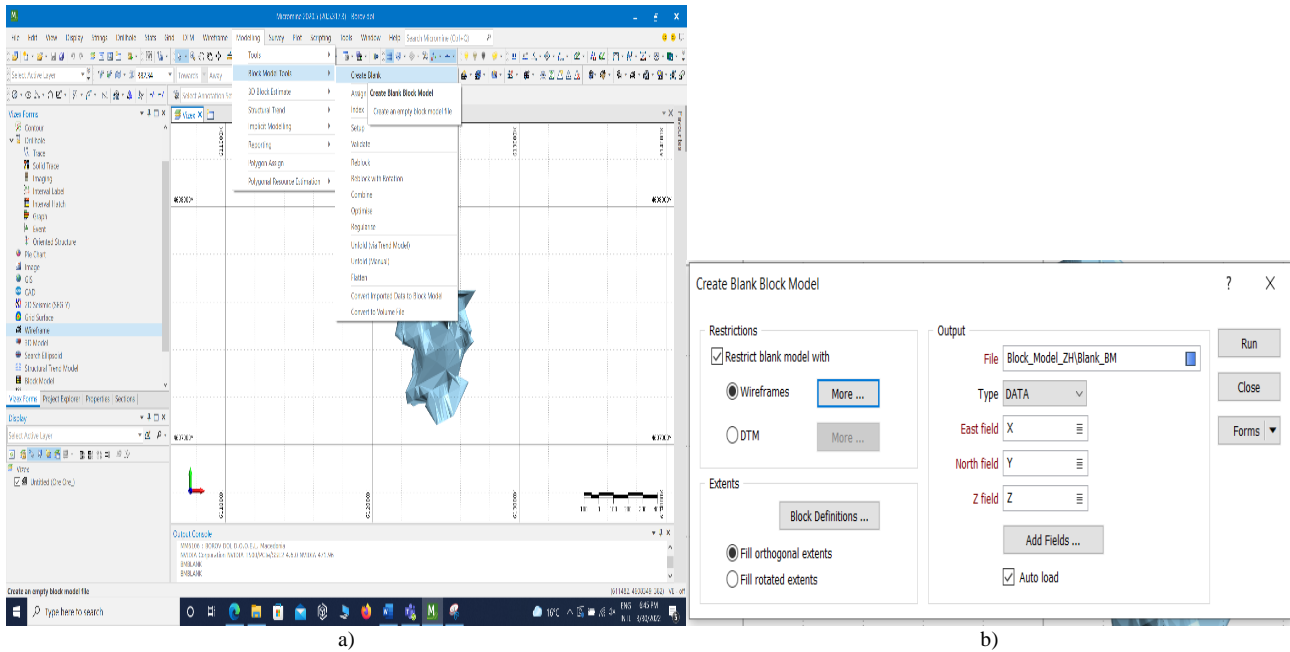


Fig. 5. a) Creation of blank block Model and b) defining certain restrictions of that model

The next step is to cut Blank Block Model, if it is required to remove something that is not needed anymore, such as already excavated ore. That process is preformed by going to Menu Bar and selecting DTM icon while from the dropdown menu is selected Assign > Block Model. This particular process proceeds through few demanding steps. The first one defines the Solid form of the Blank Block Model, its Output and its Fill. The second step is from the Block Model window to select Calculate > Bellow DTM and to select parts that are below the projected open pit mine and to create sub-block(s). The third step take care of blocks that are above the terrain surface (above the topography) by Assign > Block Model, while in the DTM > Type is selected the part, which should be removed.

In the next stage the Blank Block Model is filled or more precisely we are proceeding with an estimate. The process of estimation is preformed through several stages. The first one begins with the most database of the most representative exploration drillholes complemented with the exploitation drillholes database and lithological features of the ore deposit. The next stage filling of the Blank Block Model starts with filling the model with data from exploration drillholes going from menu through Modeling and choosing from dropdown menu 3D Block Estimation > Inverse Distance (Figure 6a), followed by steps 3D Block Estimation > Inverse Distance > 3D Block IDW Estimation (Figure 6b). Then we proceed with interpolating parent block only (Figure 6c), using the minimal

distance, maximal values as well as choosing the Au, Ag, Cu and composite from an Assay database (Figure 6d). Must to mention is the fact that the Discretization option at this particular moment is not used. Associated spheroid is created by selecting Style > Spherical > Parameters > Radius, while the other parameters of that exact spheroid are usually defined by its radius and sectors (two sectors).

With the completion of this procedure, we now have the Block Model filled with data from the studied boreholes of the first phase of the assessment. To check what we have done we may go to the left side of the monitor in Vizex forms and double click on the Block Model icon. From the dropdown menu we select Input Data > Block Model file (our just created model) and after that we define the Draw Style > 3D Shaded and Show Block Edges.

Further we may proceed with Hatch sheet by selecting Use Hatch Field where we may select which commodity we would like to see. There is an option in Hatch Colour Coding (Hatch Set) if we would like to change the colours for different classes of particular commodity values (Label > Display Block > Display Label), as shown in Figure 7a, while for displaying Block Label we have to select Label > Display Label (Figure 7b). As final step at this stage is so called Block Estimation where we can check the created model with selecting Draw Style > 2D Slice (Figure 7c). After this stage, we are ready to proceed with the stage two where we may include the existing exploitation drillholes (from already created respective database). At this point

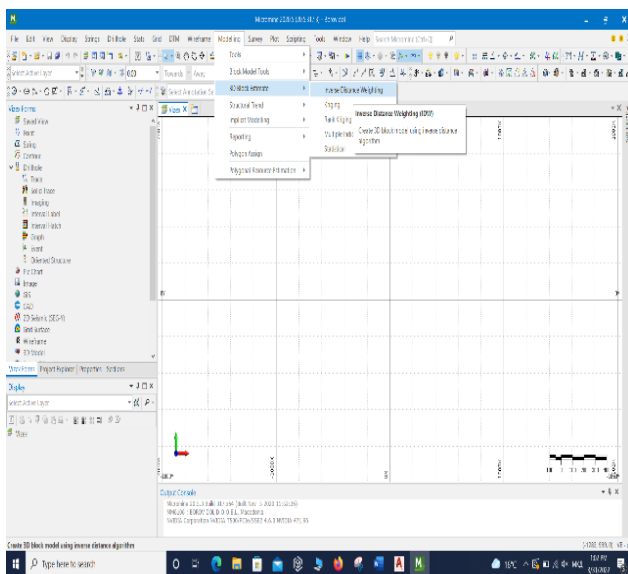
we are dealing with 3D Block Estimation through the Inverse Distance and 3D Block IDW Estimation and Interpolation of the parent block only.

After the previous step, modeling parameters should be defined through the Element Fields option where we select particular Assay (in this case % Cu) and proceed with Data Search in increments of 10 m, 15 m, 100 m and 1000 m. To finish the second stage we should perform an Estimation for each phase by setting required Modeling Parameters in several consecutive phases (Phase 1, Phase 2, Phase 3, and Phase 4).

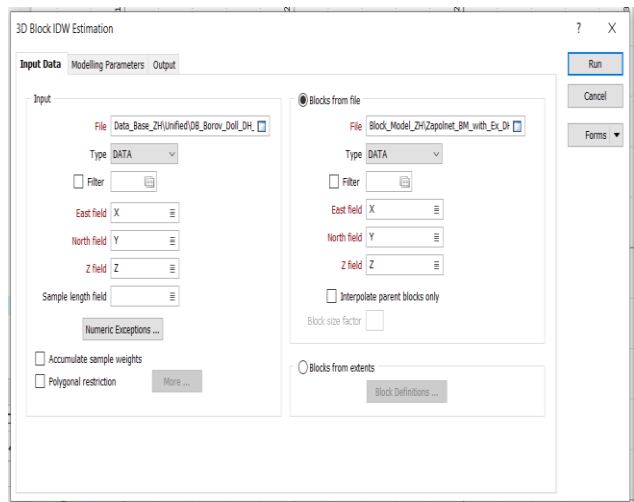
The third stage consists of filling the Block Model with lithology data for the ore deposit, in this

case the Borov Dol Cu-Au porphyry ore deposit. Here several consecutive steps are usually performed: Menu Bar > Modeling > 3D Block Estimation > Inverse Distance > 3D Block IDW Estimation (Figure 8a), then follows selection of assay(s) from the database (lithological features from Exploration drillholes) and parent block Interpolation with eventual setting of Modeling Parameters such is Rock Type (Figure 8b)

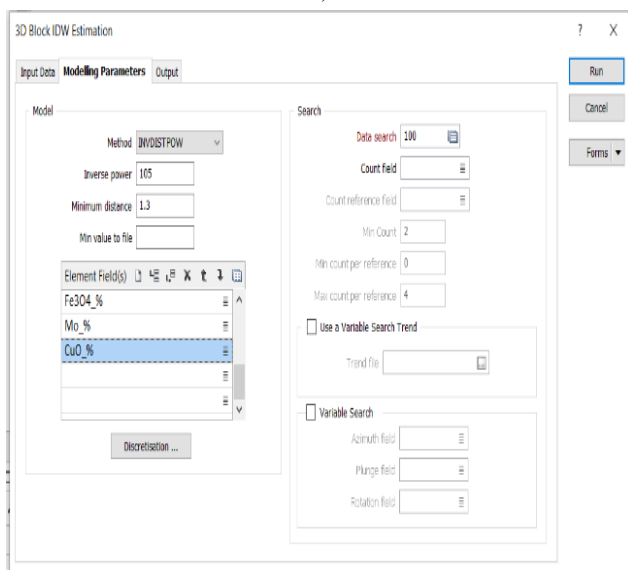
With the completion of this procedure, we now have a Block Model filled with data from the exploration drillholes, which is completion of the estimation procedure.



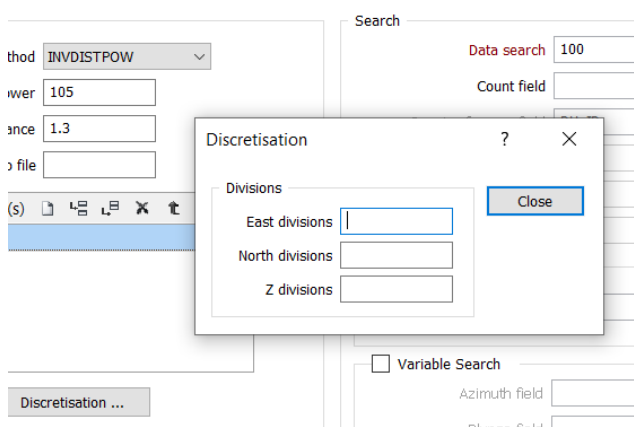
a)



b)



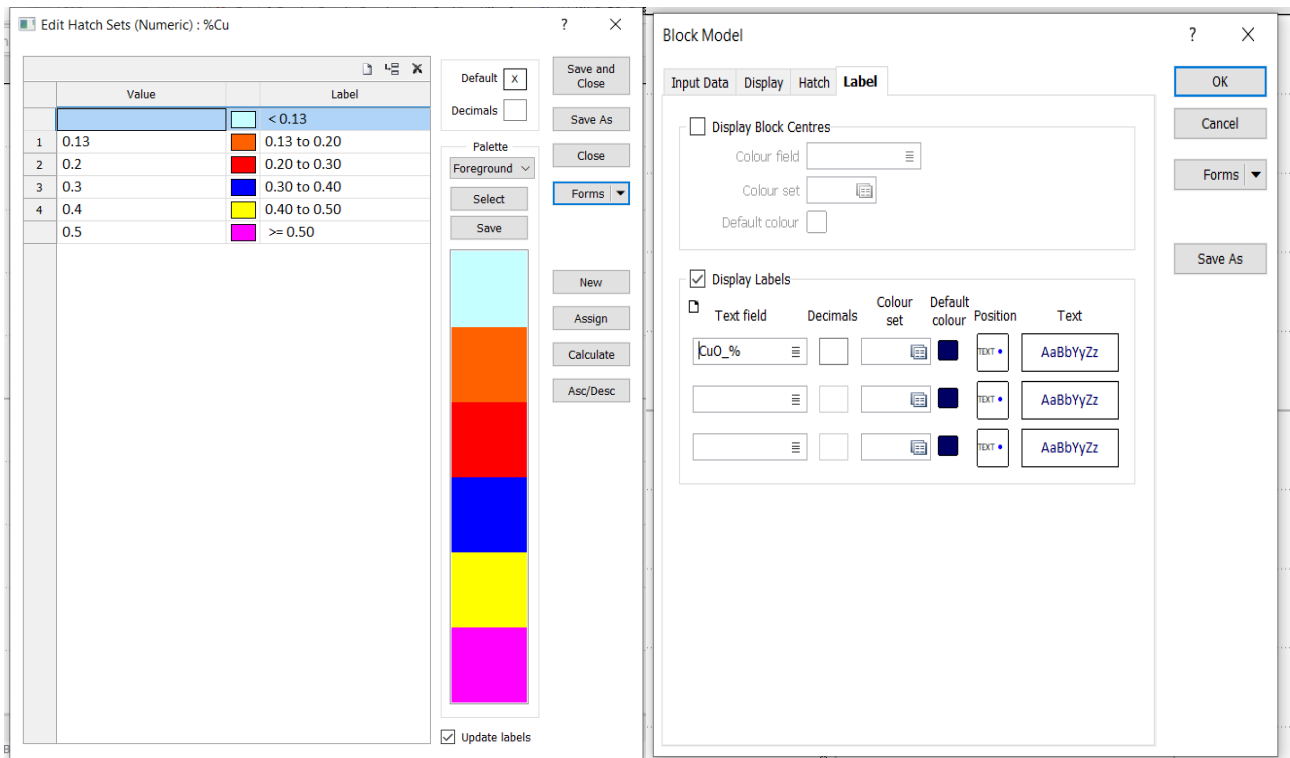
c)



d)

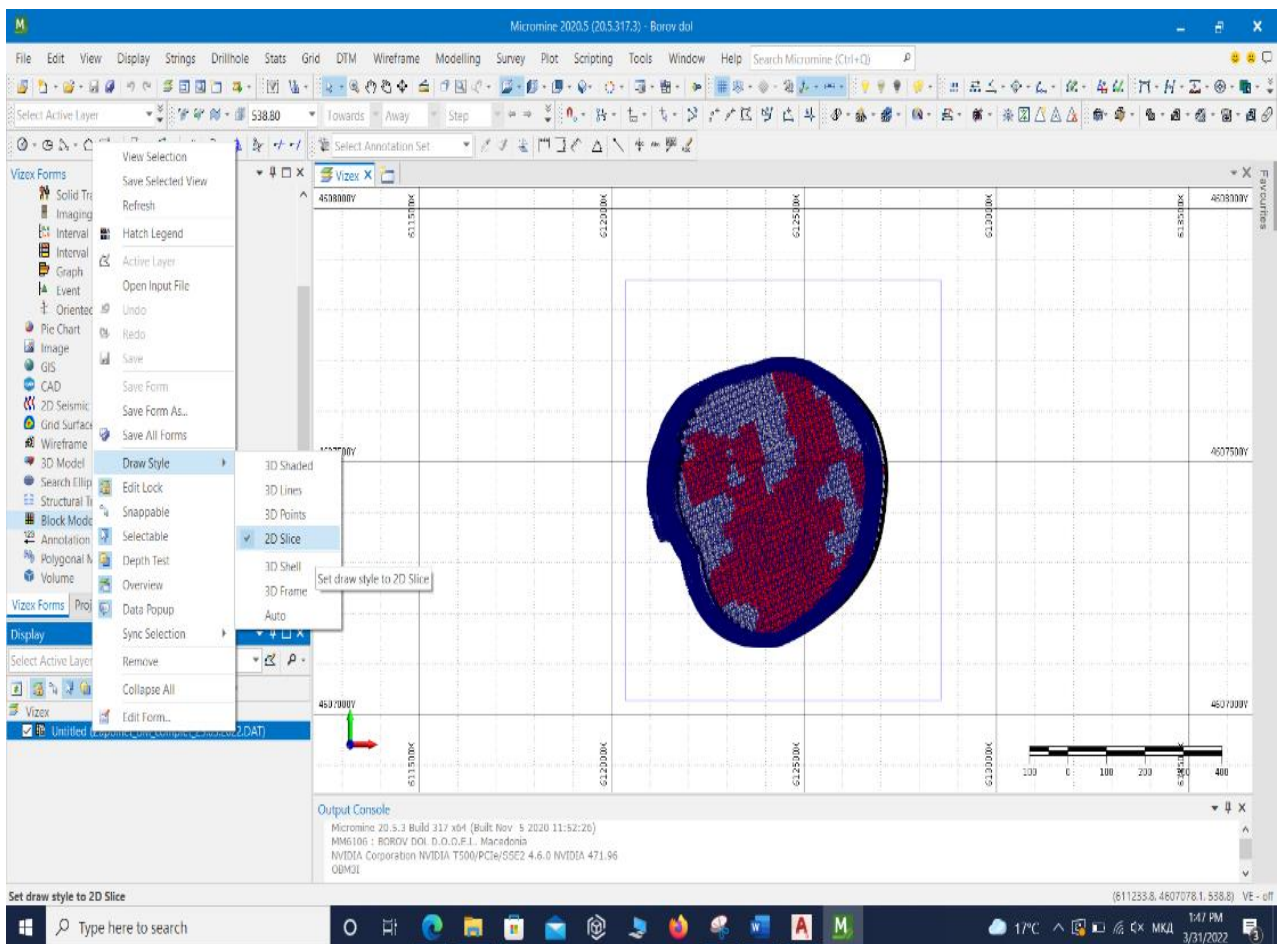
**Fig. 6.** Filing the Blank Block Model

- a) 3D Block Estimation – Inverse Distance; b) 3D Block IDW Estimation; c) interpolation of parent block only; d) selection of useful components from an Assay database



a)

b)



c)

Fig. 7. a) Colour coding; b) Label displaying; c) 2D slice drawing

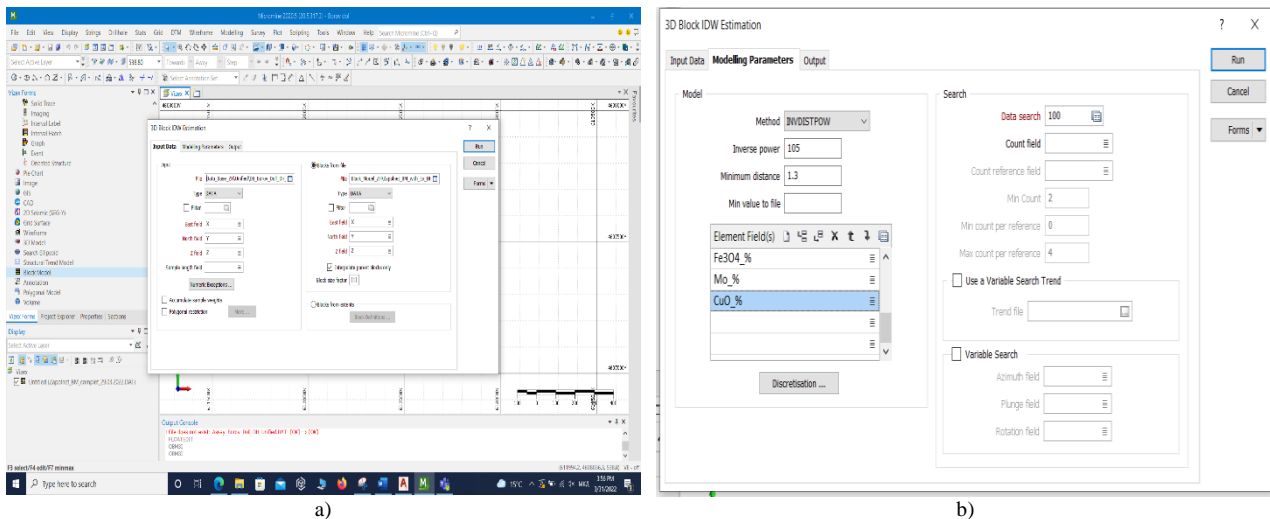


Fig. 8. a) 3D Block IDW Estimation and b) selection of Assays – lithological features from exploration drillholes

## BLOCK MODEL REPORT

In regards to obtain the Block Model Report we are applying the following procedure. In the upper of the screen we are selecting Menu Bar then choose Modeling > Reporting > Block Model, as it is shown on the Figure 9. A new window opens (Figure 9) in this window we have two lists Input/Output and Options. On the first Input/Output sheet, in the file field, we select the Block Model for which we want to receive a report, and in the Output section we have to check the standard field.

Then we proceed with settings in the second sheet named as Options (see upper part of the Figure 9) where we choose Report Category (we can obtain Summary Report). After that we continue with selection of the second option by Depth (when, if selected, we are getting report by certain levels, usually at 15 m interval). At the end we press Run

and to check the aforementioned Report we select field named File Report and with right click we choose Edit F4.

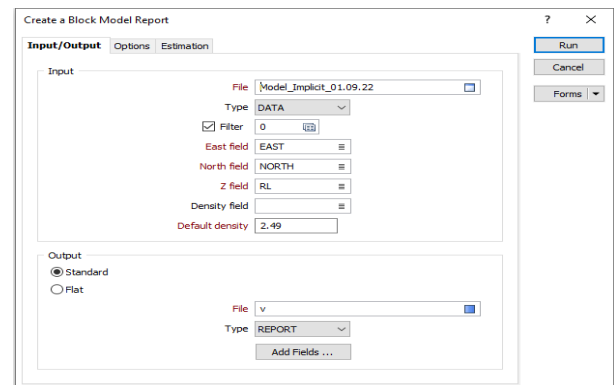


Fig. 9. Creating a Block Model Report in MICROMINE software package

## CALCULATION OF ORE RESERVES BY MICROMINE SOFTWARE PACKAGE

The calculation method according to the MICROMINE software package is taken as a control method for the calculation of geological ore reserves in the Borov Dol deposit, in quite similar manner as elsewhere (Osipov, 2018; Bariatska, 2022). The process using the Micromine software package takes place in several stages. Namely, the phase in the calculation of geological ore reserves in the Micromine software package consists of several sub-phases: creating a project, creating a database (Data Base) in Excel, creating a database in Micromine, thorough control of the created database in Micromine, creating a database of boreholes, creating polyline arrays, creating mesh of solid shapes (DTM)

from the arrays, creating a Block Model (BM), creating an Empty Block Model (BM) in the deposit, creating of a blank Block Model (BM) in the ore-body, cutting the blank Block Model (BM), filling the blank Block Model (Assessment) and creating a Block Model Report. In principle, these are the basics of calculating the geological ore reserves with the Micromine software package, which results in creating a 3-D Block Model and then calculating the geological ore reserves within the ore body, in this case the Borov Dol porphyry copper deposit. Figure 10 shows the final image, that is a view of the topography of the field and all the explorations within the concession field of Borov Dol.

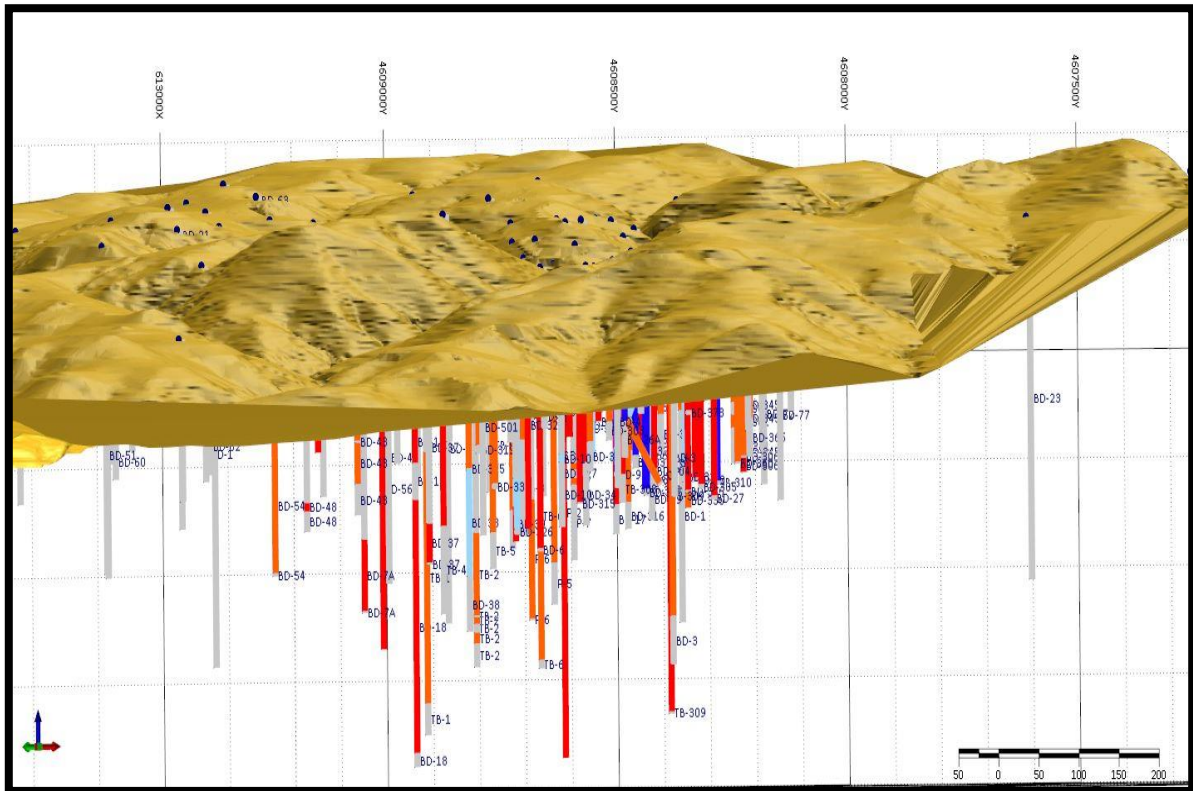


Fig. 10. Topography of the area of interest and layout of the exploration boreholes

During the process of defining the boundaries of the ore body and later calculating the reserves of the Borov Dol deposit, a cut-off grade of copper

content of 0.15% Cu was used, and during that process an ore body with the isometric shape shown in Figure 11 was obtained.

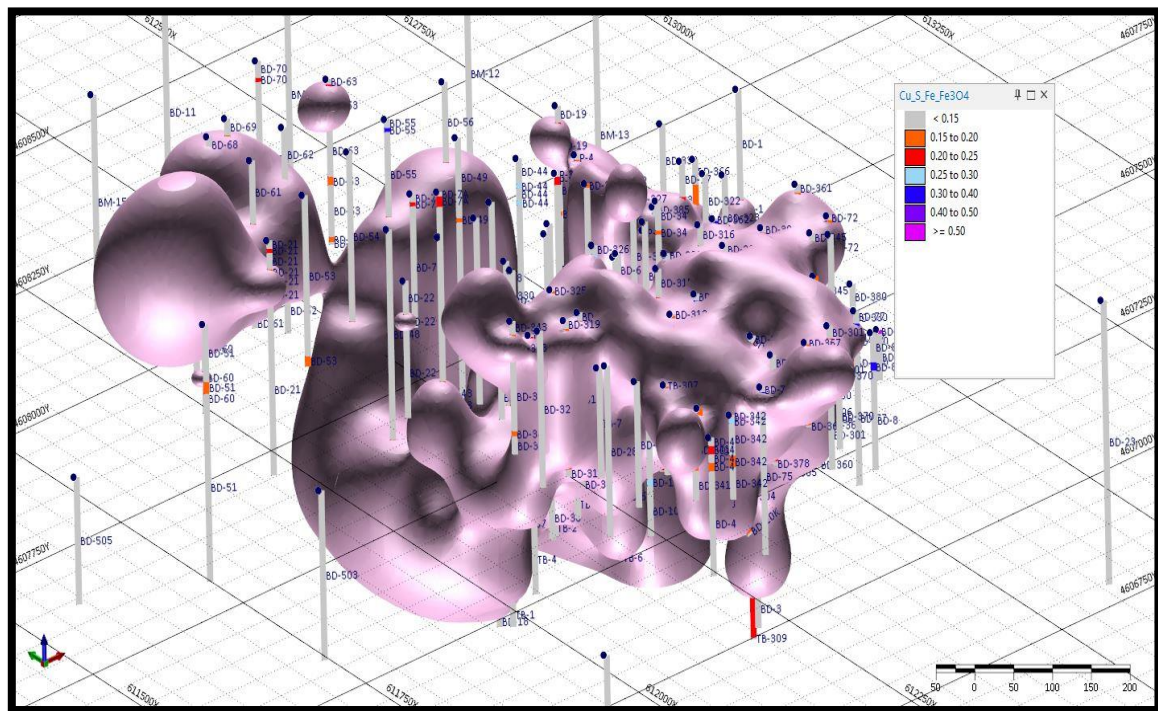


Fig. 11. Isometric shape of the ore body in the Borov Dol deposit, outlined at a cut-off grade of 0.15% Cu



At Figure 11 with the purple color is shown the ore body and the boreholes that intersect it. Within this ore body a 3D Block model is then formed in

the manner described in text above. The appearance of the 3D Block model is shown in Figure 12.

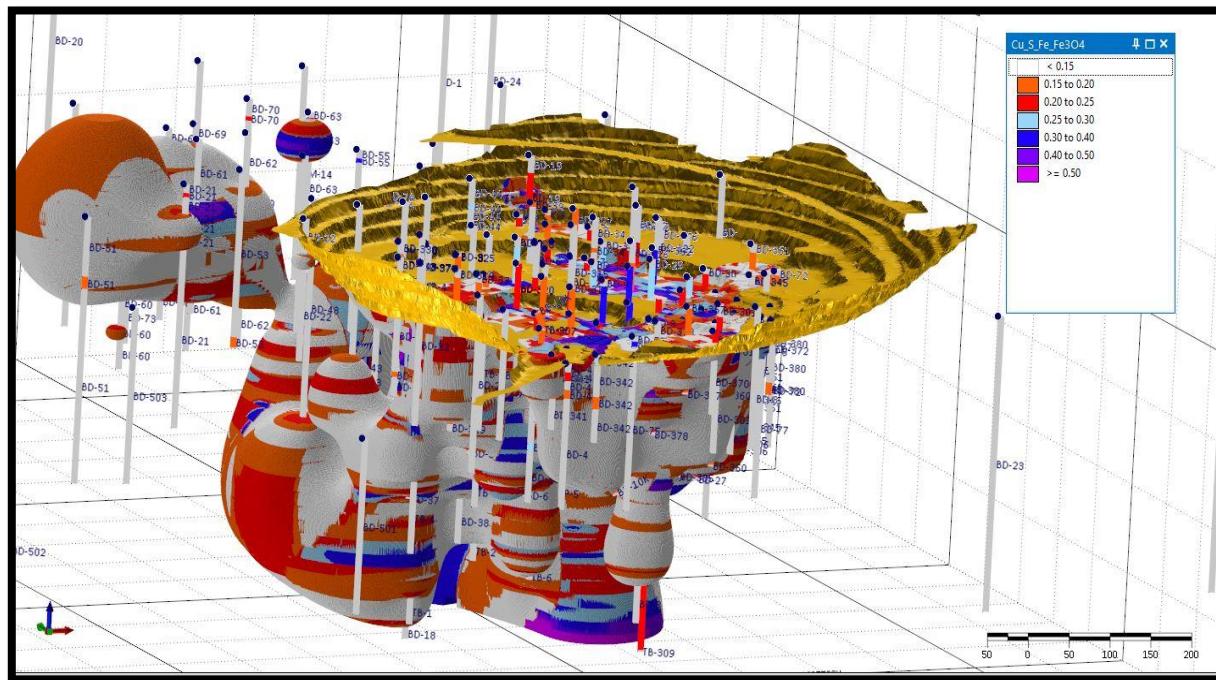


Fig. 12. Illustration of the 3D Block Model of the geological ore reserves as of 01/09/2022

As we may see from the Figure 12, the 3D Block Model is reduced for the already excavated ore quantities. This was done according to the procedure described in the section cutting the empty Block Model, and then it was moved to the calculation of ore reserves, where exploration parameters were used:

Phase 1 with an exploration radius of 20 m, while this radius is taken into account because the database also contains information from operational exploration drill holes drilled at a distance of 15 m from each other. In order for the data from them to be overlapped, it was determined that the exploration radius should be kept at 20 m. This first phase of exploration corresponds to the A Category of ore reserves.

Phase 2 has an exploration radius of 27.5 m. At the same time, this phase of exploration corresponds to the B category of ore reserves. It was decided that the exploration radius should be 27.5 m due to the fact that this exploration and filling of the Block Model is based on the data only from the exploration drill holes, i.e. without the exploitation wells. The distance between them is 50 m for B category according to the Regulation for the categorization of

geological ore reserves and their record keeping, and this distance is enough for them to overlap each other.

Phase 3 has an exploration radius of 100 m. This exploration phase corresponds to the C<sub>1</sub> category of ore reserves. It has been determined that the research radius will be 100 m due to the fact that this research and filling of the Block Model (BM) is based on the data from the research wells only, i.e. without the exploitation drill holes. The distance between them is 100 m for C<sub>1</sub> category according to our regulation and that distance is enough for them to overlap each other.

Phase 4 has a exploration radius of 150 m. This exploration phase corresponds to the C<sub>2</sub> category of ore reserves. With this exploration radius, all other blocks that are not covered with the previous three phases of research, were filled.

As we have already highlighted, this calculation was used as the control method of ore reserves calculation. The ore reserves in the Borov Dol deposit were calculated using the Micromine software package at a cut-off grade of 0.15% Cu. Calculations made by the Micromine software package were compared to the quantities and contents of metals

obtained by the basic method of vertical parallel profiles. The results obtained from the calculation according to this method, limited to A+B+C<sub>1</sub>-categories, have shown average copper content of 0.247% Cu, which compared to the results of the basic method (the method of vertical parallel profiles) shows significant compatibility, where the difference amounts to a minimal 1.21%.

This indicates the very careful approach to the calculation and standardization of the procedures provided by both methods. However, we want to emphasize once again that the difference is due to a certain reduction of the ore reserves calculated according to the method of parallel exploration profiles, because with this ore body there are some open spaces, resulting from the existing surface mine and the slightly more complex geometrization between the profiles at the existing mine surface. Such cases ultimately led to the total geological ore reserves calculated by the method of parallel exploration

profiles being lower than those calculated using the Micromine software package.

Analogously to the results obtained from the calculations according to the basic method (vertical parallel profiles) and calculations according to the Micromine software package (control method), it is clear that the amount of ore in the individual category will be identified on very different, particularities, the existing variations are not with pronounced peaks. Such differences are due to the methodology between the two methods and a small discussion is given in the calculation along the vertical of other parallel profiles and different influence in the individual blocks in the calculations of the reserves according to the software package Micromine. However, as will be seen from the above, there is no deviation between the two methods applied, which once again revealed the correct principle and the relevance of the obtained values for ore reserves in the vicinity of Borov Dol according to the applied methods.

#### COMPARABILITY BETWEEN CALCULATIONS WITH THE TWO METHODS

From the overall identified review for the calculation of geological ore reserves in the Borov Dol location by two methods of calculations (method of vertical parallel profiles and using the Micromine software package), it can be concluded that the obtained results/reserves in two ways that are they prescribe.

The values obtained from the calculations of the geological reserves according to the two calculation methods are very close. It is revealed, once again here to know that the basic method for the calculation of geological ore reserves in the Borov Dol deposit is vertical parallel profile method, while the calculation using the Micromine software package has been taken as a control method.

The calculated ore reserves obtained by the method of vertical parallel profiles (A+B+C<sub>1</sub> category), taken in consideration with a copper cut-off

grade of 0.15% Cu, and those results obtained by calculation using the software package Micromine (A+B+C<sub>1</sub> category), at a copper cut-off grade of 0.15% Cu, differ only for 1.21% in total.

Such a minor difference in the results obtained from the calculations of the geological ore reserves according to the two above-mentioned methods is a very clear indication of the reliability of the calculations, as well as those previously mentioned, the careful monitoring of the methodological procedure. All results are taken as for further treatment in the selection of technical schemes for the valorization of copper equipment from the Borov Dol deposit, the effective factors our calculations within the techno-economic assessment indicate the basis that this information on geological reserves, with these average copper contents (and other metals) in the ore, get on balance types of reserves.

#### CONCLUSION

The porphyry copper deposit Borov Dol has its own geological and metallogenetic specifics, which are reflected in the spatial distribution of copper mineralization around the fine-grained andesites of the dyke type that is intruded into the mineralized coarse-porphyry andesites of Tertiary age. Long-term detailed geological research, mainly with deep explo-

ration drilling, enabled three calculations of ore reserves, of which, based on the second calculation in 2015, the Borov Dol mine was opened and exploitation began in 2021. In the latest calculation of ore reserves in Borov Dol, the used software support from MICROMINE provided an extensive analysis of a large number of input parameters, a 3D

model view of the deposit and results of a total ore that fully reflect the quantitative picture of the Borov Dol ore deposit. The Block Model that enabled the real calculation provided the opportunity for a summary view of all previous research and allowed correlation with the previous calculations performed with different methods and different software. In the specific case, the comparability is

made between the calculations with the MICRO-MINE and AutoCAD software in which the calculation was performed through vertical parallel profiles and obtained results are not different than 1.21%. This fact also encourage us to freely apply MICRO-MINE software in calculation of ore reserves for other active deposits here in Macedonia.

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Резиме

**ПРЕСМЕТКА СО MICROMINE НА РУДНИТЕ РЕЗЕРВИ  
ВО ПОРФИРСКОТО НАОГАЛИШТЕ НА БАКАР БОРОВ ДОЛ,  
РЕПУБЛИКА СЕВЕРНА МАКЕДОНИЈА**

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Пресметките на рудните резерви во наоѓалиштето Боров Дол главно се вршени со поддршка на софтверскиот пакет AutoCAD, а тие резултати добија официјална потврда во Република Северна Македонија. Најновата пресметка со помош на MICROMINE обезбедува поширок опсег на користење на изворните податоци од деталните геолошки истражувања и брза корелација помеѓу металите и придружните елементи во наоѓалиштето. Постапката за пресметка на рудните резерви со MICROMINE во наоѓалиштето Боров Дол се состои од неколку фази почнувајќи од соз-

давање нов проект и поврзана база на податоци (Excel и Micromine), процес на валидација на базата на податоци за Micromine, градење и креирање жичена рамка, создавање на одреден блок-модел, како и пресметка на резервите на руда со софтверски пакет MICROMINE. Добиените резултати се високо корелативни и компатибилни со тие добиени преку методот на вертикални паралелни профили пресметани со помош на софтверскиот пакет AutoCAD (разлика 1.21%).

