3D Modeling and preliminary ore reserve estimation of Sheikh-Ali Copper deposit

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ABSTRACT

In the recent years a number of Copper exploration projects have been conducted in Iran, resulting in the discovery of world class and numerous small mine able deposits. The Sheikh-Ali Copper deposit, situated in Kerman province, is one of the small scale deposits. In this case, ore reserve modeling has been used to add value to the existing data and to increase the perceived prospectively of the finds. This paper presents the results of 3D modeling of ore body and reserve estimation of that deposit. 3D modeling of ore body has been conducted on the basis of exploration studies of 3 boreholes with Gems software. The exploration of this deposit is according to a new policy of Geological Survey of Iran, i.e. continuation of exploration up to pre-feasibility study phase, which is funded by government and the obtained results are available for public. According to statistical analysis of Cu grade, ore reserve estimation was done with inverse square distance technique. The total ore reserve was calculated to be 305263 tones with an average grade of %5.29 Cu.

Introduction

Geological surveys of Sheikh Ali deposit demonstrates that ore body creation is related to creation of volcanic rocks. According to some characteristics and evidences, this ore body is Cyprus massive sulfide type. Major parts of ore body are located in chert-radolarit level.

Detailed exploration activities in this part are:

- Preparation of topographic-geological map with 1:1000 scales in 2 km² area
- Surface explorations
- Geophysical survey with IP technique in order to achievement of more information about variation and expansion of ore body in depth
- Drilling of 16 boreholes (2675 meters)

Modeling of ore body

3D modeling and ore estimation was carried out with Gemcom software. First of all, assay data of samples of boreholes were gathered in suitable structures.

Data of surveying imported to Gemcom software same as points and lines. In order to preparing of 3D model of topography, other data was estimated with Laplace girding technique. All of topography points is shown same as Tree angular Irregular Network (TIN) model and 3D model of topography was prepared.

3D model of topography and 3d model of boreholes was shown in fig. 1.

In order to preparing 3d model of ore body, some section must be prepared. According to geological map and boreholes location, one plan view and one inclined section of ore body was prepared in Sheikh-Ali Copper deposit. These polygons were shown in fig. 2, fig.3.

After preparation of polygons, polygons invert to polylines and poly lines combine with tielines. The solid which created with tied polyline was shown in fig 4.

The volume of ore body solid is calculated with Gemcom equal to 65713 m³. With considering to average density equal to 4.65 ton per m³, geological reserve of ore body is estimated 305565 ton.
**Statistical analysis of Cu grade**

Statistical parameters of cu grade such as sample number, minimum grade, maximum grade, average grade, variance, coefficient of variation, kurtosis and skewness is presented in table 1. In order to selecting ore reserve estimation method, normal histogram and logarithmic histogram of data was presented.

As you see in figures 5, 6 histogram graph of data is L-shape. Minimum grade have maximum frequency and maximum grades have minimum frequency. These graphs show that frequency distribution of data is not normal.

3D semi-variograms of cu grade was plotted in various azimuths and dip with lag distance equal to 5 m. because of all of variograms are similar to each others then the structure of ore body is isotropic.

According to statistical analysis of cu grade, inverse distance method was selected for ore reserve estimation of ore body. Block model of ore body was prepared from solid. Estimation space of block model was defined as x= 477835, y=3112339 and z=1920 m. According to geometry of ore body and block dimensions, number of rows, column and levels of blocks was defined columns=190, rows=120 and levels=130. Block dimensions in block model was determined 1*1*1 m. according to block dimensions, blocks which must be estimated are 190, 120 and 130 m.

After determining of effective parameters of ore reserve estimation, the block model was prepared (fig 8). Total number of blocks was estimated 65648. Average cu grade of blocks was reported 5.29% but Average cu grade of samples was 5.36%.

According to density of ore equal to 4.65 ton per m$^3$ and volume of blocks, the ore reserve was estimated 305263 ton. Metal content of ore body was estimated 161484 ton cu.

After preparing of 3D block model, variance, standard deviation and coefficient of variation were 4.36$(\%)^2$, 2.08$(\%)$ and 0.394. also kurtosis and skewness were -0.027 and 1.57. these indicators represent estimated blocks have less variations.

Average grade of blocks were 5.35% cu but Average grade of samples were 5.36% cu.

Fig 10 represents variations of estimated average grades versus cut off grades and fig. 10 represents variations of metal content versus cut off grades.

As you see, with increasing cut off grade from 0.5 to 1 %, the average grade increases %50 and the metal content increases %74.

The average grade of blocks is 5.29% cu on the basis of cut off grade 0.5 % cu. Average grade of samples was 9.04%. In this case, Standard deviation of blocks is 2.08% cu and. Standard deviation of samples was 3.14%.

**References**

1- Monazami, A., final report of geophysics, geology and drilling results of sheikhalie ore deposit, geological survey of Iran, 1381

2- Gemcom software manual

3- Hasanipak, A., Sharafaldin, M., analysis of exploration data, 1380

4- Madani, H., geo statistic, 1378

5- Hustrulid, V., Kutcha, M., designing and planning of open pit mines, 1383
Table 1 - statistical parameters of Cu grade

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<th>number</th>
<th>Minimum (%)</th>
<th>Maximum (%)</th>
<th>Average (%)</th>
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<th>coefficient of variation</th>
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<td>3.41</td>
<td>0.63</td>
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Fig 1- topography model and boreholes in Sheikhali ore deposit

Fig 2- plan view on the basis of surface geological map

Fig 3- incline section of ore body
Fig 4- 3D model of ore body

Fig 5- Frequency distribution of Cu grade

Fig 6- Logarithmic frequency distribution of Cu grade
Fig 7- 3D variogram with lag distance 5 m, azimuth and dip 0°

Fig 8- block model of ore body

Fig 9- variation of average grade versus cut off grade
Fig 9- variation of metal content versus cut off grade