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Employing non-linear geostatistical estimation methods for grade modeling and ore reserve estimation of Yazd, Aliabad copper deposit based on selecting optimal size of blocks

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Abstract

In the present research, grade modeling and ore reserve estimation of Yazd, Aliabad copper deposit were carried out using two high accurate non-linear geostatistical methods called log- kriging and multiple indicator kriging through Datamine. Variography of the transformed data in the variety of directions revealed that most empirical variograms are fitted with the spherical type of theoretical models, whereas the deposit has geometric anisotropy. To determine optimal block size of the deposit, kriging efficiency and kriging variance criteria were also employed obtaining the optimal block size of 20*20*7.5m. Based on validation of estimation results through cross-validation method for measured assay data against estimated values, determination coefficients were attained about 0.67 and 0.68 for log-kriging and multiple indicator kriging methods, respectively which are favorite results. Ore reserve estimation for various cutoff grades of 0.1, 0.15, 0.2, 0.25 and 0.3% showed that calculated reserve by indicator kriging method for cutoff grades of 0.1, 0.15 and 0.2% are less than log-kriging method about 6, 26 and 21%, respectively. The value for cutoff grade of 0.25% is equal for the both methods while in the case of 0.3% is about 13% higher. In general, the results of the indicator kriging method are more accurate due to the better resolution to separate ore deposit and waste. The results of the present study, can be generalized and used for all metallic ore deposits with geological and exploration conditions almost similar to Yazd, Aliabad copper deposit.

Introduction

Due to the adverse effects of estimation error in increasing the risk of mineral investments, the most accurate reserve estimation method which can guarantee the minimum estimation error, should be used. Kriging geostatistical estimator, which is based on weighted moving average logic, is unbiased having the minimum estimation error (Journel, 1989; Rendu, 1981). Of course, the kriging error is a function of spatial structure of data, geometry and size of estimated blocks. In the kriging estimation method, those variables that show a spatial structure (such as grade of mineral deposits) are investigated and the estimation is performed on the basis of spatial structure in the environment. Therefore, the presence or absence of spatial structure between the data is checked first, and then the data having the spatial structure are analyzed (Hassani-pak and Sharafodin, 2001; Madani, 1995). In these methods, each sample has a spatial relationship with the surrounding samples up to a certain maximum distance called range. This distance is very important and in fact it indicates the distance where geostatistical estimators can be used (Hassani-pak, 1998). Kriging is classified to two types of linear and non-linear.

In the present research, grade modeling and ore reserve estimation of Yazd, Aliabad copper deposit has been carried out using non-linear geostatistical methods. In this research, special attention has been paid to choosing optimal sizes of blocks to be estimated, as one of the important and influential parameters in the accuracy of estimation results. To choose the size of blocks and estimating the ore reserve of porphyry copper deposits in particular, in past several studies have been done which some of the most important ones are mentioned.

Quellaveco porphyry copper deposit located in the south of Peru was explored through an irregular drilling grid by 100 meter intervals and the reserve estimation of this deposit was done by Tobar et al. (1996). In this research, estimation blocks with dimensions of 20*20*10m have been used. Todorov et al. (2000) estimated the reserve of the porphyry copper deposit of Elatsite in Bulgaria through a 100*100m regular drilling grid so that the dimensions of the estimation blocks are 30*30*15m. To estimate ore reserve of a large porphyry copper deposit in Chile by Rossi (1999), the size of 25*25*15m was selected for estimation blocks. Champigny et al. (2002) to estimate the reserve of Radomiro Tomic, the large porphyry copper mine in Chile, drilled boreholes irregularly with intervals of 50 to 60m at the middle of the region, 50 to 100m further away, and 100 to 200m at the margins of the deposit. The dimensions of the blocks for reserve estimation of this deposit was 25*25*15m.

Study area: geographical location and geology

Yazd, Aliabad copper deposit is located in the western edge of central Iran, 55 km southwest of the Yazd city, 35 km southwest of Taft city and 2 km from Damak Aliabad village, in the southwest of the 1:250000 Aliabad topography map and the southern half of the 1:100000 Khezrabad geological sheet between 768000 to 771000 east longitude and 3503000 to 3507000 north latitude. Yazd-Taft-Aliabad asphalt road is the main access way to this deposit.

According to the report of copper deposits in Iran, the lithological diversity in this region is very high and the old rocks of the region are the Shirkooh Mountain with the composition of granodiorite to granite which are located with a large extension in the east of the study area (Khoyee et al., 1999). The oldest rock outcrops in the Aliabad region are conglomerate and sandstone of the Sangestan Formation from the late Jurassic and early Cretaceous. The Sangestan Formation is taken into account one of the main formations in the region and the lower interface of this formation placed angular related to the Shirkooh granites. Copper mineralization in Aliabad deposit mainly has taken place in granitoid intrusive stock and with less extent into conglomerates and its surrounding metamorphosed sandstones (Zarasvandi et al., 2006). The dominant alteration in the region is phyllic, hence granitoid rocks and some volcanic rocks are strongly affected by this type of alteration. In general, in the Aliabad region, the first few tens of meters up to down belong to the alluvial overburden, oxidized, supergene and hypogene zones, respectively. The most high-grade parts in the hypogene zone are related to the areas with the higher intensity of phyllic alteration. The deposit form is the vein, veinlet and filling fractures of rocks. The ore mineralization type is stockwork containing azurite and malachite minerals with magnetite and rutile (Zarasvandi et al., 2006).

Exploratory studies in the Aliabad copper deposit have been carried out in two phases, semi-detailed and detailed. The semi-detailed exploration stage comprised producing the

topography-geological map and geophysical studies, against drilling of exploratory boreholes in the detailed stage. Simultaneously and after

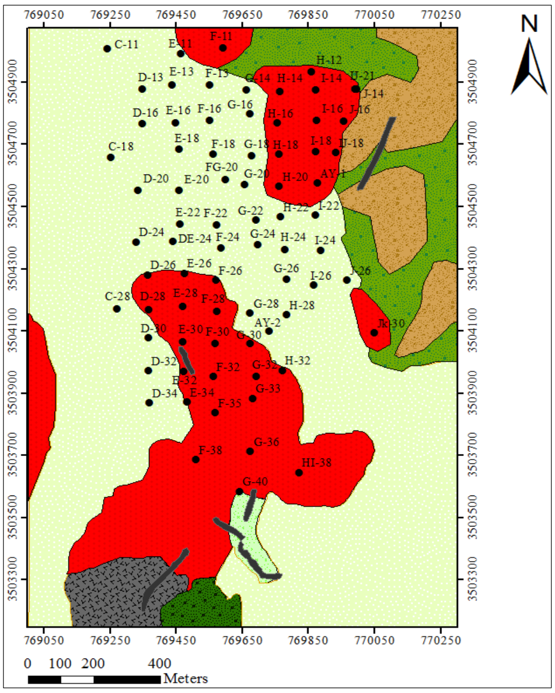
the geophysical survey (Saman-kav, 2015), exploratory drilling operation has been carried out, in which 75 exploratory boreholes with a total length of about 8800 m have been drilled. In general, from the 75 exploratory boreholes, G-40, JK-30, F-38 and IJ-18 boreholes with lengths of 200, 215, 200 and 128.5m, respectively, were drilled inclined and the rest, vertically. The length of shortest borehole (F-24) is 77 m and longest one (JK-30) is 215 m, whereas the average length is 119 m. From view point of topography, except boreholes F-11, F-38, G-36, HI-38 and G-40, the others were dug in a relatively smooth plain. The name of mineralization zones, amount of thickness, typical minerals and length of drilling performed in each zone are given in Table 1. On the drilling cores, studies such as recognition of rock type, identifying the presence and type of alteration, determining the type of mineral, identifying the type of fabric or texture, appearance color, identifying structure type and finally assay for the copper element have been done.

Table 1: Characteristics of mineralization zones and length of drilling carried out in each zone.

Status of mineralization	Zone name	Thickness (m)			Typical minerals	Length of drilling (m)
		Minimum	Maximum	Average		
No copper mineralization	Alluvium overburden	4	65	26	-	1090
	Leached	4	70	18	Iron and manganese oxides and clay minerals	1152
Containing oxide copper	Oxide supergene	6	34	15	Copper carbonates (malachite and azurite)	274
Containing sulfide copper	Sulfide supergene	2	48	17	Secondary copper sulfides (chalcocite)	1000
	Hypogene	21	176	70	Primary copper sulfides (chalcopyrite)	5311
Total length of drilling (m)						8830

Figure 1 shows the geological map of the study area with the collar location of exploratory boreholes. According to this figure, the boreholes are located in a relatively regular exploration grid, mainly on the granitoid intrusive unit.

Geological Map of Yazd, Aliabad Copper Deposit



Quaternary		Alluvium
Miocene		Quartz monzodiorite- Granodiorite
Oligo-Miocene		Granite
Eocene		Dark grey rhyodacite with porphyritic texture
		Light green rhyodacite tuffs as littic- crystal tuff
Upper Jurassic- Lower Cretaceous		Grey- green alteration of conglomerate and sandstone
		Dark grey greenish alteration of conglomerate and sandstone
		Dark brown quartzitic conglomerate and sandstone, well bedded
Symbols	•	Borehole location

Figure 1: Geological map of Aliabad copper deposit with the location of exploratory boreholes.

Materials and methods

To achieve the goal in this research, according to the status of the mineral deposit, amount and type of exploration activities carried out in the region, available exploration information and distribution of assay data, the precise non-linear geostatistical methods containing log-kriging and multiple indicator kriging (MIK) were used with Datamine software.

Basis of log-kriging method

If the data distribution is not normal, linear kriging methods cannot be used, because in this case, there will be an effect of proportionality of variance with mean (Madani, 2014). To overcome the problem in such a case, it is better to normalize the data using an appropriate transformation method so that linear methods can be used for estimation. The logarithmic transformation method is one of the common methods that is used in many cases. In the log-kriging method, instead of using the original data, their logarithm is used. In this way, estimations can be made using (ordinary or simple) kriging methods and then the estimated values are converted to real values with an inverse transformation (Matheron, 1973). The drawback of this method is that the variance of the estimated converted data is not properly returned to the real state. Unfortunately there is no comprehensive solution to get rid of this problem.

Basis of Indicator kriging method

Indicator Kriging (IK) is a nonlinear geostatistical estimation method introduced by Journel in 1983. Journell's main goal based on the work of Switzer et al. (1977), was local estimation by the local cumulative distribution function (cdf) process. The main characteristic of IK is its non-parametric nature without depending on the assumption of a specific distribution model for the results (Pierre et al., 2018). In fact, the IK method is independent of data frequency distribution.

The basic theory of IK is relatively simple. This method is used for equal distribution of N data samples to determine the probability of grade of a mineral deposit in a certain position is lower than a cutoff grade. Then, the proportion of N samples that are less than the cutoff grade, can be defined as the probability that the estimated value is less than this cutoff. If a set of cutoff grades is applied, a cumulative probability series is obtained. IK yields the cumulative probability distribution at a given location in a similar manner, except that using conventional kriging techniques, different weights are determined for surrounding samples to obtain the minimum estimation variance (Hassani-pak, 2003).

The IK equations system is the same as the ordinary kriging, with the difference that in IK, indicator variogram values are used instead of usual variogram (Catani, 2020). To calculate the indicator variogram, first, raw data should be converted to indicator variables. For this purpose, a cutoff grade must be considered as well as indicator variables obtained through the indicator function, which is defined via equation (1) (Hassani-pak and Sharafodin, 2001).

$$\mathrm{I}(\mathrm{x}, \mathrm{Zk}) = \begin{cases} 1 & \text{if } Z(x) \leq Zk \\ 0 & \text{Otherwise} \end{cases} \quad k = 1, \dots, k \qquad (1)$$

where I(x,zk) is the indicator value of the ith sample, Zk is the threshold and k is the total number of thresholds. In this scenario, the main values less than or equal to the selected threshold value are assigned a code of one and greater ones a code of zero. Therefore, all available data are converted to zero (greater than the threshold) and one (less than the threshold), then, the all kriging steps are performed based on the data converted to zero and one.

The indicator variogram for cutoff grade is calculated using equation (2):

$$\hat{\gamma}\mathrm{I}(\mathrm{h},\ \mathrm{Z_k}) = \frac{1}{2n(h)} \sum_{i=1}^{n(h)} \{ I(X_\mathrm{I},\ \mathrm{Z_k}) - \mathrm{I}(\mathrm{X_i}\ +\mathrm{hZ_k}) \}^2 \qquad (2)$$

where N(h) is the number of pairs separated by the vector h. In this case, estimated value of the indicator variable at each point is calculated through equation (3):

$$\mathrm{I}^*(\mathrm{u},\ \mathrm{Z_K}) = \sum_{i=1}^{n} \lambda(X_\mathrm{I},\ \mathrm{Z_k})\ \mathrm{I}\ (\mathrm{X_i},\ \mathrm{Z_k}) \qquad (3)$$

The indicator estimated value, i.e. I*(u, zk), ranges between a minimum of zero and a maximum of one and it represents the probability that grade of estimated block is less than assumed cutoff grade. The advantage of IK estimator is that by dividing the cumulative distribution function into smaller parts, the distribution function of those parts becomes normal and does not need to be normalized. This method can be used to determine the reserve of mineral deposit having a grade greater than the desired cutoff with the probability of its occurrence. It is also possible to draw the spatial distribution map of probability of occurrence from the deposit blocks with a grade greater than or equal to a cut off, easily (Hassani-pak, 2003). In estimation by MIK method, the probability of a block's grade passing one or more successive cutoff grades, is whatever that should be evaluated (Wang and Wang, 2020). One of the main applications of IK is determining the boundary of ore and waste in a deposit (Gossage, 1998). In fact, IK has a high efficiency in separating ore from waste.

Discussion and results

Basic statistical processing of data

In order to study the statistical attributes and determining distribution type of copper assay data from exploratory boreholes, statistical analysis for this variable was done. Descriptive statistics of raw and processed copper assay data (after removing outliers and bivariate logarithmic transformation) are summarized in Table 2. Also, figure 2 shows the histogram and probability diagram of these data. Based on the data in Table 2 and diagrams of figure 2, the distribution of assay data is not normal, but log-normal type which were properly converted to the normal distribution using a two-parametric logarithmic transformation.

Table 2: Statistical parameters of raw and processed copper assay data.

Data type	Number	Minimum (%)	Maximum (%)	Mean (%)	Median (%)	Mode (%)	Variance $(\%)^2$	Standard deviation (%)	Skewness	Kurtosis
Raw	3976	0.00001	5.57	0.23	0.14	0.25	0.108	0.33	5.4	51.6
Processed	3769	-1.95	0.74	-0.84	-0.83	-1	0.19	0.44	0.06	0.12

(C) (D)

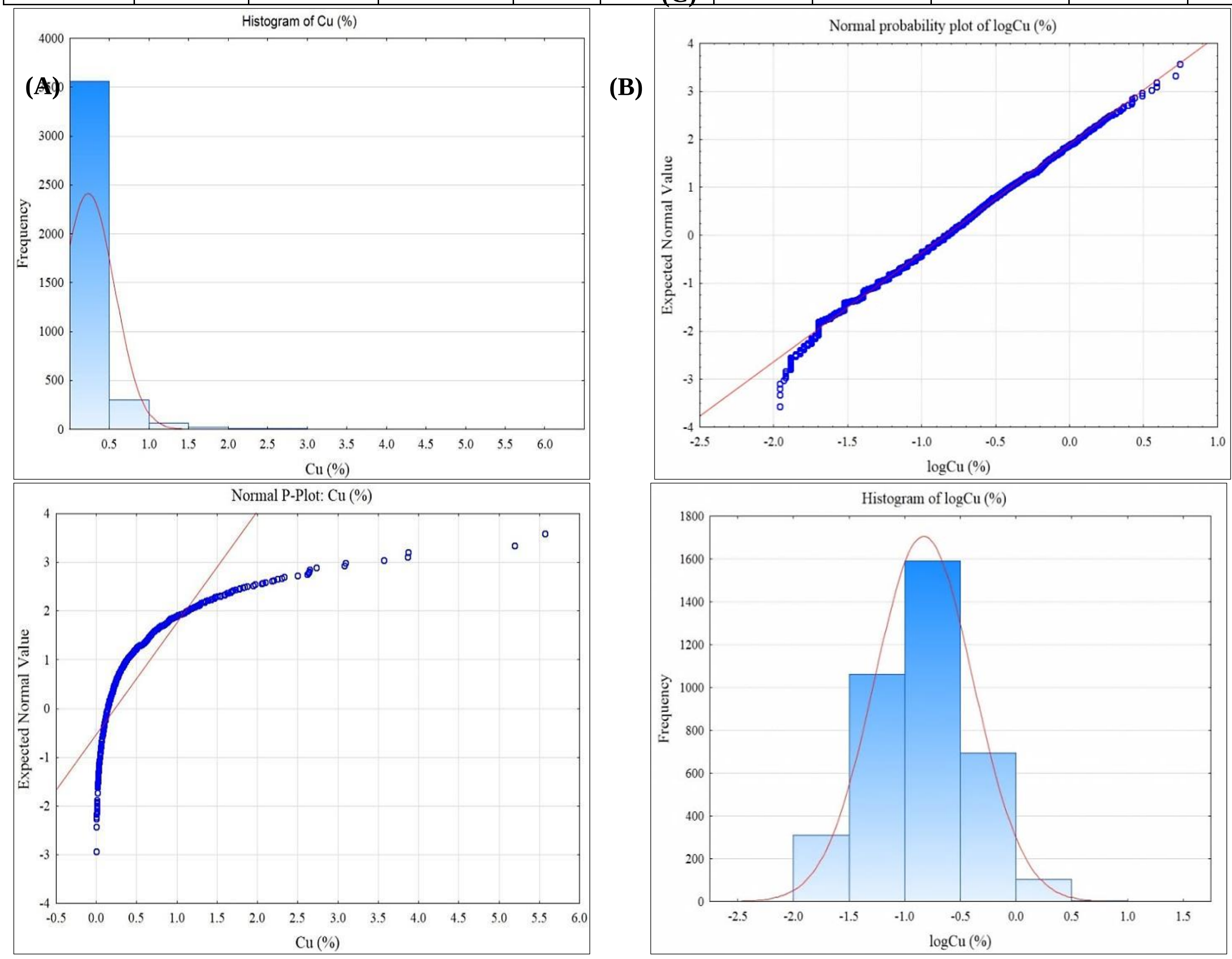
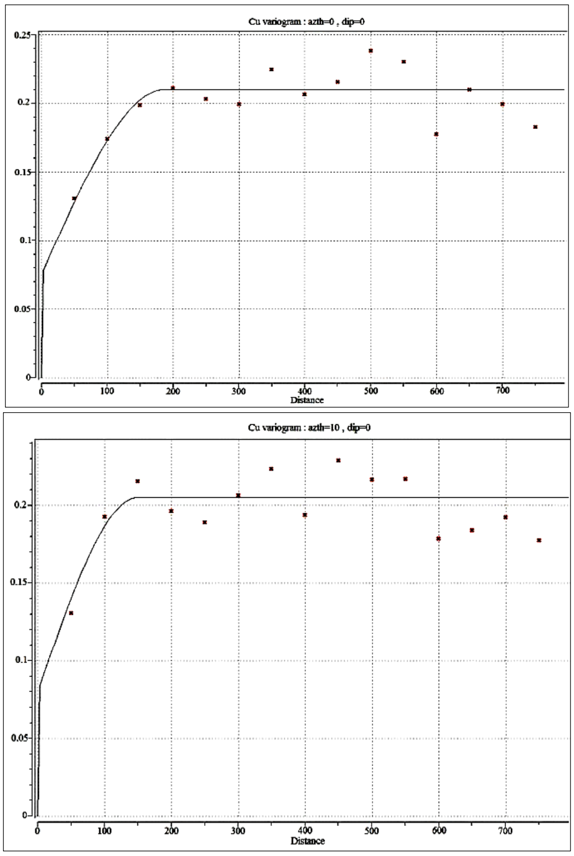


Figure 2: A) Histogram and B) probability diagram of raw copper assay data, C) Histogram and D) probability diagram of logarithmic copper assay data.

Spatial structure analysis of the copper assay data

To recognize spatial structure of the copper grade dominant in the region, strike variograms in the variety of directions were drawn. Primary parameters related to the variograms calculation were selected based on geometry of drilling grid. Regarding log-normal distribution of the copper assay data, to avoid the effect of proportionality of variance with mean and also appearance of pseudo zonal anisotropy, variography was carried out for the transformed data using SGeMS2 software (Remy et al., 2006, 2009; Bohling, 2007).

To achieve the goal, one variogram in vertical direction and horizontal strike variograms with azimuths ranging from zero to 180 degree (each 10 degree, one variogram) were drawn. The diagram of some of drawn strike variograms in the various directions have been shown in figure 3. In addition, for variograms with azimuths of 30 and 70 degrees, proper continuity and spatial structure wasn't appeared.



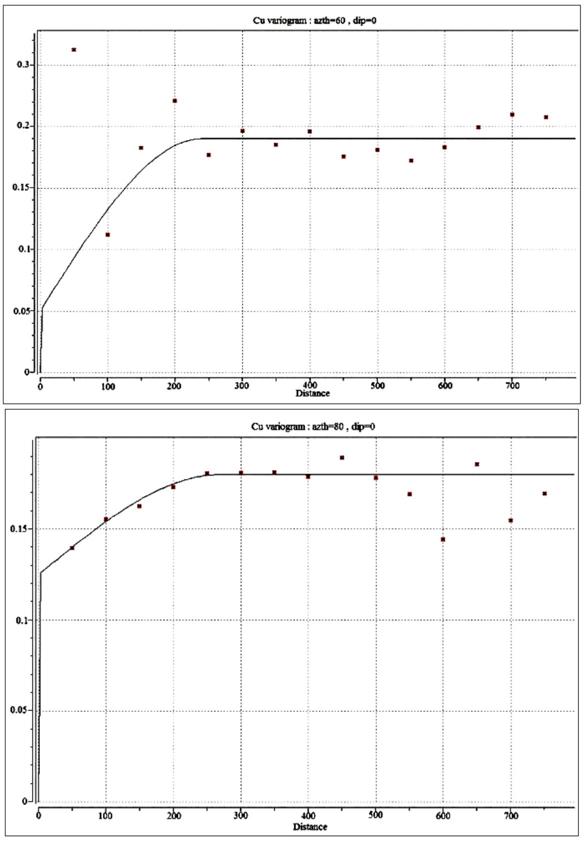


Figure 3: Strike variograms in the various directions for assay data of Aliabad copper deposit.

Determining parameters of search ellipsoid

According to the diagram of drawn strike variograms, all theoretical models fitted on empirical variograms are spherical type and strike variograms in the various directions have the same sill but different ranges; therefore, the studied area has geometric anisotropy. The range value in the depth direction is smaller than the horizontal directions, which indicates the higher variability of the grade in the depth direction. Since the strike variograms are spherical type, two-third of the variograms range was considered as the search radius. By fitting an ellipsoid on the ranges of the various strike variograms, radii of final search ellipsoid for the copper grade in the region was selected 210 m with azimuth of 150 degrees and zero degree slope, 170 m with azimuth of 60 degrees and zero degree slope, and 30 m along vertical direction. These parameters were applied for grade estimation with used kriging methods.

3D Solid modeling of the deposit

Figure 4 shows the 3D strip-logs of the assay data for all exploratory boreholes in the study area using Rockworks16 (www.rockware.com) software. In this figure, the radius of the cylinders represents the grade magnitude of the corresponding core length in the borehole. Since more than 94% of the samples have a length of 2 m, then the length of 2 m was chosen for the samples. Afterward, through string model making, estimation space was determined and according to figure 5 solid model of the deposit was produced by Datamine3 software. In this plan, boreholes F38, G36, HI38, G40 and C11 were not used to determine the estimation space due to their small thickness of mineral deposit.

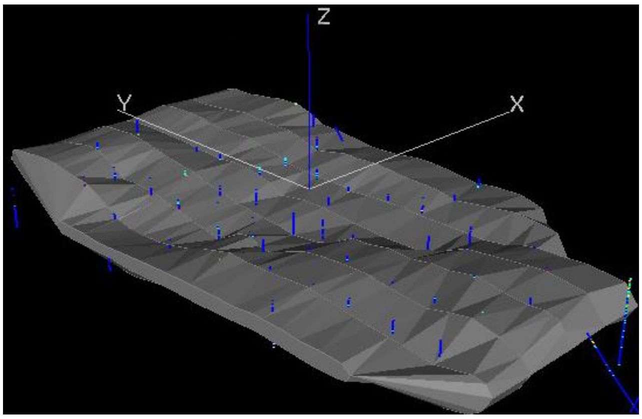


Figure 5: Solid model of Aliabad copper deposit with representing location of the exploratory boreholes (north direction is along Y axis).

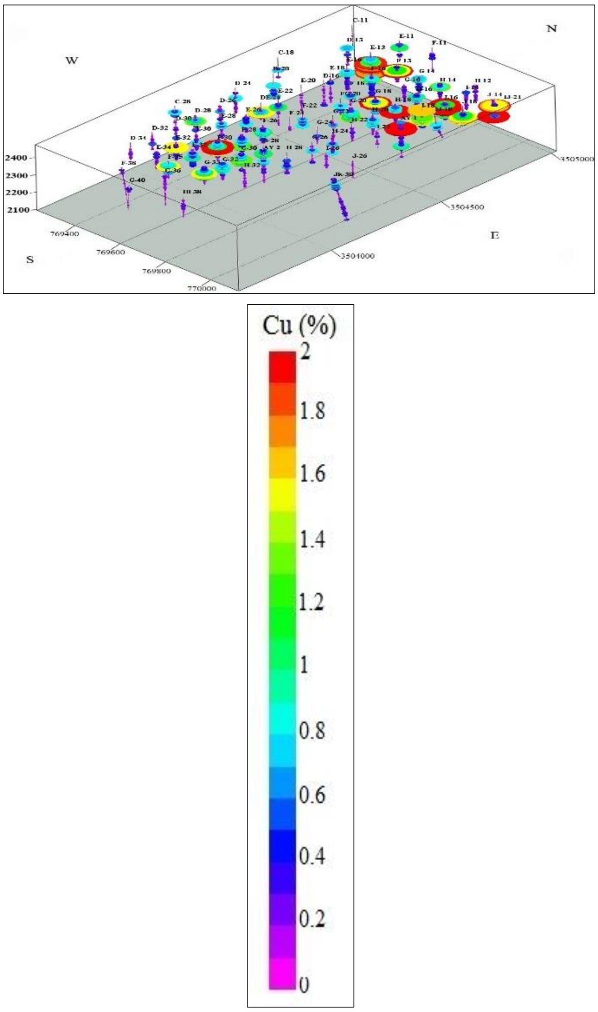


Figure 4: 3D view of strip-logs for assay data of exploratory boreholes in Aliabad copper deposit.

Determining optimal dimensions of estimation blocks

In order to determine optimal dimensions of estimation blocks in this research, first the investigations conducted in this field, were examined. According to Journel and Huijbregts opinion (1978), block dimensions should be less than the sampling intervals. These researchers have proposed one-third to half of distance between boreholes for dimensions of the blocks and they believe that choosing blocks with smaller dimensions causes artificial smoothness in the model; because the same grade is assigned to the adjacent small blocks and on the other hand, selection of very large blocks with respect to the boreholes interspacing, also reduces resolution of the model to separate ore and waste blocks. David (1979) suggested that the dimensions of blocks should not be less than a quarter of boreholes interspacing. According to Hulse (1992), choosing block dimensions equal to a quarter of sample intervals will be useful, when the length of variogram range is approximately ten times of the block dimensions. Vann and et al. (2003) believe that while the dimensions of blocks are chosen significantly smaller than the half spacing of drilling grid, acceptable results are usually not obtained, unless the grade has a lot of continuity; it means that the value of nugget effect is very low and range of variogram is very high. According to Rossi and Deutsch (2014) dimensions of estimation blocks should be chosen by considering boreholes interspacing and other engineering considerations. Estimated blocks may even be larger than selective mining units (SMU). In general, estimating the grade of large blocks is easier than small ones, and their estimated grade is closer to the actual grade, but selecting very large dimensions for blocks will also be problematic in mining planning work.

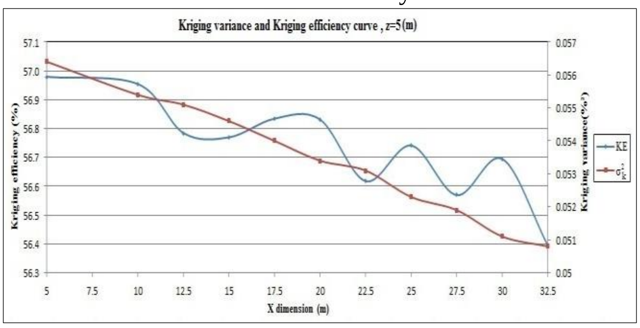
In the present research, to determine the optimal dimensions of blocks for Aliabad copper deposit, Kriging efficiency criteria (Krige, 1996) defined by equation (4) and Kriging variance were used.

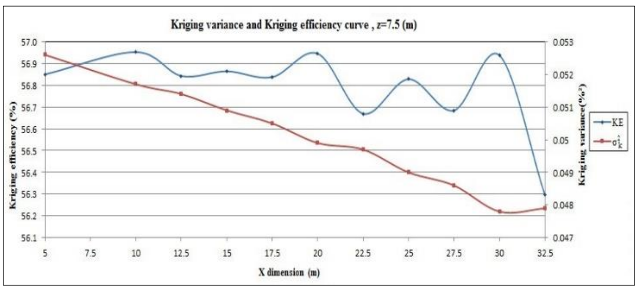
$$\text{KE }(\%) = \frac{\sigma_v^2 - \sigma_k^2}{\sigma_v^2} \times 100$$

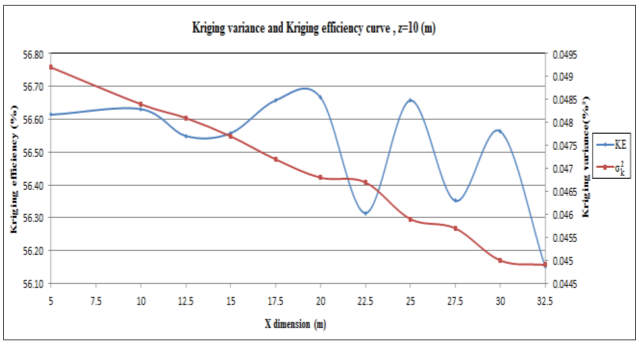
(4)

where in this equation, KE, σ_v^2 and σ_k^2 stand for the kriging efficiency, block variance and kriging variance, respectively.

In this approach, modeling and grade estimation for blocks with the heights of 5, 7.5, 10 and 15 m were done. Selection of these values for the height of blocks, has been performed based on feasibility of blasting operation and extraction of copper deposits, especially the material and type of mineralization country rock in Aliabad copper deposit (acidic igneous rocks with a lot of silica, containing granite and very hard and strong granitoids with RQD more than 80%). To determine optimum other two dimensions of the blocks through reviewing the sources and carried out researches in this regard and taking into account the geological and exploration conditions of Aliabad copper deposit, values of kriging efficiency and kriging variance for the variety of block dimensions between 5 and 32.5 m, was calculated for the deposit and their graphs were drawn (figure 6). Comparing the model behavior for the blocks with different dimensions, considering all aspects, shows that the block with dimensions of 20*20*7.5 m can be led to achieve an estimation with maximum efficiency and minimum error.







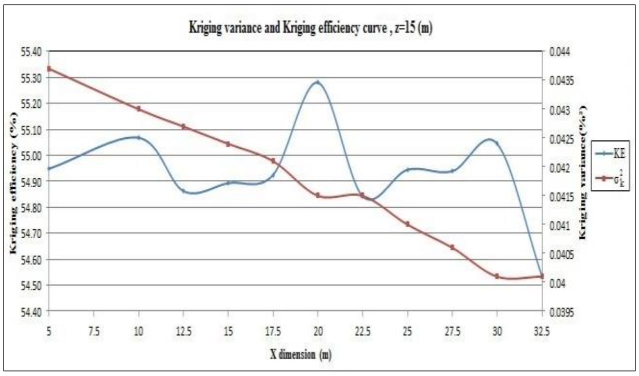


Figure 6: Kriging efficiency and kriging error diagrams for the variety of block dimensions. The heights of blocks are 5, 7.5, 10 and 15 m (up to down).

Making block model of the deposit with log-kriging method

By applying the parameters of research ellipsoid, block model of estimated grade for the deposit was made by log-kriging method with Datamine3 software according to figure 7(A) consisting of 31978 blocks with block dimensions of 20*20 m in the horizontal directions and 7.5 m in the vertical direction. The block model of estimation variance was also produced as figure 7(B).

(A) **(B)**

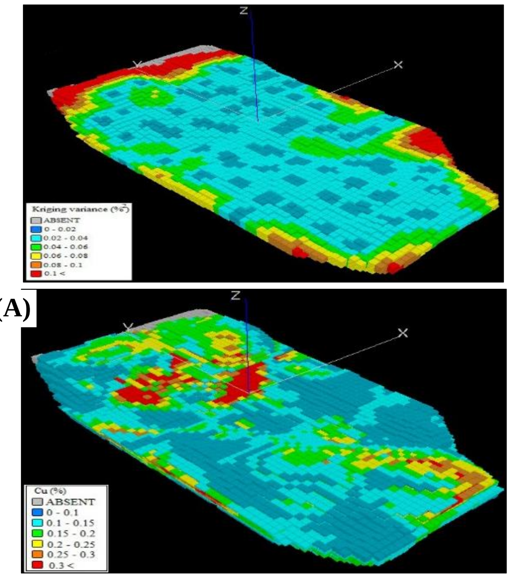


Figure 7: Block model of the deposit for A) grade, B) estimation variance.

Validation of estimation results with log-kriging method

The accuracy of the estimation results by log-kriging method was evaluated through cross-validation. In this method, based on the variogram model, each time one of the known data (input) is estimated by other data and at the end, the difference between actual and estimated data is checked. According to figure 8, determination coefficient between the actual and estimated grade values of the deposit using the log-kriging method is about 0.67 revealing a good correlation between these data. Therefore, performed estimation has a high degree of reliability.

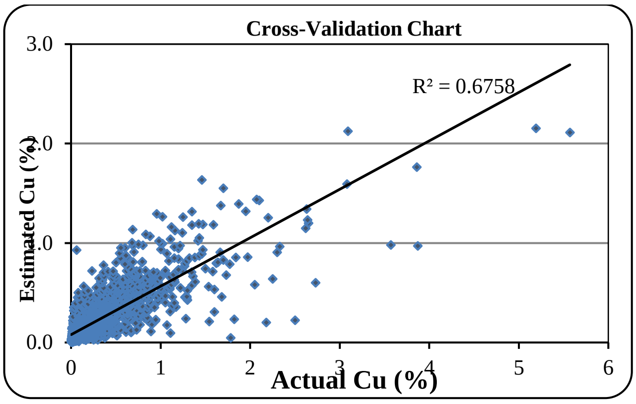


Figure 8: Cross-validation diagram of estimation by log-kriging method.

Evaluation of ore reserve with MIK method

Indicator Variography

Indicator variography of Aliabad copper deposit for five cutoff grades of 0.1, 0.15, 0.2, 0.25 and 0.3%, after converting raw assay data to zero and one values, was accomplished with SGeMS2 software. For this purpose, horizontal strike indicator variograms with azimuths from zero to 180 degrees (every 10 degrees, one variogram) and one indicator variogram in the depth direction (slope of 90 degrees) were drawn. Figure 9 shows some of indicator variograms in the various directions for the variety of cutoff grades. The parameters of search ellipsoid for different cutoff grades obtained from the indicator variography operation are also provided in Table 3.

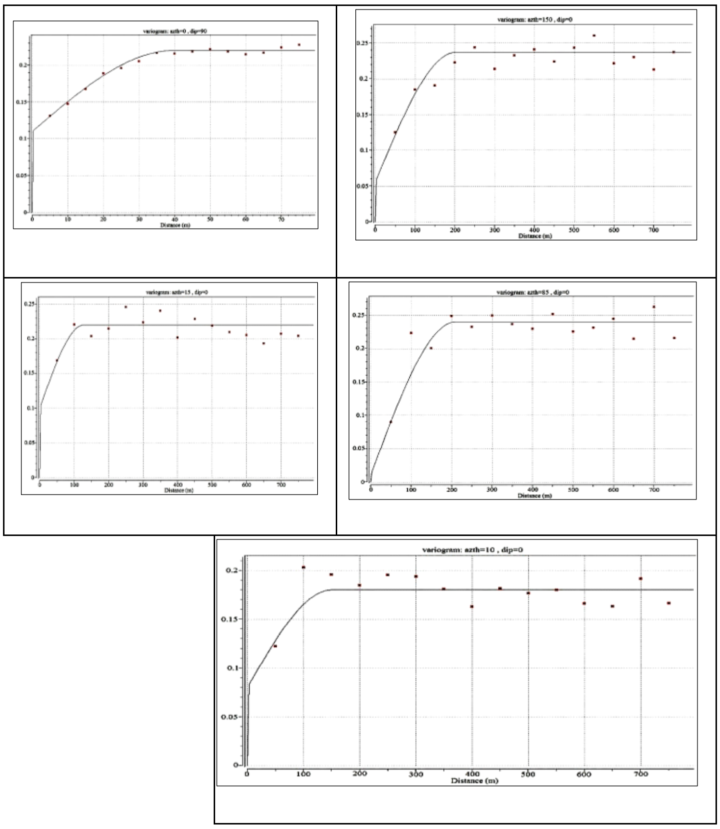


Figure 9: Strike indicator variograms for the various cutoff grades of Aliabad copper deposit.

Table 3: Parameters of search ellipsoid for the various cutoff grades in MIK method.

Short radius			Middle radius			Long radius			Parameters of search ellipsoid
Value (meter)	Dip (degree)	Azimuth (degree)	Value (meter)	Dip (degree)	Azimuth (degree)	Value (meter)	Dip (degree)	Azimuth (degree)	Cutoff grade (%)
30	90	0	130	0	150	150	0	60	0.1
25	90	0	100	0	25	160	0	115	0.15
25	90	0	100	0	175	140	0	85	0.2
20	90	0	90	0	15	120	0	105	0.25
20	90	0	90	0	10	120	0	100	0.3

Validation of estimation results with MIK method

In Figure 10, estimation results by MIK method using cross-validation method of measured grades against estimated values have been validated. According to the figure, determination coefficient between the actual and estimated grade values of the deposit samples using the MIK method is about 0.68 showing a good correlation between these data. Therefore, accomplished estimation has a high degree of reliability.

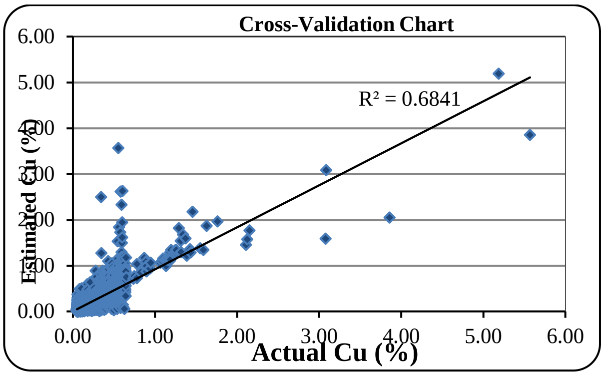


Figure 10: Cross-validation diagram of estimation by MIK method.

Ore reserve estimation and tonnage-grade diagram

On the basis of mining conditions and daily worth of the mineral deposit, average grade and ore reserve amount for cutoff grades of 0.1, 0.15, 0.2, 0.25 and 0.3% using log-kriging and MIK methods were calculated. Since copper mineralization occurred mainly in granitic and granitoid rocks, to calculate ore deposit tonnage, average density of the mineral deposit was considered equal to 2.7 gr/cm^3. Figure 11 shows tonnage-grade diagram of Aliabad copper deposit for the various cutoff grades using the applied methods. The results of calculating average grade and ore reserve amount are also summarized in Table 4. According to the diagram of figure 10 and the data in Table 4, calculated reserve for low amounts of cutoff grade by log-kriging method is higher than MIK while by increasing the cutoff grade, this difference is reduced so that for cutoff grade of 0.3%, estimated reserve with the MIK method is higher. Amount of calculated reserve by the MIK method is about 6, 26 and 21 percent less than the log-kriging method corresponding to the cutoff grades of 0.1, 0.15 and 0.2%, respectively. The value for cutoff grade of 0.25% is the same in both methods whereas becomes about 13% more for 0.3% cutoff grade.

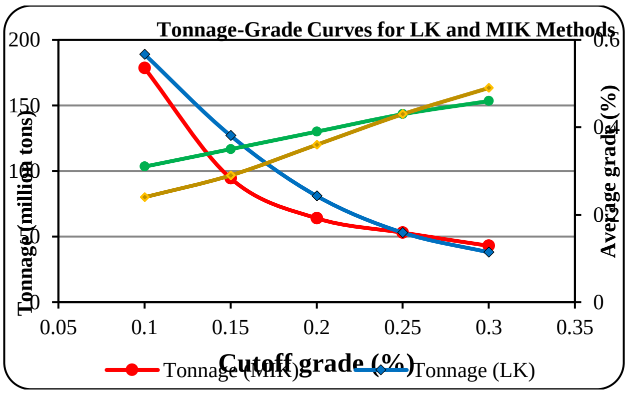


Figure 11: Tonnage-grade diagram of Aliabad copper deposit with different methods.

Table 4: Reserve estimation results of Aliabad copper deposit with different methods.

Reserve estimation method	Cutoff grade (%)	Average grade (%)	Amount of reserve (mT)
Log-Kriging	0.1	0.24	189
	0.15	0.29	127
	0.2	0.36	81
	0.25	0.43	53
	0.3	0.49	38
MIK	0.1	0.31	178.5
	0.15	0.35	94.5
	0.2	0.39	64
	0.25	0.43	53
	0.3	0.46	43

Conclusion

In the present research, grade modeling and ore reserve estimation of Yazd, Aliabad copper deposit for cutoff grades of 0.1, 0.15, 0.2, 0.25 and 0.3% using log-kriging and MIK methods have been done. Although both applied methods are the most accurate geostatistical reserve estimation methods, their results are slightly different from each other. Of course, considering the nature of the studied deposit, geological complexity and very low grade of the mineral deposit, this amount of difference between the two employed methods is acceptable. But answer to the questions of “which method is better?, the results of which method is more accurate and should always be used?”, depends on many factors, containing conditions and characteristics of the deposit, status of exploration data and knowledge level about the deposit. Obviously, each of applied methods in the present research has some advantages and disadvantages in comparison with other. For example, the simplicity of log-kriging estimation method is one of the advantages of this method compared to others and against, impossibility of recovering the estimation variance is one of its disadvantages. Better separation of ore from waste is one of the advantages of indicator kriging estimation method and relative complexity is one of its disadvantages. Therefore, the same prescription cannot always be prescribed for all different deposits and isn’t recommended a single method; rather, various methods may have better efficiency for different deposits.

The results of the present research can be generalized and used for all metallic deposits with geological and exploration conditions almost similar to Yazd, Aliabad copper deposit.

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