Resource estimation of the Damanghor gold deposit (Brdaskan, Northeast Iran) based on geological and grade continuity

Hassan Azmi*, Parviz Moarefvand, Abbas Maghsoudi
Department of Mining and Metallurgical Engineering, Amir Kabir University of Technology, Tehran, Iran
**Corresponding author, e–mail: azmi@aut.ac.ir*
(*received: 05/01/2020 ; accepted: 14/03/2020*)

Abstract
The selection of an appropriate estimation method is a crucial decision in resource estimation processes**.** There are multiple resource estimation methods of which the most important one is block modelling. Among the block modelling methods used for the estimation of gold resources, three methods have a broader application. These methods include Inverse Distance Weighting (*IDW*), Ordinary Kriging (OK), and Full Indicator Kriging (FIK). We compared the results of these three techniques and selected the most appropriate method for resource estimation of the Damanghor gold deposit. For this purpose, we prepared the geometric model of the deposit based on geological continuity and then, conducted the variography procedure to determine the grade continuity and the amount of gold resource. The dataset of the Damanghor area included eight diamond drilling boreholes and eight exploratory trenches comprising the grade results of 405 samples. The results show that FIK is the best method for resource evaluation of this case study. The OK method, however, is not suitable for this deposit. The IDW method provides reliable results when the drilling spacing is less than the variography range. This results can be used for the estimation of inferred resources when the geological continuity is appropriately determined.

Keywords: *Damanghor Gold deposit, Grade and geological continuity, Full indicator kriging, Ordinary kriging*

Introduction

There are multiple resource estimation methods that some of which provide profoundly different results when used in the estimation of the same mineral deposit. The effects of selecting an inappropriate estimation method can lead to ± 50% error in the estimate (Dominy & hunt, 2002). Therefore, the selection of an appropriate estimation method is one of the fundamental decisions in resource estimation (Mpanza, 2015; Afzal, 2018). This depends on the type of the deposit, its geometrical characteristics as well as the extent of exploration operations. This is also greatly important for low-grade and highly skewed gold deposits (Hill, 1998). The classical and geostatistical methods have been extensively applied to the estimation of gold resources, among which can point to the Inverse Distance Weighting (IDW) method as a classical approach, and to Ordinary Kriging (OK) and Indicator Kriging (IK) in geostatistics. Ordinary kriging is one of the commonly used parametric types of kriging (Daya, 2015).. The Median and Full Indicator Kriging (FIK) techniques are two of the non-parametric kriging methods frequently used (Vann & Guibal, 1998). Nowadays, however, the classical methods have a minor role in the estimation of mineral deposits. Instead, the geostatistical methods are used that are more robust. Dominy & Annels (2001) gathered the information of 24 mines in one of the Australian goldfields. They found out that eleven of these mines were evaluated through the polygonal section and averaging methods, seven of which through the inverse distance, inverse squared distance, and inverse cubic distance methods, two of them using the ordinary kriging method, and finally two of them through the indicator kriging method.

Various investigations on the Canadian mineral resources in the early 2000s showed that the estimation of about one third of the resources/deposits had been carried out through geostatistical methods, about one third by using the inverse distance and inverse squared distance methods, and one third of them through classical methods, such as the sections methods (Dagbert, 2005). With an emphasis on geostatistical methods, Sinclair & Blackwell (2004) suggested that the resource estimation of a deposit should be conducted using more than a single method.

Ordinary kriging can be used in the estimation of mineral resources and reserves. Alhassan & Boamah (2015) used this method to estimate the mineral resource of the Adansi mine in Ghana. They also compared this method with the IK method. Indicator kriging is one of the most essential and useful nonparametric kriging methods in mineral exploration. Indicator kriging was introduced by Journel (1983) and has been used extensively in grade estimation. This method is currently used in many geoscience fields from environmental to industrial projects. Some of these applications, such as the investigation of mixed population distributions of precious metals as well as the positive skewness of grade values, have increased the general application trend of the IK method. The main idea of using the IK method in geosciences is its nonparametric nature, which analyses multiple statistical communities simultaneously (Glacken & Blackney, 1998). Indicator kriging is a valuable approach for the estimation of gold resources with high skewness. For instance, Jones (1998) used this method to estimate the Morgan Cu-Au deposit. Many other authors have used this method in mineral exploration and mining projects (Keogh & Moulton, 1998; Lipton *et al.,* 1998; Fytas *et al.,* 1990; Shahbiek *et al.,* 2014; Rezai & Afzal, 2016; Rahimi *et al.,* 2018a, b).

In this study, we have investigated the application of the OK, IDW, and FIK methods to the resource estimation of the Damanghor gold deposit in the northeast of Iran. We have compared the results and introduced the most appropriate method for the resource estimation of such deposits.

Geology and mineralization

The Damanghor gold deposit deposit was explored through systematic geochemical explorations over the Bardaskan 1:100,000 geological map (Jiangxi co., 1995). This deposit is located in the north of Bardaskan (Kabudan village) Khorasan Razavi province, NE Iran (Fig.1).

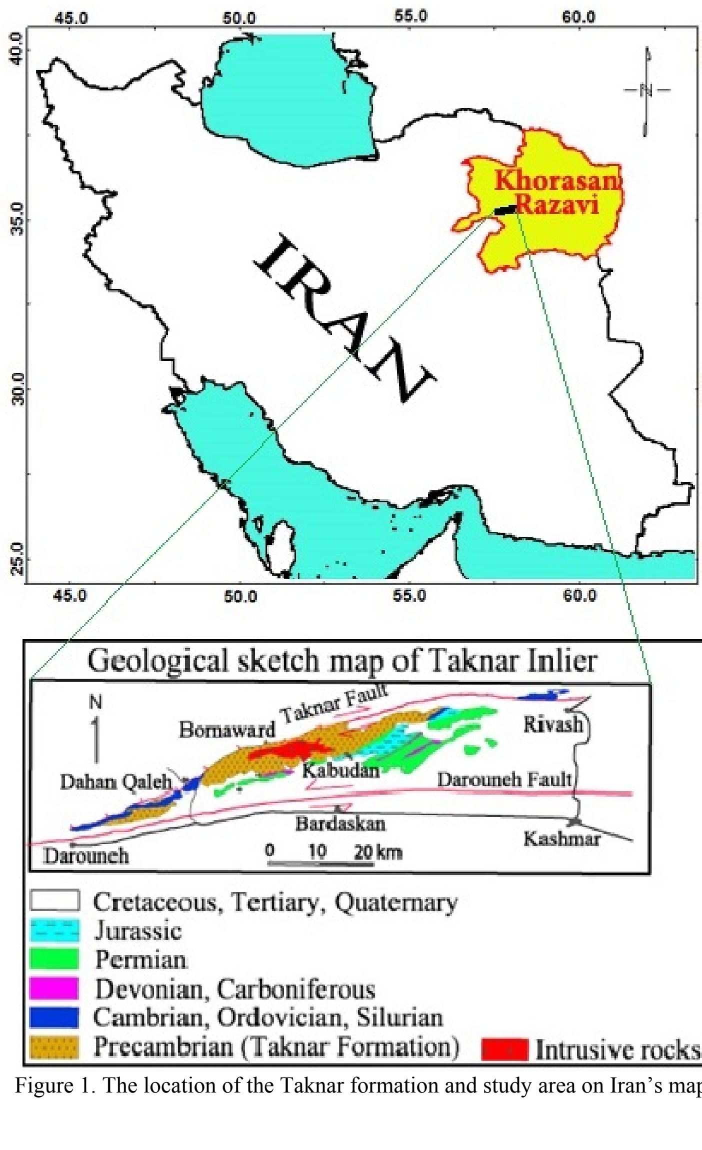


Figure 1. The location of the Taknar formation and study area on Iran's map.

Geologically, the study area is located in the Taknar Formation which is part of Sabzevar zone. The Taknar formation consists of an uplifted portion of the Central Iranian Precambrian to Paleozoic basement and its Mesozoic-Cenozoic cover (Fig.1). To the south, it is bordered by the Great Kavir Fault (Darouneh Fault), and to the north by the Taknar Fault (Monazzami Bagherzadeh *et al.,* 2015). Taknar Formation, which itself is formed of schist, meta-sandstone, and volcanic rocks and is accompanied by the Paleogene intrusive rocks and quaternary sediments.

In terms of mineral potentials, the zone is important for gold, copper, lead, zinc, silver and iron for metal group, and for feldspar, bauxite, as well as for construction and industrial soil in the non-metallic group. In addition to the Damanghor gold mine, the Taknar mine (copper, lead, zinc, gold and iron) is also located in this zone.

Figure 2 shows the geological map of the Damanghor gold deposit. There are two igneous rocks in Damanghor area; the oldest and most important igneous rocks include metamorphosed rhyolite and rhyodacite of the lower Taknar Formation.

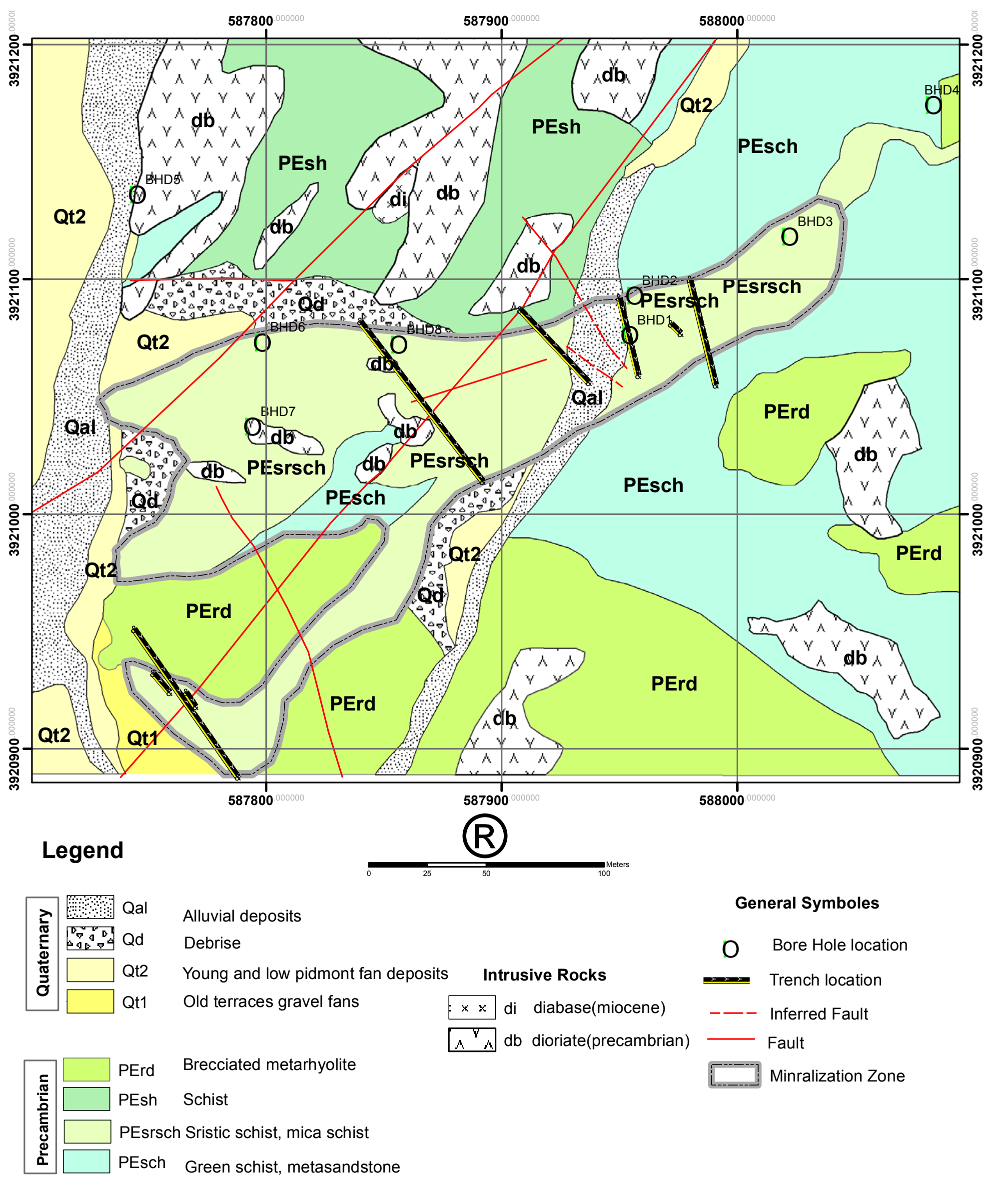


Figure 2. Geological map of the Damanghor Gold deposit (Safari *et al.,* 2014).

The Miocene diabase is the youngest igneous rock in the area that has intruded into the Taknar Formation (Abbasniya *et al.,* 2018). The basic rocks appear as minor diorites in the Damanghor area (Mazhari *et al.,* 2019). The other Precambrian rocks are including schist, sericitic schist, mica schist, green schist and meta-sandstone (Fig. 2).

The mineralized zone in the Damanghor area has an outcrop of about 400 m long and 30 m wide on average. An iron-arsenic rich sericitic schist unit mainly hosts the gold mineralization. The other host rocks include the green schists of the hanging wall and the meta-rhyolite and silica-feldspar breccia of the footwall. The genesis of this deposit was introduced as massive sulfide gold (Safari *et al.,* 2014).

Data processing

The data used in this study were obtained from trench and borehole excavations for the gold element, which will be processes in this section. It should be noted that eight exploratory trenches were excavated in the Damanghor gold deposit. These trenches had maximum, minimum, and average lengths of 107, 5, and 43 meters, respectively. 171 samples were taken from the trenches. The samples lengths ranged from 0.3 to 10 meters, with an average sample length of 1.7 meters.

Moreover, eight boreholes were drilled with maximum, minimum, and average depths of 91, 40, and 64 meters, respectively. 234 samples were taken from the boreholes. The samples lengths ranged from 0.1 to 8.8 meters, with an average sample length of 2.2 meters. It should be noted that the samples were taken from the trenches through the channel sampling method and from the boreholes through splitting the cores in half. Totally, 405 samples were collected from these surface and subsurface excavations for gold analysis. Table 1 shows the statistics parameters for gold concentration in trenches and boreholes.

In order to simultaneously use the datasets obtained from the trench and borehole explorations, we conducted the T-test on the data. As Table 2 shows, the results do not show any meaningful difference between the grade values of trenches and drill-holes.

Based on the results of the T-test, we integrated the trench and borehole samples, whose statistical parameters are presented in Table 3.

Table1. Statistical parameters of the samples taken from trenches and borehole (gold values in ppm).

Type of excavation	Number of samples	Mean	Std. Deviation	Std. Error Mean
borehole	234	0.578	1.745	0.114
trench	171	0.795	1.283	0.098

Table 2. Results of independent samples T-test for gold values (ppm) from trenches and boreholes.

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	DF	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
	Equal variances assumed	0.180	0.672	-1.37	403	0.17	-0.216	0.157	-0.526	0.093
	Equal variances not assumed			-1.43	402.9	0.15	-0.216	0.150	-0.512	0.079

Table 3. Statistical parameters of (a) analyzed samples from trenches and boreholes of the study area, and (b) one-meter-long composites of gold univariate (grade values in ppm).

Parameter	a	b
Number of data	405	804
Mean	0.67	0.46
Median	0.09	0.042
Mode	0.003	0.003
Std. Deviation	1.56	1.19
Skewness	4.81	5.2
Kurtosis	30	37.8
Range	14.5	14.5
Minimum	0.001	0.001

In this study, the length of samples varied between 0.1 and 10 m, with an average length of less than 2 m. The average lengths of trench and drill-hole samples bearing over 0.09 ppm gold are 1.3 and 1.7 m, respectively. Therefore, a one-meter-long composite of the data was prepared.

Figure 3 shows the histogram of samples with Au values higher than 0.09 ppm in the Damanghor deposit. In this figure, there is a main population of Au grades up to 2.0 ppm, and the values higher than that can be divided into several small populations. Only a few of these samples are considered as outlier values. Kim *et al* (2018) believe that in the assessment of resources, the top-cut process has no established criteria and is subject to analyst's judgment. Also, the grade range in this case study is not very high. Based on classical statistics, the number of outlier values is less than 1.0 percent of the whole dataset, which has no effective impact of the results. Therefore, we used the actual data in the resource estimation process. In addition, the variography process on outlier values in the full indicator kriging approach is conducted individually, which is a specific property of full indicator kriging.

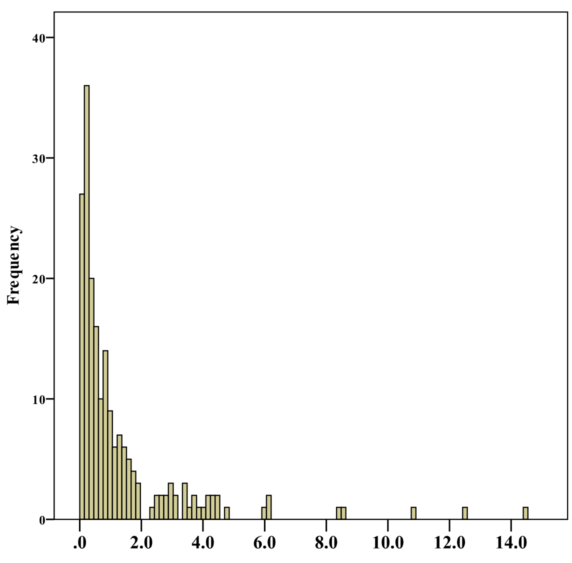


Figure 3. The histogram of gold distribution based on all data from trenches and boreholes.

Table 4 presents the number and percentage of samples in each grade class for one-meter-long composite data. This table is used for producing indicator variograms. Based on Table 4, the grade of more 50 % of samples is less than 0.05 ppm. These samples do not affect the resource value and are generally located outside of the estimation space.

Table 4. Grade classification of the samples and their cumulative distribution values.

Range (g/t)	Number of Samples	Percentage	Cumulative Percentage
< 0.05	417	52.0	52
0.05 - 0.1	81	10.1	62
0.1 - 0.2	73	9.1	71
0.2 - 0.3	37	4.6	76
0.3 - 0.4	15	1.9	77
0.4 - 0.5	2	0.2	78
0.5 - 0.6	41	5.1	83
0.6 - 0.7	10	1.2	84
0.7 - 0.8	9	1.1	85
0.8 - 0.9	12	1.5	87
0.9 - 1	11	1.4	88
1 - 1.5	30	3.7	92
1.5 - 2	16	2.0	94
2 - 3	17	2.1	96
3 -5	23	2.9	99
> 5	10	1.2	100

Geological continuity and block model

Understanding the geologic character of a mineral deposit as thoroughly as possible is an essential base on which to build an estimate of mineral inventory. Continuity is a topic of international concern in the study of mineral deposits and the classification of mineral inventories. In general, two types of continuity are defined in the framework of estimation (Sinclair & Vallée, 1994; Dominy *et al.,* 2003, Knight *et al.,* 2007): Geological continuity is the geometric continuity of a geological structure or zone hosting the mineralization, and Grade continuity is the continuity of grade that exists within a specific geological zone, sometimes called value continuity. In order to determine the geological continuity, the grade of samples taken from the trenches and boreholes is used. The geometrical model of a deposit is created based on geological continuity. Such a geometrical and 3D model is created using the information obtained from surface and in-depth drillings and provides a 3D representation of the deposit. Therefore, it is an approximate model.

The primary and most important basis of creating the geometrical model is the accurate logging of drilled exploratory excavations. After logging the boreholes and trenches, the sections are drawn in a way to cover the whole excavated zones. Finally, the drawn sections are integrated to form the geometrical model of the deposit. Since the mineralization outcrops are determined during the exploration project (Fig. 2), in the geometrical modelling of the deposit, they are tried to be correlated with subsurface mineralization zones.

In the next step, based on the geometrical model, type of mineralization, and length of samples, the block model of the deposit was prepared with a cell size of 1×1×1 m3 (maximum cell size was 2×2×2 m3). Totally, 86489 block cells were prepared with minimum and maximum volumes of 1 and 8 m3, respectively. The overall volume of the blocks was 381643 m3, which is the same of all three estimation methods. It should be mentioned that the mineralized zone in the Damanghor area is mainly hosted by an iron-arsenic rich sericitic schist. The other host rocks include the green schist of the hanging wall and the meta-rhyolite and silica-feldspar breccia of the footwall.

Estimation methods

In this study, based on the geometrical model and the block model, three highly applicable methods were used to evaluate the gold resources, which are presented in the results section.

Inverse Distance Weighting

Inverse distance weighting (*IDW*) is a type of deterministic *method* for multivariate interpolation with a known scattered set of points. In the IDW method, it is assumed substantially that the rate of correlations and similarities between neighbours is proportional to the distance between them that can be defined as a distance reverse function of every point from neighbouring point (Setianto & Triandini, 2013). This method has been used to evaluate gold resources in many Iranian projects (Fazlikhani, 2015).

In this area as well, the resource estimation was previously carried out using the inverse distance method by Safari *et al.* (2014). In order to evaluate the effectiveness of these methods, the grade-tonnage table was prepared (Table 5). This table is one of the most widely used tools to summarize the information obtained from mineral resource estimations. The total volume of the blocks was 381643 m^3 of which, for a grade of 0.1 g/t, the estimated volume was 381513 m^3, which is almost 100 percent of the total volume.

Ordinary Kriging

Ordinary Kriging (OK) is a linear geostatistical method which provides local estimation by interpolation. Krige and Matheron introduced this linear estimation technique to reduce the volume variance effect (Armstrong, 1998). OK assumes that regionalized variables are stationary where the mean is unknown (Mpanza, 2015). In this study, in order to conduct the resource estimations, a variography was carried out first. One of the features of variogram is that it can also confirm the grade continuity using the variography range (Sinclair & Blackwell, 2004). In the Damanghor area, variography was performed, and the non-directional variogram was selected as the best one. Figure 4 shows a plotted variogram showing a spherical model with two structures fitted, with the following features:

A nugget value of 0.144, a special variance 0.778, a range of 5 meters for the first structure; and a special variance of 1.072, and a range of 27 meters for the second structure. The results of resource estimations using the OK method are presented in Table 6. The total volume of the blocks was 381643 m^3 of which, for a grade of 0.05 g/t, the estimated volume was 199089 m^3.

After conducting the resource estimation through the OK method, the 3D models of the deposit were drawn.

Table 5. Estimated grade-tonnage values for various gold grades through Inverse Distance Weighting (IDW).

grade (g/t)	Average grade (g/t)	Tonnage (tons)	volume (m^3)	gold content (kg)
0.1	0.85	991933	381513	843
0.2	0.94	879964	338448	827
0.5	1.51	460779	177223	696
0.7	1.76	367179	141223	646
1	2.29	231696	89114	531
1.2	2.44	205444	79017	501
1.5	3.01	135223	52009	407
1.7	3.32	111519	42892	370
2	3.72	87851	33789	327

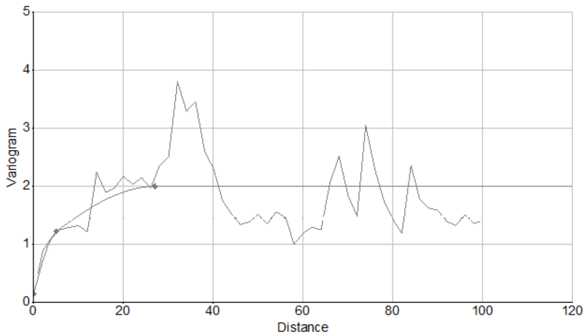


Figure 4. Various variograms of assay data for gold.

Figures 5 and 6 show the southward and northward views of the 3D model, respectively. Since, as the threshold, the grade values higher than 0.1 ppm are important for the estimation of gold resource, Figure 7 also shows the northward 3D model of the deposit.

Full Indicator Kriging

Indicator kriging is the process of transforming a dataset into a zero and one scale (Eq. 1). Indicator kriging is simply the application of (simple or ordinary) kriging in the estimation of a variable (for instance gold value; g/t) in which all indicator variables are transformed into a 0-1 scale, depending on the value to be higher or lower than the threshold called the indicator cut-off (Sinclair & Blackwell, 2004).

Table 6. Estimated grade-tonnage values for various gold grades through Ordinary Kriging (OK)

grade (g/t)	**average grade (g/t)**	**tonnage (tons)**	**volume (m^3)**	**gold content (kg)**
0.05	0.50	747024	199089	375
0.1	0.86	419796	161460	363
0.2	1.04	339063	130409	352
0.3	1.20	282641	104403	338
0.5	1.55	198463	76332	307
0.7	1.74	164715	63352	286
0.9	2.16	114647	44095	248
1	2.25	106837	41091	240
1.5	2.39	92495	35575	221
2	2.85	53305	20502	152
2.5	3.32	31689	12188	105
3	3.80	17620	6777	67
5	5.49	824	317	5

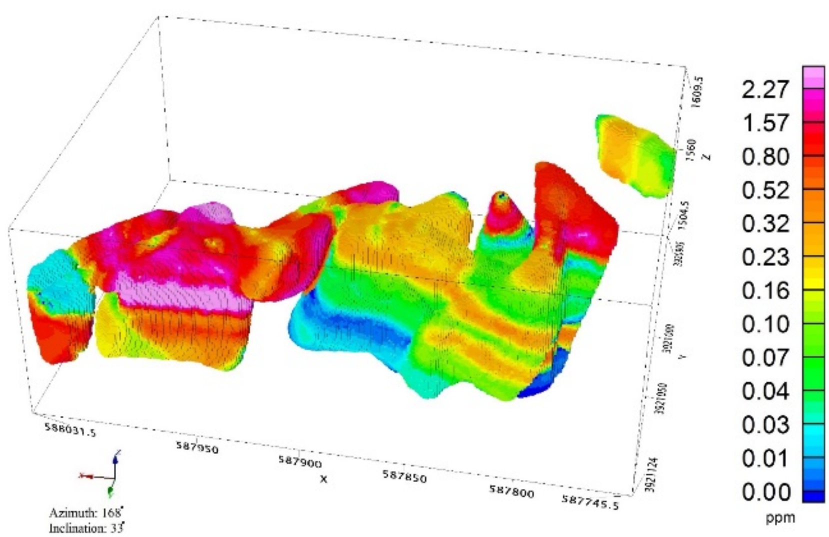


Figure 5. The 3D model of the Damanghor gold deposit based on the OK method (view southward)

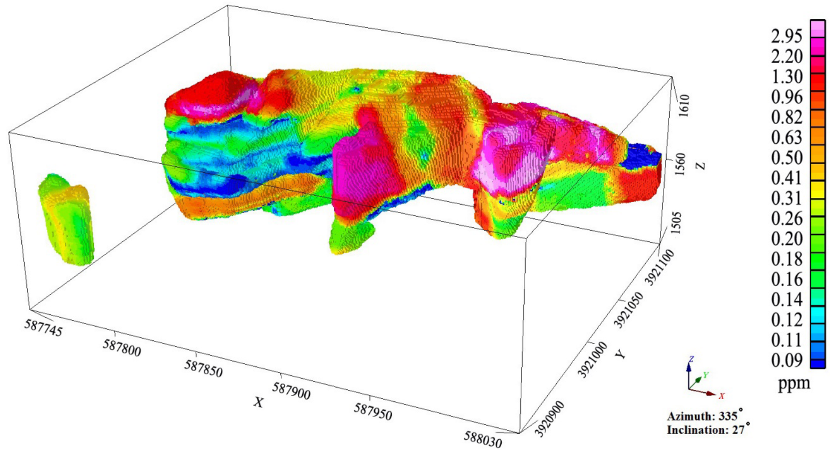


Figure 6. The 3D model of the Damanghor gold deposit (view northward).

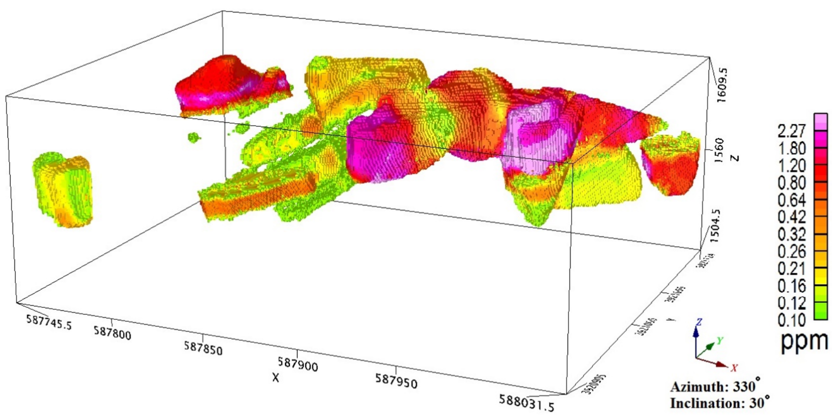


Figure 7. The 3D model of the Damanghor gold deposit for grade values higher than 0.1 ppm (view northward)

$$I(X; Z_k) = \begin{cases} 1 \; if \; Z(x) \leq Z_K \\ 0 \; if \; Z(x) > Z_K \end{cases} \quad k = 1, \ldots, K \qquad \text{(Eq. 1)}$$

where, *I* is the indicator variable defined at location *X* for the cut-off Z_k, and Z(x) is the grade at location *x* (Alhassan & Boamah, 2015). Based on the distribution of gold values and the previous experiences, the indicator kriging method and the variography were performed for resource estimation. The variograms for various grades of 0.05, 0.1, 0.2, 0.3, 0.4, 0.5, .07, 0.8, 1, 1.5, 2, 3, and 5 g/t are depicted in Figure 5. As shown, a spherical model with two structures were fitted on the variogram curves. Having plotted the variograms for different grades, we performed the indicator kriging method. The probability of the cumulative distribution was calculated for each grade and 13 thresholds using the ordinary kriging technique. The characteristics of indicator variogram for 13 grades are shown in Table 7. In this table, the spatial variance is representing the difference between the sill and nugget effect values. After conducting the resource estimation using the full indicator kriging, the grade-tonnage curve was plotted for the Damanghor gold deposit (Table 8 and Figure 8). The total volume of the blocks was 381643 m^3 of which, for a grade of 0.05 g/t, the estimated volume was 317816 m^3.

Next, the resource estimation was conducted through the FIK method. The 3D models of the deposit are shown in Figures 9 to 11. A comparison of Figures 8 and 11 show that the Au grades of higher than 0.1 ppm for the FIK method cover a bigger volume. Therefore, compared to OK, the FIK method provides a larger resource, which can be proved based on Table 7 as well.

Results and conclusions

Table 9 presents the estimated resource values through these three methods for several grades. The results of resource estimation show that OK has a big difference with the inverse distance and full indicator kriging methods.

Table 7. Characteristics of indicator variogram

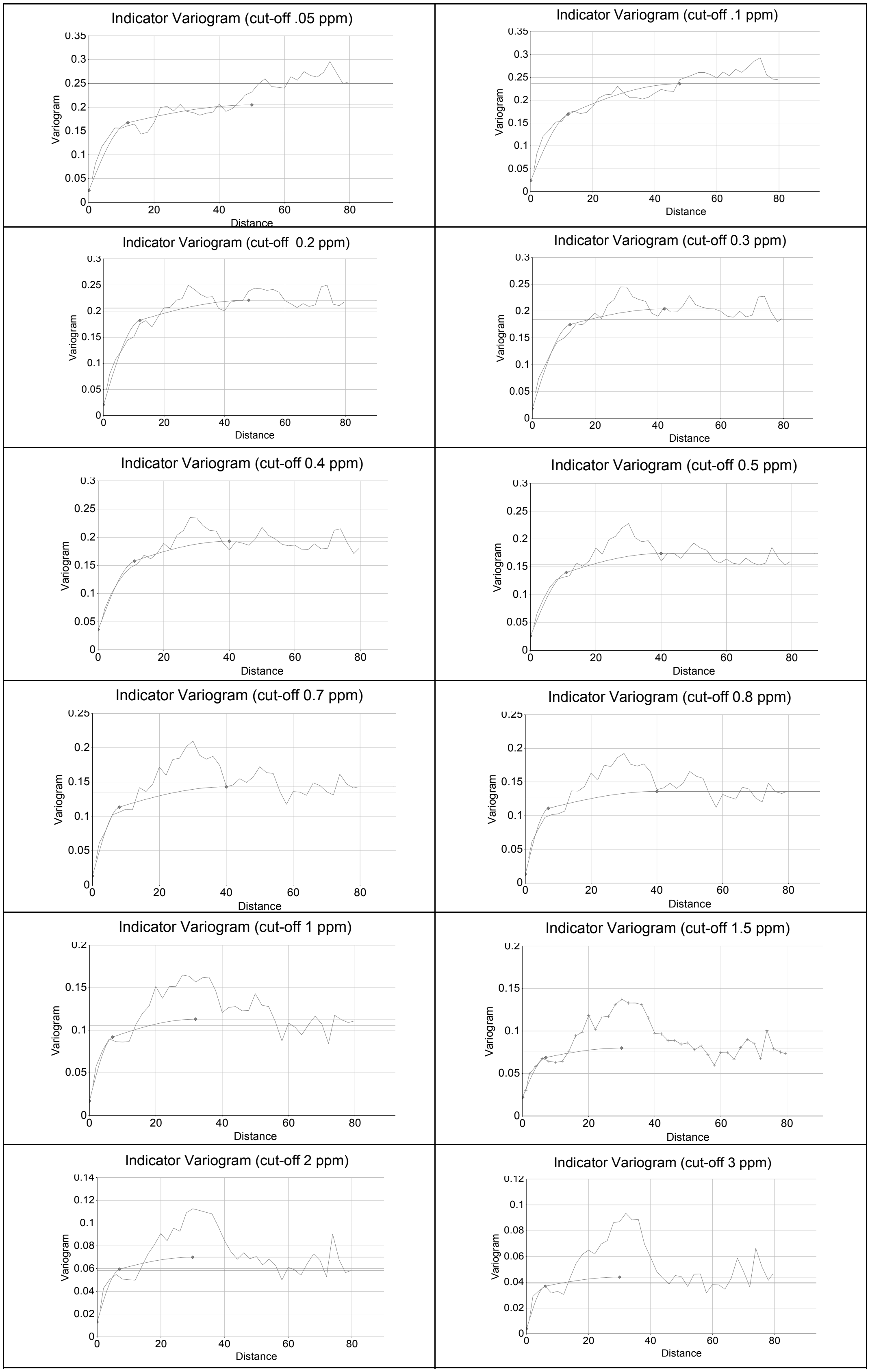
grade (g/t)	nugget	Spherical Structure	spatial variance	Range (m)	grade (g/t)	nugget	Spherical Structure	spatial variance	Range (m)
0.05	0.025	1	0.122	12	0.8	0.013	1	0.089	7
0.05		2	0.058	50	0.8		2	0.034	40
0.1	0.024	1	0.106	12	1	0.017	1	0.065	7
0.1		2	0.106	48	1		2	0.031	32
0.2	0.021	1	0.139	12	1.5	0.022	1	0.041	7
0.2		2	0.061	48	1.5		2	0.017	30
0.3	0.018	1	0.136	12	2	0.013	1	0.041	7
0.3		2	0.05	42	2		2	0.016	30
0.4	0.036	1	0.098	11	3	0.004	1	0.03	6
0.4		2	0.059	40	3		2	0.01	30
0.5	0.026	1	0.091	11	5	0.001	1	0.011	5
0.5		2	0.057	40	5		2	0.003	27
0.7	0.013	1	0.068	8					
0.7		2	0.042	40					

Table 8. The estimated grade-tonnage values for various gold grades using the Full Indicator Kriging (FIK)

grade (g/t)	average grade (g/t)	tonnage (tons)	volume (m^3)	gold content (kg)
0.05	0.76	826322	317816	624
0.1	0.83	745183	286609	618
0.2	1.14	516919	198815	587
0.3	1.32	430342	165516	566
0.4	1.56	344731	132589	537
0.5	1.70	304678	117184	519
0.6	1.89	263383	101301	497
0.7	2.02	237585	91379	480
0.75	2.09	225397	86691	471
0.8	2.10	222828	85703	469
0.9	2.58	161938	62284	418
1	2.68	152438	58630	409
1.25	3.13	119322	45893	374
1.5	3.28	110139	42361	361
2	3.58	91413	35159	327
2.5	4.17	63261	24331	264
3	4.83	43571	16758	211
3.5	5.12	37084	14263	190
4	5.33	32040	13323	171
5	5.97	18707	7195	112

Table 9. The results difference of the FIK, OK and IDW methods.

	IDW			OK			FIK		
grade (g/t)	grade (g/t)	volume	gold content (kg)	grade (g/t)	volume (m^3)	gold content (kg)	grade (g/t)	volume (m^3)	gold content (kg)
0.1	0.85	381513	843	0.86	161460	363	0.83	286609	618
0.2	0.94	338448	827	1.04	130409	351	1.14	198815	587
0.5	1.51	177223	696	1.55	76332	307	1.70	117184	519
0.7	1.76	141223	646	1.74	63352	286	2.02	91379	480
1	2.29	89114	531	2.25	41091	240	2.68	58630	409
1.5	3.01	52009	407	2.39	35575	221	3.28	42361	361
2	3.72	33789	327	2.85	20502	152	3.58	35159	327


Indicator Variogram (cut-off .05 ppm)
Indicator Variogram (cut-off .1 ppm)
Indicator Variogram (cut-off 0.2 ppm)
Indicator Variogram (cut-off 0.3 ppm)
Indicator Variogram (cut-off 0.4 ppm)
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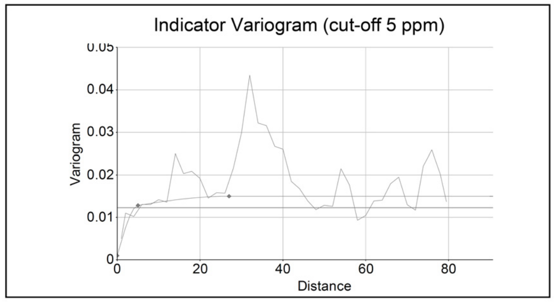

Figure 8. Indicator variograms of different gold grades. All distance values are in meter.

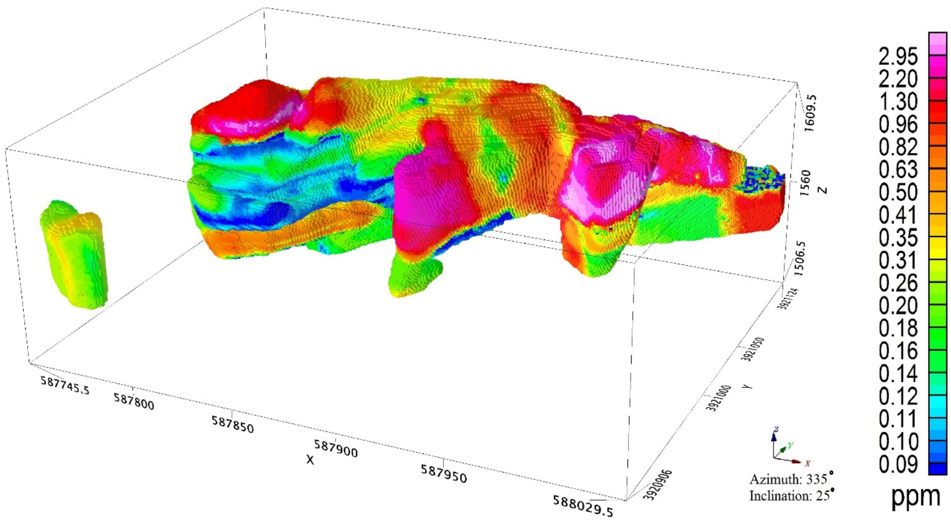

Figure 9. The 3D model of the Damanghor gold deposit based on the FIK method (view northward).

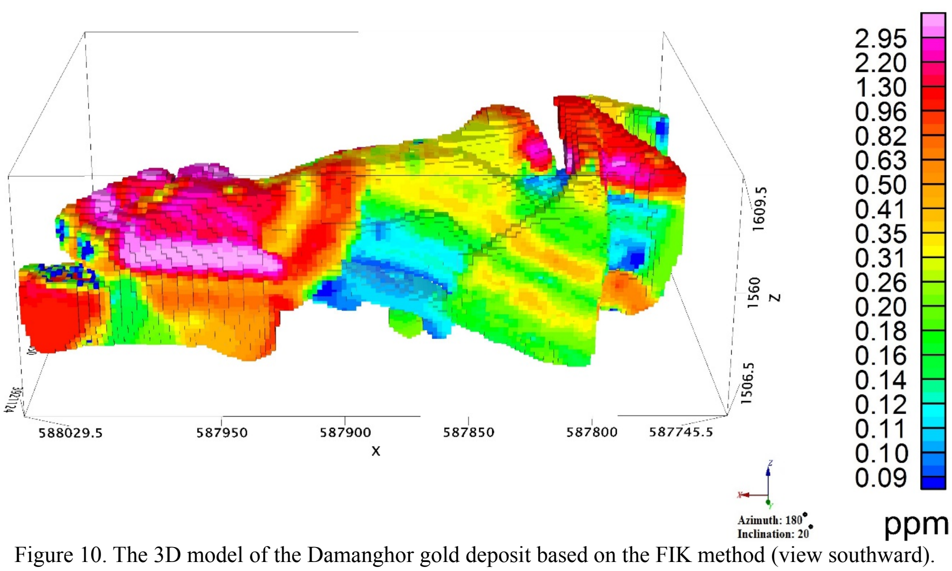

Figure 10. The 3D model of the Damanghor gold deposit based on the FIK method (view southward).

As Table 7 shows, such a big difference between the estimated resource could be due to the estimated volume in each method and somehow due to the average grade values estimated through different methods. The overall estimated volume of the block model for these three methods is 381463 m^3. The grade of 0.1 g/t in the inverse distance method was able to estimate the whole volume of the model.

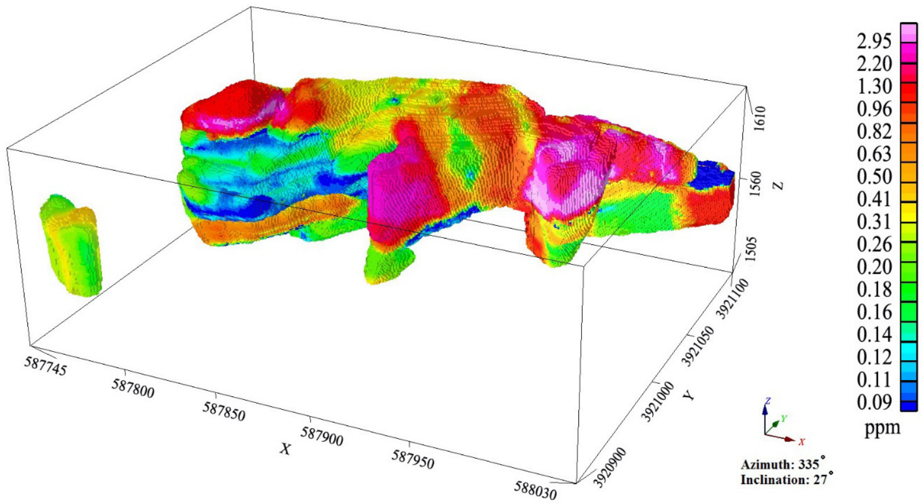

Figure 11. The 3D model of the Damanghor gold deposit based on the FIK method for Au grades higher than 0.1 ppm (view northward).

For a grade of 0.1 g/t, about 40 percent of the overall volume was estimated in the OK method and around 70 percent in the FIK method. The average estimated grade using the FIK method is higher than that of the inverse distance and OK methods. The OK method has the minimum estimated volume and a lower average grade for higher grades. The difference in the estimated volumes through different methods depends on the way that grade continuity is determined. In the inverse distance method, grade continuity is determined based on the spacing of exploratory excavations and geological continuity. The geostatistical methods, however, are conducted based on variography, and the effective range shows the grade continuity. When the effect range is less than the exploratory excavations, it covers a lower estimation space. If the drilling spacing is low and an appropriate geometrical model is selected based on geological continuity, the results of the inverse distance method are closer to that of the indicator kriging method. On the other hand, when the drilling spacing is higher than the effect range of the FIK method, the inverse distance method covers a higher volume and the estimated resource is therefore larger than that of the indicator kriging approach.

Since the gold grades are highly skewed, they are not used in the resource estimation through the OK method. In other words, the data used in the OK method should be normalized first. In the literature, the log-normal kriging method has not been accepted in the estimation of gold resources (Sinclair & Blackwell, 2004). Generally, the full indicator kriging and inverse distance methods are used in various steps of gold exploration. Therefore, as the difference between the FIK and IDW methods increases, the spacing of exploratory excavations should reduce to lower than the effect range of the kriging method.

In this study, the results obtained from IDW and FIK methods are relatively close. For lower grades, the IDW overestimates the resource, and for higher grades the results of the two methods are close. The inverse distance method is not a geostatistical approach. If the spacing of exploratory excavations is low (about 25 m for gold), the grade continuity or discontinuity is provable, and this method can be an appropriate approach for the estimation of gold resources. Finally, the application of inverse distance and full indicator kriging for gold resource estimations are suggested. However, since the indicator kriging method is a non-parametric approach and considers grade continuity in gold resource estimations, it outperforms other methods.

It should be noted that although geostatistical methods are preferable to classical methods, by considering the nature of gold, there is a need for complete datasets and a lot of drilling, which unfortunately in many of gold projects in our country, the drilling data are limited. There is the same problem in this research as well.

Acknowledgment

The authors would like to appreciate the Geological Survey of Iran (Northeast Territory, Mashhad) for permitting the publication of exploration data of the Damanghor gold deposit.

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