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COMPARING THE ACCURACY OF KRIGING AND IDW INTERPOLATION FOR ESTIMATING A CU-ZN DEPOSIT IN TURKEY

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Abstract

In mining, resource and reserve estimation is used to determine both the quantity and quality of ore. Mineral resources can be defined as the concentration of economically important material within the Earth's crust, while mineral reserves are the portions of a mineral resource that can currently be economically mined. Different portions of a deposit may contain different concentrations of minerals and structural components, and therefore a geological model of the deposit allows for the selection of the most appropriate exploration technique. Accurate reserve estimates for mining sites require accurate calculations of ore quantity and grade. For metal ores in particular, IDW and kriging are well-known interpolation methods that have been used for many years. Inverse distance weighting (IDW) is a deterministic interpolator that produces estimates without associated error measures, while geostatistical kriging is a probabilistic technique that allows both the estimates and the assessment of their uncertainty through the estimated variances. This study aims to calculate and compare interpolation methods such as IDW and kriging for a Cu-Zn mineral deposit in Turkey.

Keywords: *Resource estimation, interpolation, geostatistics*

1. INTRODUCTION

When choosing an investment project, it's natural for an investor to choose between a low-risk and a higher-risk option. However, in the mining industry, this situation unfolds somewhat differently. Mining projects carry higher risks and the time it takes to pay off the investment, and the exploration process, in particular, requires significant time and money [1]. The first and often most critical phase of a mining operation is the exploration phase. It is also one of the most difficult assessments to make when accurate data is lacking. The primary goal of mineral exploration is to identify locations with sufficient, economical mineral deposits, including metals such as gold, silver, copper, and iron, or industrial minerals such as gypsum, limestone, and potassium. The value-added component of a significant exploration success can be many times the company's initial value. While crucial for the company, it is difficult to predict the likely outcome of an exploration program, especially for external investors. However, it is important to be aware of some basic exploration principles and terminology when dealing with resource companies. It is important to note that exploration results are critical for establishing confidence by providing a clear picture of three key characteristics of the orebody: ore grade, volume, and ore continuity. Confidence regarding the ore's grade, volume, and ore continuity will increase as the number of data points increases. That is why ore characteristics must be verified using different interpolation techniques.[2]

2. GEOLOGICAL MODEL

The project area is predominantly underlain by the Upper Cretaceous (Maastrichtian) volcanics unit, composed of mafic to intermediate lavas and volcanoclastics like spilite, spilitic basalt, and andesite. Mineralization is associated with rock types including basalt, trachyandesite, sosuritic basalt, and dolerite. The geological interpretation suggests the basalts and andesites formed the original volcanic structure, which was subsequently intruded by dolerite. Additionally, granite of presumed Tertiary age is present within the project boundaries.

- Andesit (AND)
- Basalt (BAS)
- Dolomit (DOL)
- Silisified zone (SZ)
- Silisified basalt (SB)

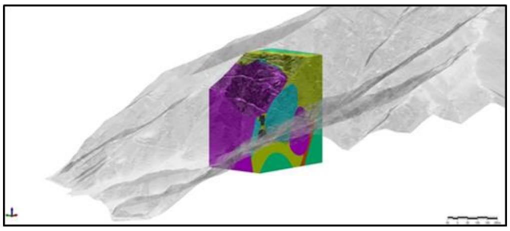

Figure 1- Lithological model

3. WIREFRAMING

As it is known explicit modeling is the traditional method, where the geologist manually draws and edits each polygon and surface, relying largely on artistry and expert interpretation. It is time-consuming, and different geologists may produce different results (subjective interpretation). Therefore, implicit modeling method is preffered in this study. Impicit modelling uses mathematical algorithms to create a "scalar field" (grade values or geological affiliation) in 3D space using geological boundaries and grade thresholds. A specific threshold value in this field (0.3% Cu grade and 0.5% Zn grade) automatically defines the 3D surface (solid model) of the ore body. It is more objective, faster, and repeatable.

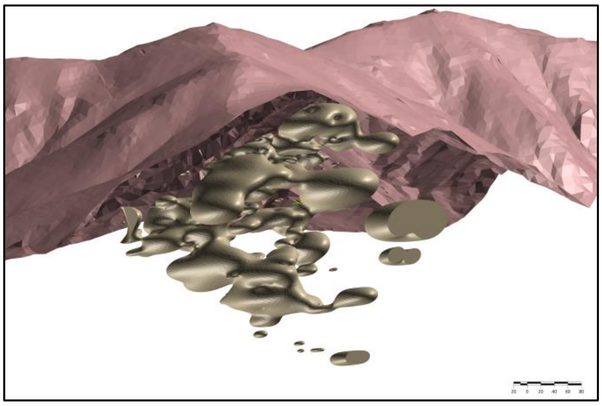

Figure 2- İmplicit solid model

4. INVERSE DISTANCE WEIGTHINING (IDW)

IDW, the inverse distance weighting method, is an interpolation method that uses spatial distance in correlation calculations. For an unknown point D with a location (A0, B0, C0), there are known points in its vicinity. Considering the spatial coordinates of each known point as (Ai, Bi, Ci) and the grade value to be assigned to the unknown points as G, the distance between each known point and the unknown point is (A, B, C) [6]. The inverse distance weighting force is set to three separate estimations were performed with continuously increasing search parameters to maximize the number of blocks within the specified model. After this stage, we examined whether grade assignments were made to the majority of the blocks, observed the blocks by comparing them with the borehole data, and examined whether the borehole spacings were consistent with the generated block model.

• Measured block calculation: Calc 1, minimum sample size (point) ≥25

• Indicated block calculation: Calc 1, Calc 2, minimum sample size (point) ≥15

• Inferred block calculation: Calc 1, Calc 2, Calc 3, minimum sample size (point) <15

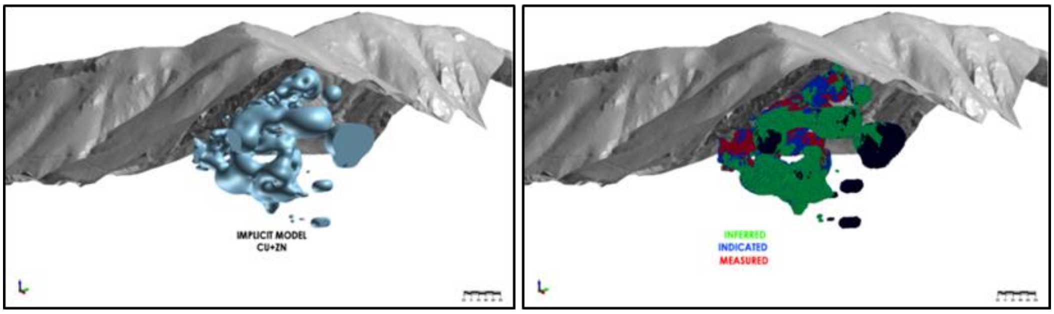

Figure 3- Block model in terms of resource clasiffication

Table 1- Grade and tonnage by IDW calculation

Category	Cu	Zn	Cu	Zn	Cu	Zn
	Ore Tonnage		Grade (%)		Metal (Ton)	
Mea	1,356,976	1,447,877	0.97	1.27	13,163	18,388
Ind	3,540,080	3,882,626	0.98	1.84	34,693	71,440
Inf	506,468	639,522	0.85	2.04	4,305	13,046
Mea+Ind+Inf	5,403,524	5,970,025	0.97	1.72	52,160	102,684

5. KRIGGING

The first requirement for using the Kriging spatial interpolation technique is the calculation of a variogram and covariance functions. Subsequently, an unsampled location must be evaluated [3]. Variograms are one of the most successful methods for demonstrating spatial consistency in geostatistical estimations. Geostatistical estimations are based on the spatial structure of the data. [4]. An empirical variogram is ideal for examining local data and is constructed based on a basic measure of heterogeneity. Variograms are measures of spatial correlation and can determine anisotropy if the extent of such spatial correlation varies with direction. To determine the anisotropy of a spatial variation, an empirical variogram must be generated in several directions. Consequently, the anisotropic direction is determined using variogram modeling in two or three orientations. Anisotropy can be divided into geometric anisotropy, which responds to differences in the range or area of the variograms, and regional anisotropy. Anisotropy can be used to predict and simulate subsurface conditions based on their orientation and dimensions [5]. Z(x0) represents the block with an unknown grade and is calculated using a linear combination of known values. wi represents the weight value of sample number w, and Z(xi) represents the grade value of sample xi.The important point here is that the amount of error must be accounted for when assigning values. Calculating a variogram is a prerequisite for reserve calculation using kriging, a geostatistical method. A variogram is a measure of the change in the target variable depending on direction and distance.

Table 2- Grade and tonnage by kriging calculation

Category	Cu	Zn	Cu	Zn	Cu	Zn
	Ore Tonnage		Grade (%)		Metal (Ton)	
Mea	1,455,522	1,550,808	0.98	1.29	14,264	20,005
Ind	3,650,877	3,901,742	1.02	1.88	37,238	73,352
Inf	511,900	640,090	0.83	2.01	4,248	12,865
Mea+Ind+Inf	5,618,299	6.092,640	0.99	1.74	55,750	106,222

6. CONCLUSION

This study, the reserve modeling of a real Copper-Zinc mine site was conducted using two fundamental interpolation methods in geostatistics: Inverse Distance Weighted (IDW) and Ordinary Kriging (OK), and the results were comprehensively compared. The analyses demonstrated that both methods reasonably captured the overall grade distribution and geometry of the site. However, the radical differences in the fundamental philosophies of the methods resulted in significant and significant deviations in the final estimates, reflected in the evaluation of estimation errors, and the block model to be selected. According to the findings, the Inverse Distance Weighted Method highlighted local anomalies and high-grade samples more clearly because it is based only on the distance to the sample points, without relying on a precise mathematical model. In contrast, the Ordinary Kriging Method produced more reliable and objective results because it works by building a variogram model that represents the statistical and spatial behavior of the data. Kriging provides a critical measure of the reliability of the estimates by providing the variance of the estimates for each block (kriging variance) along with the estimates.

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