Study and Suitability of Ore Estimation Technique

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Abstract : The importance of accurate ore reserve estimates has consistently been recognized in the past. Mining companies need accurate ore reserve estimates since the quality of the estimate may directly affect the company's profitability. Accurate ore reserve estimates are also becoming crucial to governmental bodies that must make policy decisions regarding nonrenewable natural resources.

Based on ore estimated value, we convert the estimated ore into ore resources and ore reserves And ore estimated values can vary according to level of geological knowledge, type of sample obtained, competent person qualifications doing estimation. The paper explain the analysis of orebody modeling carried out, which is explained in detail. Furthermore, the geostatistical method of reserve estimation has been compared with other conventional methods. The conventional methods tested are the polygon method, the inverse of the distance square (IDS) method, and ELIP, similar to IDS but allows different weights in different directions.

Keywords: Ore, estimation, Mineral resources.

1. INTRODUCTION

Ore estimation is the primary step for determining whether a mineralization terrain is worthy of mining or if it is just a concentration of a specific mineral but not to a satisfactory level. Different techniques have been introduced and implemented for the purpose so far. Conventional methods were predominantly used in the past when there were no sophisticated computers and related software. Nevertheless, after the advancement of technology, many new methods have come to make things easier.

The purpose of ore reserve estimation of a mineralized body is to determine the quantity, quality, and amenability to commercial exploitation of the raw material. The estimates are made at all stages of the life of a mine, from the ore body's discovery to its mining. The ore reserves are estimated to determine the extent of exploration and development, distribution of values, annual output, the productive life of the mine, method of extraction and plant design, improvements in extraction, treatment, and processing, and requirements for capital, equipment, labor, power, materials, etc.

There are different estimation methods used for different scenarios, dependent upon the ore boundaries, geological deposit geometry, grade variability, and the amount of time and money available. Some of them are: -Triangular method, Polygonal method, cross-sectional method, classical method, Inverse distance method, Inverse distance square method, Kriging method, Nearest neighbor method, Fractural method, etc.

Finally, we convert the estimated ore body into ore resources and reserves based on ore estimation results.

2. REVIEW OF LITERATURE

UmitEmrah Kaplan and Erkan Topal(2020)., One of the critical tasks in the mining value chain is to accurately estimate the grade of interest within a mineral deposit. The grade can be in observation or estimation and is used in several stages of mining. The author presents a new grade modeling approach that combines K-nearest neighbor (KNN) and J (ANN) models to perform grade estimation of mineral deposits.

ShahebSheik(2014)., Estimation of ore resources and reserves with low-value errors is essential in mineral exploration. The aim is to compare inverse distance weighted (IDW) and waste. The Dardevey iron ore deposit, Ne iron, density, continuity of ore and waste, the number of points involved, and discretization factor in the estimation of ore and waste are being determined.

David.M(1988)., It addresses the problems commonly encountered in orebody modeling when the data does not conform to the early theoretical models. It offers solutions to problems like irregularly disturbed samples of varying sizes, showing how to get the best possible variogram and how to model it in practice. It addresses the problems of grade tonnage curves which vary with block size and proposes ways to compute estimation variances for an entire deposit or in the presence of a cut-off. Fundamental studies are presented in every chapter using, as far as possible, well-known deposits.

King, H. F(1982). Ore reserve estimation has remained one of the most prickly topics in the mining industry and one on which various professional institutions have unsuccessfully sought consensus. Recently, the ASULMM/AMIC Joint committee on ore reserves organized a symposium on ore reserve assessment as it affects metals, coal, oil, and gas. The authors suggest in this guide that there is no difference in principle between reserve estimation in various kinds of deposits. They all involve the quantity and quality (tonnage and grade) of a (usually) hidden resource, recoverable reserves, economics, and governmental constraints.

Simon C Dominy and Mark A Noppo(2002)., Mineral Resources and their subsequent conversion to Ore Reserves are of key importance to mining companies. Their reliable estimation is critical to both the confidence in a feasibility study and also to the day-to-day operation of a mine. Together with sampling assaying, geological and other errors introduced during interpretation and estimation, other errors are likely to be introduced during the application of technical and economic parameters used for the conversion of resources to reserves. There is thus a requirement for high-quality interpretation and estimation to be supported by high-quality data. Any company expecting to make a sound investment or operational decisions must base these on both relevant and reliable information. An Ore Reserve statement generally contains a single set of grade and tonnage figures without a discussion, but confidence limits are rarely quoted and, if they are, often do not take into account many of the factors that cause uncertainty in the grade and tonnage estimates.

3. METHODOLOGY

To evaluate and analyze the different aspects of ore estimation through this study, there has been formed some objectives which are given below-

- To study how to find out the most appropriate method of resource estimation for a particular resource.
- To find out the tonnage of the reserve.
- To find out that, does estimate ore tonnage will be economical for doing mining or not.

3.1. Study the use of geology in ore estimation

- Geology is generally considered as the front-end step in mining activity. Geology gives the initial idea of ore body geometry, such as depth, horizontal extent, outcrop, length, width, groundwater condition, orientation, etc.
- After infill drilling, the majority of ore estimation, mineral processing strategies, and operational procedures are planned and put into the effort with minor geological input, mainly in open-pit operations.
- Even though geologists are working throughout the mining operation, they are often fully occupied with grade control and production issues, with little timegiven to access potential geology input into the mine operation.

3.2. Reserve estimation errors and their significance

The economic consequences of errors in reserve estimation can be severe. An 11% error in grade estimation is regarded as a minor or small error. If production costs are at least 51% to 76 % of the mine site revenue, an 11 % decrease in grade can translate to a 21 % to 41 % decrease in cash operating surplus. That can generate an accounting loss, depending on the proportionate level of amortization and depreciation charges. It can also render a heavily geared project nonviable. Another consequence of severe errors is the necessity of producing a new estimation that may involve a heavy reduction in the reserve tonnage. Unit capital charges are increased to a level that may generate an accounting loss and a negative return on investment.

3.3. Determining the geometry of the ore body

By the infill drilling stage, the exact assurance of lithology, design, and mineralization dispersion, yet obliged by our understanding of cycles, has started to rule the investigation into brain science (Figure 3). During this investigation stage, the geologists call upon their 'tool compartment' to oblige these mathematical issues, as they are the primary issues starting here through to the mine advancement stage. While hereditary models and comprehension of mineralization measures are imperative to outline augmentations to metal and approach mines to far-field investigation endeavors, they are not as fundamental to asset assessment and improvement. For instance, if a store is interrupted, it usually is unimportant to its fruitful turn of events. Indeed, complete hereditary comprehension of mineral stores is once in a while reached even after the asset has been completely misused. By and by, a comprehension of cycles is as yet significant.

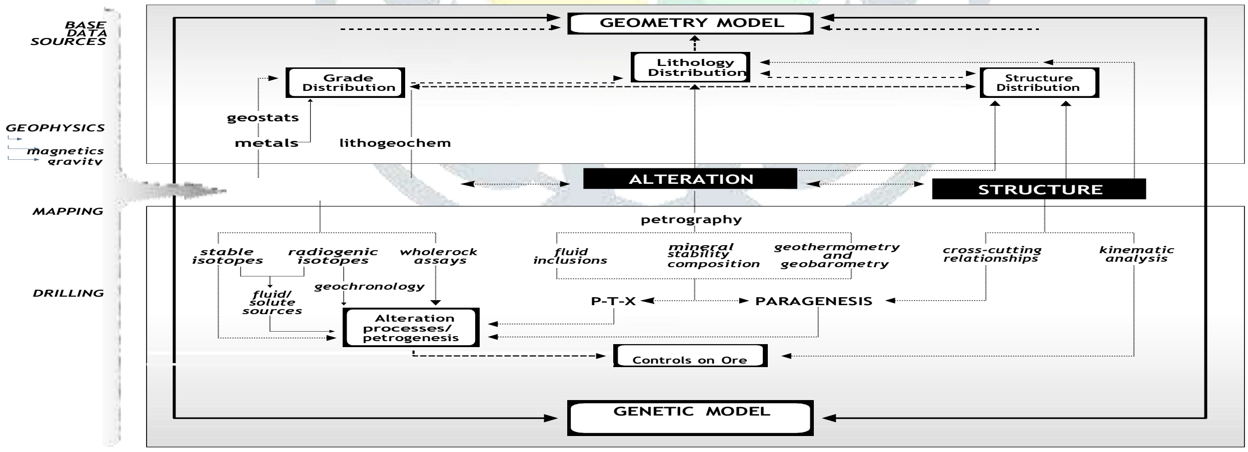

Fig.3.1. Orebody geometry model
(source- https://www.slideshare.net/NumanHossain2/the-mineral-reserves-amp-reserves-estimation-using-triangular-methods)

For instance, seldom does a task finish infill boring without requiring tremendous extra work to be done at the feasibility, possibility, or mining stages. While completely resolving all potential issues on projects is anything but a for all intents and purpose’s reachable objective, it is the creators' dispute that such extra work, and resultant postponements or lethal (material) imperfections in project improvement, can to a great extent be stayed away from. This can be accomplished if geologists and the board have an intense awareness of the mix of geography in the mining interaction and by coordinating information assortment and amalgamation at early undertaking stages towards end-client necessities, e.g., asset assessment (area definition issues; drill direction, thickness and information quality issues affecting asset order), geotechnical (calculation and construction issues – early characterization of designs and rock mass), metallurgical (recuperation issues – early petrography of metal, measure for potential punishment components),hydrogeological(water issues), name a couple.

3.4. Geological interpretation and resource estimation

Geostatistical ore estimation strategies have grown impressively in the last 10-20 years, and PCs being capable of numerical dissecting the data has gotten all the more remarkable. Numerical strategies for demonstrating grade fluctuation through resources based on broadly dispersed information have improved. Some central points of contention in understanding and estimation are: to guarantee that land input is sound and that full use is made of it in translation; to appropriately consider that topographical information in choosing the viable estimation strategies for a specific deposit; to utilize more than one strategy for estimation and to approve the gauge by utilizing elective procedures.

3.5. Ore estimation techniques

- Conventional method
  a. Triangular method
  b. Polygonal method
  c. Cross-sectional method
  d. Classical method
- Non-conventional method
  1. Inverse distance method
  2. Inverse distance square method
  3. Kriging method
  4. Fractural method
  5. Nearest neighbor method

A. Triangular method

The triangular method of ore estimation is the method in which we use no's of small imaginary triangles and by using trigonometry formulas to estimate tonnage, area, volume, grade, etc., of the reserve.

Procedure: -

- First finding of an area of the reserve formation by diving the whole area into no. Of small-small triangles.
- Then finding an average thickness of the reserve by making the drill/boreholes at each vertices of each small triangle.
  for ex: - if thickness t1, t2, t3 is 12m, 13m, 14m,
  then, avg thickness = (12+13+14)/3 =13m
- Then find the volume of the reserve with the help of estimated thickness and area.
  i.e. volume = area * average thickness
- It is then finding of grade and tonnage with the help of the above-calculated values.

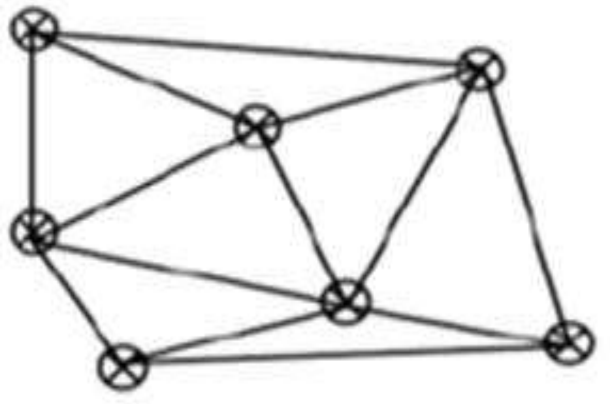

Fig3.2. Formulation of triangle
(source-http://www.ijetsr.com/images/short_pdf/1514359804_896-903-jbrec228_ijetsr.pdf)

B. Polygonal method

The polygonal estimation method is most ordinarily utilized for even deposits that have been penetrated by a progression of vertical drill openings and vein-like deposits that have been bored by point openings for gathering test information. This method uses the standard of "rule of closest neighbor." In the polygonal technique, the polygonal methods are built by construct opposite bisectors to lines interfacing all example focuses. The volume and grade calculations in this method are straightforward. The volume and the tonnage are then calculated as bellow:

Volume (V) = Area (A) × Height (H)

Tonnage = Volume (V) × Tonnage Factor (TF)

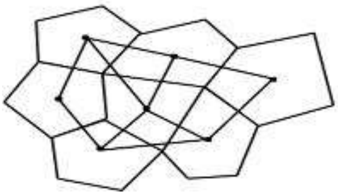

Fig 3.3. Illustrates the formation of the polygons
(source-http://www.ijetsr.com/images/short_pdf/1514359804_896-903-jbrec228_ijetsr.pdf)

C. Cross-sectional method

The cross-section method is another kind of traditional estimation method wherein typically, a progression of cross areas is built to the fundamental pattern of the mineralization. A unique alert ought to be paid to the geologic and mining requirements, which limit the estimation. Discrete regions might be characterized not just by equivalent grade in contiguous drill openings but additionally by the stone kind, primary squares, metal sort, and different boundaries considered to have economic and hereditary importance. The methodology for estimating the region and the ensuing volume of the proposed mineral resource is clarified by "CHAS.F.JACKSON and JOHN B. KNAEBEL" as follows.

In this method, cross-sections of the mineral body are ready on which are plotted the convergences or projections of mine activities and drill openings. The cross-section might be upward, level, or at the right points to the plunge, typically corresponding to one another, and frequently is divided into equivalent distances separated.

Much of the time, they are taken to lines of drill openings where investigation has been finished by drilling from the surface. Estimations are usually produced using areas ordinary to the strike of the metal body. In getting ready such sections, it might likewise be essential to make longitudinal areas, working one set against the other in deciphering the construction. If the sections are pretty similar in outline, the average area, in square meters, multiplied by the distance between them, in meters, will give the volume, in cubic meters, closely enough for practical purposes, the standard "end-area formula.

$V = H [(A1+A2) \div 2]$

where A1 and A2 are the end areas of the block,

H is the perpendicular distance between them, and V is the volume of the block.

If there is a series of sections spaced equidistantly, this formula becomes $V = ½ H (A 1+2A2+2A3+\text{--} An)$,

Due to the regular irregularity of ore bodies, this may never be the case but is often a close enough "approximation for all practical purposes. The tonnage of the deposit is that calculated by the volume times the overall specific gravity.

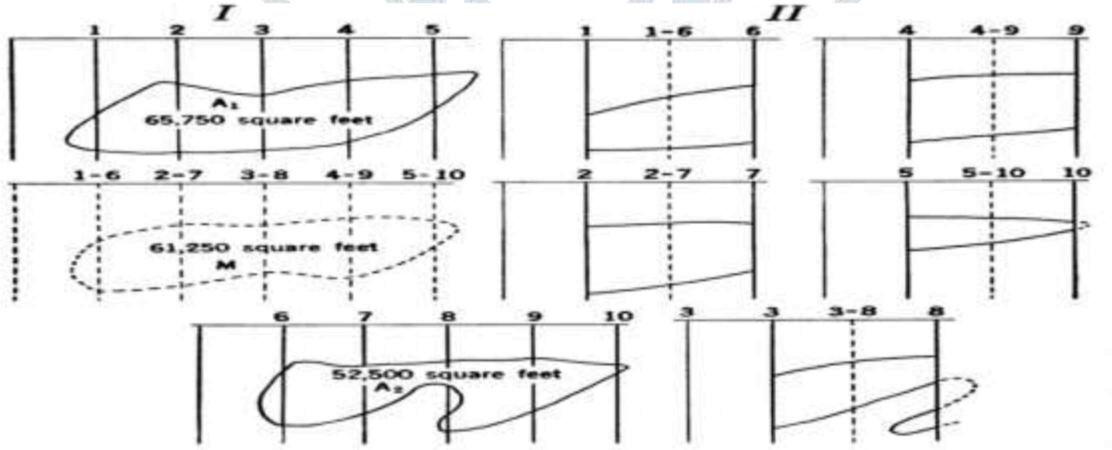

Fig3.4.Cross-sectional method
(source-http://www.ijetsr.com/images/short_pdf/1514359804_896-903-jbrec228_ijetsr.pdf)

D. Inverse distance weighting method

The name "Inverse distance weighting technique" was persuaded by the weighted typical applied since it resorts to the inverse of the distance to each known point ("measure of vicinity") when doling out loads. The most straightforward weighing capacity in like manner utilization depends on the inverse of the distance of the sample from the point to be estimated, typically raised to the subsequent force, albeit sequential forces might be helpful.

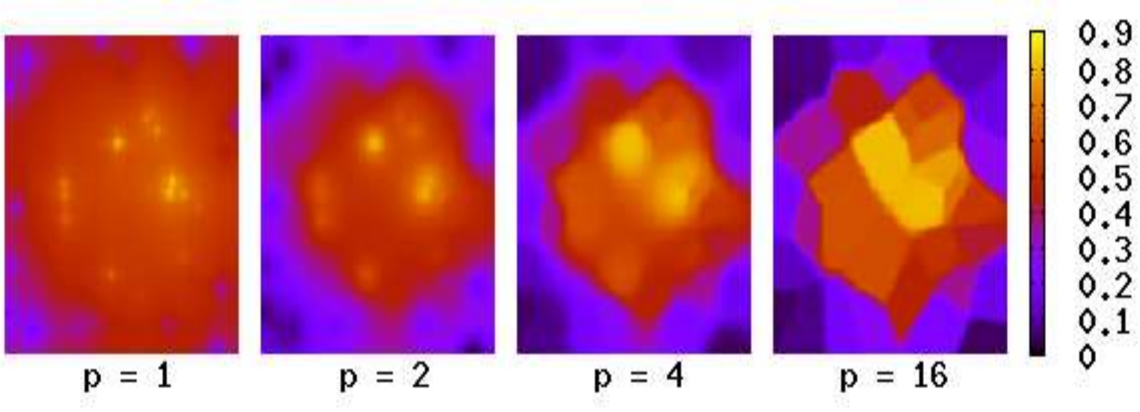

Fig.3.5. Inverse distance interpolation for different parameters p
(source- http://www.ijetsr.com/images/short_pdf/1514359804_896-903-jbrec228_ijetsr.pdf)

4. COMPARISON OF THE METHODS

The conventional method offers number of advantages like it is mathematically simple and also not not require initial data's in detail way as non-conventional method require. In a certain way, these strategies are "topological," i.e., think about the overall spatial situation of the data in the resource, which is of outrageous significance in any mine arranging even within sight of the absence of objectivity typical to the utilization of exact models. A portion of the downsides of the Conventional Methods gets from the way that they are not founded on likelihood suspicions, which do not permit the assessment of the mistake present in any assessment made, regardless of how sophisticated it is. Another deficiency is their one-sided character, which in normal think little of the significance of typical example esteem squares and overestimate the boundaries of those of high worth. This inclination may result in risky when examining a store dependent on remove grades. In any case, the traditional strategies are the most utilized throughout the planet in the assessment of a wide range of mineral items, including uranium.

The Statistical method, in their turn, enjoys the extraordinary benefit of permitting the assurance of the blunder part in the assessment of a segment or the whole store. This is especially significant when the store is close to as far as possible, either as for the weight or the grade. Nonetheless, these techniques are basically founded on likelihood and don't think about the spatial situation of the data in the store, considering thusly, all examples are probabilistically autonomous. What's more, measurable techniques generally require an enormous number of computations, which prompts the use of complex electronic machines or PCs and a specialized workforce with information on advanced math.

5. SUITABILITY

After comparing the different ore estimation techniques, we determined that conventional methods are most suitable for uniform grade ore deposits and for deposits having less horizontal extent or slight to moderate sizes.

While non-conventional methods (computer-aided ore estimation method) are suitable for both regular and irregular ore deposits having variable grades, more considerable horizontal extent, and large size, they can easily be applied in difficult geographical/geological conditions where conventional methods are complicated.

6. RESULT AND CONCLUSION

In general, there is no clear-cut choice of which reserve estimation method to use on a particular ore deposit. At an already producing mine like the Patmunda mine, having a substantial number of drill holes in a reasonably uniform grid, ELIP or IDS may be a good choice for the following reasons: They have substantially fewer computer costs than the geostatistical method, the accuracy of the method chosen may be determined by applying the results of the simple tests described, utilizing the records on both diamond drill holes and blast hole assay.

For prospective or new properties, the geostatistical method is more attractive for the following reasons:

- It is the only method to calculate the estimation variance and construct a confidence limit on the estimate.
- It is capable of pinpointing areas needing more drilling in order to obtain a specific confidence limit and can calculate the new confidence limit before the holes are drilled.

Kriging is a more sophisticated interpolation technique than either ELIP or IDS. Its ability to take the spatial relationship of the sample into account is most apparent in deposits that are very regularly drilled and have few drilled and drill holes, such as is the situation at the most prospective properties.

7. ACKNOWLEDGEMENT

Talent, capabilities, and hard work are necessary, but opportunities and the proper guidance are always the keys to a successful future and career.

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8. REFERENCES

[1] Krige, D. G., (1952). A Statistical Analysis of Some of the Borehole Values in the Orange Free State Goldfield. J. Chem. Met. and Min. Soc. South Africa, V. 53, No. 3, pp. 47-64.

[2] Thomas, B. I., McKinney, C. M., Tignor, E. M., Cattoir, F. R., Lytle, F. W., Birge, G. W, ... & Garton, E. L. (1957). A Comparative Study of Statistical Analysis and Other Methods of Computing Ore Reserves, Utilizing Analytical Data from Maggie Canyon Manganese Deposit, Artillery Mountains Region, Mohave County, Ariz: 1957 (No. 5371-5380). US Department of the Interior, Bureau of Mines.

[3] Hazen, S. W., Jr. (1958). A Comparative Study of Statistical Analysis and Other Methods of Ore Reserves Utilizing Analytical Data from Maggie Canyon Manganese Deposit Artillery Mountains Region, Mohave County." U.S. Bureau of Mines Report of Investigations5375. 188 pp.

[4] MATHERON, G. (1963). Principles of geostatistics, Economic Geology, vol. 58, pp. 1246-1266.

[5] Blais, R. A. and Carlier, P. A. (1968). Applications of Geostatistics in Ore Evaluation. Ore Reserve Estimation and Grade C.I.M.N. Special Vol. No. 9, Montreal, pp. 41-68.

[6] O'Brian, D. T., & Weiss, A. (1968). Practical aspects of computer methods in ore reserve analysis. Reference [42], 109-113.

[7] David, M. (1969). The Notion of Extension Variance and Its Application to the Grade Estimation of Stratiform Deposits.A Decade of Digital Computing in the Mineral Industry. A.I.M.E., particular volume, pp. 63-81.

[8] David, M. (1974). A Course in Geostatistical Ore Reserve Estimation, Ecole Polytechnique, Montreal, Canada, 303 pp.