COMPARISON BETWEEN GEOLOGICAL PROFILE AND PROFESSOR SOBALEVSKAYA'S METHODS OF ORE RESERVE TONNAGE ESTIMATION

DR. R. A. OSEMENAM
Dept. of Mining Engineering
Federal University of Technology
Akure - Ondo State.

ABSTRACT

The main objective of this paper is to determine a more rational method for the estimation of ore reserve in Nigeria. Its scope entails the comparison of geological profile and Professor Sobalevskaya's methods of ore reserve tonnage estimation. This will ultimately help to dictate which of the methods is best suited for ore reserve tonnage estimation in Nigeria.

INTRODUCTION

Ore is defined as a solid naturally occuring aggregate from which one or more valuable constituents may be recovered and which has sufficients economic interest and requires adequate method of estimation of tonnage and grade. Bukrinski (1976) on evaluation of various ore reserve tonnage estimation found that some traditional methods of ore estimation such as geological profile, polygon methods produce biased estimate. He went further to conclude that the bias may be removed by adopting alternative methods of estimation and comparing their results with data from already excavated or exploited zone in a given ore deposit. Anistratov (1980) on review of geometrical distribution of ore samples in a deposit found that the tonnage calculation of an ore deposit can be keep under statistical control and deviations, which must occur with some calculable frequency that can be forecast and dealt with.

Borovski, Arlov and Samokin (1982) on study of optimal of ore reserve estimation in USSR came to a conclusion that it is necessary to analyse the entire structure of the deposit to ascertain the nature of mineralisation since this will assist to obtain a proper estimate of the deposit in terms of tonnage, grade etc. Ershov (1983) on practical application of Professor Sobalevskaya's method in Krivoe rog iron ore deposit, USSR found that the method gave a good result with negligible deviation from the fact compared with the geological profile method which was initially used to predict the tonnage of the deposit. This geological profile method gave a deviation of +35% from the fact leading to an overestimation of the deposit. Osemenam (1986) on evaluation of natural resources and investment pattern in the Nigerian Mining Industry noted that the Mine Surveyors and Geologists must issue an "ore statement" with a deviation of not more +10% when mined since this has a very great impact in the overall economic planning of a mine project.

All the above studies have a place in determining a rational method for ore reserve estimation in Nigeria and hence the author carried out a comprehensive study on the Itakpe iron ore deposit with aim to achieve the stipulated objective of this paper.

THEORETICAL CONSIDERATION

The geological method entails drawing of sections across the ore body, determining areas of ore in each section and computing the final volume by using the distance between the sections. This can be expressed further with the help of fig 1 and fig 2. From fig 1 let the distance between parallel cross section A- A',..... G-G' equal 1_1, 1_2,..... 1_n; and from fig 2, let the vertical thickness of ore layer along the boreholes equals M_1, M_2,..... M_n and their respective average grade equal C_1, C_2,..... C_n. The areas S_A, S_B'.....S_G of the vertical profile of the body can be determined as the sum of the area of any given geometrical configuration e.g. trapezium, rectangle or by use of a plainmeter.

Volume of ore layer within the interior contour of the ore body is determined by formulae.

$$V = \frac{S_A + S_B}{2} 1_1 + \frac{S_B + S_C}{2} 1_2 + ... \frac{S_F - S_G}{2} 1_{n-1} \quad \text{----- (1)}$$

If the average weighted volume of the ore is given as Y. The total ore reserve statement is deduced from the formular.

$$Q = V.\overline{Y} \quad \text{----------(2)}$$

The average simultaneous ore reserve statement of useful ore for any given-ith profile line is calculated by formular.

$$q_i = \overline{Y}\left[(m_1c_1 + m_2c_2/2)1_1 + (m_2c_2 + m_3c_3/2)1_2 + ... (m_{n-1}c_{n-1} + m_nc_n/2)1_{n-1}\right] \quad \text{----------(3)}$$

Overall ore reserve statement of ore in tonnage is given as follows:

$$P = K\left[\frac{q_A + q_B}{2} 1_1 + \frac{q_B + q_C}{2} 1_2 + \ldots + \frac{q_F + q_G}{2} 1_{n-1}\right] \text{---(4)}$$

Where K - Constant

K = 0,01 when 'C' - average grade of ore is expressed in percentage (%) and P expressed in Tons

K = 0,001 when 'C' is expressed in grams per ton and P in kilograms.

For the case of Prof. Sobalevskaya's method, we initially proceed to ascertain the degree of mineralization of the deposit (using geological borehole data) by applying such adequate techniques as the geostatistics. The concept of geostatistics is centered on the investigation made by G. Matheron (1963). The basis tool of geostatisties is the variogram. The variogram graph is represented by

$$Y_{(h)} = \left[E\{f(X+h) - f(X)\}^2\right] \text{----------(5)}$$

Where, X take the values at all various positions in the given field and h is a constant.

The ordinate values for the dimensional variogram are calculated from the following basic equation.

$$Y_{(h)} = \frac{1}{2(1-h)} \left[f(X-h) - f(X)\right]^2 dx \text{----------(6)}$$

Where f(X) and f(X+h) are the assay values of the samples taken at points separated by a constant interval h, and L is the length of the linear series of assay values h. This structural analysis of the deposit will assist to produce a graphical model of isothickness of the ore layer in a given deposit. This graphical model of isothickness can be further explained with the aid of fig 3 and scheme 1.

In a given ore deposit (as the case in fig 3) the graphical construction of the isothickness is undertaken according to the procedure laid down by Prof. Sobalevskaya (1964). With the help of a transparent paper, set of points (grid configuration) arranged at distances of 0,5 or 1cm from each other are marked as shown in fig 3. Each point say M with coordinate $D(X_D\ Y_D)$ represent an elementary area of ore layer dx.dy = ds. This point has a vertical prismatic column with M_D as its height (i.e. thickness of ore layer).

Elementary volume of this column is given as follows:

$$dV = M_D\, dx.dy = M_D ds$$

OR

$$dV = f(X,Y)\, dx.dy \text{----------(7)}$$

The sum value of isothickness in each column of th deposit is noted accordingly in a format represented in scheme 1.

For the entire deposit we have that the volume (V) of the ore reserve is expressed by formulae:

$$V = S \lesssim M_i \text{----------(8)}$$

Where S = area covered by each point and can be calculated by formulae in 2 and 4 respectively.

EXPERIMENTAL DESIGNS

The tonnage estimate of Itapkpe iron ore deposit was first carried out by defunct NSDA (Nigerian Steel Development Authority) in 1974. Here the geological profile method was used. Within each block, the mineral surfaces were measured at different levels which are 25m apart from each other vertically. Volumes between levels which are 25m apart calculated by systemically applying the following geological profile method formulae.

(a) $\frac{S_A + S_B}{2} 1$ When S_A and S_B have close or equal values ----------(9)

(b) $\frac{S_A + S_B \sqrt{S_A \cdot S_B}}{3} 1$ When S_A and S_B have values differing by 40%

The following values shown in table 1 where obtained.

TABLE 1

ORE LAYER	TONNAGE (MT)
Northern layers (N)	45,00
Intermediate layer (1)	30,00
Central layer (C)	185,00
Southern layer (S)	20,00

TOTAL ORE RESERVE = 280MT.

Osemenam (1987) on geometrical evalution of Itakpe iron ore deposit established the nature of mineralisation of Itakpe itorn ore deposit in the East-West and North-South directions of the deposit. This is shown in fig 4 and fig 5.

With the configuration of mineralisation of the entire deposit known, the author proceed further to construct the graph of isothickness of the above said deposit by applying Professor Sobalevskaya's method. The plan is represented in fig 6. Results from Professor Sobalevskaya's method of tonnage calculation are shown in table 2.

TABLE 2

ORE LAYER	TONNAGE (MT)
Northern layers (N)	36
Intermediate layer (1)	24
Central layer (C)	130
Southern layer (S)	17

TOTAL = 207MT.

Result from Prof. Sobalevskaya's method shows that Itakpe iron ore deposit has been overestimated with a variance of + 26, 1% when compared with geological profile method.

To come to a better conclusion on the superiority of Prof. Sobalevskaya's method the author went further to apply the both methods in an already mined zone along the East-West pit of Itakpe iron ore deposit with block dimension of (200 x 100 x 30)m. Results from this is shown in table 3 (abstract from authors on going research work on optimasation of sampling pattern and estimation of mineable blocks)

MINE UNIT	FACT (T. T.)	GEOLOGICAL PROFILE METHOD (T. T.)	PROFESSIONAL SOBALEVSKAYA'S METHOD (T. T.)
(200 x 100 x 30)M EAST-WEST PIT.	700,000	950,000	720,000

From the above figure it is clear that Professor Sobalevskaya's method of estimation of the given mining unit of Itakpe iron ore deposit produce an unquestionable result in contrast to geological profile method that potrays an overestimation with a variation of + 26, 3% from the fact.

CONCLUSION

Recognition of the fact that Professor Sobalevskaya's method is partly random and partly spatial leads to estimates that are unbiased and have lower error of estimation.

Tonnage estimation operations can be kept under statistical control, and deviations, which must occur with some calculable frequency, that can be forcast and dealt with. The unbaised nature of estimations is of prime importance for such control.

The more rational method of ore reserve tonnage estimation is the Professor Sobalevskaya's method of isothickness.

REFERENCES

1. **Anistrator, U. I.** (1980). Geometrical distribution of Ore samples in Krivoe rog iron ore deposit Moscow pp. 85 - 89.
2. **Bukrinski, V. A. (1976).** Evaluation of ore reserve statement in USSR. Moscow. pp. 12 - 25.
3. **Barovski, Arlov and Samokin** (1982). Optimal method of ore reserve estimation in USSR, Moscow, pp 105 - 130.
4. **Ershov, V. V.** (1983). Geometrical appraisal of Krivoe rog iron deposit, London, pp. 25 - 32.
5. **Matheron, G.** (1983). Principles of geostatistics, Scoul Geol., Vol. 58: 1246 - 1266.
6. **NSDA** Project report on contract No. 1717 (1974). Project report on exploration of Itakpe Hill Iron Ore Deposit, Okene, Nigeria pp. 69 - 70.
7. **Osemenam, R. A.** (1986). Evaluation of natural resources and investment pattern in the Nigerian mining industry. AOMC Bulletin. Benin City. Vol. 014: 2-3.
8. **Osemenam, R. A.** (1987). Ph.D. Dissertation, Moscow, pp. 85 - 89.
9. **Osemenam, R. A.** (1990). Research work on Optimization of Mining Blocks.
10. **Sobalevskaya, B.** (1964). Evaluation of Ore Deposits Moscow. pp. 106 - 109.

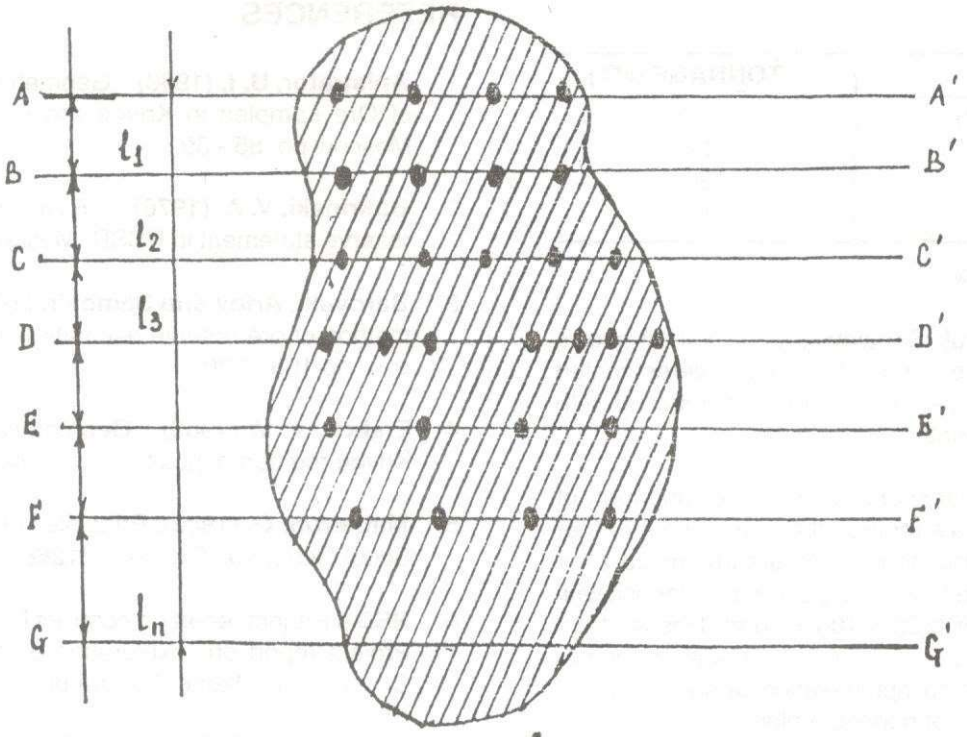

A
B
C
D
E
F
G
A'
B'
C'
D'
E'
F'
G'
l_1
l_2
l_3
l_n

fig. 1

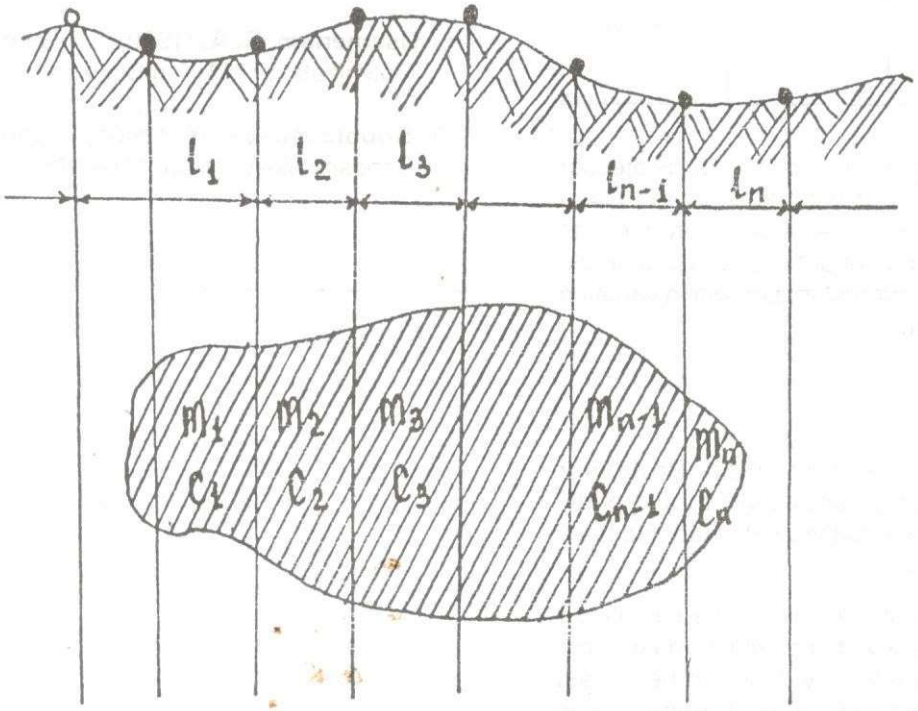

l_1
l_2
l_3
l_{n-1}
l_n
m_1 c_1
m_2 c_2
m_3 c_3
m_{n-1} c_{n-1}
m_n c_n

fig. 2

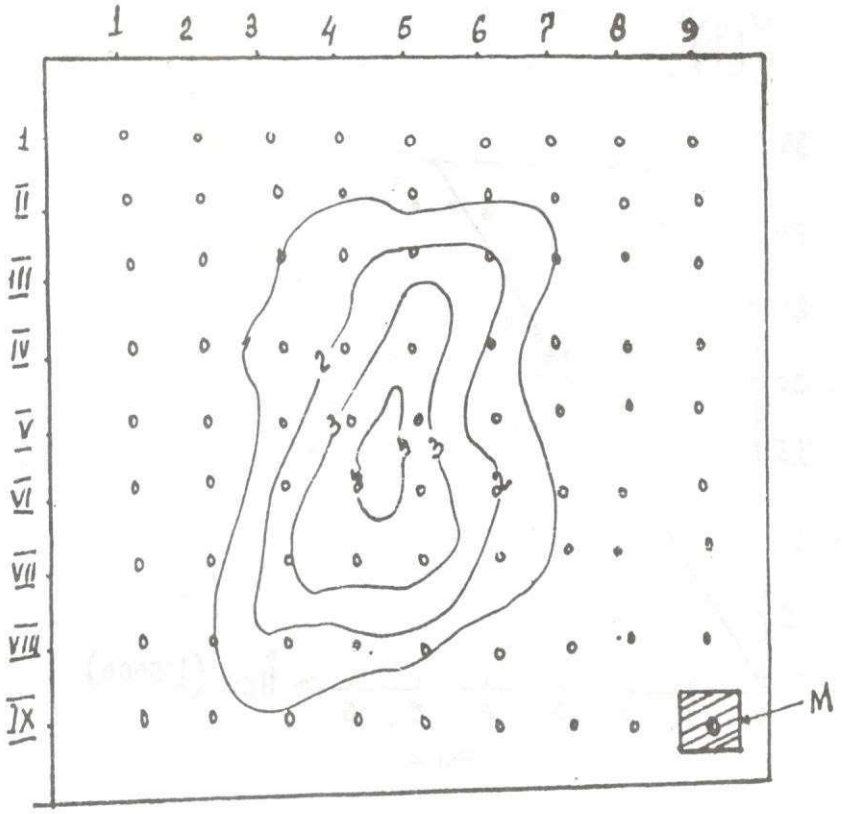


fig. 3

	1	2	3	4	5	6	7	8	9	Σ
I										
II										
III										
IV										
V										
VI										
VII										
VIII										
IX										Σ_M

Scheme 1

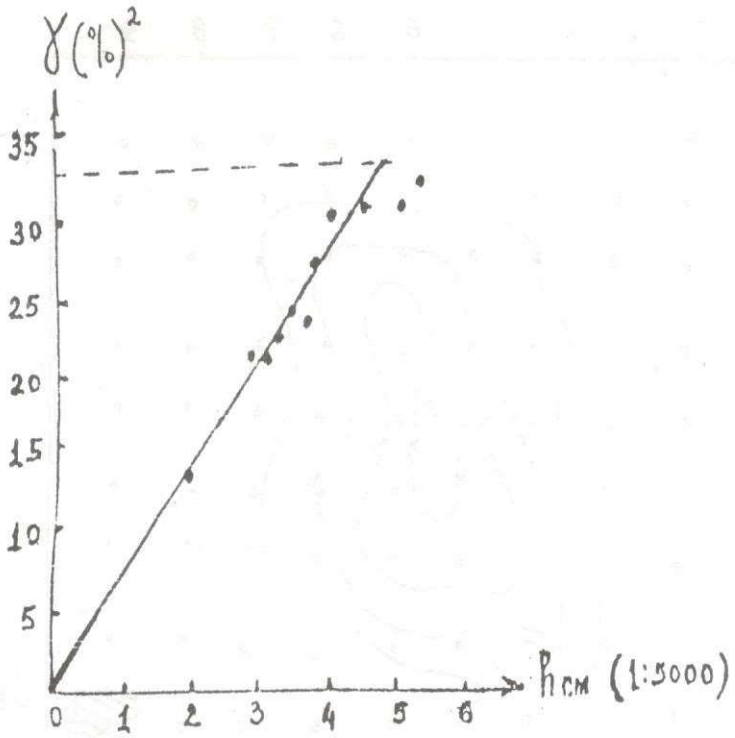


Fig. 4

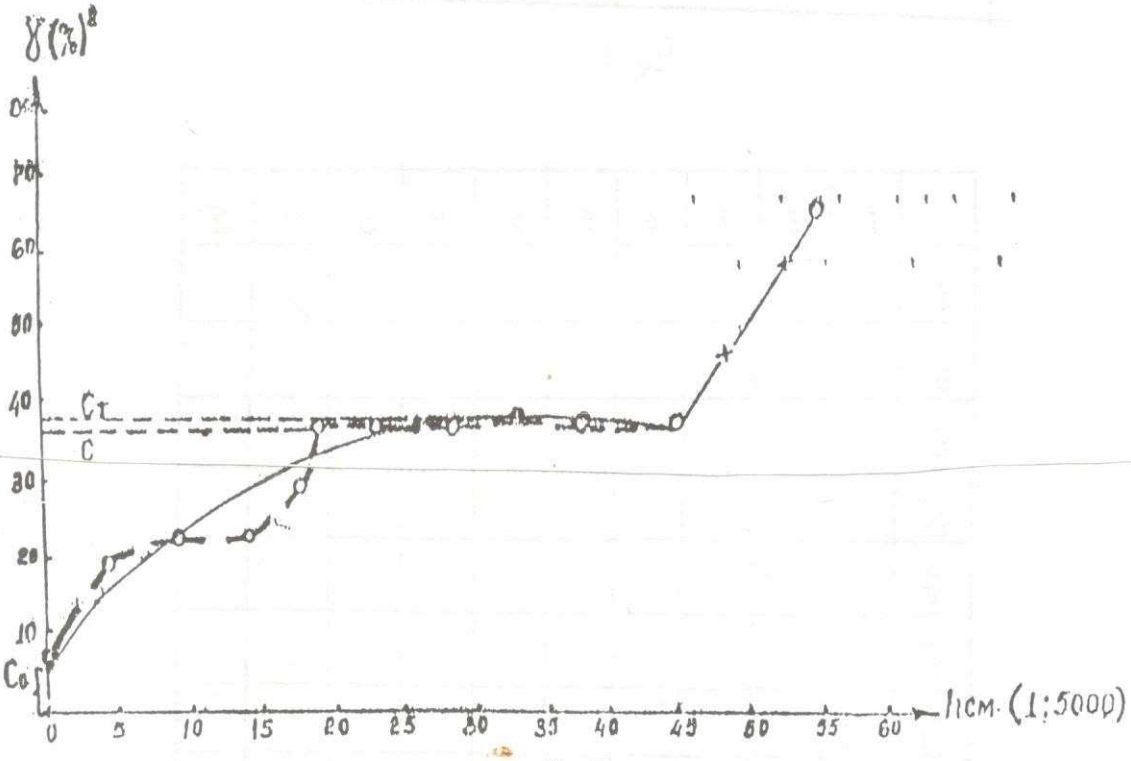


Fig. 5

Experimental variogram

Theoretical Variogram

Zone of trend.