NSE TECHINCAL TRANSACTION VOL. 44, N0.3, JULY-SEPT., 2009
R.A. OSEMENEM

ASSESSMENT OF EKINRIN-ADE CALCITE DEPOSIT FOR THE OPTIMUM DEVELOPMENT OF MINING WORKS

BY

R.A. OSEMENEM
Federal University of Technology
Akure, Ondo -State

ABSTRACT

No other industrial mineral is widely used in such a diverse range of industrial application as calcium carbonate. Calcite, the most common mineral form of calcium carbonate is the principal constituent of most carbonate rocks hence this project aim/objective is to focus on economic evaluation of Ekinrin-Ade calcite deposit for the purpose of development of mining works in Nigeria. This was achieved by not only the verse study of the geology of the deposit but also the use of geo-statistic techniques to establish the optimal configuration of the deposit. This led to the establishment of economic model, an exploration grid that can be used in the development of other deposit of the same geometrical characteristics as that of Ekinrin-Ade calcite deposit.

1.0 INTRODUCTION

Carbonates particularly the calcite variety are extensively used as paper filler and in paints, limelium and rubber. Ershov (1989) on the role of calcites in metallurgical development noted that the important properties of filler grade carbonate (calcites) include whiteness, fineness, free from grit, low oil absorption and equal dimensional particle shape. He also stated that they are relatively cheap for use in industries. There are over seventy thousand (70,000) uses of limestone, (recrystallise metamorphic product which form calcium carbonate).

Gillson et al (1998) on close study of carbonate rocks stipulated that lime and limestone basically have been linked to one leg of a size legged stool on which industry revolves, the other essential legs being iron ore, salt, sulphur, petroleum and coal. These essentially form building block commerce and industry, which limestone in physical volume, surpassing coal in recent times. Severinghaus (1998) on study of industrial minerals and rocks classified the uses of limestone and lime products into three main groups. These include chemical and metallurgical, construction and agriculture.

He went further to state that the first group is lime that is used in the production of iron and steel, water treatment etc, while the second group is lime for construction for example the manufacture of cement. The main criteria for determining the use to which any given limestone should be used is its chemical purity. Thus the purest limestone is used for metallurgical and chemical purposes for which purity of up to 95% calcium carbonate is required.

Limestone deposits such as Calabar, Yandev, Jakura and Ekinrin-Ade are good for cement production but should be better for metallurgical and chemical purposes. Osemenam (1991) on geometric evaluation of Itakpe iron ore deposit noted that the exploration and extraction of mineral deposit in Nigeria have been carried out with relative wide risk. He further stated that the risk was due to inadequacy of estimation techniques for the quantification of mineral reserves. He concluded that the valuation of mineral program can be designed economically. And geo-statistics can help to optimize sampling patterns.

At Ekinrin-Ade calcite deposit there were twenty – three boreholes drilled by the Nigerian Mining Coporation. The result of the drill holes presented the Ekinrin-Ade calcite deposit to appear to be economical viable but the entire exploratory project did not provide solution to the limit of possible boreholes, but recommended the need foe additional boreholes to ascertain the proper geometrical configuration of the deposit.

This entails more cost on exploration. This paper therefore presents a solution by the use of geo-statistics techniques to assess the Ekinrin-Ade calcite deposit for optimum development of mining works.

2.0. GEOLOGY OF EKINRIN-ADE CALCITE DEPOSIT:

Ekinrin is about 22km south-west of Kabba in Kogi-State, and is about 15km north-east of Omuo-Ekiti, a border town between Ekiti – State and Ondo-State. The calcite deposit is 16.5km west of Ekinrin-Ade. The deposit is situated in 'henhen' farmland of Odo-Ade family land whose history had it that they migrated to join the present Ekinrin-Ade some 50 years ago.

The outcrop of the calcite is more than 15km. and up to 1km, wide. Drilling measurements indicate an average depth of 62m. The irregular form of the outcrop and presence of trap – fold suggest however that depth may vary considerably. Ekinrin-Ade deposit is believed to be an extension of Igbeti marble deposit in that the deposit stretches from Igbeti to Alaguntan in Oyo-State and outcrop again at Isale Osin in Ilorin South local Government area and again at Elebu in Moro Local Government area, Oreke Oke and Owa Kajola in Ifelodun Local Government area all in Kwara State.

From the deposit outcrop at Igbagun near Mopa and Auetoro–Gbede it stretches to Odo – Ade and Otun-Ade (Ekinrin-Ade province) from there to Iluagba, Osara and Jankara all in Kogi-State. In Kogi-State along Osara and Jankara the deposit is divided into two main veins one going to Ajaokuta to Yandeu and Gboko in Borno-State and other to Ubo, Ukpilla down to Nkalagu to Ugbeb in Cross river- State.

Ekinrin-Ade calcite occupies two shallow valleys that drain into river Oyi and took source from Ikole Ekiti in Ekiti-State. It is composed of ridges of gneiss and quartzite. There is little seasonal variation in surface flow of water. The area is sparsely populated with economic trees. The calcite can be reached from Ekinrin-Ade and Mopa in which consruction of road is possible.

The calcite outcrops are massive rounded boulders that are frequently exfoliated and affected by solution weathering. The mineral is whitish in colour with patches of black spot and decreases with depth but elsewhere it is black on fresh surface. The rock varies in colour from pure white to grey and blue – grey but these changes do not correspond with any great changes in its chemical composition. The rock consists almost entirely of crystalline calcite of variable grain size with minor inclusions of graphite quartz mica. The grain size varies between 1mm and 5mm. The graphite inclusions range in size from minute steaks to shreds 0.2m long and included within the calcite crystals and occur at their margins.

2.1. Structural history:

There can be little doubt of sedimentary origin of the limestone and concentration of quartz and mica in definite bands can be regarded as representing the original sedimentary concentrations and bedding planes. According to Harker (1980) graphite, pyrite, Muscovite and Quartz have no reaction with carbonates and recrystallize without change during the regional metamorphism of non- dolomite limestone.

The re-crystallization of the calcite limestone is thought to be in line with the strong folding during regional metamorphism. Following the folding, the marble was disrupted by diagonal faults that served as the loci of emplacement of pegmatite, quartz-feldspar rocks and quartz-veins. Further movement on these faults caused intensive brecciation and mylonitiation of these intrusions. The same movements probably induced the north trending lineation in the enclosing gneiss. It is suggested that the faulting, the intrusions of pegmatites and the development of lineation in the gneiss may be related to the post-tectonic emplacement of large mass of older granite, which outcrops is several miles to the north. Furthermore, the Jakara, Ubo and Ukpilla marble might be very closely correlated with Ekinrin-Ade calcite, although the latter is more calcite and that of Ukpilla has more dolomite than the Jakura marble deposit.

2.2 Chemical composition of the calcite:

in order to ascertain the chemical characteristics of the calcite mineral there was an extensive analysis of the borehole samples that gave the average percentage of caco3, mg co3 and other gangue minerals as 96.2% and 1.4% respectively. This showed that the calcite body is fairly chemically homogeneous and does have wide variations. Tables 1-23 in Olukayode (2001) show the partial chemical analysis of the boreholes.

3.0. THEORETICAL CONSIDERATIONS

The methodology here entails an extensive study of the geo-survey documents of the deposit. The data from this was subjected to geo-statistical analysis to determine the degree of mineralization of the calcite along east-west and north-south directions of the deposit. The concept of geo-statistic is centered on the investigation made by G. metheron (1963 & 1971) of which the basic tool is the variogram. A detailed theoretical deductions and calculations involved in geo-statistics techniques can be found in Osemenam (1991).

4.0. GEOSTATISTICAL DESIGN OF EKINRING-ADE CALCITE DEPOSIT:

Figure 1 is the geological map of Ekinrn-ade calcite deposit showing the various positions of the exploratory boreholes as drilled by the Nigerian Mining Corporation. The average grades of the calcite mineral used in geo-statistical design of the said deposit were obtained from the chemical analysis of the borehole samples.

4.1 Calculation of semi-variogram:

Tables 1 and 2 represent the average grade of calcite from each of the boreholes used for the calculation of semi-variogram in east-west and north-south directions of the calcite deposit.

Table 1: Average grades of calcite used in determining the value of experimental semi-variogram in the east-west direction of Ekinrin-Ade calcite deposit

Borehole numbers	Average grade of calcite (%)
1	89.59
2	96.6
3	87.9
4	97.0
5	98.7
6	79.4
7	89.6
8	73.2
9	75.8
10	89.11
11	92.0
12	93.80
13	87.82
14	95.80
15	94.70
16	95.80
17	98.00
18	94.70
19	68.58
20	81.19
21	94.50

Table 2: Average grade of calcite used in the determination of experimental semi-variogram in the north-south direction of Ekinrin-Ade deposit

Borehole numbers	Average grade of calcite (%)
1	85.59
2	85.19
3	96.66
4	87.90
5	97.00
6	79.40
7	89.60
8	73.20
9	75.80
10	89.11
11	92.00
12	93.80
13	87.82
14	95.80
15	94.70
16	95.20
17	94.40
18	95.60
19	68.58
20	81.19

5. RESULTS

With the data in tables 1 and 2 the experimental variogram in the east-west and north-south direction of Ekinrin-Ade calcite deposit were calculated using the equation as contained in Osemanam (1991). Table 3 and 4 show the results of calculating the experimental semi-variogram in the east-west and north-south directions of the Ekinrin-Ade calcite deposit.

Table 3:

Borehole numbers	Distance between boreholes on scale 1:5000	Experimental variogram $(\gamma\%)^2$
13,14,14,7,17,19.	0.50	45.14
4,3	4.50	46.08
1,6,6,23.	9.50	25.16
10,21,21,9.	14.50	18.37
5,11,11,6.	18.50	38.56
22,3.	24.20	56.70
12,18.	34.10	18

Table 4: Results of experimental semi-variogram in the north-south direction of Ekinrin-Ade calcite deposit.

Borehole numbers	Distance between boreholes on scale 1:5000	Experimental semi-variogram $(\gamma\%)^2$
4,5	1.80	41.41
4,22	2.80	22.50
3,11	3.00	22.40
3,1	3.20	24.00
2,10	3.50	35.40
14,21	3.60	9.62
7,8,8,9	3.80	35.30
12,15	4.00	7.22
17,14	4.50	26.50
20,19	5.00	0.72

5.1. Interpretation of Results

Fig. 2 represents the graph of experimental semi-variogram of calcite grade in the east-west direction of Ekinrin-Ade deposit. From the graph there seem to be even variation of calcite showing evidence of continuous mineralization along this direction. However there was a slight scale of discontinuity observed near the central zone of the deposit. This may be attributed by strong presence of outcrops and the existence of cracks found around the zone. Consequently, it can be said that on the strike direction of Ekinrin-Ade deposit the experimental semi-variogram is characterized by geometric anisotropy of calcite grade.

Figure 3 represents the graph of semi-variogram in the north-south direction of the Ekinrin-Ade calcite deposit. Interpretation of the semi-variogram graph showed that the calcite deposit is classed as fairly complex. This is shown by the behaviour of the graph at distances of 2.8cm, 3cm and 3.2cm where there was little indication of the existence of a sill that immediately disappeared by sudden jump of the graph at a distance of 3.5cm. On the whole there seem to be a relative even variation of the calcite mineral giving the deposit a characteristic of continuous mineralization. This result also revealed a strong geometric anisotropy along the direction of the dip of the Ekinrin-Ade deposit.

5.2. Exploration grid model:

The search to establish an economic model-exploration carried out by the construction of experimental semi-variogram with arbitrary intervals between boreholes using the known grades of calcite mineral. As usual, the investigation was carried out in the east-west and north-south direction of the calcite deposit. The following arbitrary intervals were used on geological map of Ekinrin-Ade deposit with scale 1.5000: 5cm 10cm, 15cm, 20cm and 30cm.

Tables 5 and 6 show the results of experimental semi-variogram in east-west and north-south directions respectively (for the establishment of exploration grid).

Table 5:

Borehole numbers	**Distance between boreholes on scale 1:5000**	**Experimental semi-variogram $\gamma(\%)^2$**
1,2,3,4,5;5,6,7, 8;8,9;9,10;11,12;12, 13;13,14;14,15;15,16; 16,17;17,18;18,19,20; 20,21;21,22;22,23.	5	2.33
1,3;5,7;9,11,13,15;15 17;17,19;21,23.	10	2.89
1,4;4,7;7,10;11,14; 14,17,20	15	5.43
1,5;5,11,16;16,21,	20	0.8
1,6;6,12;12,18.	25	6.49
1,7;7,14;14,21.	30	4.73

Table 6: Result of experimental semi-variogram in the north-south direction (for exploration grid)

Borehole numbers	**Distance between boreholes on scale 1:5000**	**Experimental semi-variogram $\gamma(\%)^2$**
1,11;11,21;2,12;12, 22;3,13,23;4,14;5 15, 16,7,8,18;9,19;10, 20.	5	2.57
1,21;2,22;3,23.	10	1.67

5.2.1. Discussion of results:

The search for the establishment of an exploration grid through the construction of semi-variogram in the east-west and north-south direction of Ekinrin-Ade calcite deposit with arbitrary intervals of 5cm, 10cm, 15cm, 20cm, 25cm and 30cm showed that there existed periodical fluctuations of the calcite body. Along the strike of the calcite deposit (fig.4 east-west direction of the deposit) there seem to be an even variation of the periodical fluctuation at the central zone. It was also observed that the even variables in the graph of the semi-variogram in the east-west direction of the Ekinrin-Ade calcite deposit tend to disappear as the distance between the boreholes are increased. This disappearance shows that not much information can be obtained in the nature of mineralization of the calcite body. In fig.5 there was relatively not much information on the nature of mineralization of the calcite along the dip of the deposit 9north-south direction of the deposit) hence in the calculation of semi-variogram the distance between the boreholes were limited to 5cm and 10cm.

From the above investigation, an economic model was established with grid dimension of 3cm. (on scale of map 1:5000) along the strike of the deposit and 3cm. along the dip of the deposit (On scale of map 1:5000). The development of the model led to the reduction of the number of the boreholes in Ekinrin-Ade calcite deposit to 16 against 29 boreholes drilled by Nigerian Mining Coportion. On the whole this gave a reduction of approximately 40%.

The paramount importance of this exploration grid is that it can be applied to the development of a new deposit of the same geometric characteristics as that of Ekinrin-Ade deposit.

CONCLUSION

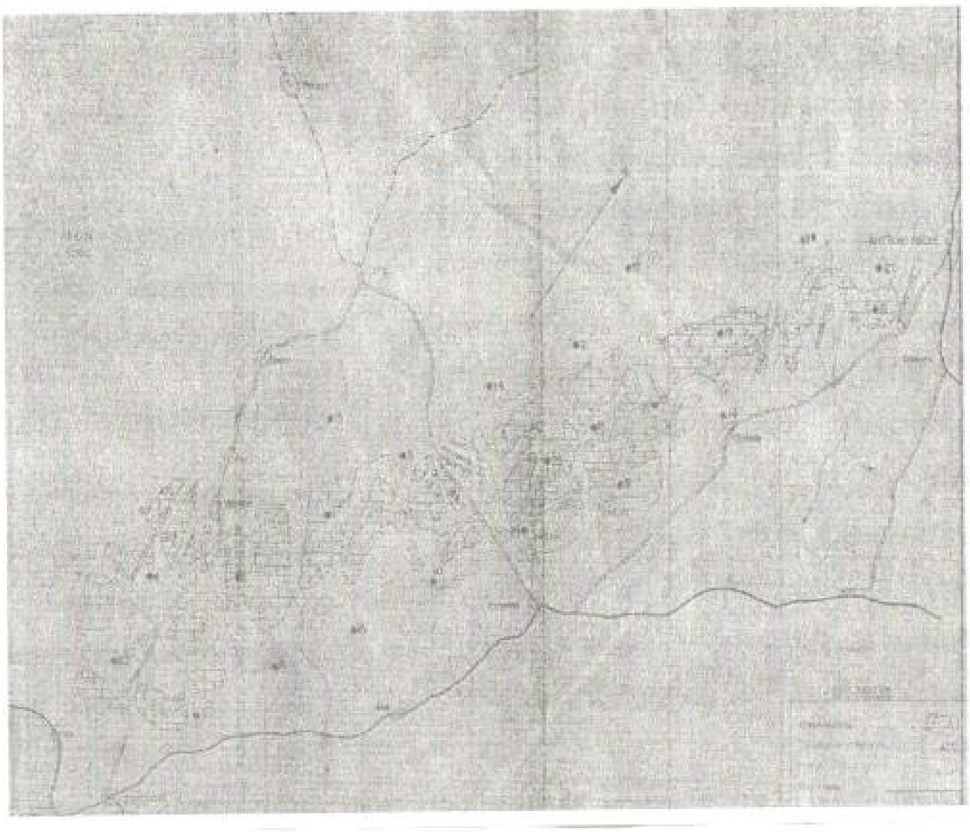
The presence of geometric anisotropy along the strike and dip of the Ekinrin-Ade deposit permits us to assume the presence of faults and structural displacement within the calcite layers. The application of geo-statistical techniques that led to the establishment of exploring grid gave us possibility to recommend an optimal size of the grid along the strike and dip of the deposit to be 3cm and 3cm respectively on scale of map 1:5000.

Geo-statistics evaluation of Ekinrin-Ade calcite deposit confirms that mine planning can be kept under statistical control, and deviation, which must occur with some calculable frequency that can be forecasted and dealt with.

Geological map of Ekinrin-Ade calcite deposit. Scale 1:5000

The assessment of Ekinrin-Ade calcite deposit showed that valuation programs can be designed economically and that will save the huge amount of money usually spent during exploration of mineral deposit.

1.



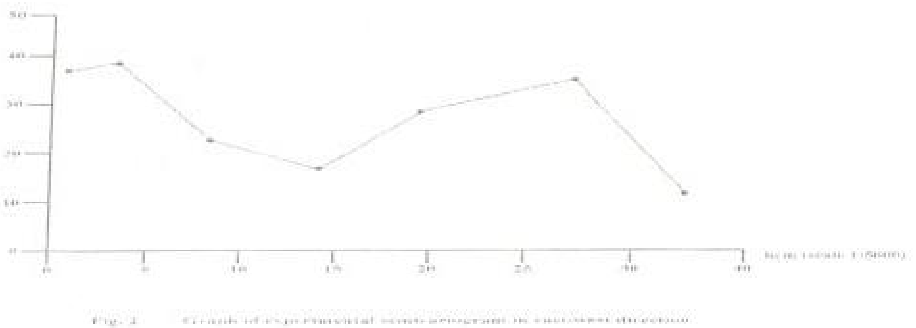


Fig. 2 [illegible]

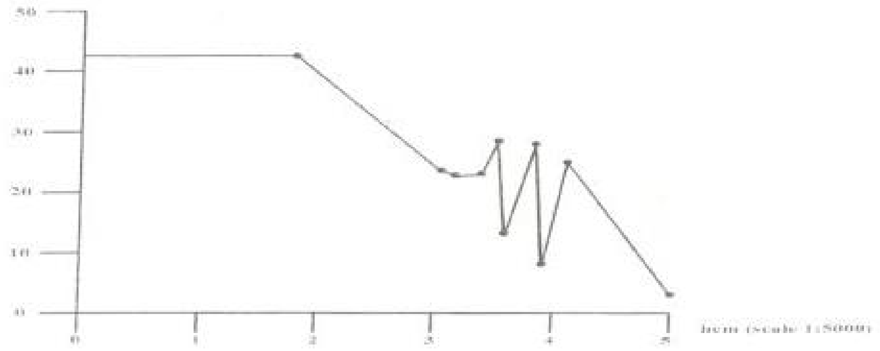


Fig. 3 Graph of experimental semivariogram in north-west direction of Ekinrin-Ade calcite deposit

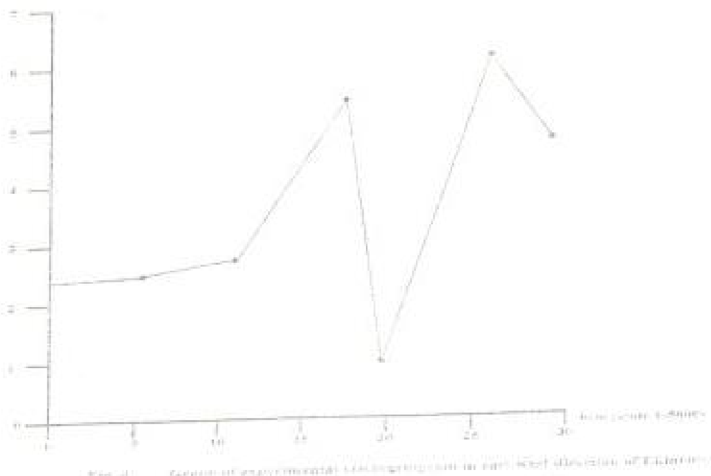


Fig. 4 Graph of experimental semivariogram in [illegible] west direction of Ekinrin-Ade calcite [illegible]

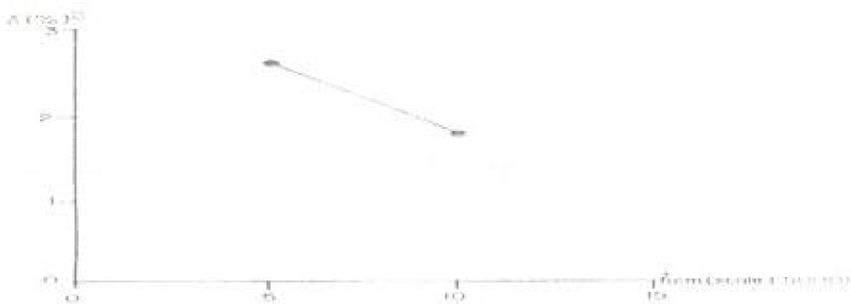


Fig 5 Graph of experimental Semivariogram in North – South direction of Ekinrin – Ade deposit (for exploration grid)

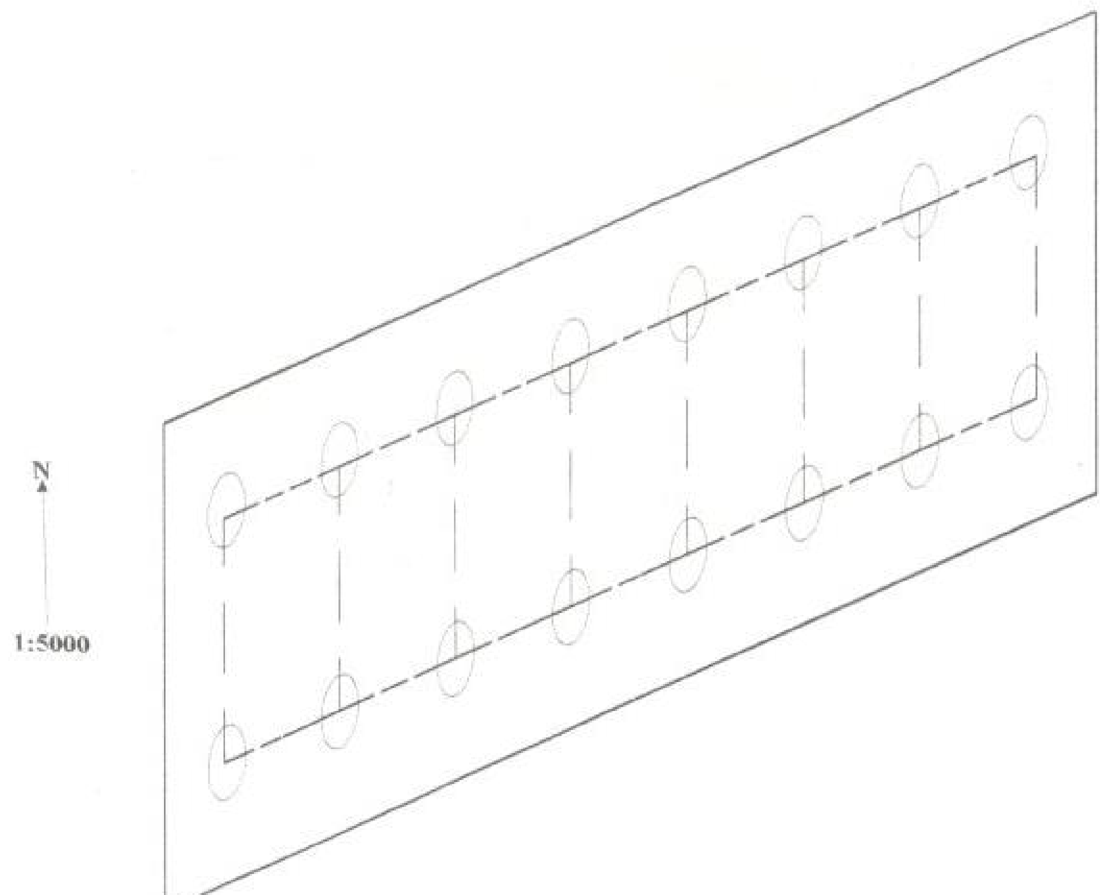


Fig. 6 Scheme of exploration grid of Ekinrin-Ade calcite deposit

REFERENCES:

1. Ershov V.V. (2000): Economic of limestone. Izvestia Journal, Moscow, 64(3), 50-56.

2. Gillson A., Smith G.N. (1998): Fragmentation of carbonic rocks. Mining Congress Journal, Sweden, 27(3): 63-68.

3. Harker G. (2001): Crystallisation of calcite mineral. M.Eng. London 35(6): 24-29

4. Matheron G. (1963): Principles of Geo-statistics. Scoul. Geol., 58: 1246-1266.

5. Matheron G. (1971): Precision of exploration of a stratified formation by boreholes with rigid spacing. Int. symposiuon Mining Research. University of Missouri, 407-423.

6. Olukayode F. (2001): Geology of Ekinrin-Ade calcite deposit. M.Eng. project.

7. Osemenam R.A. (1991): Geometrical evaluation of Itakpe iron ore deposit. The Nigeria Engineer, 28(2): 55-61.

8. Severinghaus E. (1998): Industrial minerals and rocks. Symposium, Institute of Mining and Metallurgy, 16(2): 13-18.