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# THE APPRAISAL OF A PROPOSED BARITE QUARRY IN AKPET AREA, CROSS RIVER STATE, FROM RESISTIVITY INVESTIGATION

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ABSTRACT

Electrical resistivity survey was done at a site at Akpet area, Cross River State to evaluate the subsurface for barite mineralization. Both vertical electrical sounding (VES) and horizontal resistivity profiling (HRP) were performed in conjunction with surface geological mapping in the area. In both VES and HRP, the Schlumberger electrode array was adopted and measured resistivity data interpreted using conventional curve matching techniques and iterative computer modelling. Results show that three (3) zones designated A, B and C with barite mineralization occur within a depth of 5m in the subsurface at the project site. The combined high specific gravity of 4.4 g/cc and high $BaSO_4$ (>92%) show that the barite of the study area are of high quality. The practical recovery of over 8 tons of barite at the project site shortly after this report which revealed the occurrence of large deposit of barite in the area; show that the applicability of the resistivity method in the search of barite and other minerals alike is very reliable.

**KEY WORDS**: Barite, resistivity, subsurface, recovery.

## INTRODUCTION

Ever since the discovery of barite in the early eighties by primitive farmers in Akpet and environs, the mining of barite in the area followed shortly after. Presently, many mining companies have tested and found out that good quality barite exists in the area based on measured specific gravity of about 4.45 g/cc

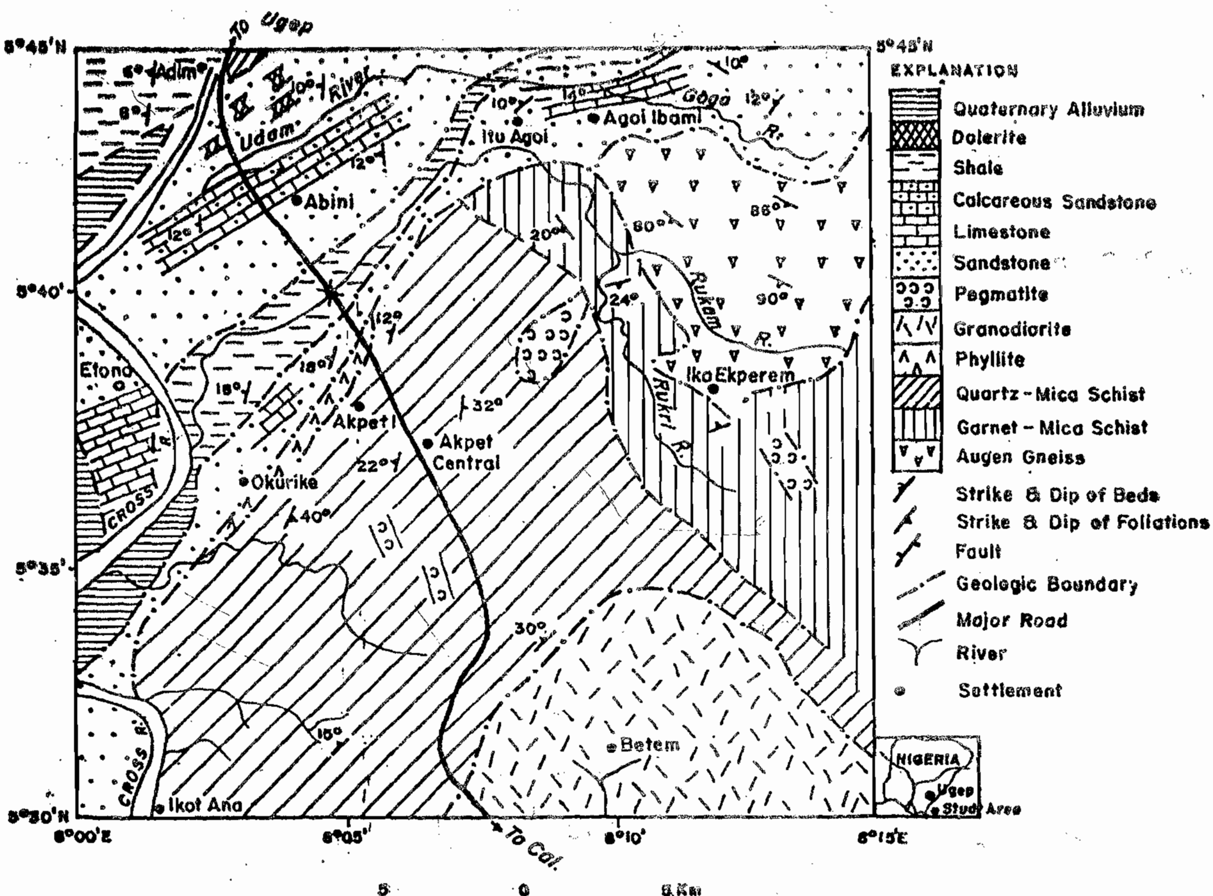


*Fig. 1: Geological map of soulthwest Ugep southeastern Nigeria (after Ekwueme 1990a)*

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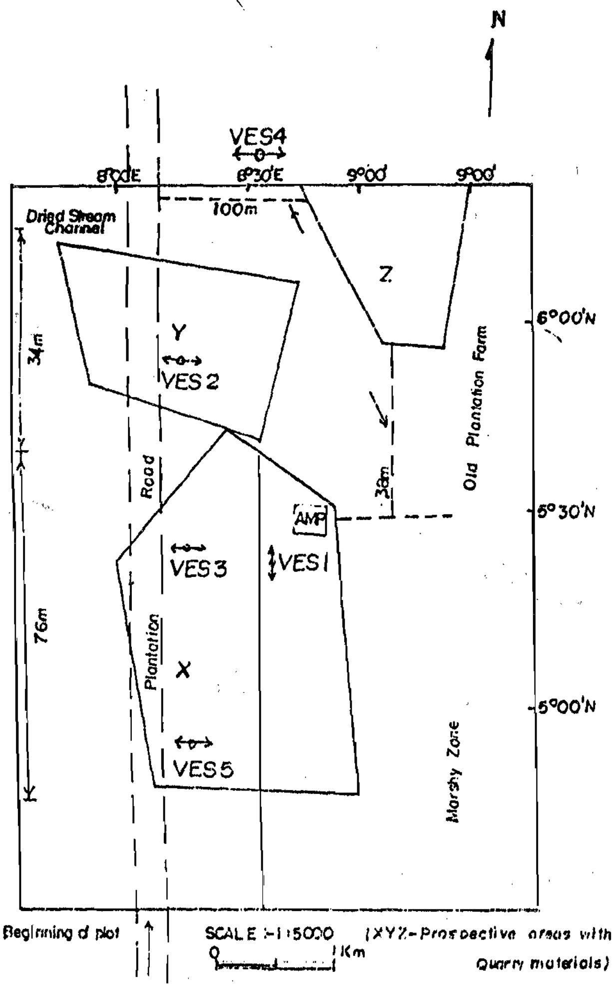


*Fig. 2: Suspected Barite Mineralised Zones*

(Akpeke, 2000) obtained for most samples. The importance of barite in the world market cannot be over emphasized. Beside its utilization in drilling fluid in the oil industry, it is also used in the production of white pigment for paint and as a filler in papers. Therefore the search for and mining of this mineral is ever on the increase and in areas where it has been suspected a fal in the expected economic turnovers is usually the ultimate outcome due to lack of prior site investigations. In other words, curious miners, merely involved in a sort of 'trial and error' approach by way of a debased/crude correlation approach. In order to avoid undue economic loses occasioned by presumptive mining approach, Brown Rock Company, the Leasor of the investigated site decided to adopt a more professional approach as a preliminary step to evaluate the subsurface of their proposed lease in terms of barite productivity. On the basis of the above, the main object of the study was to investigate the possible occurrence of barite mineralization in the proposed quarry lease (QLS), as well as delineating the zones of occurrence within the area. It is on the basis of this that the expected mining activities would be based. To achieve the stated objective, a surface resistivity survey utilizing the vertical electrical sounding (VES) and horizontal resistivity profiling (HRP) techniques were carried out. Okereke et al (2001) have used a study of this nature to evaluate a site in terms of granite productivity, for the sake of siting a mining quarry. The work therefore attempts to ascertain the validity of the electrical resistivity method as a tool in solid mineral exploration, where these materials were concealed under thick overburden cover.

## Location, Physical Setting and Geology

The study Lease (Figure 2) is located some 3-4kms away in the eastern axis of Akpet community in Biase Local Government Area of Cross River State. It is linked from Ibogo community through Ibogo-Iko Essai road, via a 1.0km by-pass into the government reserved area/plantation road. No corner beacons (CBs) were

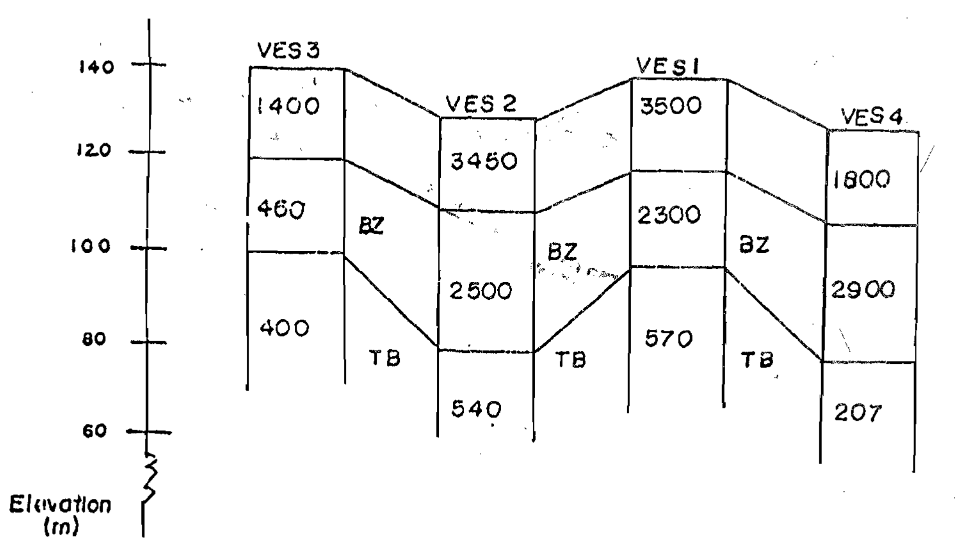


*Fig. 3: Geoelectrical model showing Barite zones BZ along VES lines*
*(TB = Top of Basement)*

observed in the field in order to establish the actual areal extent of the area.

Physiographically, the area is dominated by an undulating topography with several stream channels at the base of the hills covering most parts of the area. Gully erosion which is the dominant type of erosion is mostly accentuated on the steep hills, but due to the high resistant nature of the rocks in the area, hard and raised ground surfaces often stand out forming cast topographies. Elevation measurements made with GPS gave values ranging between 280 and 360ft (85-110m).

Geologically, the area falls within the Precambrian basement province of Western Oban Massif in Southeastern Nigeria (Nganje, 1985; Nganje and Ekwueme, 1996). Rocks of this area (Figure 1) are dominantly schists and gneisses (Eshiet, 1999). The schists of the area are characterised by well developed biotite and muscovite crystals. Where weathering activity is severe on these rocks, numerous muscovite flakes can be seen glittering on the surface of the ground. Regional tectonic trend obtained from measured foliation, and fracture planes indicate a NE-SW trend of the Pan African Orogeny, (Egeh et al., 2002; Ekwueme, 1987).

## METHODOLOGY

The entire area was first mapped to determine the regional trends of the rocks including areas where barite mineralization occurs. Some barite samples (Figure 6) were collected and analysed for chemical constituents and specific gravity (Table 1).

Electrical resistivity study of the area was then done using an Abbem Terrameter (300 SAS model) and employing the vertical electrical sounding (VES) and horizontal resistivity profiling (HRP) techniques.

The VES technique was based on the Schlumberger electrode array using a maximum half-current electrode spacing of 200m. The current electrode spacing (AB/2,m) was varied from 1 to 150-200m at logarithmically equal intervals giving a depth of investigation in the range of 40 to 80m or more. In each case, the expansion of the current electrodes was in a direction parallel to the average strike (NE-SW) of the outcrops. The apparent resistivity (a) versus AB/2 were plotted bilogarithmically and the resultant sounding curves were smoothed and then interpreted by curve matching techniques. The interpretation yielded a geoelectrical section of the area (Figure 3). The VES

Table 1: Chemical compositions of barite samples of the study area

| Component analysed (%) | $IB_1$ | $IB_1$ | $U_{2-2}$ I | $U_{2-1}$ A | $U_{2-1}$ B |
|---|---|---|---|---|---|
| $BaSO_4$ | 92.66 | 92.59 | 89.94 | 84.25 | 87.50 |
| $SiO_2$ | 0.80 | 0.50 | 1.00 | 6.40 | 7.05 |
| $Al_2O_3$ | 3.43 | 2.99 | 4.40 | 4.83 | 3.41 |
| $Fe_2O_3$ | 0.07 | 0.06 | 0.10 | 0.17 | 0.09 |
| $TiO_2$ | N.D. | N.D. | N.D. | N.D. | N.D. |
| $Na_2O$ | 0.24 | 0.20 | 0.24 | 0.22 | 0.21 |
| $K_2O$ | 0.006 | 0.004 | 0.04 | 0.004 | 0.04 |
| CaO | 1.25 | 1.25 | 1.12 | 1.39 | 0.28 |
| MgO | 0.50 | 0.50 | 0.60 | 0.80 | 1.21 |
| L.O.I | 0.40 | 0.30 | 0.80 | 0.10 | 0.15 |
| SG | 4.21 | 4.15 | 4.10 | 4.17 | 3.92 |

Table 2: Thickness estimate of barite bodies based on VES data

| VES | Layer number | Depth range (m) | Thickness (m) |
|---|---|---|---|
| 1 | 2 | 45 - 16.8 | 12.4 |
| 2 | 2 | 2.6 - 9.4 | 6.8 |
| 3 | 2 | 1.5 - 12.0 | 11.5 |
| 4 | 2 | 2.2 - 18.6 | 16.4 |

The width of the zones deduced from HRP measurements (Figures 4 and 5) are as shown in table 3 below:

Table 3: Width of barite-bearing zones

| Line | Range of stations | Width of zones (m) |
|---|---|---|
| $HRP_1$ | 13 - 29 | 16 |
| $HRP_2$ | 7 - 27 | 20 |
| $HRP_3$ | 11 - 18 | 70 |
| $HRP_4$ | 9 - 29 | 20 |

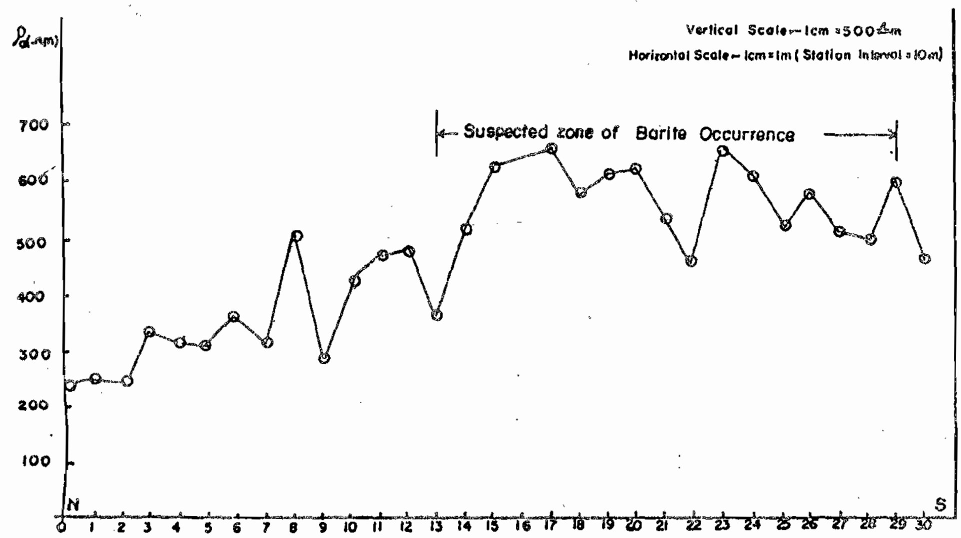


*Fig. 4: Graph of apparent Resistivity (Pa) Vesus station along HRP, Station Position*

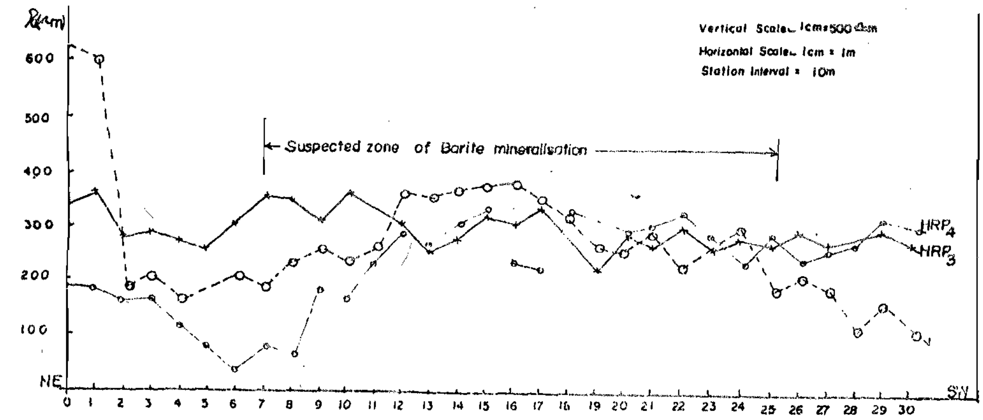


*Fig. 5: Graph of apparent Resistivity (Pa) Vesus station along $HRP_2$ and $HRP_3$*

measurements were carried out to reveal the variation of rock resistivity with depth and hence the top and bottom surfaces of the concealed barite bodies. On the other hand, the HRP was done using the Wenner electrode array with a constant station interval of 10m. Thirty (30) stations spaced at 10m interval were occupied along the four HRP lines chosen at the project site. The choice of the electrical resistivity method was based on the anomalous high resistivities usually associated with most mineralized ores like barite, which generally exhibit high densities and extremely low porosities. The resistivity measurements made were then subjected to iterative computer modelling (Figure 3) as well as manual interpretation to delineate zones with anomalous resistivities in relation to the local geology. Such anomalous zone within the subsurface were then mapped to reflect possible zones and depth to the anomalous mass.

## RESULTS AND DISCUSSION

Interpretation of the vertical electrical sounding (VES) using interactive computer modelling programme yielded a geoelectrical models typical of a 3-layer earth model (except in VES 3) as shown in Figure 3. Resistivity values in all the occupied VES stations indicate moderate to high values. The high resistive layer two having values in the range of 2000 to 3000 Ohm-m are attributed to the presence of barite ores within the subsurface. Underlying this layer is a moderately high resistivity layer composed of gravelly sands believed to be the top of the basement layer.

Barite is known to possess low porosity and high density (Oden, 2001). The high density is due to lack of adequate pore spaces in the crystal structure. The absence of pores and the compact nature of the material skeleton account for the high resistivity attributed to it. Materials of this sort when embedded in a relatively porous and less dense material medium usually stand out distinctly on any interpreted resistivity map or profile (Reynolds, 1998). In the study area, barite occurs as disseminated materials within thick alluvium and gravelly cover. These host materials are relatively more porous and therefore less resistive to inhibit the anomalous resistivity values attributed to barite ores.

Figure 2 shows the barite delineated zones based on the interpreted VES data (Table 2) and horizontal resistivity profiling (HRP) curves of figures 4a and b. The thicknesses of the barite layers along the occupied VES are shown in table 2 below:

From the data of table 3, it is apparent that barite mineralization occur in large quantity in the subsurface of the study area. The specific gravity values for most samples (Figure 6) which ranged between 4.15 and 4.45 g/cc places the barite from Akpet area on the high ranking scale. However, the disseminated mode of occurrence evident from both geological mapping and resistivity interpretation clearly portrays enormous difficulties during exploitation (personal communication with a local miner). A recent visit by the lead author to the investigated area revealed that not less than 8.03 tons of barite have already been mined by the Leasor and active mining activities is on-going.

## CONCLUSION

Surface resistivity measurements carried out at a site for the purposes of evaluating the subsurface for barite mineralization, indicates a significant reliability of the technique. By the combination of both vertical electrical sounding (VES) and horizontal resistivity profiling (HRP) both vertical thickness and lateral extent of the material in search can be known. The results of the study show that barite ores exist in large quantity in the area and lies beneath an overburden thickness not less than 5 meters. Therefore, probing the subsurface of a suspected mineralized area using the relevant geophysical technique(s) prior to the actual mining activities is a worthwhile venture.

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