APPLICATION OF ELECTRICAL RESISTIVITY TECHNIQUES TO DECIPHER GRANITIC DYKE WITHIN SEDIMENTARY TERRAIN FOR QUARRY PURPOSE

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ABSTRACT

The study area is situated in the southeastern part of Nigeria, geographically located at 32P between 649475 to 649550 UTM Latitude and 323800 to 323900 UTM Longitude coordinates about 12km North-East of Okigwe and about 4-5km North of Uturu town, Abia State. The study was conducted having an objective of the geophysical assessment to provide important subsurface geological formations and structures for potential granite quarry site within sedimentary basin environment. Six and nine Vertical Electical Sounding (VES) points along gridded profile lines for AREA A&B respectively were collected. VES data were entered to the computer and structural map were plotted and interpreted using wing link interpretation software. The aeromagnetic and field geological maps combined withVES results revealed resistivity value of 850Ωm to 29000Ωm in AREA A (known quarry site) showing a large difference in comparison with AREA B (this study) with values ranging from 500Ωm to 850Ωm for spotted dyke. Although, aeromagnetic map for this study shows that the dyke region is correlative with the zones where quarry activity is already taking place. AREA A has a dyke which is about 260m long and an overburden thickness of about 20 to 30m compared to AREA B with overburden thickness of about 60 to 70m which may not be profitable for quarrying considering volume of overburden.Dyke in AREA B can be suggested for core drilling investigations to ascertain its petrology and competency.

Keywords: *Vertical Electrical Sounding (VES), Dyke, Aeromagnetic map, UTM, Subsurface, and Quarrying,*

1. INTRODUCTION

The study areas falls within Abia State,south-eastern Nigeria, located at about 12km North-East of Okigwe and about 4-5km North of Uturu town. It falls largely on Ugodo community and partly on Ugwele community, Isuikwuato Local Government Area. Abia State is a state in southeastern Nigeriabounded in the north and northeast by the states of Anambra, Enugu, and Ebonyi. To the west of Abia is Imo, to the east and southeast are Cross River State and Akwa Ibom State, and to the south is Rivers State. The area also falls within the Federal Survey of Nigeria Topographic Map sheet No. 312 (OKIGWE), 1:100,000.One of the main economic means of Abia state apart from Aba commercial market is in the exploration and recovery of oil & gas and less agriculture. The topography of the area is undulating, Thus with the traditional agricultural practices, natural resources are severely degraded due to human interference as well as natural devastation through sand quarrying. Source of construction material like the dimension stones is often a challenge to transport from several kilometers to this region because of lack of stone quarry close by. This had led to high cost of building and construction. This report contain the summary of electrical resistivity techniques applied to unravel subsurface geology of an area aimed towards a comprehensive geo-technical study for quarrying evaluation and feasibility study of setting up competent quarrying plant in Ngodo and Ugwele village, Isuikwuato Local Government Area, for the production of granite. This paper mainly contains definitive conclusions on all the basic parameters used for this study and is presented in a format that would easily be understandable by investors.

Fig1: Image map showing the study area (inset; vegetation view within the study area)

2. GEOLOGIC SETTING

2.1 THE LOWER BENUE TROUGH AND THE ANAMBRA BASIN

The study area lies largely on the Cretaceous sedimentary terrain of Nigeria. This can be narrowed down to the Lower Benue Trough and Anambra Basin. Sedimentation in the Lower Benue Trough (Fig. 2) commenced with the marine Albian Asu River Group, although some pyroclastics of Aptian – Early Albian ages have been sparingly reported (Ojoh, 1992). The Asu River Group in the Lower Benue Trough comprises the shale, limestone and sandstone lenses of the Abakaliki Formation in the Abakaliki area and the Mfamosing limestone in the Calabar Flank (Petters, 1982). The marine Cenomanian – Turonian Nkalagu Formation (black shales, limestones and siltstones) and the inter fingering regressive sandstones of the Agala and Agbani Formations rest on the Asu River Group. Mid-Santonian deformation in the Benue Trough displaced the major depositional axis westward which led to the formation of the Anambra Basin. Post-deformational sedimentation in the Lower Benue Trough, therefore, constitutes the Anambra Basin.

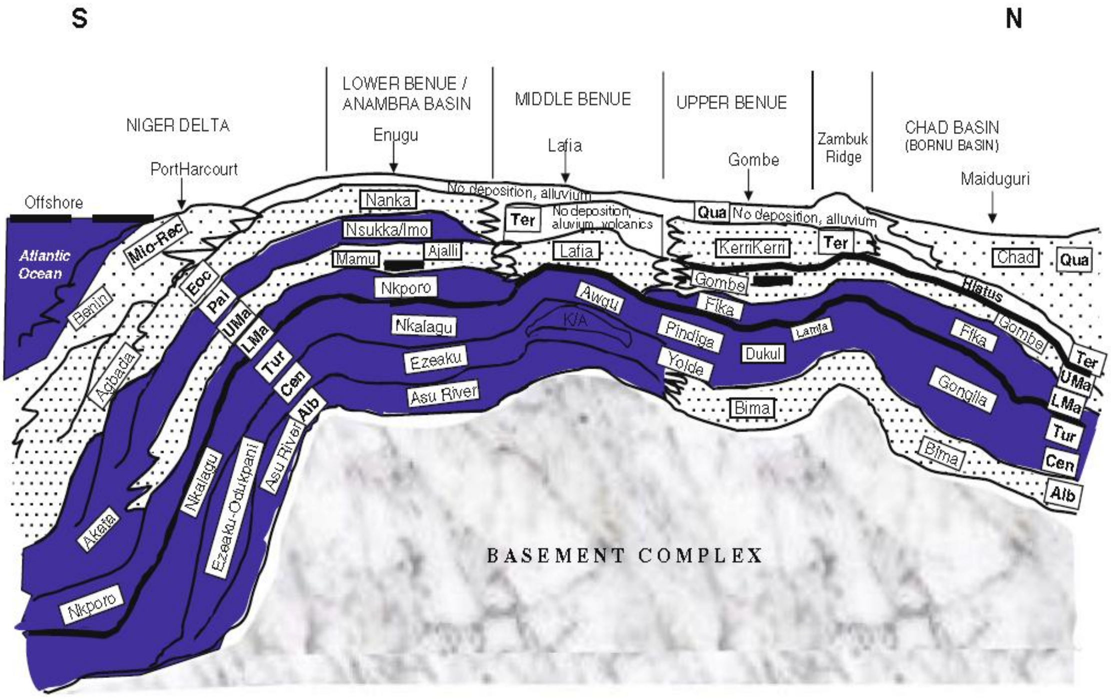

Fig 2: Idealized N–S stratigraphic cross-section across the Chad Basin–Benue Trough – Niger Delta depicting a connected Trans-Atlantic seaway between the South Atlantic and the Tethys Sea during the Coniacian – Turonian (in Obaje, 2009)

2.2 LOCAL GEOLOGY

The study area lies geologically within the Lower Benue and Anambra Basin. Itis made up of shale which is overlain by sandstone with few intercalations of limestone between the Shale and the Sandstone. The area is predominantly occupied by Sandstone ranges from medium grained to fine grained. Hills surrounding the area are made up of sandstone which were either exposed by the river/stream channels or exposed by road cuts. Some of these outcrops were exposed as boulders while most of them were actually in-situ. Shale is the second most predominant rock mapped to overlain by the sandstone. It is believed that the sandstone overburden overlaying the shale is very thick which to justify why shale outcrops were not pronounced. Shale outcrop was only observed at the Northern end of the area trending in East-West direction, though the outcrop was poorly exposed for further readings, however outcropped along footpath and along erosion channel. Limestone is rarely exposed around this but was seen exposed along a stream course. Limestone has the chemical formula as: $CaCo_3$which when tested with hydrochloric acid (HCl), it reacts with the calcite and gives out carbon dioxide (CO_2) as gas. Here is the chemical reaction tested on field which gives a strong reaction: $CaCO_3 + 2HCl = CaCl + H_2O + CO_2$. Dolerite is a volcanic rock similar to basalt, it contains crystals which can be seen with a hand lens. This indicates that it cooled a little more slowly than basalt. Typically it is found in volcanic plugs which channeled the basalt to the surface.

3. METHODOLOGY

3.1.SURVEY DESIGN

Three categories of field techniques exist for conventional resistivity analysis of the subsurface. These techniques are vertical electric sounding (VES), constant separation traversing (CST), and combined procedures which utilize characteristics of both VES and CST. Meanwhile this study was limited to vertical electric sounding (VES) techniques. Current and potential electrodes are maintained at the same relative spacing and progressively expanded about a fixed central point with the whole spread (Philip and Michael, 1984). Four electrodes are placed along a straight line on the Earth surface in the same order, A M N B, with AB ≥ 5 MN (fig. 3). For any linear symmetric array A M N B of electrodes, the apparent resistivity (ρa) applying Schlumberger array where AM is the distance on the Earth surface between the positive current electrode A and the potential electrode M. When two current electrodes A and B are used and the potential difference (ΔV) is measured between two measuring electrodes M and N, the apparent resistivity can be written in the form: $\rho a = \pi\ \Delta V/I * [((AB/2)2 – (MN/2)2) / MN]$ or $\rho a = \pi\ K\ \Delta V/I$

The value of the apparent resistivity (ρ) depends on the geometry of the electrode array used, as defined by the geometric factor (K) (Reynolds, 2000).The principal instrument used for this survey is the ABEM (Signal Averaging System, (SAS 300) Terrameter with appropriate electrodes, cables on reels, and other accessories.

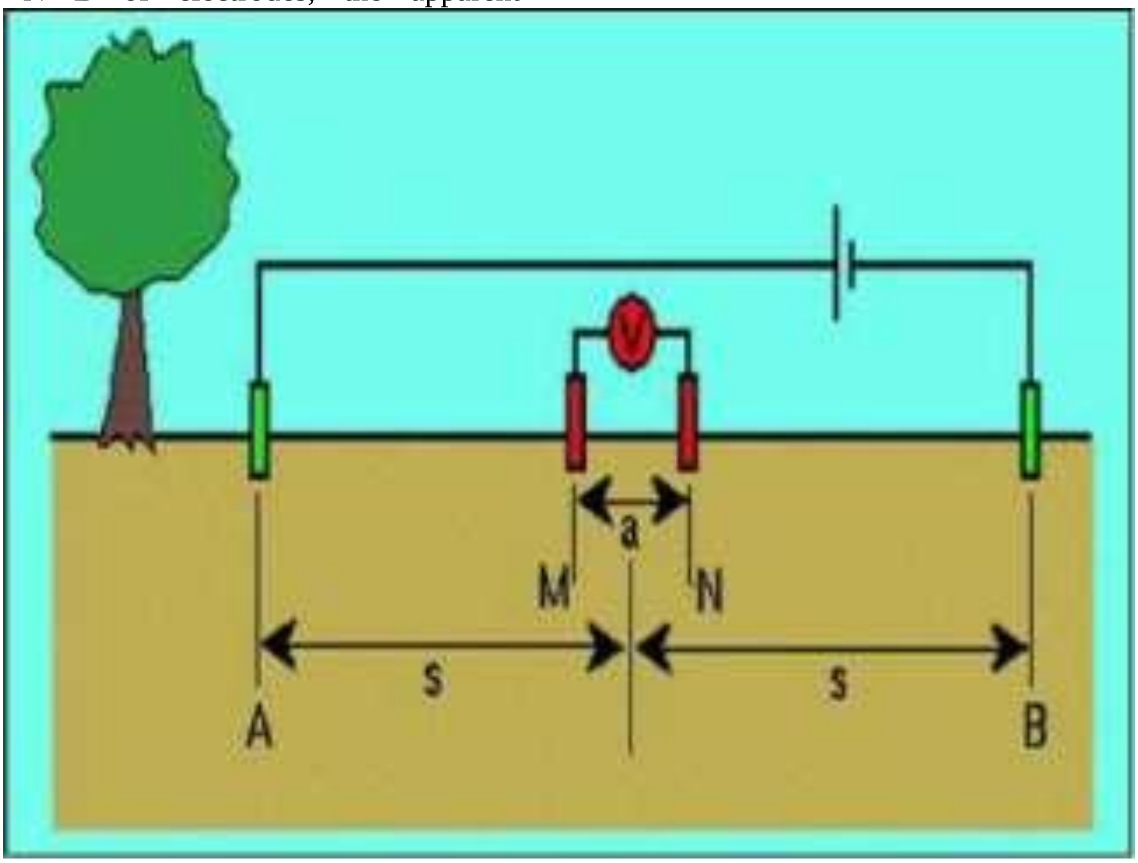

Fig.3: Electrode configurations in Schlumberger array (Mines, 2003)

3.2. SURVEY APPROACH

Dolerite had been reported from Aeromagnetic map (fig. 4) to occur as intrusions within the sediments and mostly buried beneath other rocks. This is the reason for the introduction of geophysics to carry out sub-surface survey of the area (this study) to confirm the presence of dolerite when compared to already know dolerite quarry in the same geologic environment. The known dolerite quarry is termed as AREA A and for this study termed AREA B. Vertical Electrical Soundings (VES)with the commonly used Schlumberger array were carried out at six (6) stations for AREA A and nine (9) stations for AREA B for the purpose of determining the vertical variation of resistivity. Comparison, correlation and deduction for potential quarry within the study area using appropriate software was drawn from acquired data, interpreted and presented below.

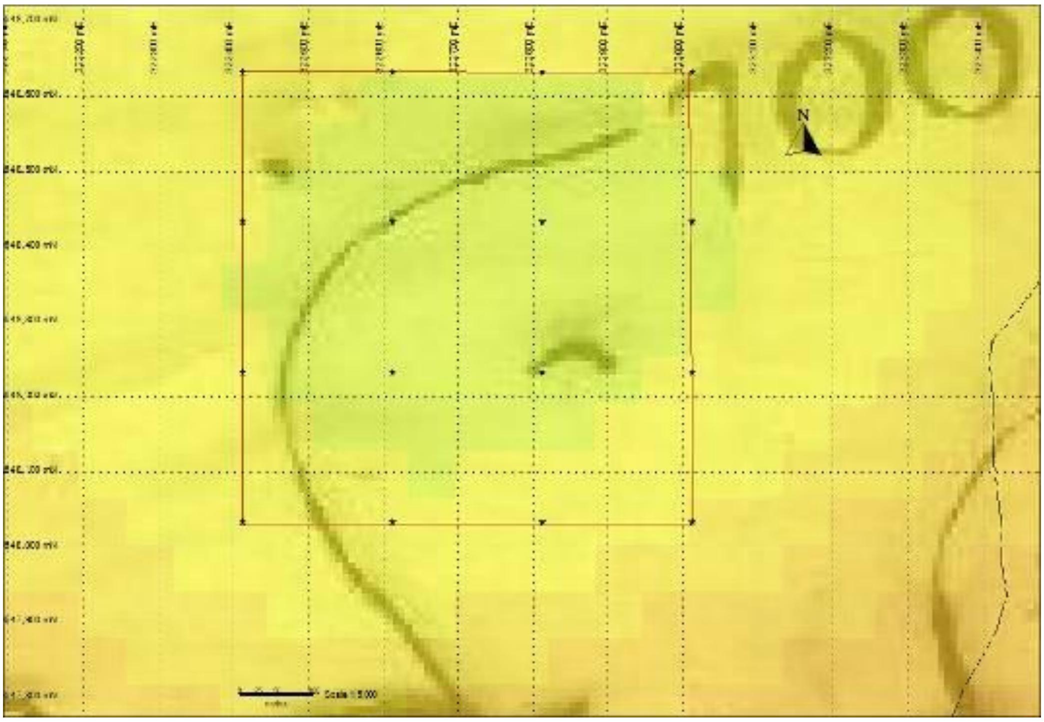

Fig 4: Aeromagnetic map showing study area correlated with the known dolerite exposure and marked out for ground geophysical survey.

4. DATA PROCESSING AND INTERPRETATION

The geophysical data was processed with wing link software and interpretation made from it. It helps in gridding the VES points based on the mapping, iterating the data, and smooth curving, it creates a pseudo section which plots the un-iterated (raw) data and the cross section which helps in delineating subsurface structure based on different elevation and depth to the subsurface. The collected data are interpreted to determine the thickness, nature and lateral variations of the geological formations which are used to obtain a complete geological picture of the area.

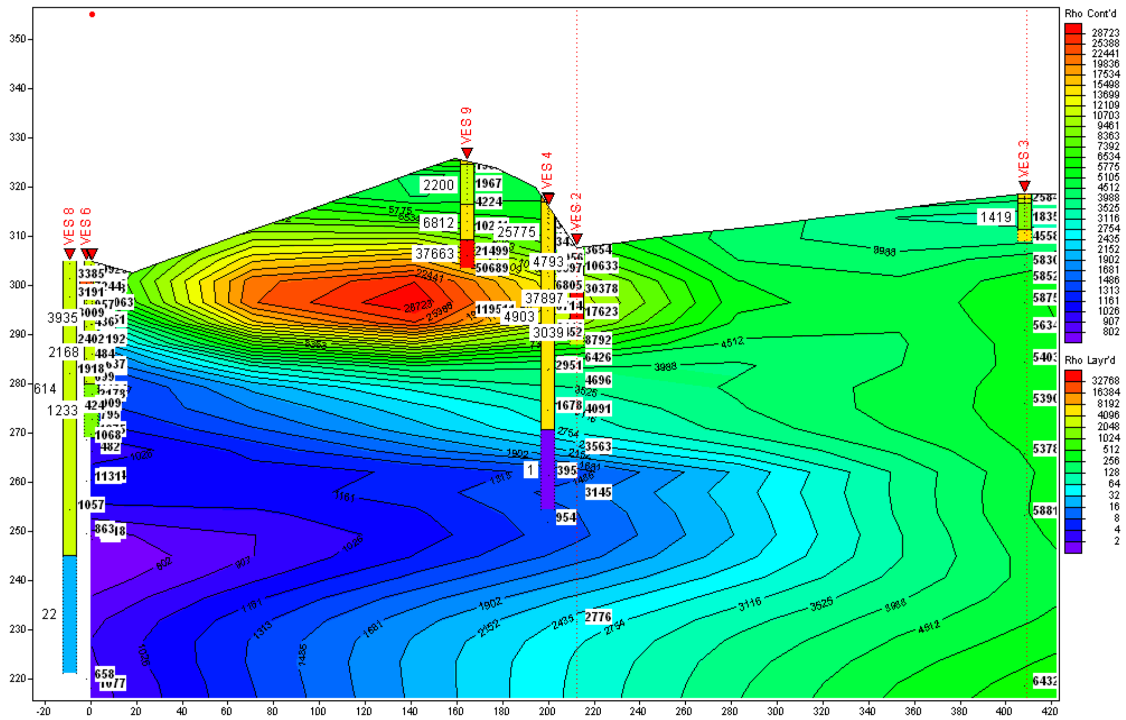

Fig.5: Interpreted structural map of AREA A (for a known quarry site)

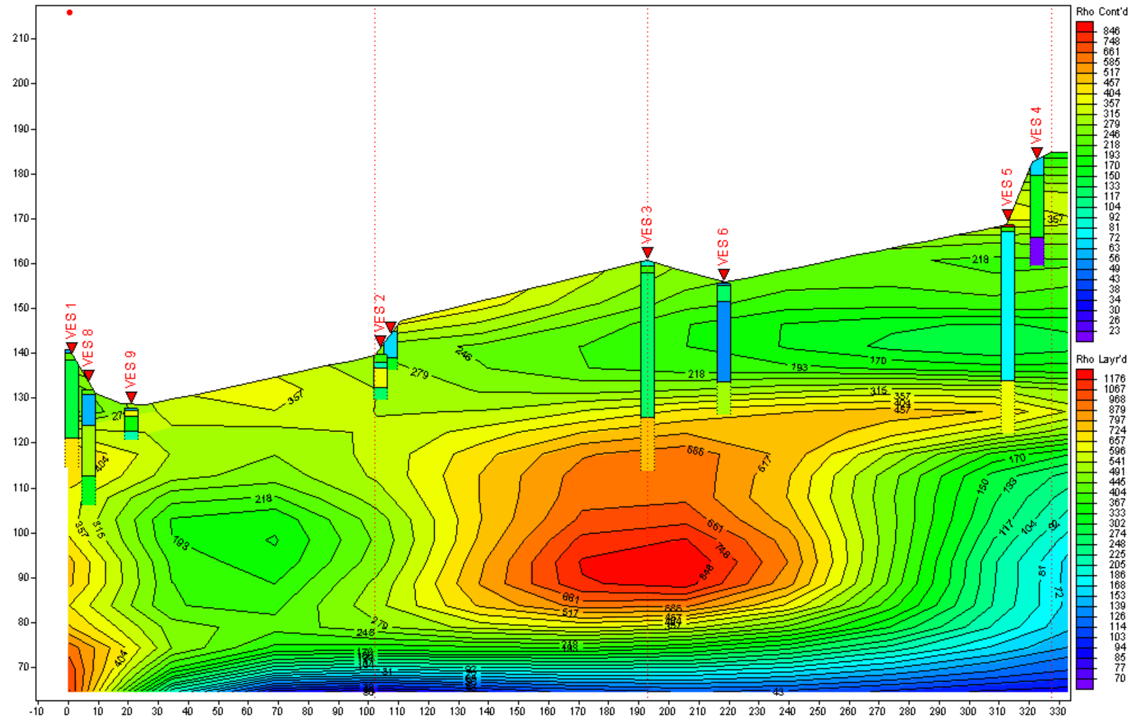

Fig.6: Interpreted structural map of AREA B (This study)

5. Discussion and Conclusion

The known dimension stone quarry in this area where an history of activity has been confirmed to be close to 30 years was visited and the coordinate system was emplaced on previous aeromagnetic map which was conducted by Nigerian Geological Survey Agency (NGSA) to show correlated geological and geophysical notations which was observed in about three locations within close geologic environments showing that there is a magnetic range of value attributed to a basement dyke in the area in which one of the dyke (AREA A) is being mined by an existing company. The areas are marked by alternating high and low resistivity signatures typical of sedimentary and granitic rocks. Electrical resistivity and conductivity were revealed by both pseudo sections and cross sections maps while contact of these structures were clearly defined by contour lines and colour differentiations. Resistivity value in AREA A is around 850Ωm to 29000Ωm, which is very high in the range of the location where the survey was conducted. This also confirms the high magnetic intensity shown in the area. The dyke is shown with the red colour code with high resistivity value for geologic materials, high enough to quarry (fig. 5). The dyke is observed close to the sub-surface around VES 8,6,9,4 and 2. Resistivity values in AREA B investigated for this study (fig. 6) are marked by alternating high and low resistivity signatures typical of sedimentary and granitic rocks. The dyke is shown with the red contoured area in the interpreted structural cross sectional area map with resistivity value around 500Ωm to 850Ωm, which is relatively high but is average in comparison with the hilly area which shows a highly magnetic value to depict dyke.

In conclusion, resistivity value of 850Ωm to 29000Ωm is relatively highest in AREA A showing a large difference in comparison with AREA B with values ranging from 500Ωm to 850Ωm. Although, aeromagnetic map shows that the dyke region is correlative with the zones where quarry activity is already taking place. More so, AREA A has a dyke which is about 260m long and an overburden thickness of about 20 to 30m compared to AREA B with overburden thickness of about 60 to 70m which may not be profitable for quarrying.

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