

Viability of a potential quarry rock matter in Lekwesi, Umunneochi area of southeastern Nigeria using geological and geoelectrical sounding approach

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ABSTRACT

The study involves the geological and geoelectrical investigation of potential quarry rock material at Lekwesi, Southeastern, Nigeria. 13 Vertical Electrical Sounding (VES) were carried out using Schlumberger configuration with a maximum electrode spread of 55m. The mean density of the potential quarry material (diorite) was calculated to be $2.88 \times 10^3 \text{ Kg m}^{-3}$. Microscopic study of the diorite revealed the presence of CaCO_3 veins within the diorite outcrops. The VES result shows that the length of the outcrop is about 530m and that the diorite deposit was not encountered at every location in the study area. While the mean thickness of the diorite deposit modeled to 37m was about 5.8m, the thickness of the overburden material was estimated to about 10.49m. The rock deposit of 5.8m thick and overburden thickness of more than 10.49m may not be viable for large scale quarrying.

Keywords: Quarrying, viability, diorite, geological study, VES

INTRODUCTION

The study area, Lekwesi is in southeastern Nigeria and bounded by latitudes $5^{\circ}56.999^{\circ}\text{N}$ – $5^{\circ}57.290^{\circ}\text{N}$ and longitudes $7^{\circ}28.113^{\circ}\text{E}$ – $7^{\circ}28.290^{\circ}\text{E}$ covering an area of about 12,2071.70 hectares **Fig. 1**. The study area is highly accessible through Port Harcourt-Enugu expressway at Lekwesi Junction.

The potential quarry material in the study area was investigated using geological and geophysical methods to determine its viability for the establishment of a commercial quarry site within the diorite outcrop vicinity. Diorite a grey to dark-grey intermediate intrusive igneous rock is characteristic of the Lower Benue Trough (Short and Stauble). It is composed of plagioclase feldspar, biotite, hornblende (amphibole) and/or pyroxene (augite). It may contain small amount of quartz, microcline, olivine and iron ore.

Due to the durability of diorite, it is used among other things as aggregate for construction purposes (Ibe, et al., 2013). This potential quarry material is locally exploited by the local dwellers as a means of livelihood. The extensive outcrop of the diorite deposit in the study area has recently attracted the attention of quarry companies. Quarrying a capital intensive investment requires certainty of the presence of rock material suitable for quarrying purpose and also its availability in rightful proportion before huge amount of money is committed, hence the present study.

The study is aimed at establishing the downward trend, quality and viability of the diorite deposit at Lekwesi area, Nigeria for quarry purposes.

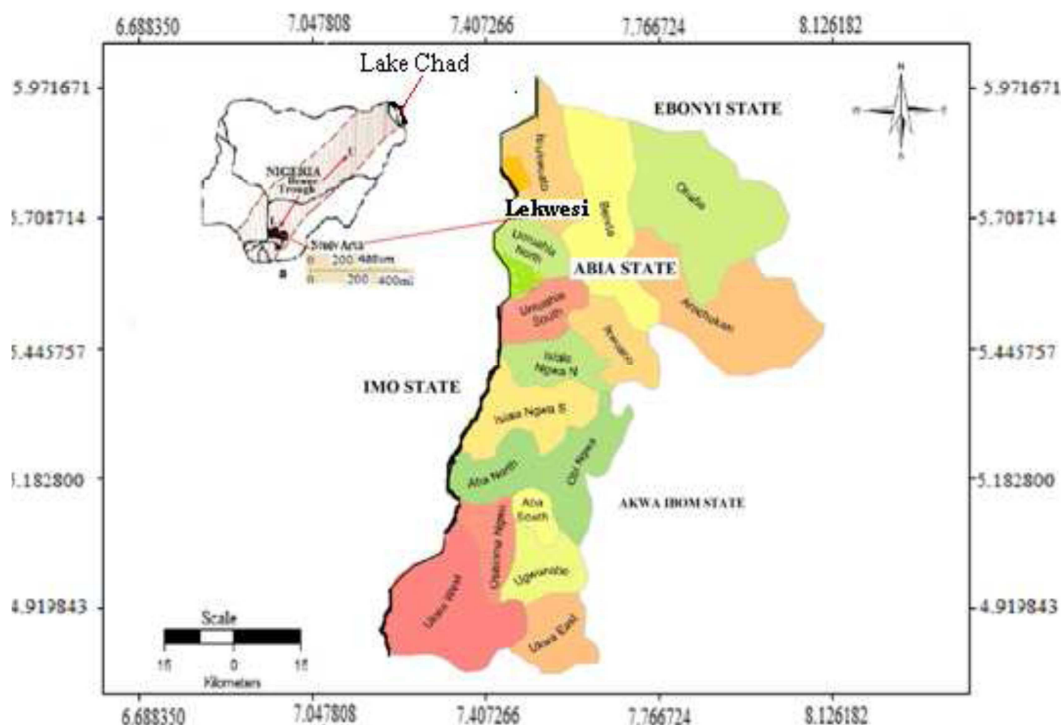


Fig. 1. Map of Nigeria showing the study area-Lekwesi

GENERAL GEOLOGICAL SETTING

The study area is underlain by rock units belonging to the Upper Albian Asu River Group and bordered on the south by the Turonian Eze-Aku Formation (Reyment 1965; Kogbe, 1965; Adegoke, 1969). The Asu River group is the oldest lithostratigraphic unit of the Cretaceous age deposited within the Benue Trough (Fig.2). The Benue Trough originated from series of tectonic activities, accompanied by magnetism and repetitive sedimentation in the Cretaceous period during the separation of South America from Africa. This separation left the Benue Trough as an aulacogen, a failed arm of the Triple junction (Burke, 1972, Olade, 1975). The Benue Trough is a part of the very expansive West and Central African rift system (Emery *et al*, 1975).

The Albian Asu-River Group is made up of sandstones, limestones, mudstones and intermediate intrusive such as diorite, dolerite and are over-flown by basaltic suites during the Santonian period (Whiteman (1972). This is evident in areas like Ishiagu, Lekwesi, Lokpaukwu, Abakaliki, Lafia, Egbede hills, and Agilla areas. These intrusive and extrusive igneous rocks are quarried for construction aggregates forming the major source of livelihood to the local inhabitants. From the field studies, most of these igneous rock bodies strike E-W and NW-SE (Etuk, *et al.*, 2008). The dips vary largely due to the faulting that characterizes the SW arm of the Abakaliki anticlinorium of which the study area forms part of.

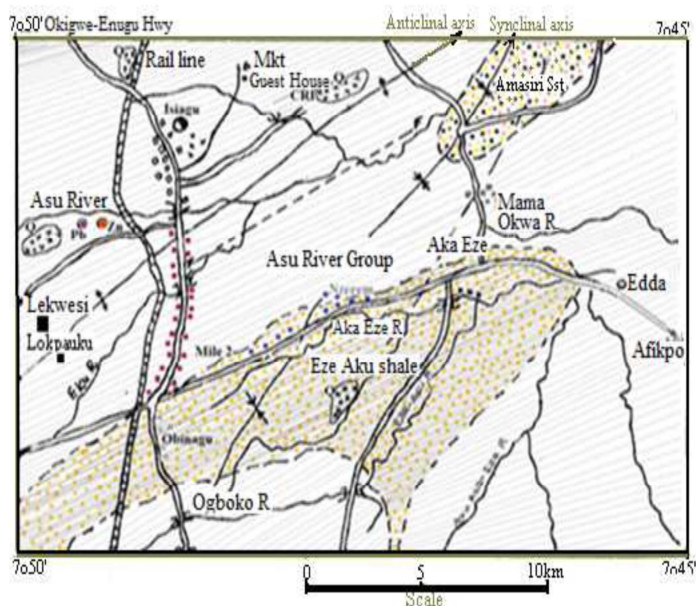


Fig. 2 Geologic map of the study area within the Lower Benue Trough (After Nwachukwu *et al.* 2010)

MATERIALS AND METHODS

A detailed geologic mapping of the study area was carried out using a base map to determine the general trend of the outcrop and hence the trend of the profile for the Vertical Electrical Sounding (VES). Petrographic analysis for detailed physical and textural features of the rock samples was carried out at the Department of Geological Sciences Nnamdi Azikiwe University Awka, Nigeria. The mean density of the rock samples was calculated using Archimedes principles and the values presented in table 1.

Table 1: Calculated Density of Diorites in the study area ($\times 10^3 \text{kgm}^{-3}$)

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
P_D	2.85	2.77	2.95	2.84	3.10
P_w	2.80	2.71	2.93	2.79	3.06
P	2.83	2.74	2.94	2.82	3.08
Mean	$2.88 \times 10^3 \text{kgm}^{-3}$				

Electrical method is a generally accepted method for subsurface investigation because it is not only easy to operate but also cost effective (Keller and Frischknecht, 1966). 13 Vertical Electrical Sounding (VES) using ABEM Terrameter SAS 1000 model was carried out the area to determine the depth and thickness of the potential quarry material. A maximum current electrode spacing ($^{AB}/_2$) of 55m was used, ensuring up to 37m of depth of penetration (Koefoed, 1979). The field data was interpreted using Zody software and VES curves shown in Fig. 3.

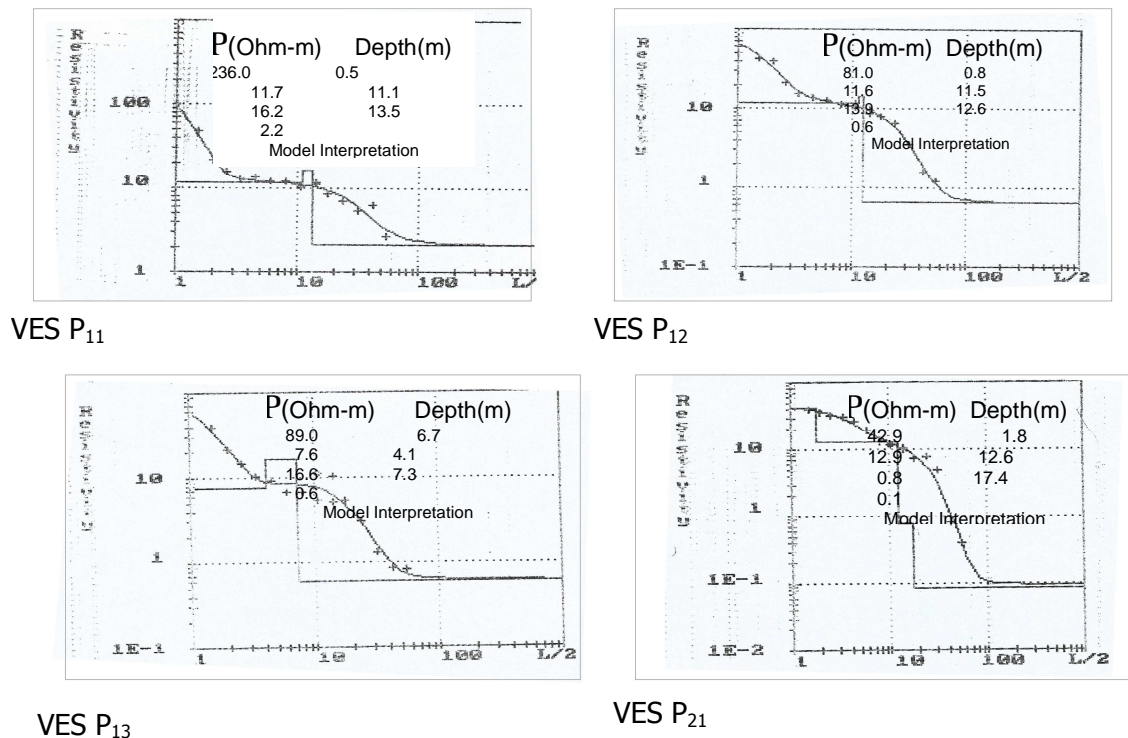


Fig. 3. Typical VES curves of the study area

RESULTS AND INTERPRETATION

The diorite occurred as boulders with oval to spherical structure and exhibit spheroidal weathering. The length of the studied outcrop is about 530. Fresh samples collected were dark grey in colour with visible plagioclase, olivine and dark minerals. Some diorite intrusions found in the area have variations within them. Fracture and calcite (CaCO₃) veins were common signatures in Lekwesi diorite. These veins were evident along the N-S fault as obtained from microscopic study (Fig. 4). In hand specimen, recrystallized calcite form geodes along fault-generated cracks. Samples of shale exposed near the outcrop area were highly fractured and hard probably due to contact metamorphism from the high thermal diorite matter.

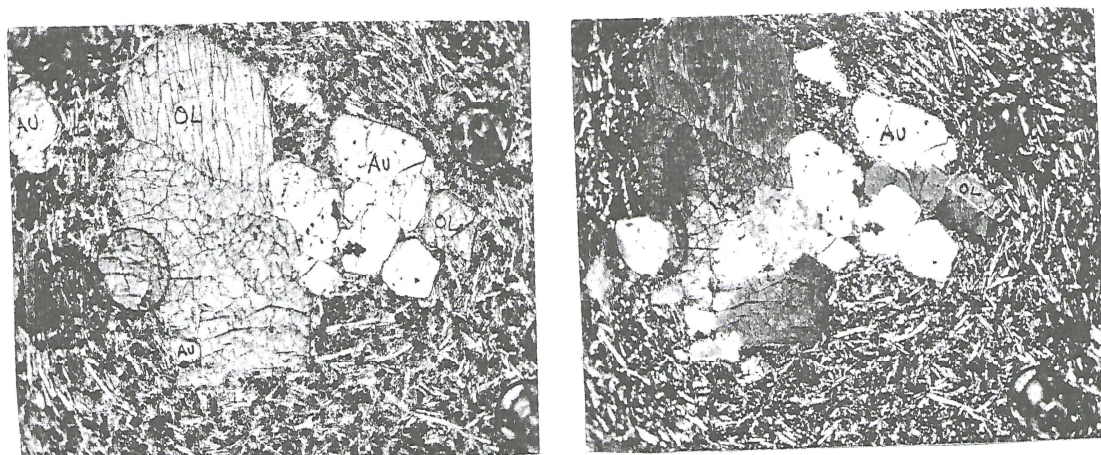


Fig. 4 Photomicrograph of diorite rock x 40 x PL with calcite along cracks

Five samples were used for the density study from 5 sample points. Table (1) shows the result of the density analysis. The values of density of the samples from the study area range from 2.74 to $3.08 \times 10^3 \text{kgm}^{-3}$ with an average value of $2.88 \times 10^3 \text{kgm}^{-3}$. The value is in line with the density of diorite in literature thereby confirming the potential quarry material as an igneous with diorite characteristics.

Data generated from the Thirteen (13) VES points were run on a Zohdy software to generate true resistivity values and depth to various geoelectric layers. The geoelectric layer interpreted from the VES data ranged from three to four geoelectric layers with the thickness of the rock material varying across the VES points. The geoelectric models across the VES points are presented in Fig. 5a and b. The Mean thickness of the deposit, modeled to 37m is about 5.8m and the rock matter was not encountered at VES P₄₁. The thickness of the overburden material ranges from 4 m to 19.5m with an average overburden thickness of about 10.49m.

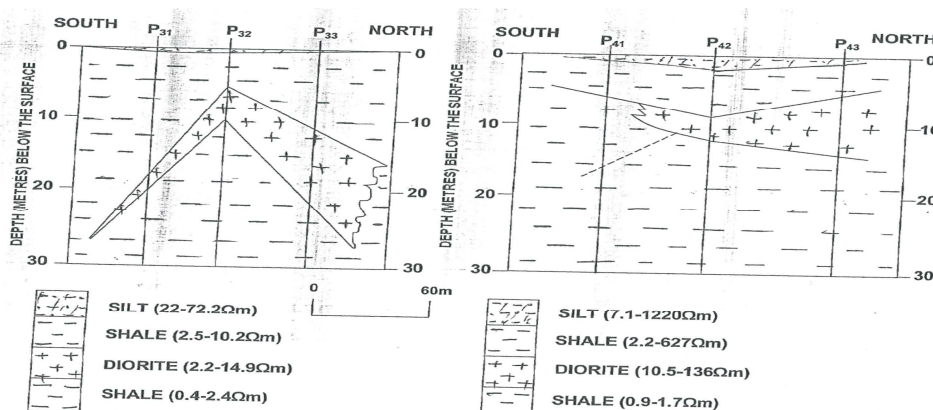


Fig. 5a. Geoelectric sections along P31 – P33 and P41 – P43

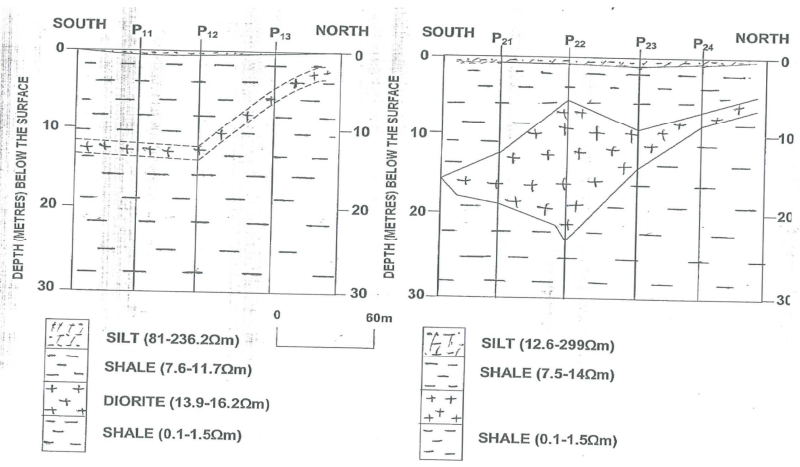


Fig. 5b. Geoelectric sections along profiles P11 – P13 and P21 – P24

CONCLUSION

The considerable high thickness of about 10.49m of the overburden will require high cost excavation before quarry the rock material. The presence of calcite veins and fractures will hence groundwater flow that may affect quarry activity. The relatively low thickness of the potential quarry material in the area as well as the high overburden thickness the area may not be viable for commercial quarry venture however, local quarrying may be profitable.

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