Exploration for Marble Deposit in Parts OF Okpella, South-Southern Nigeria

ABSTRACT

The ultimate aim of the electrical resistivity survey is to determine the resistivity distribution with depth on the basis of surface measurements of the apparent resistivity and to interpret it in terms of geology. Marble deposit was investigated with the application of electrical resistivity method using Vertical Electrical Sounding (VES) technique with the aim of characterising the marble deposit in parts of Okpella. Six (6) VES were acquired using the Schlumberger array for data acquisition with current electrode spacing varying from 1.0 to 150.0 m. The VES data obtained were interpreted using ipi2win Software. The results showed three layers indicating subsurface geologic sequence probed 26.4 m and beyond with clay/clayey sand (23.3 – 219.1 Ωm), sand (423 - 2040 Ωm) and marble (12661 - 404498 Ωm). The occurrence of marble deposit was revealed at VES points at 1, 2 and 5 in the studied area. This study concluded that the study area had vast occurrence of the marble deposits, which would be of economic importance, if exploited.

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Keywords: Crystalline, Schlumberger array, Non-foliated, Resistivity, Lithology

1. INTRODUCTION

Marble, a crystalline, non-foliated metamorphosed limestone through the action of heat and pressure occurs within the migmatite gneiss- schist-quartzite complex as relicts of sedimentary carbonate rocks. These are Upper Proterozoic schist belt metasediments which are normally marked by a general absence of carbonates. Such marble deposits appear to be limited to the western portions of the south and central parts of the country [1]. The schist (metasediments) occurs as a supracrustal cover on the basement and consists of quartz – biotite, calc-gneiss and marble, metaconglomerate and mica schist [2] - [7]. Marble is extremely valuable industrial rock raw material. Construction (eg building, sculpture, monuments, and as dimension stones) and cement manufacturing industries are principal consumers. It is also used in the production of chemicals, fertilizer, abrasives, paint making, tooth paste, detergents, soaps, pharmaceuticals, cosmetics, chewing gum, sweets, water treatment, soil treatment, ceramics making, asbestos making, industrial adhesives, paper conversion, livestock concentrate, chemical fillers (rubber and plastic products) and steel and iron refinery. The marbles are of varying colours of whitish, grayish, cream and pale greenish. The marble is predominantly composed of calcite with specks of iron sulphide and calc-silicate minerals. Marble is composed essentially of calcite ($CaCO_3$), dolomite [$CaMg(CO_3)_2$], or a combination of the two, with a fine- to coarse-grained crystalline texture [8].

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The high contrast in resistivity values between carbonate rock, clayey and sandy materials favours the use of electrical resistivity method for determining the boundary between these Earth materials [9]. Since the electrical resistivity of earth materials can be influenced by parameters such as rock matrix, porosity, permeability, temperature, degree of fracturing, grain size, rock type and the extent of weathering. The electrical resistivity method is therefore adopted for this research. The electrical resistivity method is particularly handy in investigating the nature of subsurface formations by studying the variations in their electrical properties. Proceeding to this research work, there has been dearth of information on the existing literature of marble deposit in the area been investigated. Therefore the current effort is directed at unveiling the situation with a view to find an enduring solution in characterising the marble deposit in parts of Okpella.

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1.1 LOCATION AND GEOLOGICAL SETTING

The studied area lies within Latitudes 7.37563^{o} and 7.35902^{o} North and Longitudes 6.44548^{o} and 6.44536^{o} East (Figure 1) of Okpella in the northern part of Edo State, Nigeria. Geologically, it falls within the Basement Complex of south southern Nigeria which is underlain by undifferentiated older Granite mainly coarse grained granite and porphyritic granite of the Pan-African older Granitoids. The rocks are generally in the NW direction and dipping to the East. The Older Granites were first distinguished from the “younger” alkaline granites by [10]. The schist belt of Okpella are seen to have been severally invaded by the event of tectonic activities in the area giving rise to large mass of plutonic and volcanic rocks which are of granitic origin. Relic folds are evident on the rock mass seen to be floating as xenolithic structures with minor and micro folds which originated from the various stages of metamorphism.

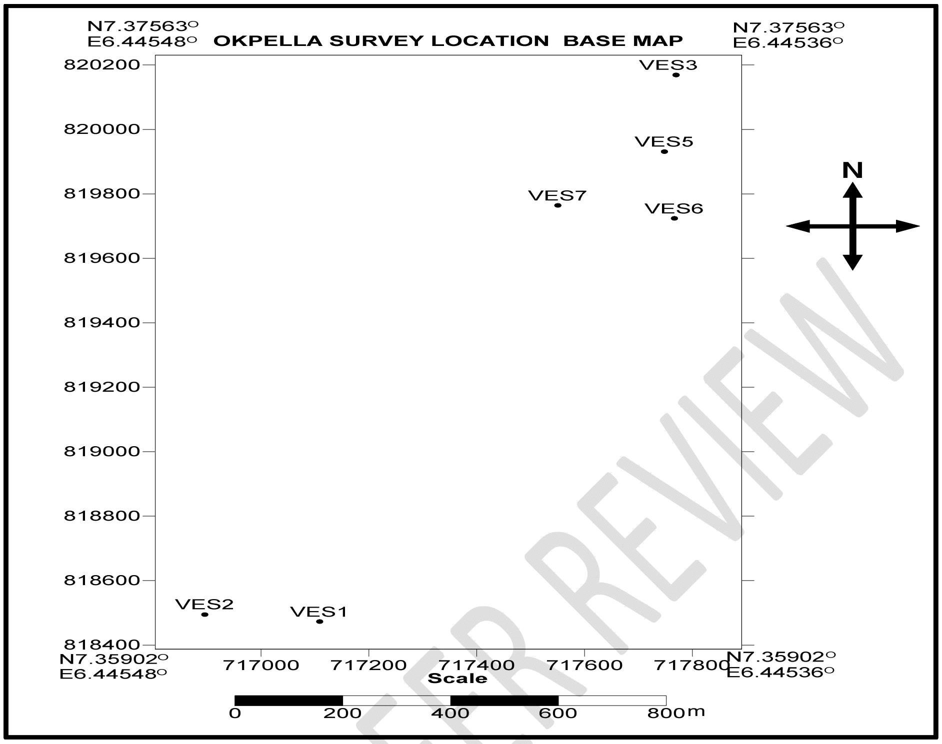

Figure 1: Location base map

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1.2 THEORETICAL BACKGROUND

The resistivity method provides a quantitative measure of the conducting properties of the subsurface. In this method a series of potential differences are acquired at successively greater electrode spacings while maintaining a fixed central reference point. The induced current passes through progressively deeper layers at greater electrode spacing. The potential difference measurements are directly proportional to the changes in the deeper subsurface. Apparent resistivity values calculated from measured potential differences can be interpreted in terms of overburden thickness, water table depth, and the depths and thicknesses of subsurface strata [10]. The two most common arrays used for VES are the Wenner array and the Schlumberger array. Vertical electrical sounding (VES) field method that used in this research involves the measurement of the variation of resistivity value with depth. This technique can be used to find the depths of layers in the earth having anomalously high or low conductivities and to determine the depth, approximate shape of ore bodies with anomalous resistivity. The foundation for electrical resistivity theory is governed by Ohms law.

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The resistance (R) of the wire to current flow can be expressed as:

$$R \alpha \frac{L}{A} \quad (1)$$

$$R = \frac{\rho L}{A} \quad (2)$$

From Ohm's law,

$$R = \frac{\Delta V}{I} \quad (3)$$

$$\Delta V / I = \rho L / A \quad (4)$$

$$\rho = A \Delta V / IL \quad (5)$$

Where

ρ is the resistivity (in Ohm-metre), L is the length of wire (in metres)

A is the cross- sectional area of the wire (metre^2), R is the resistance (Ohms)

I is the current (ampere).

2. MATERIALS AND METHOD

Geophysical surveys are efficient and cost-effective in providing geotechnical information since they combine high speed and appreciable accuracy in providing subsurface information over large areas [12]. In this study, Vertical Electrical Sounding (VES) using Schlumberger array (Figure 2) was adopted in order to study the variations in the resistivity distribution of the soil with depth. An electrical current is passed through the ground and two potential electrodes allow us to record the resultant potential difference between them, giving us a way to measure the electrical impedance of the subsurface material. The apparent resistivity is then a function of the measured impedance and the geometry of the electrode array. The importance of electrical resistivity method makes its usefulness in many fields like investigating natural resources, environmental problems, and engineering studies for the last three to five decades. Six (6) VES were carried out which is enough for the anticipated depth of investigation using Schlumberger configuration array with current electrode spacing varying from 1.00 to 150.00 m. The resistivity techniques especially the Vertical Electrical Sounding (VES) has been used for investigating subsurface layer properties and groundwater potential. By this method, the subsurface characterization is determined based on the change of resistivity values with depth. Range of specific resistivity value indicates the presence of certain rock mass characteristic [13] and some other researchers have the proposed range of resistivity values based on the rock or soil conditions. The processing of the acquired data was done by plotting the apparent resistivity against half–current electrode spacing (AB/2) on a log–log graph sheets. The outcome of these served as input for numerical iteration using ipi2win Software.

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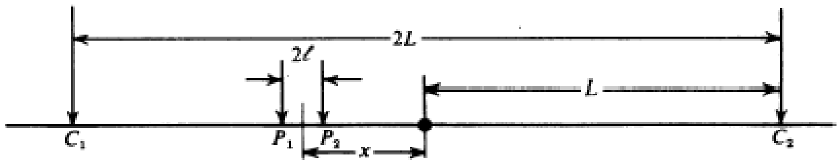

Figure 2: Schlumberger (gradient) array. The distance between the potential electrodes is much smaller than the distance between the potential and current electrodes. The most common configuration is to put the measuring dipole in the centre of the array.

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3. RESULTS AND DISCUSSION

Geoelectrical resistivity survey involving vertical electrical soundings have been used to characterise the marble deposit in parts of Okpella. The summary of the interpreted results of the VES curves at each VES stations are presented in (Table 1). Data generated from the Vertical Electrical Sounding using Schlumberger configuration was presented as geoelectric sounding curves. The results showed variable composition of subsurface geologic sequence probed 26.4 m and beyond with clay/clayey sand (23.3 – 219.1 Ωm), sand (423 - 2040 Ωm), marble (12661 - 404498 Ωm). This is accordingly represented in figure 3. The characteristic curve types obtained in the area are H and K curve types (Figure 4) depicting three geoelectric layers. VES 1, 2 and 5 with resistivity values ranged from 12661 to 404498 Ωm shows the existence marble.

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Table 1: Summary of VES Results

VES STATION	LAYER	RESISTIVITY (ΩM)	LAYER THICKNESS (M)	DEPTH (M)	CURVE TYPE	INFER LITHOLOGY
VES1	ρ_1	423	3.99	3.99	K	Sand
	ρ_2	12661	6.3	10.3		marble
	ρ_3	2040	-	-		sand
VES2	ρ_1	577	2.36	2.36	H	Sand
	ρ_2	219.1	10.44	12.79		Clayey Sand
	ρ_3	404498	-	-		Marble
VES3	ρ_1	646	0.98	0.98	H	Sand
	ρ_2	23.5	7.03	7.99		Clay
	ρ_3	1061	-	-		Sand
VES5	ρ_1	1140	1.54	1.54	H	Sand
	ρ_2	103	24.87	26.4		Clayey Sand
	ρ_3	41644	-	-		Marble
VES6	ρ_1	915	2.01	2.01	H	Sand
	ρ_2	147	17.41	19.4		Clayey sand
	ρ_3	502	-	-		Sand
VES7	ρ_1	636	0.96	0.96	H	Sand
	ρ_2	23.3	7.11	8.07		Clay
	ρ_3	1135	-	-		Sand

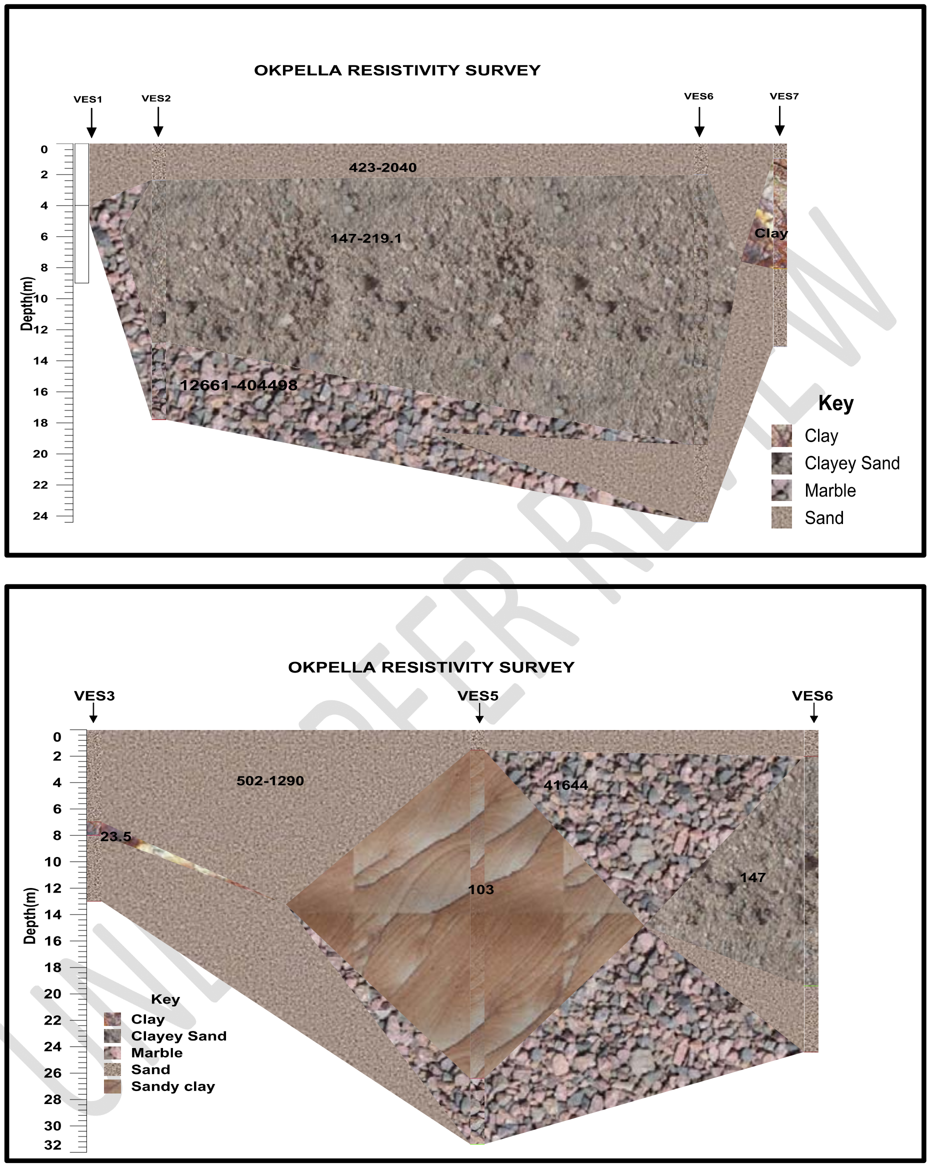

Figure 3: Geological Cross Section in location

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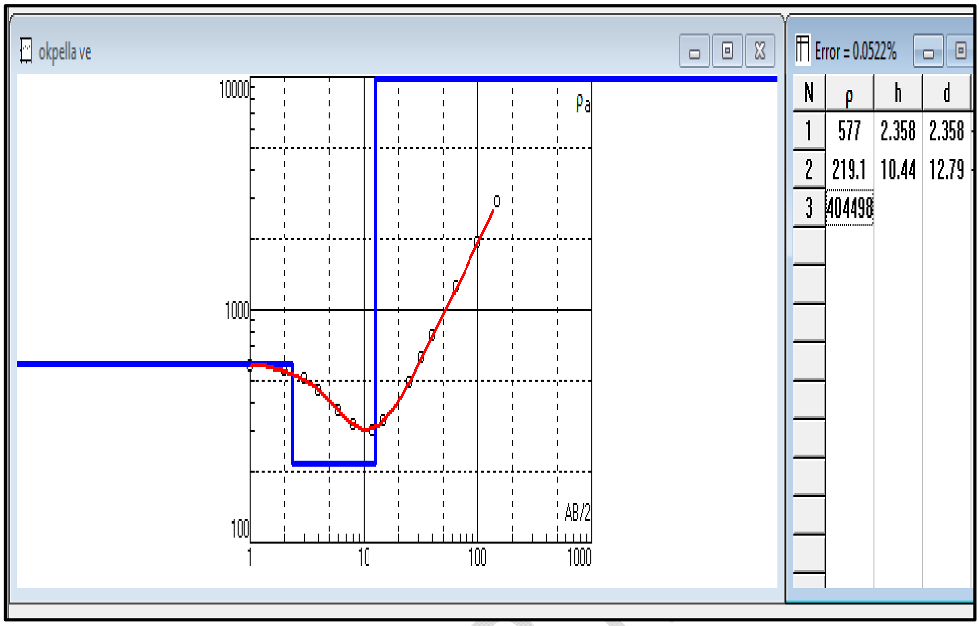
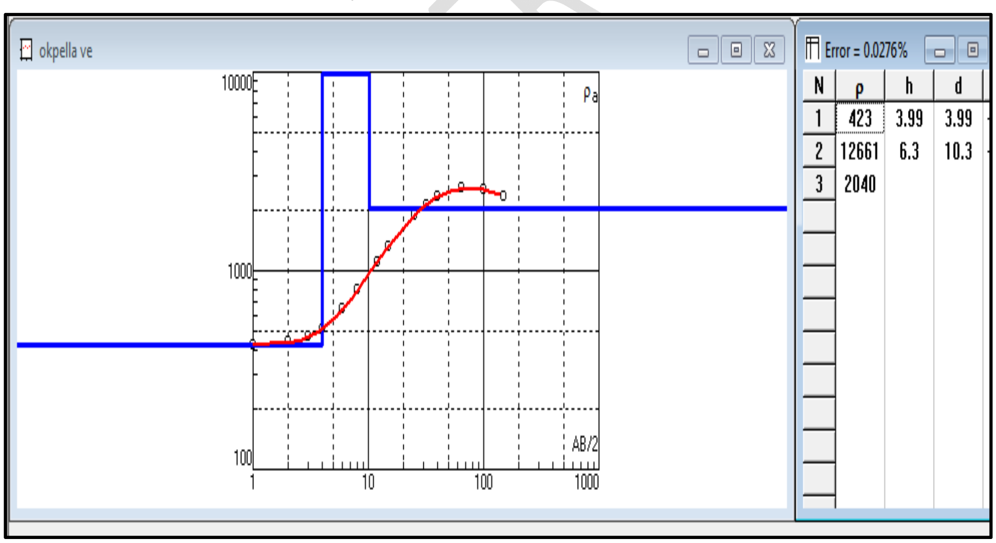


H curve type. (VES 2)



K curve type. (VES 1)

Figure 4: Samples of VES curve types of the study area

4. CONCLUSION

Resistivity measurements at the surface of the earth are associated with varying depths relative to the geometry of the current and potential electrodes in the survey. Vertical Electrical Sounding technique using Schlumberger configuration was carried out at six (6) VES stations in parts of Okpella in Etsako East local government area of Edo State Southsouth, Nigeria. The results obtained from VES delineated three geoelectric units which comprises clay/clayey sand (23.3 – 219.1 Ωm), sand (423 - 2040 Ωm) and marble (12661 - 404498 Ωm) horizon units. The results show that VES 1, 2 and 5 revealed occurrences of marble deposits. It follows that the studied area had vast occurrence of the marble deposits, which would be of economic importance, if exploited.

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