International Journal of Advance Research, IJOAR .org
Volume 3, Issue 6, June 2015, Online: ISSN 2320-9119

EXPERIMENT ANALYSIS OF ELECTRICAL AND MAGNETIC PROPERTIES OF ABAKALIKI STONE IN EBONYI STATE

Nweke F. U.

Industrial Physics Department
Ebonyi State University, Abakaliki
Email: frinwek@yahoo.com

Abstract

The electrical and magnetic properties of Abakaliki rock were obtained through the vertical electrical sounding (VES) technique. The schlumberger array was used to delineate the vertical variation in resistivity of the subsurface earth materials. The values of the conductivity and conductance were calculated from the result obtained. From the result, it was discovered that Abakaliki rocks contain indurated silty shale, lead and zinc with some degree of conductivity. Shale can be used to produce semiconductor materials depending on the presence of water on it.

Keywords: Schlumberger, Resistivity, Conductivity, ABEM SAS 300C, Tarameter, Vertical Electrical Sounding (VES)

Introduction

Every material, including soil and rock has an intrinsic property (i.e. resistivity) that governs the relation between the current density and the gradient of electrical potential variations. Properties that affect the resistivity of a rock include porosity, water and grain size distribution [1, 2, 3].

In an electrically conductive body (i.e. like wire), the relationship between the current and potential distribution is described by ohm's law

$$V = IR \qquad 1$$

Where V=voltage, I=current, R= resistance

The resistance of a length of wire is given as

$$R = \rho \frac{L}{A} = \frac{VA}{IL}\ \Omega \qquad 2$$

Where A= area of the conducting cross section, L= length of the material, ρ = resistivity.

The conductivity, σ of a material is defined as the reciprocal of its resistivity given as

$$\rho^{-1}\ (\Omega m\ )^{-1} \sigma = \frac{IL}{VA} \qquad 3$$

But current density $J = \frac{I}{A}$

Hence $\sigma = \frac{JL}{V} = \frac{J}{E}$

$$\therefore \quad J = \sigma E \quad [2, 3, 4] \qquad 4$$

In most earth material, the conductivity, σ of electric current takes place entirely in the water occupying the pore spaces or joint openings, since most soil and rock forming minerals are conductive clay. Few other minerals notably magnetite, specular hematite, carbon pyrite, and other metallic sulphide, may be found in sufficient concentration to contribute measurably to the soil or rock. [3, 4, 5].

The electrical conductivity of pure metals are usually of the order 10^{7} $(\Omega\text{-m})^{-1}$ whereas that of insulator is of order of $10^{-16}(\Omega\text{-m})^{-1}$. Thus the conductivity of metals is about 10^{23} times that of insulators. Semiconductors like silicon and germanium has conductivity between insulator and conductors. [2, 6]

The conduction of current in the soil and rock is through the electrolyte contained in the pores, resistivity, and ratio of the materials and the geometry of the pores. Pore space may be in the form of inter-granular voids, joints or fracture opening and binds pores, such as bubbles or vugs. It is only the interconnected pores that effectively contribute to conductivity. [2, 7]. The resistivity, ρ of saturated pores can be expressed as

$$\rho = f\rho_w \quad 5$$

Where f =formation factor, ρ_w = resistivity of pore water

Bodies of clay or shale have lower resistivity than other rocks composed of bulky mineral grains [7]. Table 1 shows some resistivity value for some materials.

Table 1: Resistivity value for some materials [7]

Materials	Resistivity
Clay	1-20
Sand met to moist	20-200
Shale	1-500
Porous limestone	100-1,000
Dense limestone	1000-1000000
Metamorphic rock	50-1000000
Igneous rock	100-1000000

The electrical and magnetic properties of rocks, soil and fluids control the speed of propagation of radio waves and their amplitude. Electrical properties are classified into two basic types: one that describes the energy dissipation and the other that describes energy storage. Electrical dissipation comes as a result of change in motion called conduction. There are three ways in which electric current can be conducted through rocks: electrolytic, electronic (ohmic) and dielectric conduction. Electrolytic conduction occurs by the relatively movement of ions within an electrolyte. [2, 4, 8]. Electronic conduction is the process by which metals for instance allow electrons to move rapidly thereby carrying the charge. Dielectric conduction on the hand occur in very weakly conducting materials (insulators) when an external field high enough to cause the drifting of electrons in the materials is applied [2, 4, 8].

In most rocks, conduction is by way of pore fluids acting as electrolyte with the actual mineral grains contributing very little to the overall conductivity of the rock (except where those grains are themselves good electrical conductors).

Electricity is said to be the flow of charges, and the rate of the flow of electron is called electric current. This was made possible at 1800, when a Halian Physicist, Alesandra Volta invented a primitive electric battery called voltaic pole, in which electricity was produced by chemical action. [4, 6]. George Ohm established the relationship between the electric current in conductor and the voltage from the cell in 1927. Also coulomb established that the force of attraction or repulsion between two charged bodies is proportional to the product of the individual electric charges and inversely proportional to the square of the distances between the centres of the body. [2, 4, 6].

Aim of the Study

The purpose of this research is to know the resistivity and conductivity of Abakaliki rock in Ebonyi State of Nigeria, which will help in recommending for the use in production of semiconductor material, conductors and electrical insulators.

Method and Collection of Data

The experiment was conducted beside the Joeak Oil Ltd, Enugu-Abakaliki, Expressway, Ebonyi State at co-ordinate No 6.3104E 008.1004^{o} and latitude 006.319^{o}N. The data was collected by the electrical sounding method (i.e. basically the vertical electrical sounding, VES method) using the Schlumberger array (i.e. electrode configuration). This was employed to delineate the vertical variation in resistivity of the subsurface earth materials. The instrument used to carry out this experiment is ABEM SSA 300C Tarameter which measures the resistance R (Ω) values of the rock layers in the subsurface from which the resistivity, conductance and conductivity were computed. [3, 4]. The result of the experiment and the computation of resistivity, conductance and conductivity of the rock are shown in table II

Table II: Resistivity, Conductance and Conductivity of Abakaliki rock of Ebonyi State

s/n	AB/2	MN/2	Geometric factor	Resistance (R)	Resistivity (ρ)	Conductance ,σ (1/R)	Conductivity 1/ ρ
1	1.00	0.25	5.90	24.40	143.96	0.409	0.0096
2	1.50	0.25	13.70	5.07	69.46	0.1972	0.0144
3	2.00	0.25	24.70	2.07	14.05	0.4608	0.0186
4	2.00	0.50	11.80	14.05	3.59	0.0711	0.0060
5	3.00	0.50	27.50	3.59	1.42	0.2988	0.0101
6	4.00	0.50	49.50	1.42	1.581	0.7012	0.0141
7	6.00	1.00	55.00	1.581	0.470	0.6325	0.0040
8	8.80	1.00	99.00	0.470	2.361	2.1276	0.0214
9	10.00	1.00	156.00	2.361	4.480	0.4235	2.7150
10	10.00	2.00	70.00	4.480	14.40	0.2232	0.0030
11	15.00	2.00	174.00	14.80	0.358	0.6694	0.0003
12	20.00	12.00	311.00	0.358	0.121	2.7932	0.0089
13	20.00	4.00	50.80	0.121	0.795	8.2640	0.0549

14	30.00	6.00	226.20	0.795	0.795	1.2570	0.0050
15	40.00	6.00	409.507	0.757	0.914	1.3400	0.0032
16	40.00	8.00	301.60	0.914	275.66	1.0940	0.0036
17	50.00	8.00	487.30	0.738	352.99	1.3550	0.0028
18	60.00	8.00	694.30	0.315	218.70	3.1746	0.0045
19	60.00	10.00	408.46	0.439	179.31	2.2779	0.0055
20	80.00	10.00	989.75	0.140	138.55	7.1438	0.0072
21	80.00	12.00	818.91	0.189	154.77	5.2910	0.0064
22	100.00	12.00	1290.15	0.138	178.04	7.2463	0.0056
23	120.00	12.00	1851.81	0.107	195.79	9.3457	0.0051
24	150.00	12.00	2926.39	0.0433	9.345	23.094	0.0078
25	150.00	15.00	2332.63	0.0870	132.96	11.494	0.0075
26	180.00	15.00	3369.00	0.0630	212.20	15.873	0.0047

The lithological description of subsurface rocks in Abakaliki LGA of Ebonyi State is shown in table III

Table III: Lithological Description of Subsurface rocks in Abakaliki LGA of Ebonyi State

Lager	Apparent resistivity (Ωm)	Conductivity	Layer depth(m)	Probable lithologic description
1	528.39	0.0189	0 – 0.190	Laterite, weathered clayed top soil
2	95.60	0.0105	0.190 – 2.906	Clayed shale
3	840.6	0.0012	2.908 – 2.446	Fossil (saturated shales)
4	2311.1	0.0043	24.446 – 4.356	Baked silty shales (aquiferous)
5	33.32	0.0300	43.656 – 50.70	Indurated fractured shales with a quartz vein (highly aquiferous)
6	2023.8	0.0049	50.7	Indurated silty shales

Discussion

It was discovered that Abakaliki rock contained an indurated silty shale. The lithologic description of the subsurface rock was used to delineate the electrical properties of the rocks. From the table, it was discovered that Abakaliki rock which contains indurated silty shale has an element of conductivity in varying proportion. Hence the rock can be processed and used to produce conducting and semiconducting material like aluminum, zinc and lead, silicon germanium etc.

Conclusion

The conductivity of Abakaliki rock was verified. The result obtained showed that Abakaliki rocks contain indurated silty shale which contains an element of conductivity in varying proportion. This rock can be processed and used to produce a conducting or semiconducting materials.

Recommendation

The following is suggested in this research:

(1) Government and Investor should see the possibility of harnessing the Abakaliki rock for production of semiconductor, conductors and insulator materials.
(2) More research should be carried out to encourage the use of Abakaliki rocks for other purposes rather quarry business for building houses, roads, bridges and culverts etc.

Reference

(1) Singh K. K., Amargect K. B. and Singh A. (2006). 2D Resistivity survey for citing water supply tube wells in metaprophic trans. A case studies of campus Dhambad, India the leading edge December 2006. Pp 1458-1460.
(2) Aparna Gupta and Santosh Kumar (2004). Material Science for Engineers. CBS Publishers & Distributors. New Delhi.
(3) Mbah C. N. and Ameh E. M. (2005). Materials Science. SCANN Publisher, Nigeria.
(4) Theraja B. L. and Theraja A. K. (1997). A Textbook of Electrical Technology, 23rd edn, S Chad and Company LTD. New Delhi, India.
(5) Asokpha, M. B. (1992). Amague Toleunrine Method for Determination of Aquifer Depth. Nig Ass Math 87-94.
(6) Nweke F. U. and Agbo P. E. (2011). Electronics Principals and Applications. IZU Prints Water Works Road Abakaliki. Ebonyi State.
(7) Hodlur G. C., Dhakate R. and Andrade R. (2006). Correlation of Vertical Electrical Sounding and Borehole log Data for Delineation of salt water and fresh water equators. Geophysics Vol. 71. Pp 11-20
(8) Reyman R. A (1963). Aspect of Geology of Nigeria, Ibadan University Press.