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Original Research Article

2 – DIMENSIONAL ELECTRICAL RESISTIVITY SURVEYING FOR MINERAL DEPOSIT IN EGUARE, IGUEBEN LGA, SOUTH – SOUTH, NIGERIA.

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ABSTRACT

The experimental approach of two-dimensional (2D) geoelectrical resistivity imaging in which the resistivity is allowed to vary both laterally along and vertically beneath the survey line but constant in the perpendicular direction was carried out for mineral exploration. A series of 2D apparent resistivity data were generated in a parallel and perpendicular direction using dipole-dipole electrode configuration engaging the SAS 1000 ABEM terrameter. 2.5m electrode separations (interline spacing) in the study area was adopted. The 2D data sets were collated and inverted separately using RES2DINV software producing 2D model for each line. These survey locations were observed to be composed of lateritic soil, sand, sandstone, shale, limestone, clay, dolomite with resistivity values ranging between 259 Ωm to 2159 Ωm for the unit electrode spacing adopted.

KEYWORDS: 2 – Dimensional, Electrical, Resistivity, Surveying, Mineral Deposit.

1. INTRODUCTION

A mineral is a naturally occurring homogeneous solid with a definite (but generally not fixed) chemical composition and a highly ordered atomic arrangement. It is usually formed by inorganic process. This means that minerals consist of a single and solid substance that cannot be physically subdivided into simpler chemical compounds. The determination of homogeneity is difficult because it is related to the scale on which it is defined. For example, a specimen that appears homogeneous to the naked eye may prove to be inhomogeneous, made up of several materials, when viewed with a microscope at high magnification.

A mineral has a definite chemical composition which implies that it can be expressed by a specific chemical formula e.g the chemical composition of quartz is expressed as SiO_2. Because quartz contains no chemical elements other than silicon and oxygen its formula is definite. Quartz is therefore, often referred to as a pure substance, most minerals, however, do not have such well-defined compositions. Dolomite, $CaMg\ (CO_3)_2$, is not always a pure Ca-Mg-carbonate. It may contain considerable amounts of Fe and Mn in place of Mg.

The resolution of subsurface geoelectrical resistivity surveys decrease with depth and very long layouts are needed for large depth penetration. The presence of a conductive layer at the surface can significantly reduce the depth of penetration. Borehole resistivity imaging, often referred to as electrical resistivity tomography (ERT) can be used to overcome the problem of depth limitation and obtain higher resolution at depths since the electrode are closer to the structures of interest. The strong influence of near-surface inhomogeneities on inversion results will also be reduced.

2D and 3D images that reflect the resistivity contrast can be obtained from borehole resistivity tomography (La Breque et al., 1996; Ramirez et al., 1996; Slater et al., 1997; Brown and Slater, 1999). The measurement may be done by arranging the electrodes in the borehole(s) only (Daily and Owen, 1991; Shima, 1992; Spies and Ellis, 1995; Bing and Greenhalgh, 2000) or borehole and surface (Becy and Morrison, 1991; Binley et al., 2002; Dhu and Heinson, 2004). In general, any array used for surface resistivity survey can be adapted for borehole resistivity measurements; but pole-pole (Daily and Owen, 1991; Shima, 1992; Spies and Ellis, 1995), pole-dipole (Bing and Greenhalgh, 1997; Zhou and Greenhalgh, 2000) and dipole-dipole (Sasaki, 1992; Zhou et al., 2002) arrays are commonly used in borehole resistivity surveys. Based on sensitivity pattern and anomaly effect, the pole-dipole and dipole-dipole arrays have been shown to have better target definition and delineation properties than the pole-pole array. Alile et al, (2013) carried out subsurface imaging using different electrode configurations for geoelectrical investigation. Also Alile et al, (2012) worked on the applications of 1-D and 2-D electrical resistivity methods to determine the depth of aquifer around camp house in Canaan land, ota, Nigeria. The effectiveness of short electrode spacing in geoelectrical subsurface investigation using dipole – dipole array was carried out by Alile et al, (2016). In the study they engage both the 2 – D and 3 – D geoelectrical investigations. The study showed that the shorter electrode spacing gave a detail and better resolution.

2. METHODOLOGY

Two-Dimensional survey was carried out at Eguare Community in Igueben Local Government Area of Edo State which is located within longitudes $6^0 10' 0''$ $6^0 12' 30''$ east and latitude $6^0 27' 3''$, $6^0 30' 0''$ north. The approximate average elevation is about 180m above mean sea level. The survey area occupies North Central part of Edo State and is underlain by sedimentary rocks of Paleocene to recent age. The sedimentary rock contains about 90% of sand stone and shale intercalations. The base map is as shown in Figure 1.

The first and second survey grids at Eguare Primary School compound and Amahor Secondary School compound with co-ordinates of latitutes, longitudes and elevations about sea level on a detailed scale are as shown in Figure 1.

The dipole – dipole array was engaged in this survey and the RES2DINV program was adopted in the analysis and interpretation of the acquired data.

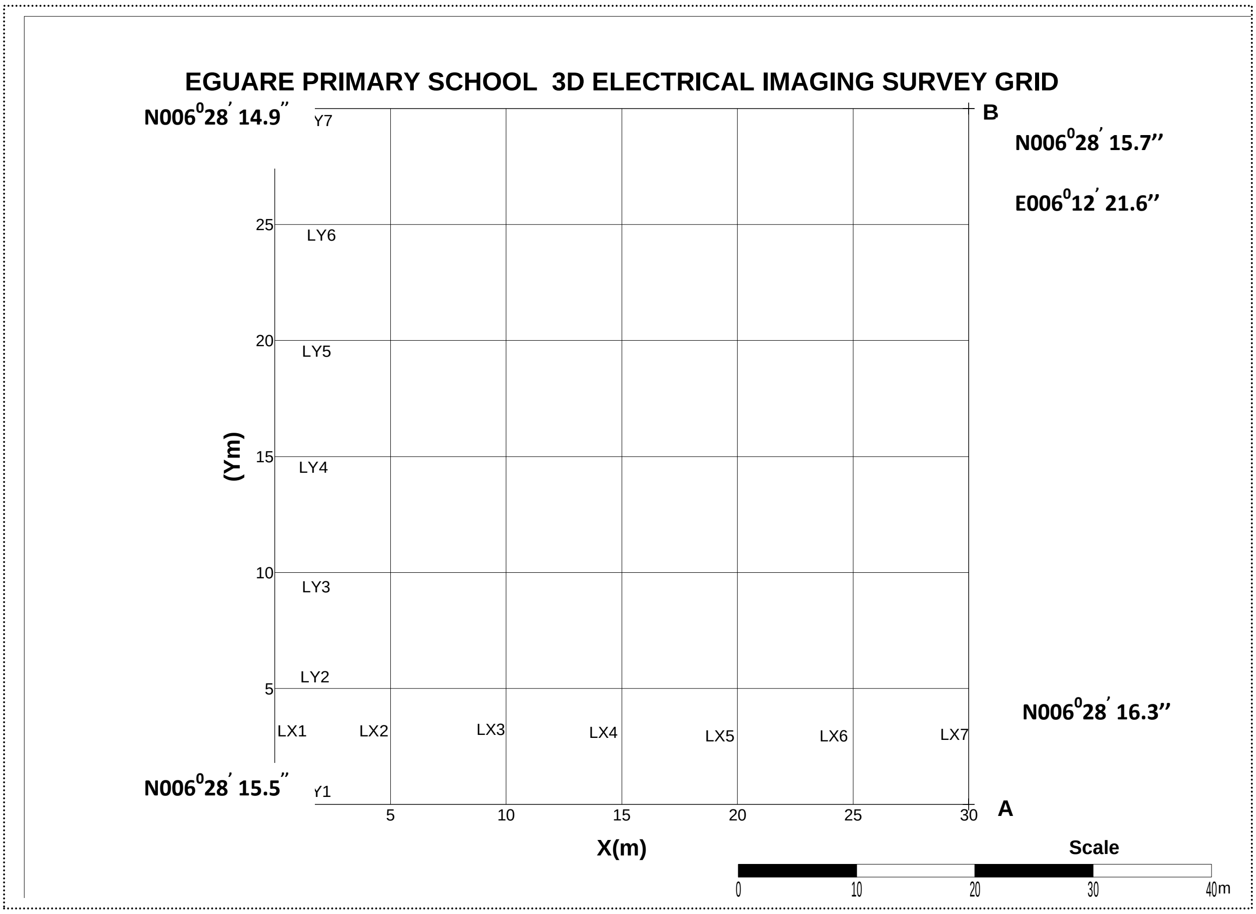


Figure 1: 2 – Dimensional Electrical Resistivity Survey grid showing latitude and longitudes (base map)

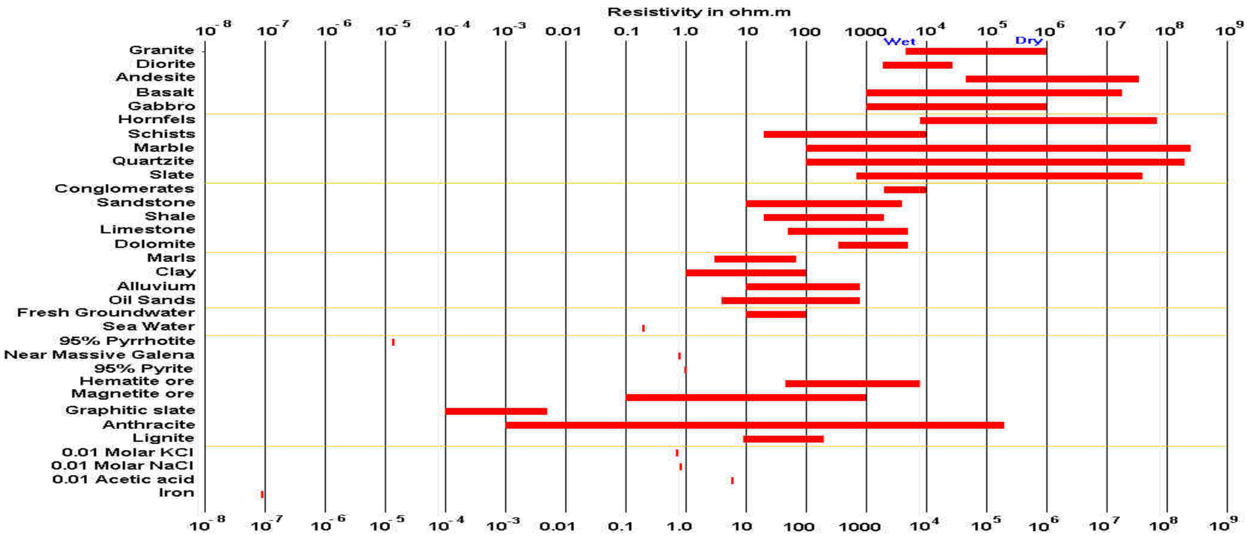
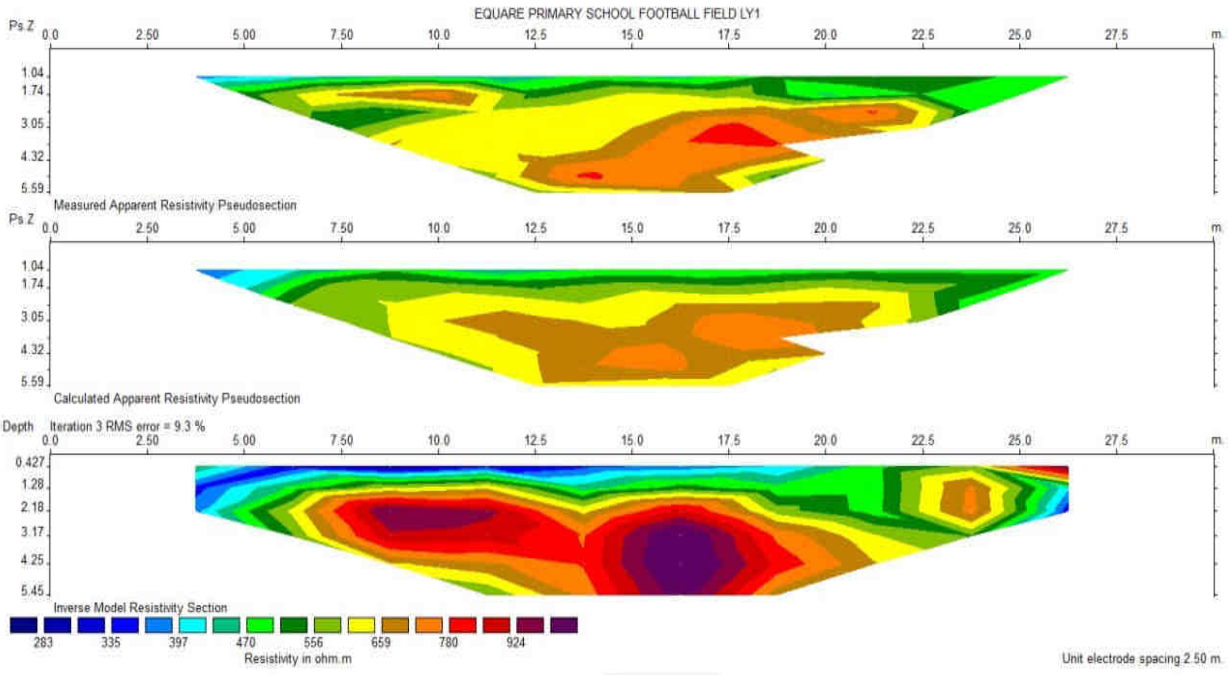


Figure 2: Typical ranges of electrical resistivities/conductivities of earth materials and minerals. (Source: Loke, 2014).

RESULTS AND ANALYSIS

After acquiring 2D geoelectrical resistivity data set, it is necessary to model or invert the data set so as to obtain the desired subsurface resistivity images or distribution. The process of estimating geophysical model parameters of a multi-layered and heterogeneous earth model from observed field data is known as inversion. The observed data can be predicted (forward modeling problem) using the laws of physics relating the model parameter to the observed data. Inversion of observed geophysical data involves the mapping of the geophysical data into the model that will, in some defined sense, best satisfy the measured data and our preconception about the given model. The choice of the model parameters is largely dependent on the nature of the geophysical problem to be solved. The relationship between the observed data and the model parameters is a non-linear, ill-conditioned and largely under-determined inverse problem. Standard modeling and inversion techniques for linear inverse problems cannot be employed successfully for such non-linear inverse problems. In solving non-linear inverse problems, an initial model (a skilled quess model) is usually modified in an iterative procedure so that the difference between the model response and the observed data values can be minimized. The model parameters are then updated using a linearized interactive adjustment procedure. The result of the inversion depends on both the choice of the forward model whose response should match the observed data as well as the solution of an appropriate error criterion for minimization and smoothness criteria (Constable et al., 1987). Conventional approaches are based a cumulative least-squares errors and cumulative least-absolute deviation.

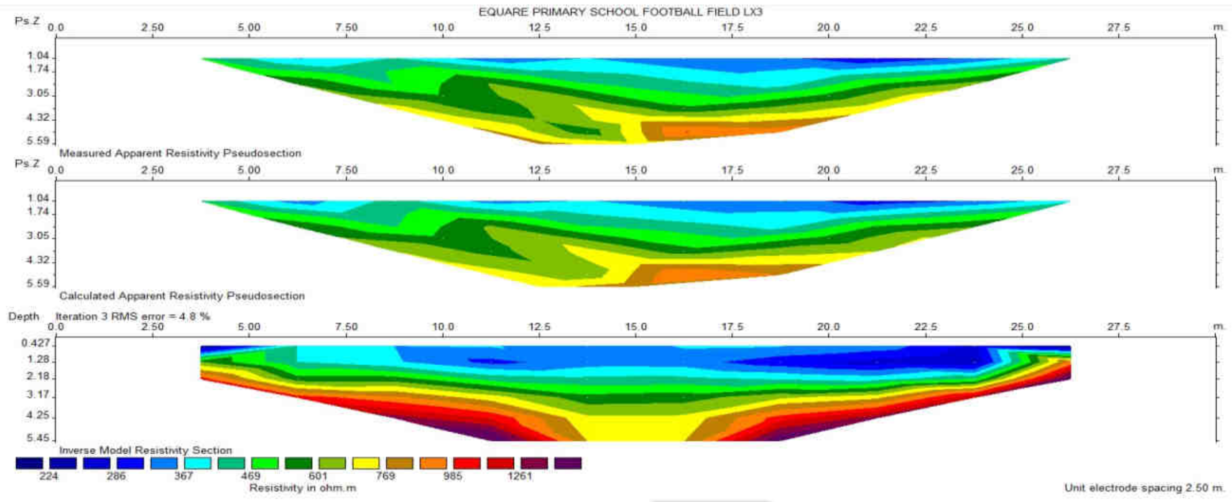
The apparent resistivity data got over the series of parallel 2D profile extracted from the 2D data, set were inverted separately using the RES2DINV inversion code in both x and y directions that is in-lines and cross-lines (Loke and Barker, 1996). The 2D inversion was done in order to assess the quality of the 2D apparent resistivity data generated. The RES2DINV computer program uses a nonlinear optimization technique which automatically determines a 2D resistivity model of the subsurface for the input apparent resistivity data (Griffiths and Barker, 1993; Loke and Barker, 1996). The program divides the subsurface into a number of

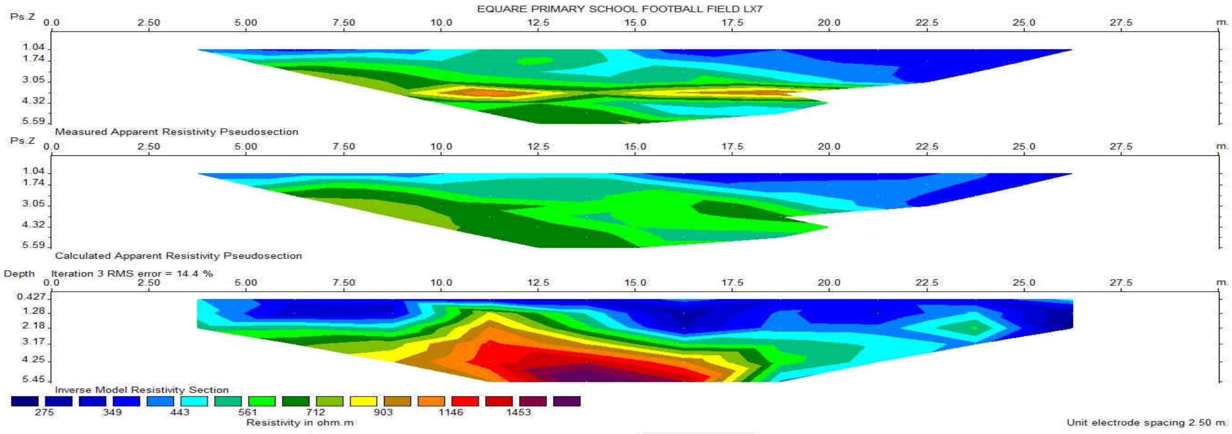


Rectangular blocks and then calculates the apparent resistivity values that agree with the measured values using a forward modeling routine. The arrangement of the rectangular blocks is loosely tied to the distribution of the data points in the pseudosections. The inversion routine used by the program is based on the smoothness constrained least squares method (DeGroot-Hedlin and Constable, 1990; Sasaki, 1992). The optimization method then adjusts the resistivity of the model blocks and tries to reduce the difference between the measured and calculate apparent resistivity values using iterative procedure.

The results of the inverted images of the various profiles in the study area are presented in the figures below.

Figure 3a**:** Eguare line Lx_1; 2D smoothness constrained inversion model resistivity section





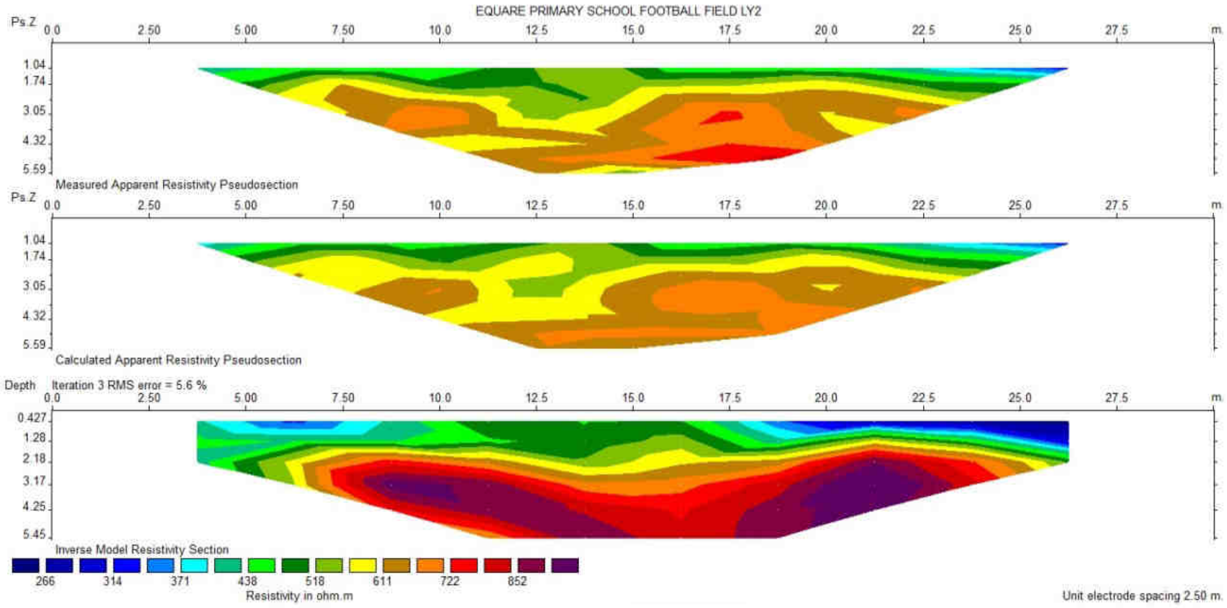


Figure 3b: Eguare line Lx_2; 2D smoothness constrained inversion model resistivity section

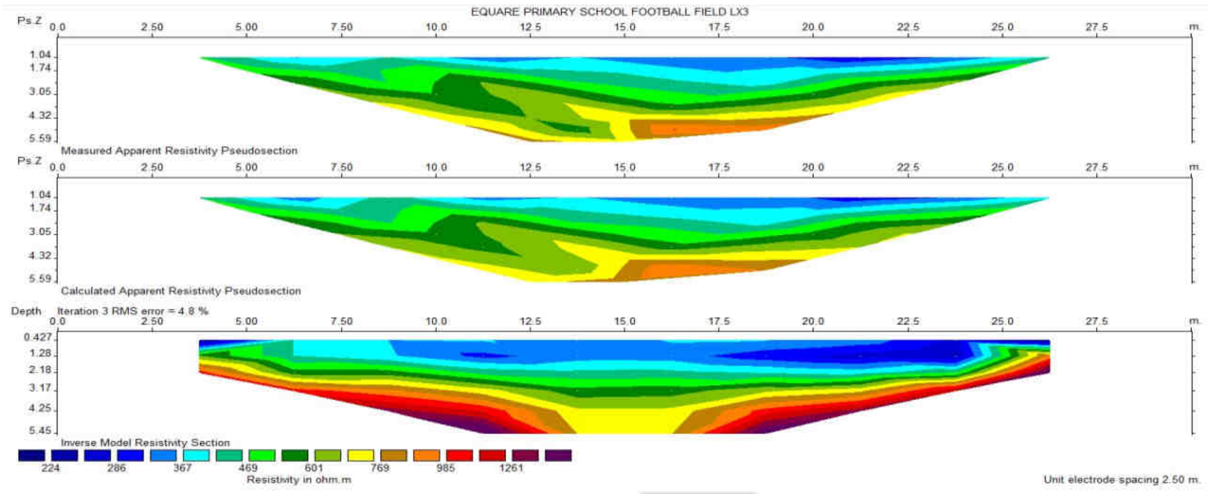


Figure 3c: Eguare line Lx$_3$; 2D smoothness constrained inversion model resistivity section

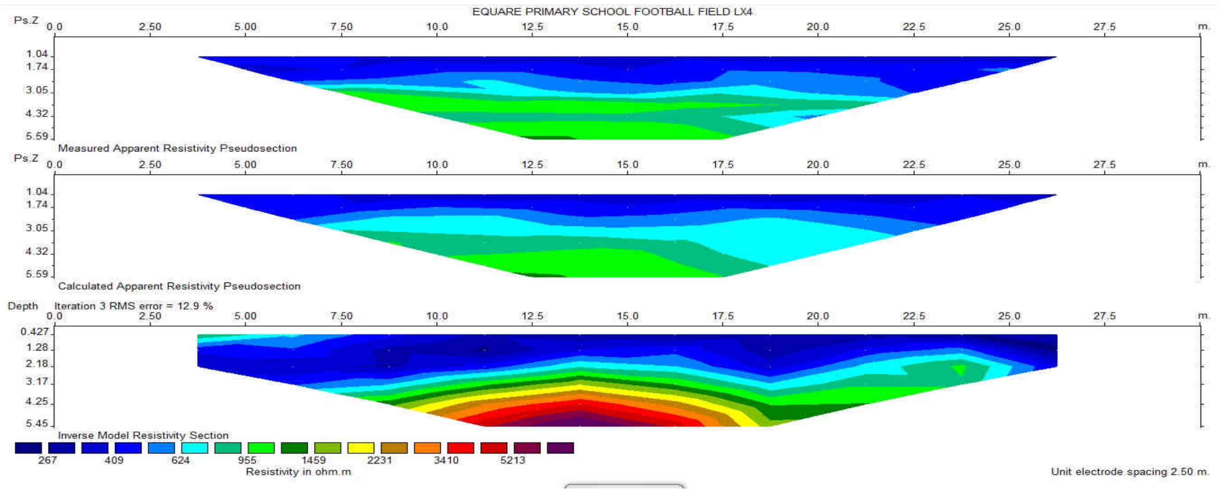


Figure 3d: Eguare line Lx$_4$; 2D smoothness constrained inversion model resistivity section

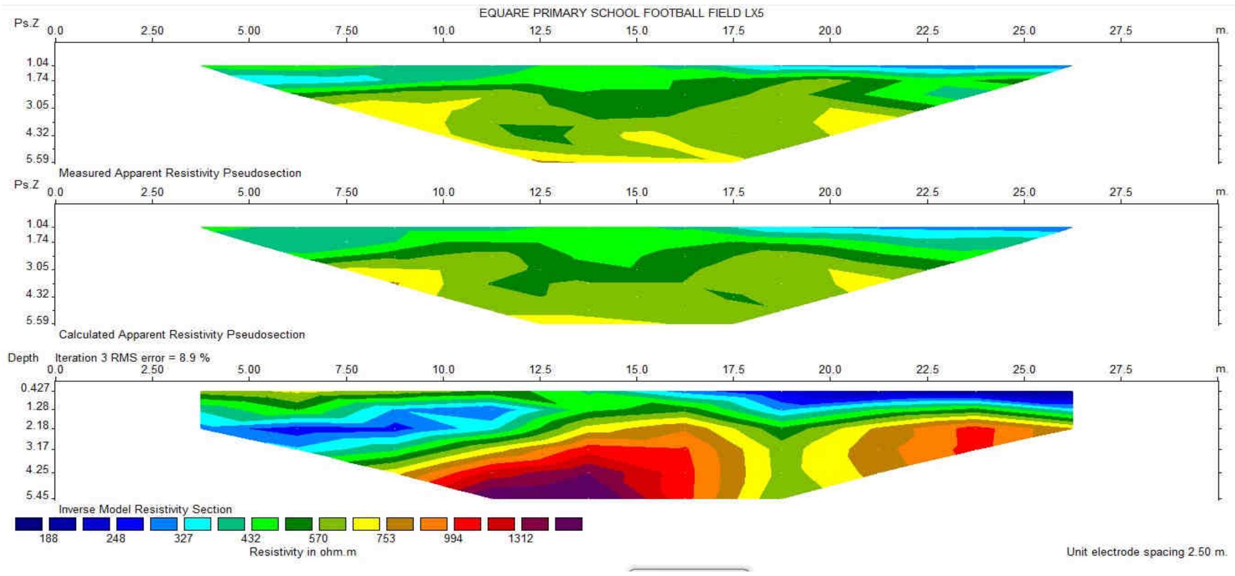


Figure 3e: Eguare line Lx$_5$; 2D smoothness constrained inversion model resistivity section

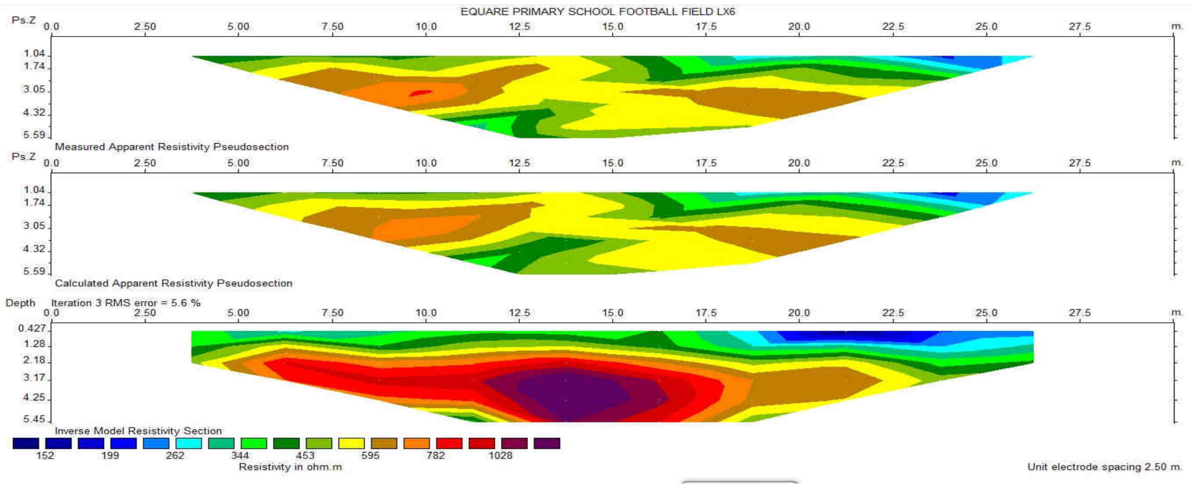


Figure 3f: Eguare line Lx$_6$; 2D smoothness constrained inversion model resistivity section

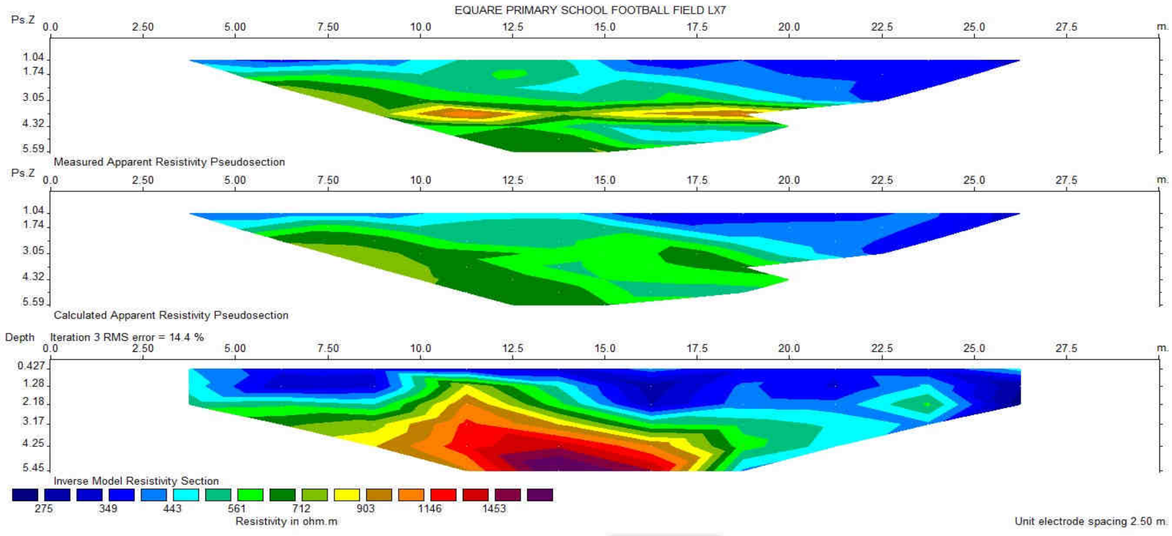


Figure 3g: Eguare line Lx$_7$; 2D smoothness constrained inversion model resistivity section

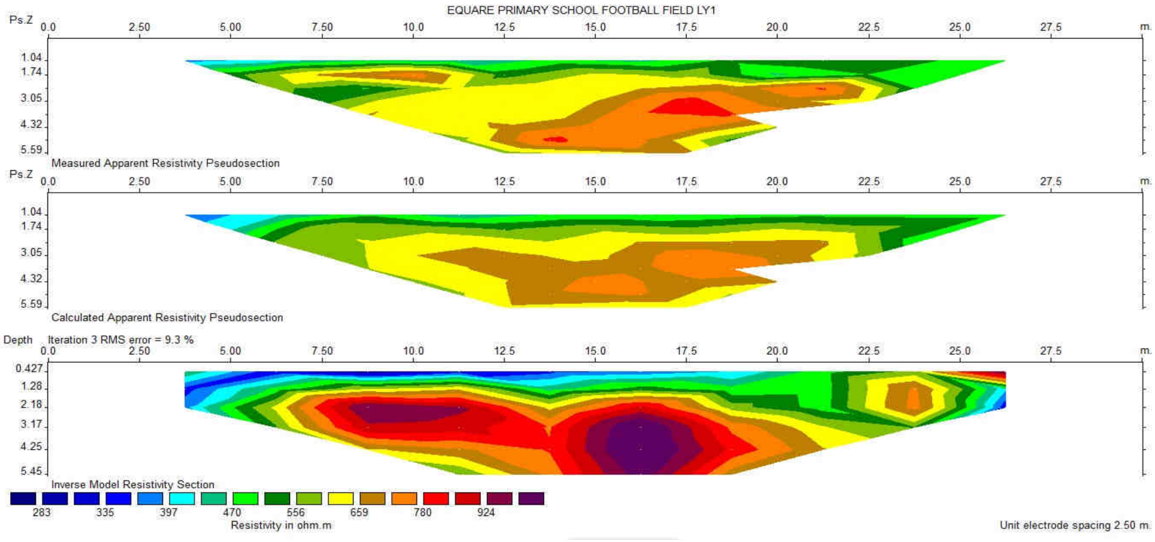


Figure4a: Eguare line Ly$_1$; 2D smoothness constrained inversion model resistivity section

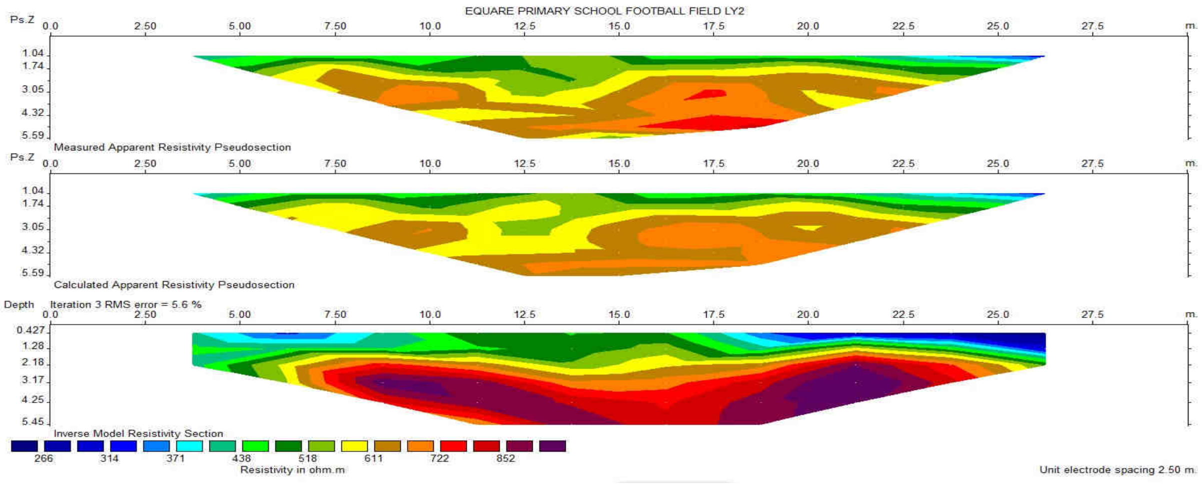


Figure4b: Eguare line Ly_2; 2D smoothness constrained inversion model resistivity section

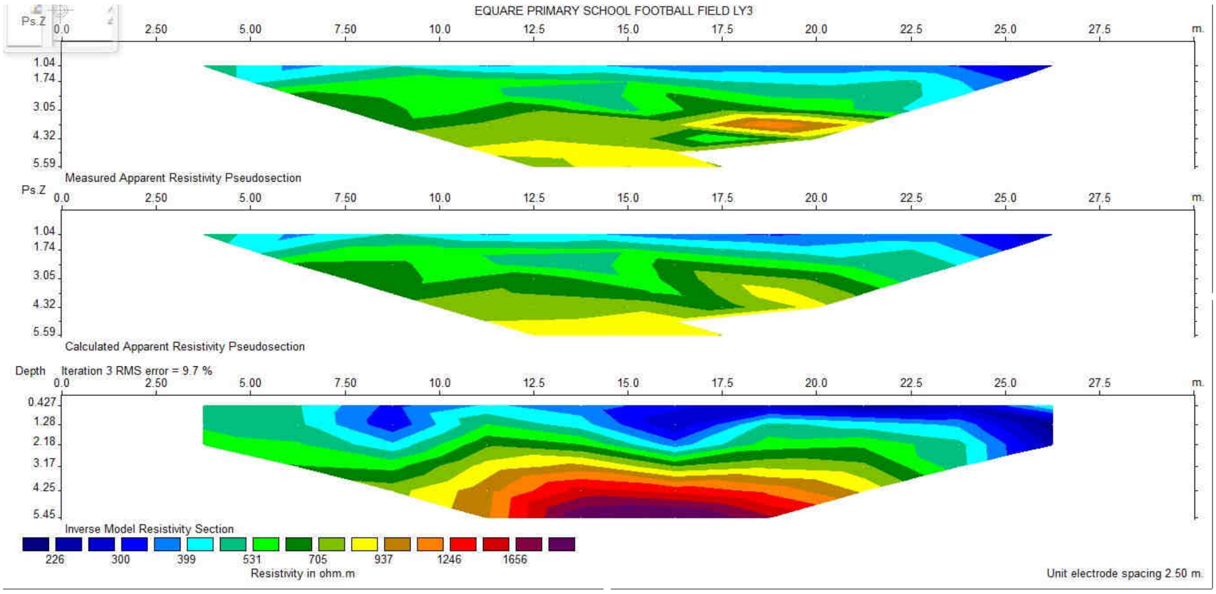


Figure4c: Eguare line Ly_3; 2D smoothness constrained inversion model resistivity section

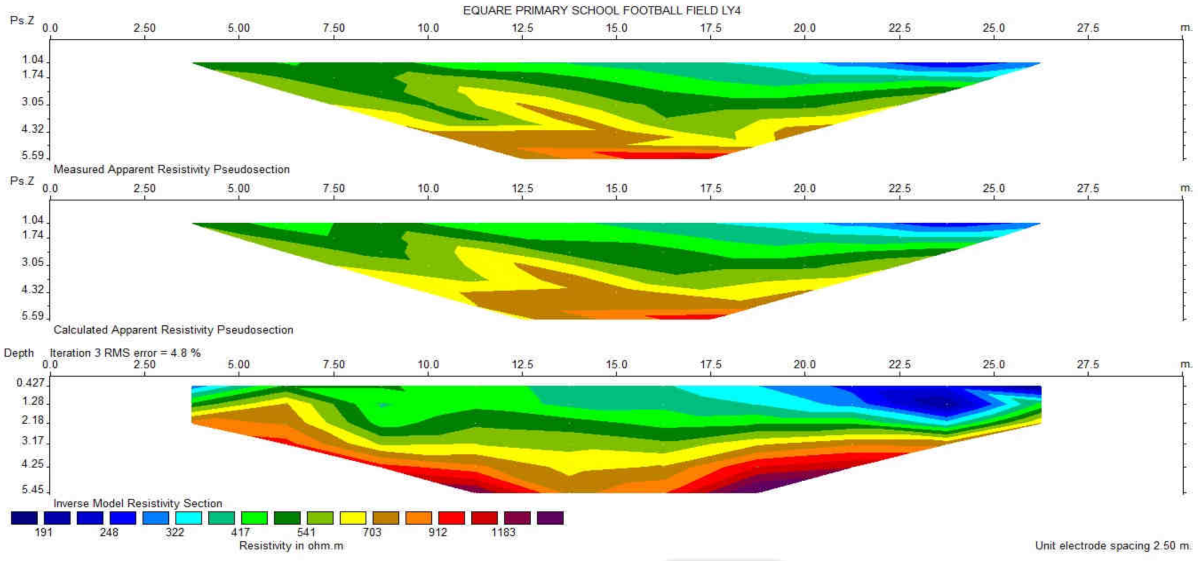


Figure 4d: Eguare line Ly_4; 2D smoothness constrained inversion model resistivity section

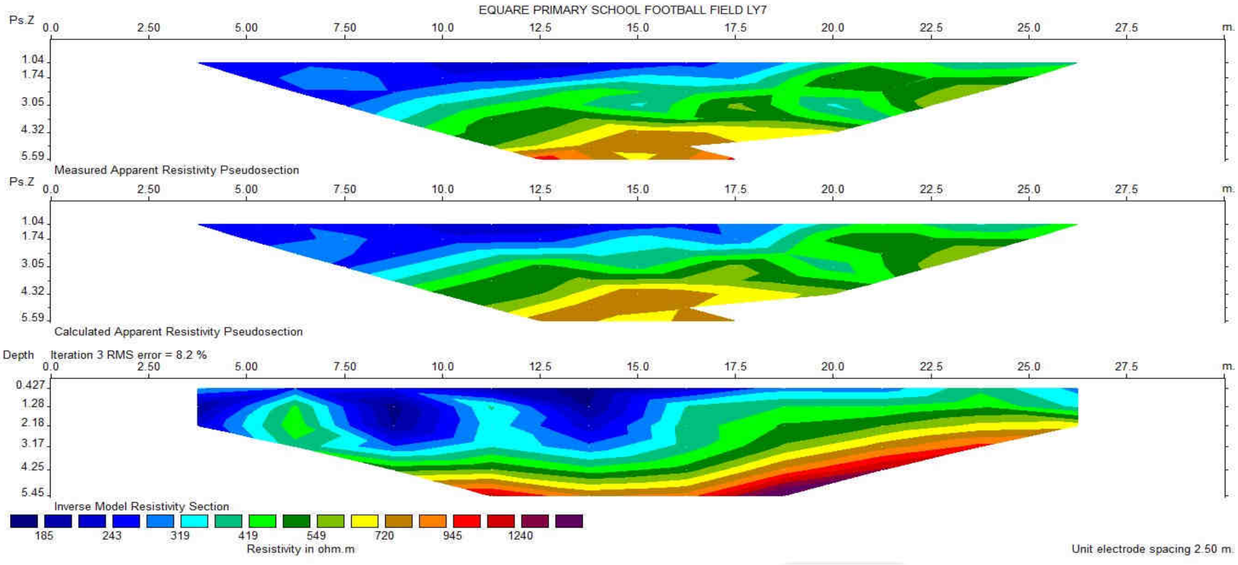


Figure4e: Eguare line Ly_5; 2D smoothness constrained inversion model resistivity section

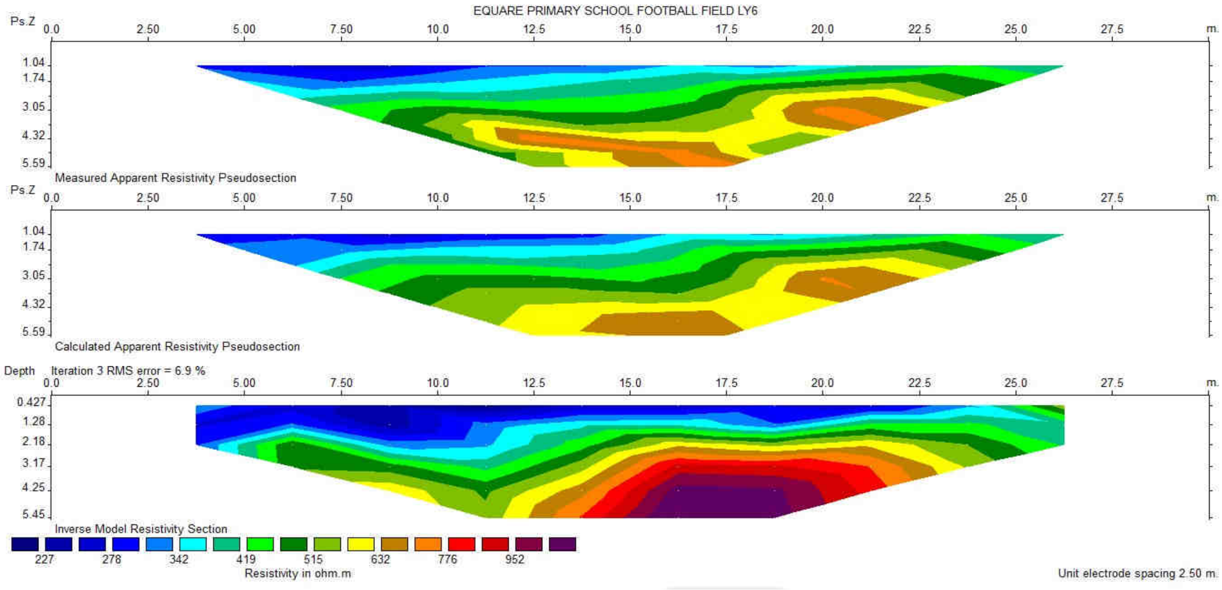


Figure4f: Eguare line Ly_6; 2D smoothness constrained inversion model resistivity section

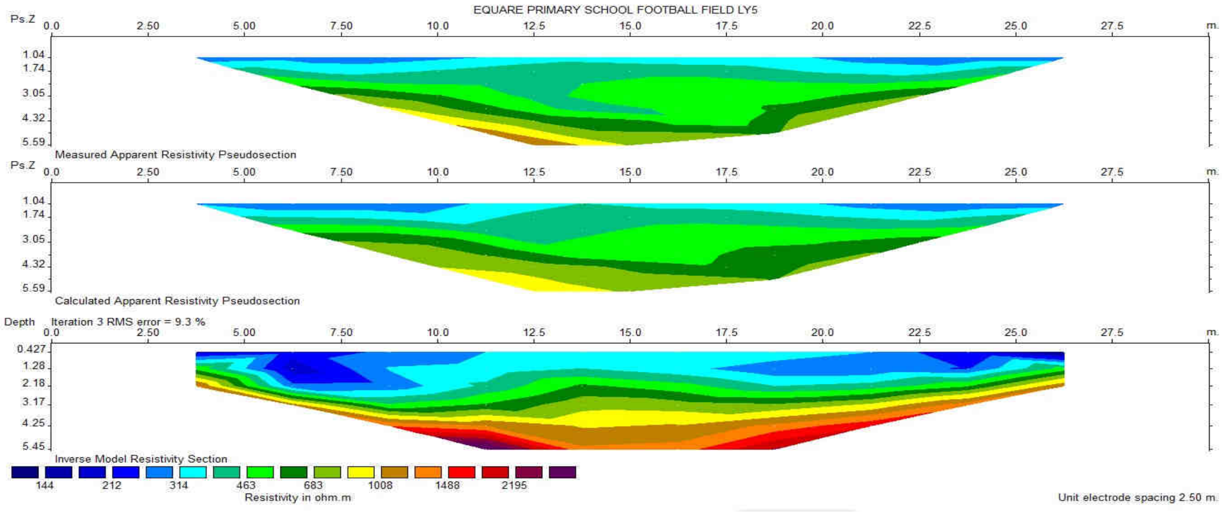


Figure4g**:** Eguare line Ly_7; 2D smoothness constrained inversion model resistivity section

DISCUSSION

Seven parallel and seven orthogonal 2D geoelectrical resistivity field data were collected manually engaging ABEM Terrameter SAS 1000, a resistivity instrument using the Dipole-dipole electrode configuration. In both cases, the observed 2D apparent resistivity data were collated and inverted using RES2DINV software.

Considering both the parallel X – Directions and orthogonal Y – Directions, the first, second and third layers having a lower resistivity ranges of $259\Omega m$ to $503\Omega m$ for unit electrode spacing of 2.5m showed that this top few layers is probably composed of lateritic soil, sand, sandstone, sand clay, limestone, and shale. Also for the fourth, fifth and sixth layer having a higher resistivity range of $403\Omega m$ to $1217\Omega m$ for the same unit electrode spacing showed that the last 3 layers is probably compose of sand, sandstone, shale, limestone, clay and dolomite.

Table 1: Interpretation table for Location 1

NAME OF SURVEY SITE: Eguare community				
ELECTRODE SPACING: 2.5m				
LAYER NO	IN-LINE(m)	CROSS-LINE(m)	RESISTIVITY RANGE	INTERPRETATION
1	0.88	0.88	$259\text{-}503\Omega m$	lateritic soil, Sand, Sandstone, Sandclay, Limestone, Shale.
2	1.0	1.0		
3	1.16	1.16		
4	1.33	1.33	$503\text{-}1217\Omega m$	Sand, Sandstone, Shale, Limestone, Clay, Dolomite.
5	1.53	1.53		
6	1.76	1.76		

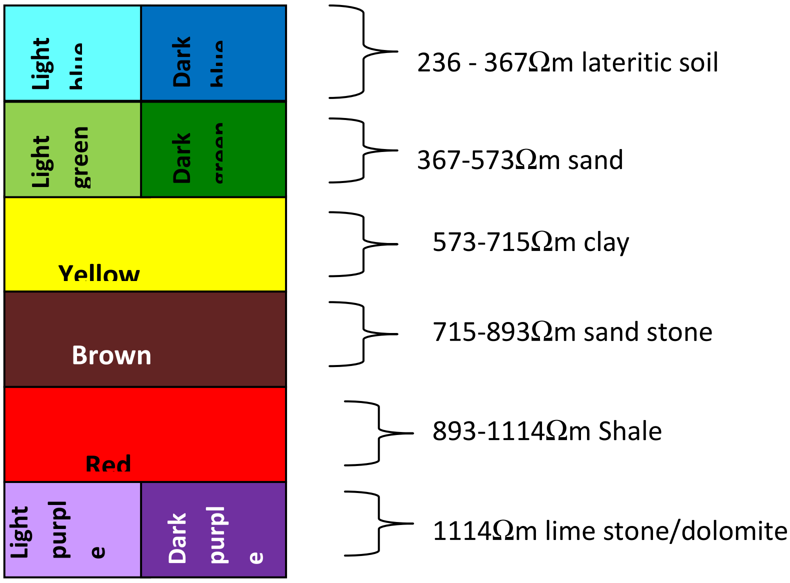


Figure 5: Legend showing the Aggregate/Mineral distribution in the subsurface of study area.

CONCLUSION

The 2 – Dimensional Electrical Resistivity Surveying For Mineral Deposit in Eguare, Igueben LGA, South – South, Nigeria, has successfully been carried out engaging geoelectrical resistivity imaging in which the resistivity is allowed to vary both laterally along and vertically beneath the survey line but constant in the perpendicular direction. This was carried out using the dipole – dipole electrode configuration. The resolution of the images help to delineate appropriately the subsurface structure and with their respective resistivity distributions presented.

The survey locations were observed to be composed of lateritic soil, sand, sandstone, shale, limestone, clay, dolomite with resistivity values ranging between 259 Ωm to 2159 Ωm for the unit electrode spacing adopted. Therefore, it is feasible to carry out an investigation of this type by engaging the instrumentality of electrical resistivity method.

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