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Full Length Research Paper

Using the Dar- Zarrouk Concept to Infer the Subsurface Lithological Extent of Agbani Sandstone, Enugu State, Nigeria

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ABSTRACT

The lateral extent of the Agbani Sandstone, within the Enugu state university of science and technology, Agbani campus was investigated using the Dar - Zarrouk parameters. The study area is underlain by Agbani Sandstone and Awgu Shales. A total of 13 (thirteen) vertical electrical sounding (VES) was carried out within the study area. Longitudinal resistivity, transverse resistance and apparent resistivity data was computed from the interpreted VES data. These were used to infer the lateral extent of Agbani Sandstone in the study area. High longitudinal resistivity, transverse resistance and apparent resistivity are indicative of a thick succession of a substratum. Areas around the law faculty building, health centre and near the existing borehole at the back gate were observed to have high longitudinal resistivity, transverse resistance and apparent resistivity values, with average thickness of 48meters. These areas are recommended for citing of productive boreholes. The anomaly trend is roughly NE – SW direction. The Agbani Sandstone is however limited in extent within the study area. The information provided from this study should therefore guide future groundwater development in the study area.

Keywords: Longitudinal resistivity, Transverse resistance, apparent resistivity, Agbani Sandstone, Anomaly trend, Lateral extent.

INTRODUCTION

The concept of Dar Zarrouk parameters was first proposed by Maillet (1947). This postulation holds from the fact that, when the thickness and resistivity of a lithologic subsurface layer is known, its transverse resistance (R) and longitudinal conductance (S) can be calculated easily. Hence their correlative resistivities determined. Dar – Zarrouk parameters have since been used in the estimation/study of the hydraulic properties of aquifers. Onuoha and Mbazi (1988) used the concept of Dar – zarrouk parameters to estimate the transmissivity of Ajali Sandstone aquifers in southeastern Nigeria. Ezeh (2011) applied the concept of Dar – Zarrouk parameters for estimating aquifer hydraulic properties in Enugu State. Okonkwo and Ezeh (2013) applied the concept in estimating aquifer hydraulics and delineation of groundwater quality zones. Ekwe, et al*.,* (2010) also applied the same concept in a low permeability formation for aquifer hydraulic characteristics.

In this present study, the concept has been used to study the lateral extent of Agbani Sandstone at Enugu State University of Science and Technology, Agbani campus, Enugu State.

Location and physiography

The case study area is the Enugu state university Agbani

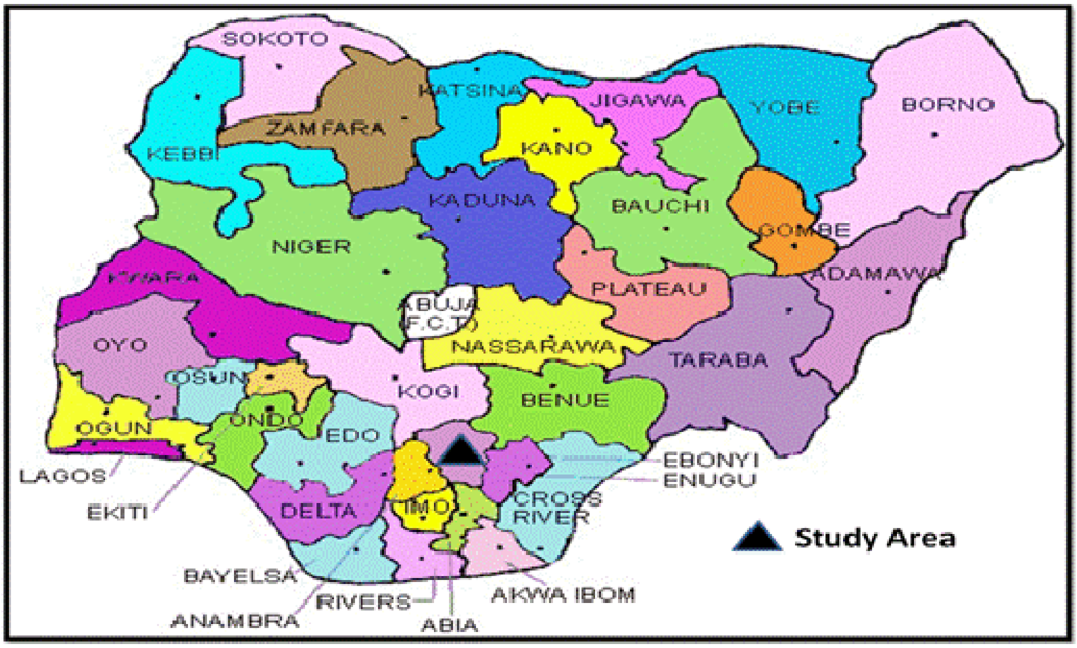

Figure 1. Map of Nigeria showing the study area (World Gazette, 2011).

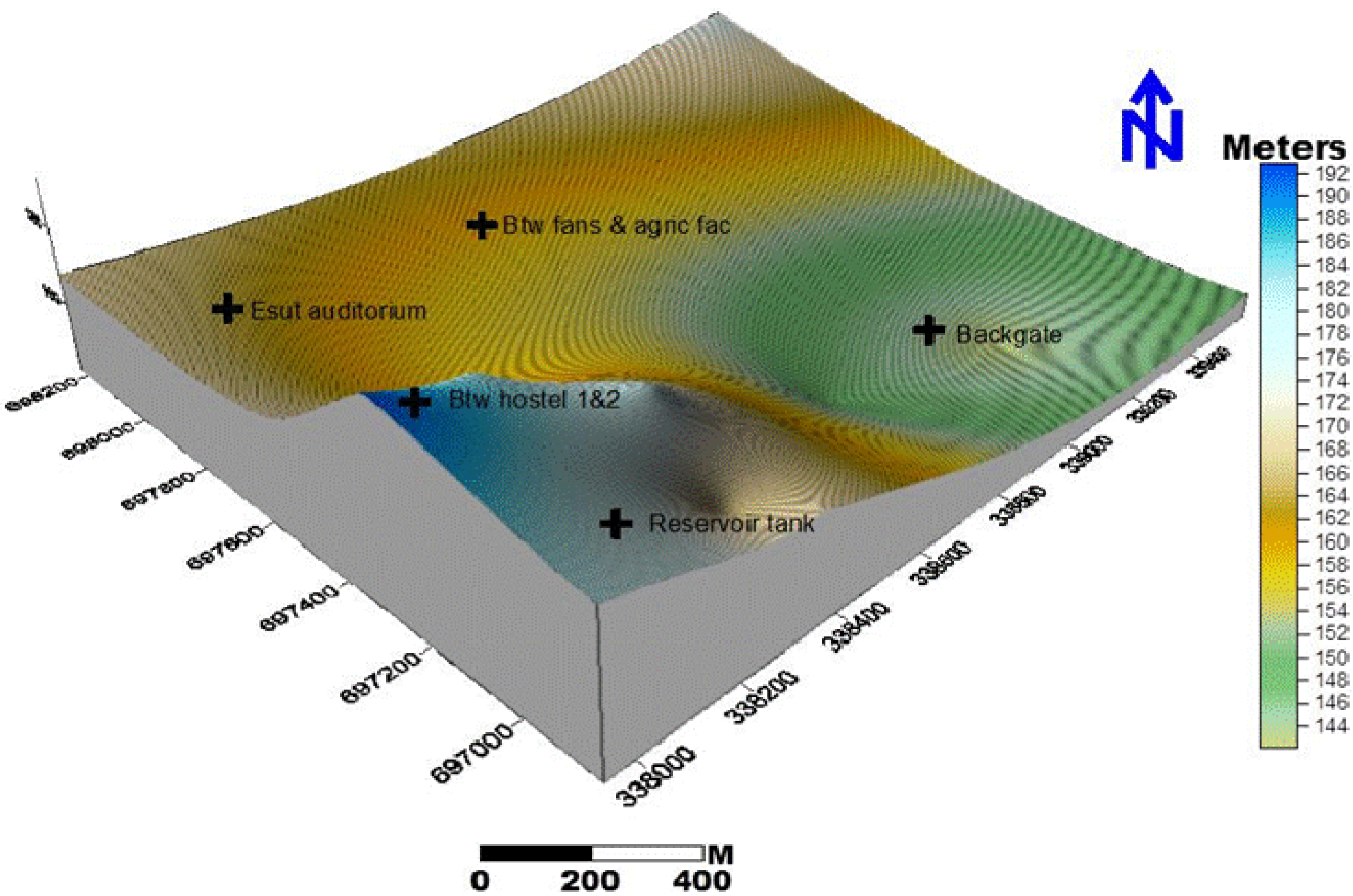

Figure 2. Surface map of the study area.

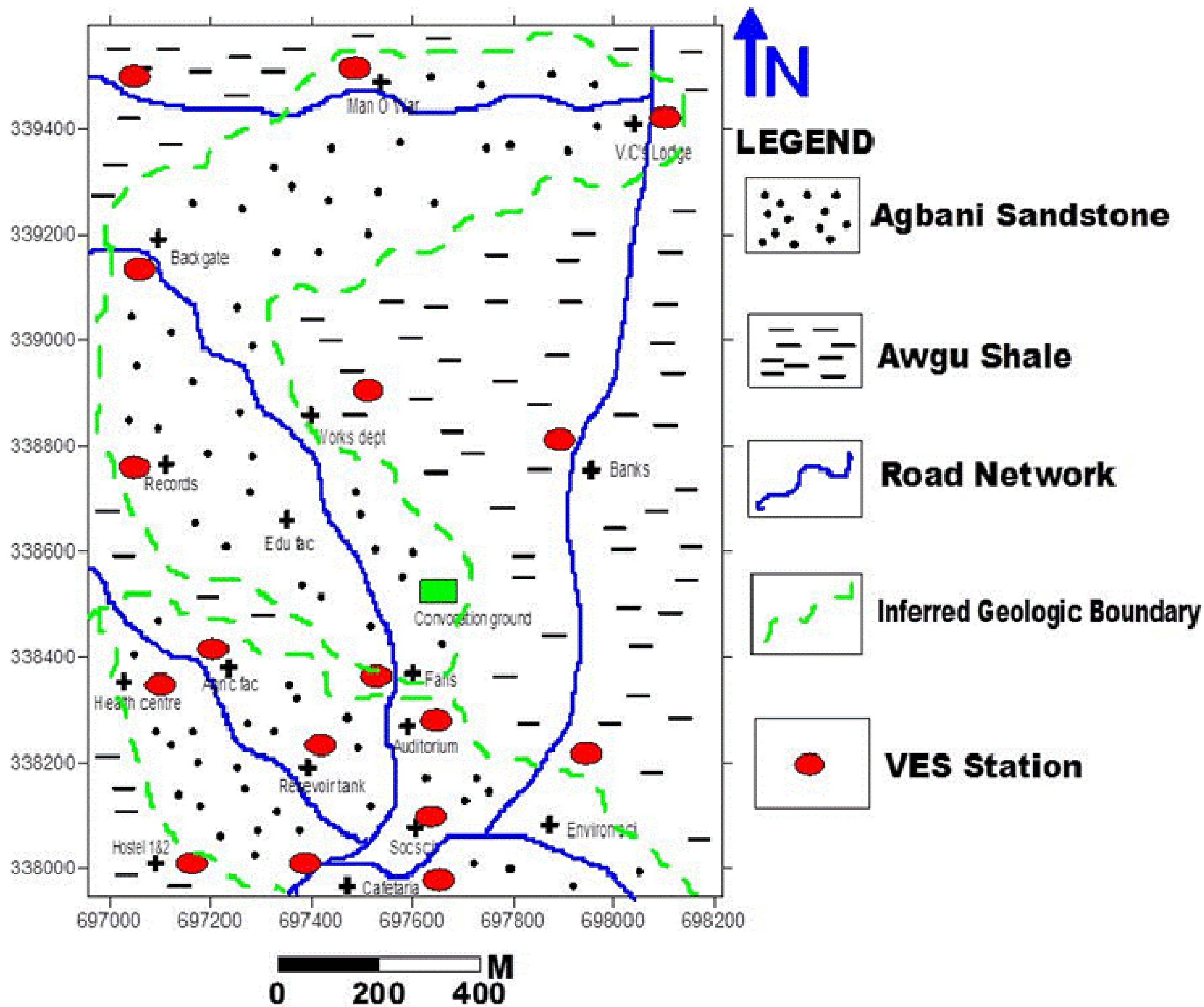

Figure 3. Geologic map of the study area and VES stations

campus, located in Nkanu west local government, Enugu state (Figure 1). Agbani is located roughly about 15.9km southeast of Enugu metropolis and about 6.85km northeast of Ozalla town. It is bordered at the west by the Udi highlands, about 5000ft (1524m) above sea level (ASL) and practically situated in the lowland areas of Akpugo and Amurri about 250ft (76m) ASL. Locally, (Figure 2) the topography is typically undulating with a maximum elevation of 633ft (193m) ASL.

Geology

Agbani town, where the study area is located is practically underlain by Agbani Sandstone, (Figure 3) which is a lateral equivalent of Awgu Shale group. The Sandstone is quite laterally not extensive, as it outcrops only within the country around Agbani. It consist of medium to coarse grained, white to reddish brown, moderately consolidated at depth and highly consolidated at outcrop areas. Thickness variation is predominant in areas (towns) far from Agbani town centre. The Agbani sandstone is the reservoir aquifer at Agbani and environs. Hence, the need to investigate the subsurface extent within the Enugu state university campus, in order to determine suitable locations for groundwater development.

Figure 4. Longitudinal resistivity map of the study area

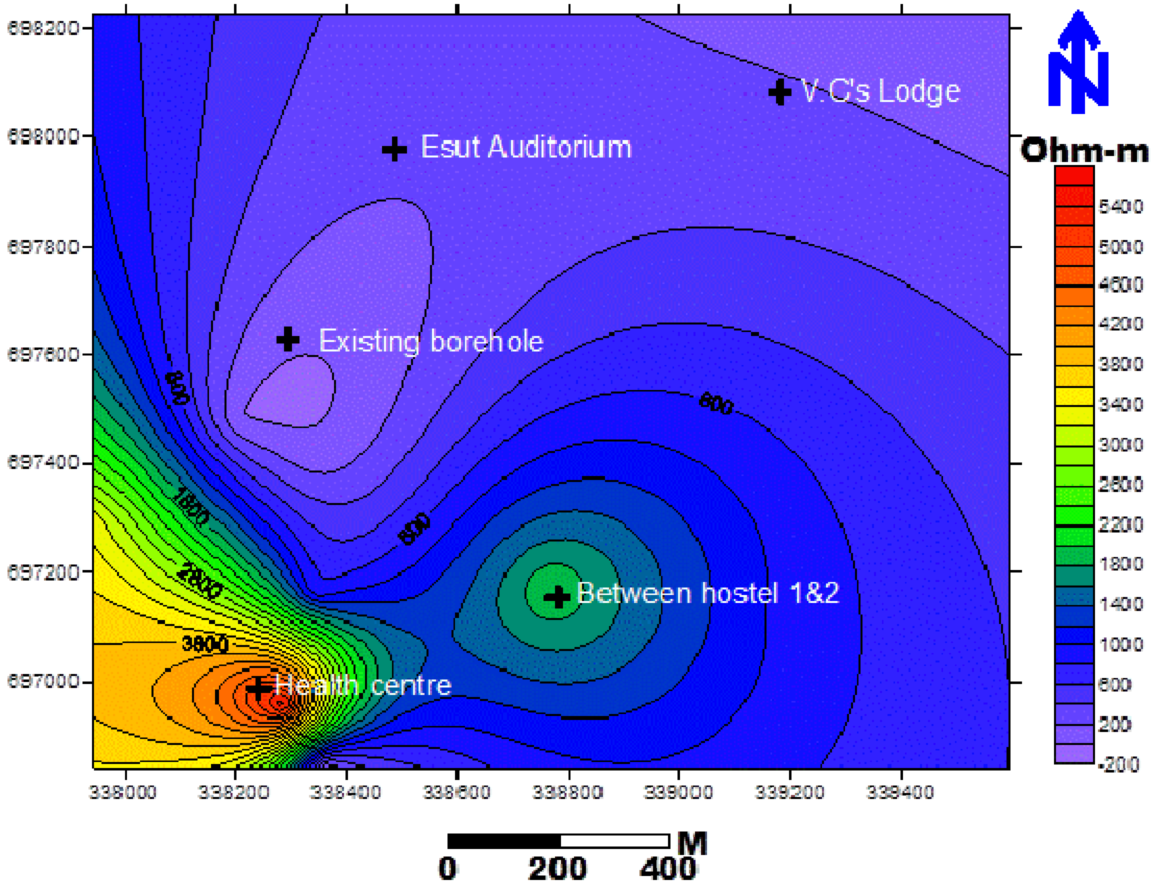

Table 1. Computed Geoelectric parameters for VES stations of the study area

S/NO	Location	ρ_a (Ωm)	Thickness (m)	S (Ω^{-1})	T (Ωm^2)	ρ_L (Ωm)	ρ_T (Ωm)
1	Behind exams and records	2014	57.0	0.0283	114798	2014.13	2014
2	Behind health centre	5547	41.0	0.0073	227427	5616.43	5547
3	Opp; Agric faculty	875	53.0	0.0605	46375	876.03	875
4	B/w Hostel 1 and 2	3304	48.0	0.0145	158592	3310.34	3304
5	Behind social sciences	1302	46.0	0.0353	59892	1303.11	1302
6	Existing Borehole	965	75.0	0.0777	72375	965.25	965
7	Auditorium	13	38.0	2.9230	494	13.00	13
8	V.C's Lodge 1	45	135.0	3.0000	6075	45	45
9	V.C's Lodge 2	20	55.0	2.75	1100	20	20
10	B/w FANS & Agric faculty	90	85.0	0.9444	7650	90.00	90
11	Reservoir tank	100	55.0	0.5500	5500	100	100
12	Cafeteria	60	80.0	1.3333	4800	60.00	60
13	Opp; Man O war	14	44.0	3.142	616	14.00	14

MATERIALS AND METHODS

Theoretical Basis

The apparent resistivity (ρ_a) function of current passed into the ground, measured by potential electrodes as potential difference (Voltage) is given as interpreted

$$\rho_a = \frac{(AB/2)^2 - (MN/2)^2 x R}{MN} \quad (1)$$

Where R is the resistance, AB and MN are current and potential electrodes respectively. A multilayer resistivity

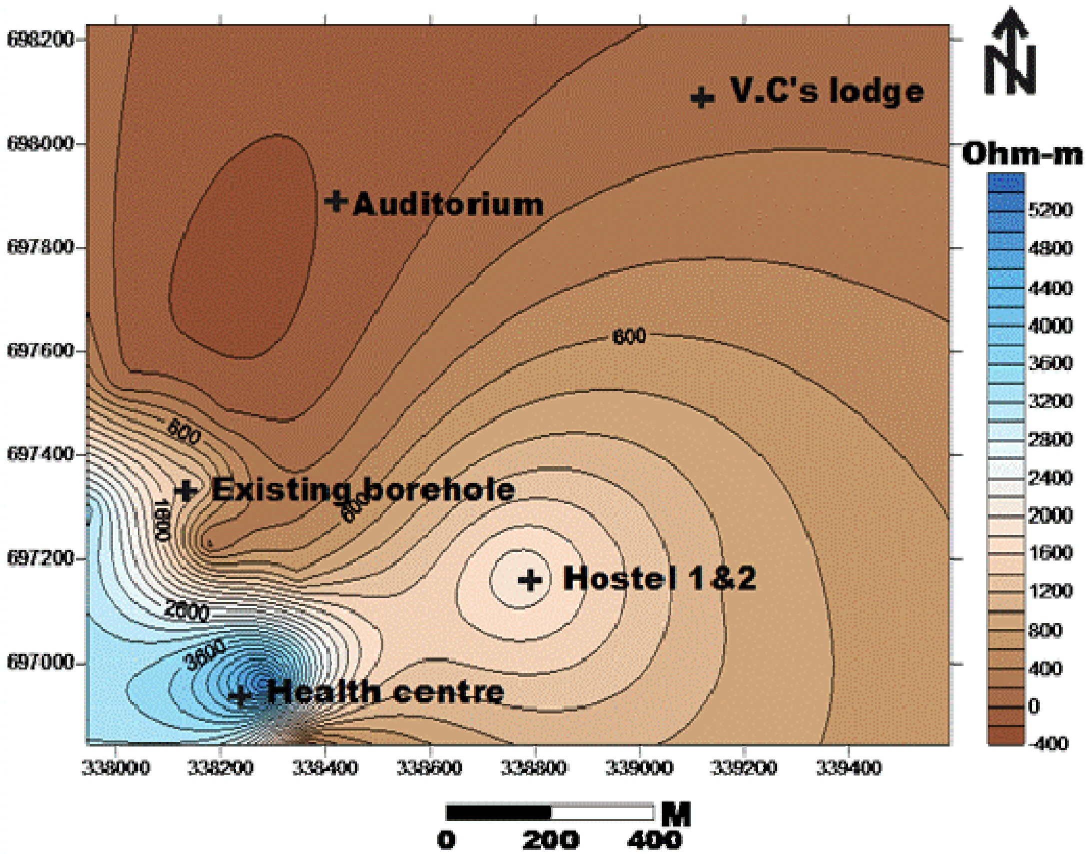

Figure 5. Apparent resistivity map of the study area

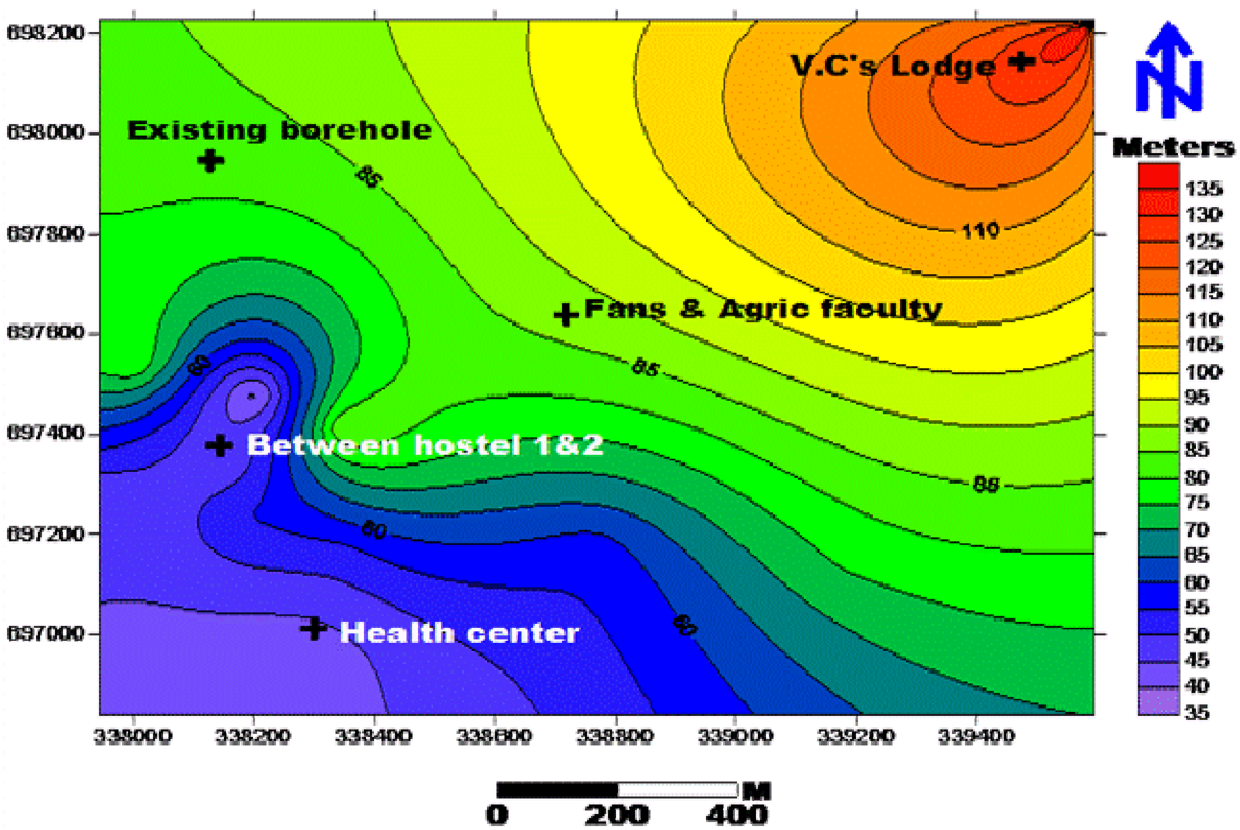

Figure 6. Isopach map of the study area

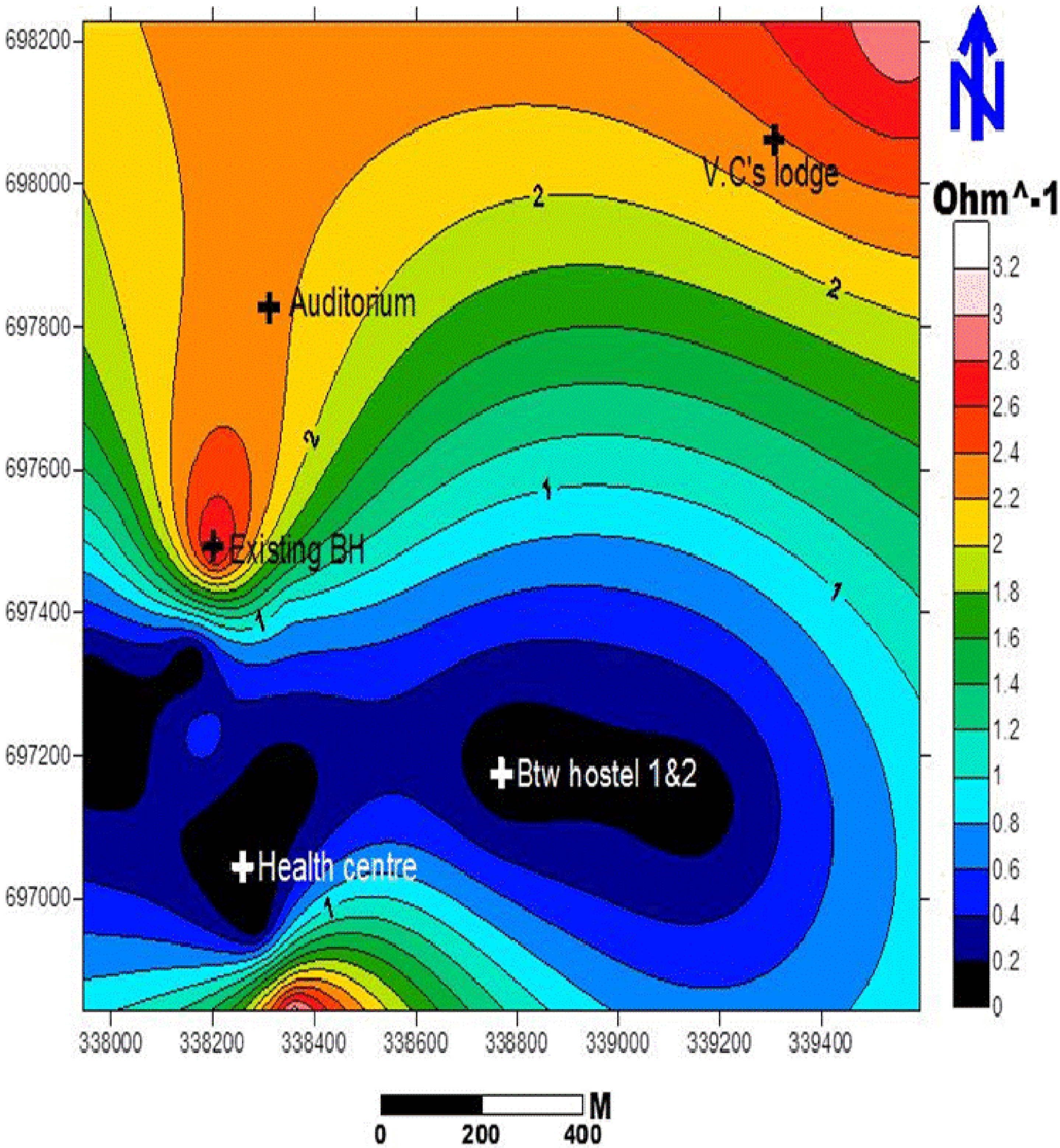

Figure 7. Longitudinal conductance map of the study area

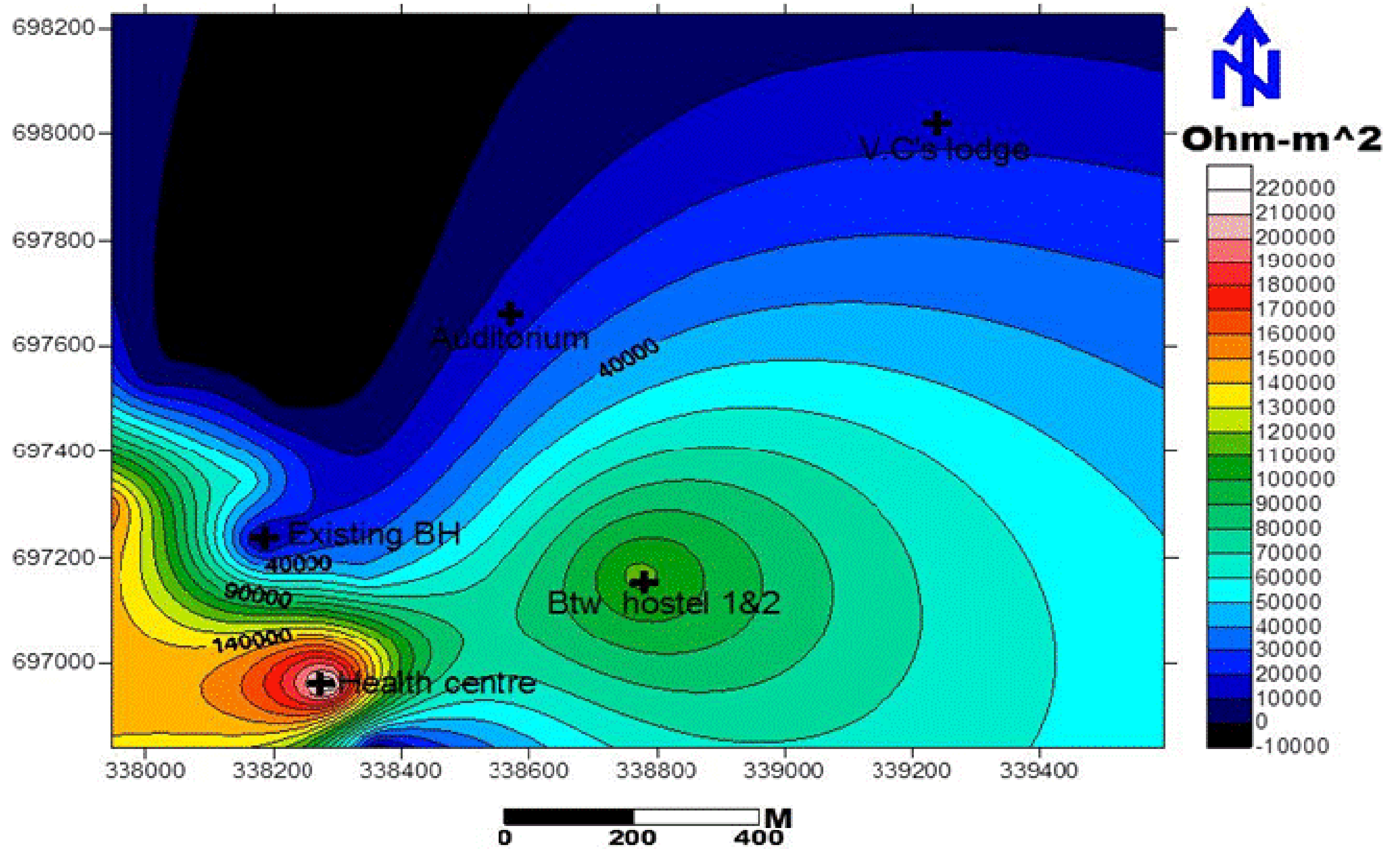

Figure 8. Transverse resistance map of the study area

model consists of layer apparent resistivities, thickness and depth. Further derivatives are convolved to generate the Geoelectric parameters. These show electric boundaries separating layers of different resistivities (Zohdy, *et al.*, 1990). A Geoelectric layer is described by two fundamental parameters: its layer apparent resistivity (ρ_a) and its thickness (h). The Geoelectric parameters derived based apparent resistivity and thickness, Longitudinal conductance (S)

$S=h/\rho_a$ (2)

Transverse resistance (T)

$T=h.\rho_a$ (3)

The parameters T and S were named the "Dar – Zarrouk parameters "by Maillet (1947). Correlative resistivities of T and S are given below.

Longitudinal resistivity (ρ_L)

$\rho_L=h/S$ (4)

Transverse resistivity (ρ_T)

$\rho_T=T/h$ (5)

Substituting equation (2) into equation (4), and equation (3) into equation (5) it appears that apparent resistivity equals longitudinal resistivity and transverse resistivity.

$\rho_a = \rho_L = \rho_T$ (6)

Therefore, if apparent resistivity values can be used to infer subsurface lithology, then stacked longitudinal resistivity and transverse resistance can be used to investigate the lateral extent of subsurface lithology.

Data Acquisition and Interpretation

A total of 13 (thirteen) vertical electrical sounding (VES) were carried out within the case study area (figure 3) The Schlumberger electrode spreading was used with maximum current electrode separation (AB) of 400m. The initial interpretation of the VES data was accomplished using the conventional partial curve matching technique, with multilayer master curves in conjunction with auxillary point diagrams (Orellana and Mooney, 1966; koefoed, 1979; Keller and Frischknecht, 1966). From this, estimates of layer resistivities and thicknesses were obtained which served as starting points for computer assisted interpretation. The computer program RESOUND, was used to interpret all data sets obtained. From the interpretation of the resistivity data it was possible to compute, for every VES station the Geoelectric parameters (Table 1).

RESULTS AND DISCUSSION

Interpreted VES data were used to compute the longitudinal conductance, transverse resistance, longitudinal resistivity and the transverse resistivity (Table 1). Contour maps of apparent resistivity, isopach, longitudinal conductance, transverse resistance and the longitudinal resistivity were also constructed and compared. The apparent resistivity, transverse resistance and longitudinal resistivity proved diagnostic, as relatively high values usually indicated thick succession of Arenaceous (sandy) subsurface rocks. Hence, areas of high longitudinal resistivity (Figure 4), high apparent resistivity (figure 5) and high transverse resistance (figure 8) possibly show the trend of the Agbani Sandstone in the study area. The longitudinal resistivity, transverse resistivity and the apparent resistivity show lateral trend section of the Agbani Sandstone in a NE – SW direction within the study area. Areas around the law faculty building through the health centre to the back gate, close to the existing borehole are underlain by a thick succession of Agbani Sandstone (figure 4). The isopach map show high variable values in the study area (Figure 6). In the southwestern part, underlain by the Agbani Sandstone, the thickness range between 35 and 70m with an average of 52.5m. While in a NW – SE trend, the thickness range between 70 and 100m with an average thickness of 85m. The distribution of the longitudinal conductance computed from the resistivity sounding interpretation of the study area is shown in figure 7. Minimum longitudinal conductance values were observed in an E – W trend (Health centre – Cafeteria – Btw hostel 1 and 2). Maximum values were observed in the northwest, north central and northeastern part of the study area, underlain by Awgu Shales, thus indicating ahighly conductive environment. Agbani Sandstone in the study area, is however limited in extent.

CONCLUSION

The application of Dar – Zarrouk parameters has proved useful in the study of lateral extent of subsurface lithology (Agbani Sandstone) within the Enugu state university of science and technology (ESUT) permanent site. The Sandstone is quite limited in extent in the study area. However, groundwater development can be undertaken within areas around the law faculty, as this area has the highest thickness of the Agbani Sandstone. This study should therefore serve as useful guide for future groundwater development and citing of productive boreholes in the campus

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