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Hydrogeophysical Evaluation of Federal College of Agriculture, Akure, Campus, Ondo State

Mogaji Kehinde and Oladapo Ilesanmi
Department of Applied Geophysics, Federal University of Technology, Akure, Nigeria

Abstract: The requirement for water usage has increased significantly over the years within the federal college of agriculture, Akure campus because the existing surface water supply scheme has proved inadequate. Electromagnetic (EM) and electrical resistivity studies were conducted within the campus in 4 major areas of human concentration namely; old rural education college (Location 1), academic/male hostel/administrative blocks (location 2), junior staff quarters/female hostel/workshops/sports centre (location 3) and senior staff quarters/ provost lodge (location 4). The aim was to establish the groundwater potential of the locations within the college campus. Very Low Frequency (VLF) data were acquired at 10 m intervals along 21 traverses. Linear features presumed to be fractures inferred from the VLF-EM anomaly profiles were further evaluated using electrical resistivity method. Geoelectric sections generated from iterated sounding curves revealed 4 subsurface geologic layers consisting of topsoil, weathered basement, fractured basement and resistive bedrock. The identified weathered and fractured basement materials constitute the main aquifer units in the area. The isopach map generated revealed areas underlain by thicker overburden materials marked Z_1 at location 1, Z_2 at location 2, Z_3, Z_4 and Z_5 at location 3 and Z_6 and Z_7 at location 4. Bedrock relief map revealed that the depressions zones are mostly overlain by relatively thick overburden materials portions while the basement ridge zones are overlain by thin overburden materials. The maps enabled the zoning of the locations into high, medium and low groundwater potential zones. High and medium groundwater potential zones underlie the northeastern area of location 1, central area of location 2, Northeastern, Western and Southeastern areas of location 3 and Southwestern and parts of Southeastern areas of locations 4. Northwestern and Southeastern parts of location 1, Western and Eastern parts of location 2, central parts of location 3 and Northern and Southern parts of location 4 constitute low groundwater potential zones. The VES stations underlain by high and medium groundwater zones in the study locations are viable for groundwater development within the college campus.

Key words: Resistivity, geoelectric, aquifer, isopach, anomaly, overburden, fractured and bedrock

INTRODUCTION

The demand for water has been on the increase within the federal college of agriculture, Akure campus since the existing surface water supply scheme (Dam) in the college has proved inadequate. Therefore, for the college to cope with the needs of an increasing population of staff and students there is a need for an elaborate groundwater development scheme.

The college is within the basement complex setting of Nigeria. Studies show that groundwater development in a typical basement setting requires a quantitative knowledge of hydrogeophysical parameters of the hydrogeological units such as the superficial material overlying the crystalline bedrock and the bedrock structures/relief.

During the last decades, Electromagnetic (EM) and electrical resistivity methods are some of the most popular of the several non-invasive geophysical methods commonly used in hydrogeophysical evaluation of a studies site (Mullern and Erikson, 1982). Studies show that VLF-EM and electrical methods are able to detect changes related to variation in fluid content, chemical composition and temperature in the subsurface (Adepelumi *et al*., 2005). The Very Low Frequency Electromagnetic (EM) method is an inductive exploration technique that is very sensitive to small changes in ground conductivity. The electrical resistivity method is able to measure the physical property of rock and soil which are mostly affected by the presence of water. Therefore, for a detailed hydrogeophysical evaluation of a study site VLF-EM and Electrical resistivity methods are

Corresponding Author: Mogaji Kehinde, Department of Applied Geophysics, Federal University of Technology, Akure, Nigeria

the most appropriate geophysical prospecting tools to adopt. In this study, a detailed hydrogeophysical investigation was carried out in 4 major areas of human concentration namely; old rural education college (location 1), academic/male hostel/administrative blocks (Location 2), junior staff quarters/female hostel/ workshops/sports centre (location 3) and senior staff quarters/ provost lodge (location 4). The study was performed to determine the geoelectric parameters (layers resistivity and thickness) of the overburden materials overlying the bedrock, the subsurface structural disposition of the bedrock and their hydrogeological chacteristics. Another goal was to evaluate the groundwater potential of the locations. Hydro geologic maps were produced using the geoelectric parameters. These maps are to provide information to enable groundwater development in the study locations.

PHYSIOGRAPHY, GEOLOGY AND HYDROGEOLOGY

Federal college of agriculture Akure occupies an area of about 5.0 Km^2. It is located northeast of Akure town within longitudes 5° 11' 51.6 and 5° 15' 00."E and latitudes 7° 5' 33.6 and 7° 17' 16.8"N (Fig. 1). The terrain across the study area is fairly flat and it is characterized by dense and evergreen vegetation.

The college campus is underlain by rocks of the precambrian basement complex of south-western Nigeria (Rahaman, 1976). The lithological units include porphyrithic granite and granite gneiss, though some of the rock types underlying the study area are concealed by a sequence of unconsolidated but variably thick materials (basement regolith, weathered mantle or overburden) produced by prolonged weathering of parent rock.

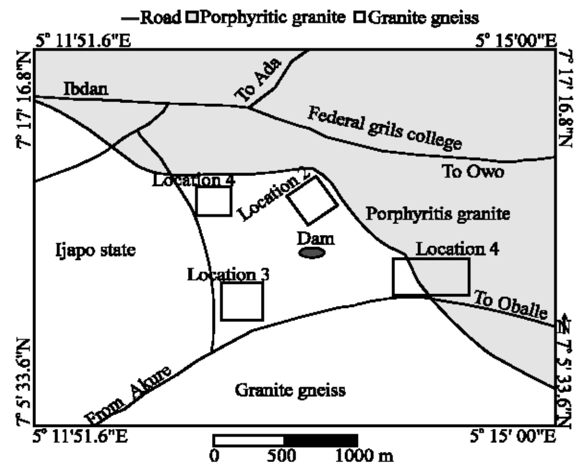

Fig. 1: Map of Akure showing the location and geological features of the study area

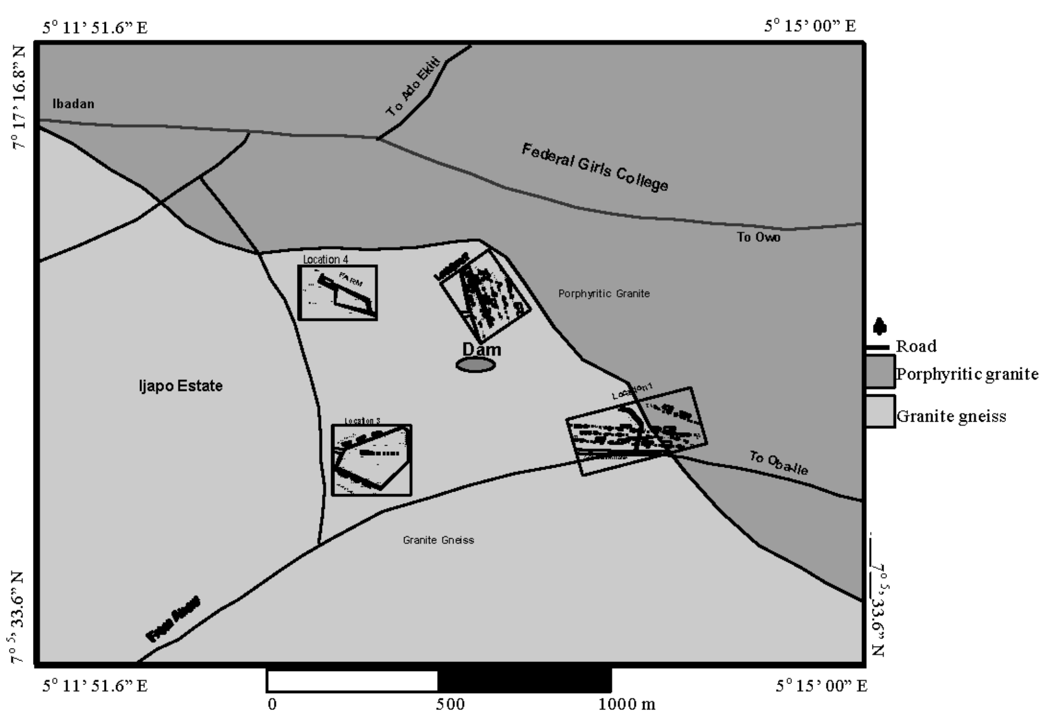

Fig. 2: Map of Akure showing the locations VLF traverses

MATERIALS AND METHODS

Twenty-one Traverses (TR) were established in 4 locations within the study area (TR1-TR4 at location 1, TR5-TR11 at location 2, TR12-TR17 at location 3 and TR18-TR21 at location 4 in (Fig. 2) for the purposes of carrying out VLF-EM and resistivity surveys. VLF-EM survey was undertaken on the twenty-one traverses using the ABEM WADI equipment with a station separation of 10 mas a reconnaissance tool. The VLF data (filtered real and filtered imaginary) are presented profiles and interpreted qualitatively. The results of the VLF technique aided in the choice of location for Vertical Electrical Sounding points within the study locations.

Forty-seven Vertical Electrical Sounding (VES) points were occupied on the locations utilizing the Schlumberger electrode configuration. Electrode spacing (AB/2) was varied from 1.0-100 m. Field measurements were made with R-D 50 Resistivity Meter. The VES data were utilized in generating field curves. The curves were interpreted using partial curve matching technique. The geoelectric parameters obtained from manual interpretation of each VES data were refined using the software algorithm resist version 1.0 (Vander,1988).

RESULTS AND DISCUSSION

VLF results: The filtered real and filtered imaginary VLF data obtained along the traverses are presented as VLF profiles. Typical profiles representing the locations are shown in Fig. 3-6. The profiles enabled qualitative hydrogeophysical evaluation of the selected locations 1-4 on the study site. Generally, it was observed that the profiles show some considerably high amplitude (Filtered real) signals zones in all the traverses. Along Traverse 1 (TR1) such high amplitudes were obtained at station numbers, 16-18. At Traverse 6 (TR6) high amplitudes were obtained at station numbers 7-9. On Traverse 14 (TR14) station numbers 16 and 17 displayed high amplitudes. On Traverse 19 (TR19) station numbers 5 and 6 also displayed high amplitudes. The appreciably high amplitudes are thought to be occasioned by deep weathering or fractures and were further investigated using Vertical Electrical Sounding technique of the electrical resistivity method.

Vertical Electrical Sounding (VES) results: The results of the electrical resistivity data are presented as sounding curves, geoelectric sections and maps. The curve types obtained from the study area are A, H, K, QH, KH and HKH Fig. 7-10. The geoloelectric sections for the locations Fig. 11-18 revealed 4 subsurface geologic

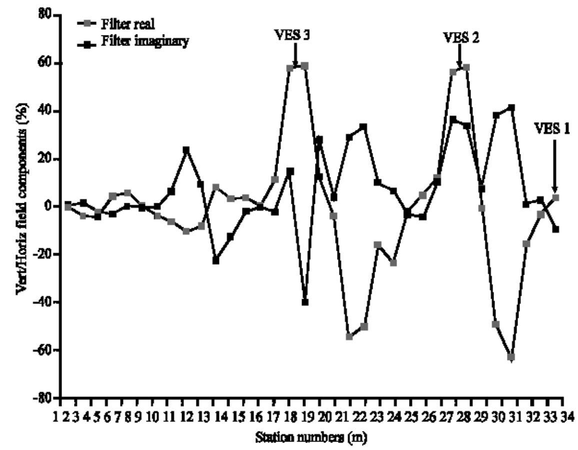

Fig. 3: VLF profile along Traverse 1 (TR1) of location 1

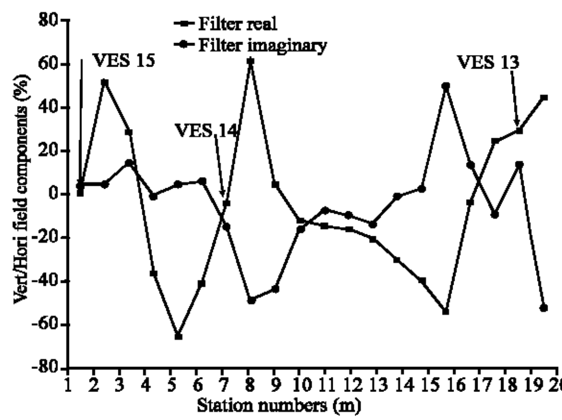

Fig. 4: VLF profile along Traverse 6 (TR6) of location 2

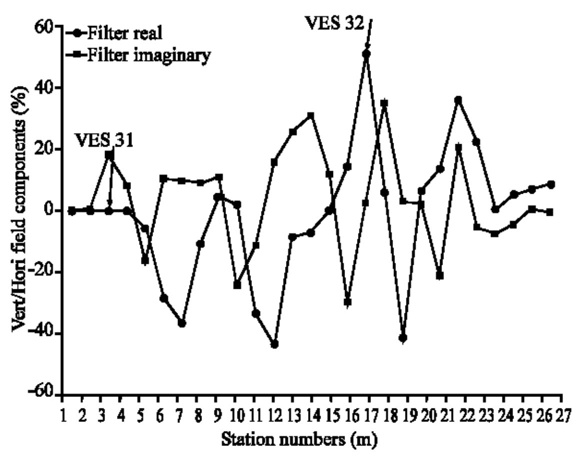

Fig. 5: VLF profile along Traverse 14 (TR14) of location 3

layers consisting of topsoil, weathered basement, fractured basement and resistive bedrock. The topsoil resistivity values range from 37-319 Ω-m at locatio 1,119-833 Ω-m at location 2, 179-319 Ω-m at location 3 and 75-318 Ω-m at location 4. The low resistivity (<100 Ω-m is

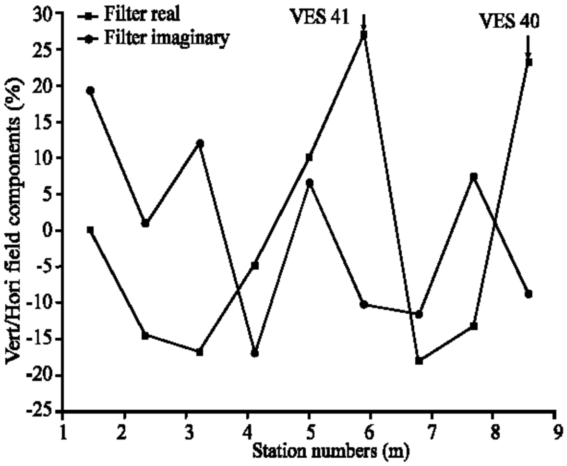

Fig. 6: VLF profile along Traverse 19 (TR19) of location 4

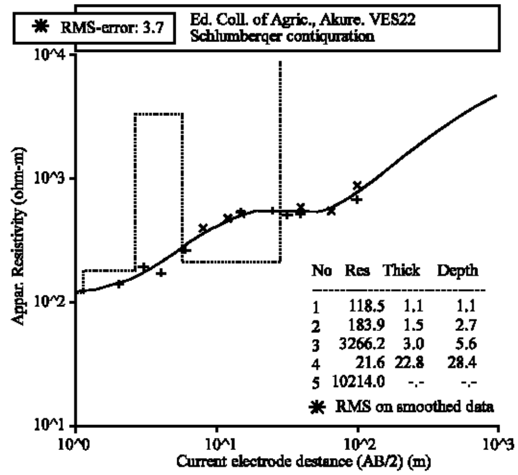

Fig. 8: Typical VES curves for location 2

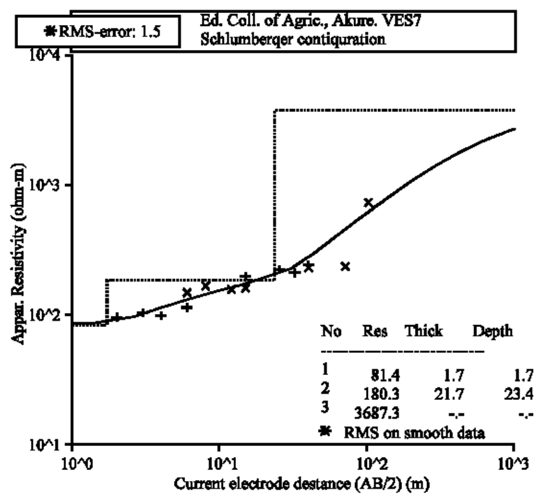

Fig. 7: Typical VES curves for location 1

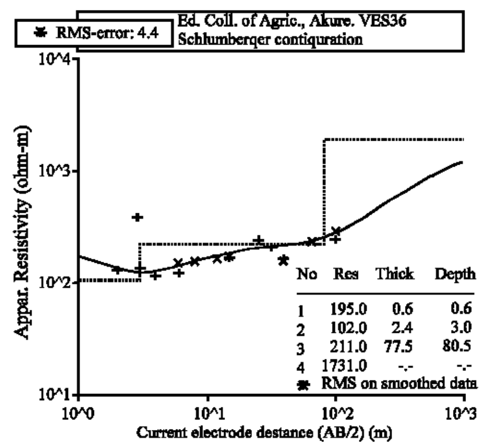

Fig. 9: Typical VES curves for location 3

a characteristic of clay while the high resistivity end (>100 Ω-m) may typify sandy clay, clayey sand and lateritic sand. Layer thickness ranges from 0.9-2.4 m (Location 1), 0.6-1.2 m (Location 2), 0.5-2.7 m (Location 3) and 0.4-3.8 m (Location 4).

The weathered basement resistivity values vary from 24-180 Ω-m (Location 1), 35-780 Ω-m (Location 2), 54-1.586 and 75-846 Ω-m (Location). The electrical resistivity characteristics of this layer are controlled by the degree of water saturation (Odusanya and Amadi, 1990). The thickness of this layer varies from 4.3-22 m (Location 1), 1.9-25.4 m (Location 2), 2.8-24.6 m (Location 3) and 1.3-23 m (Location 4).

The fresh bedrock resistivity values across the locations vary between 416 and 55,557 Ω-m. Study shows that the resistivity value of fresh bedrock often exceeds

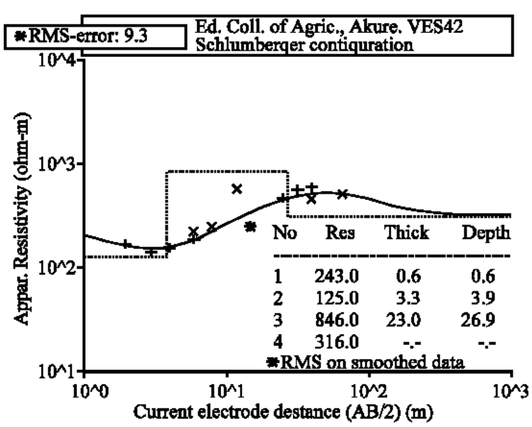

Fig. 10: Typical VES curves for location 4

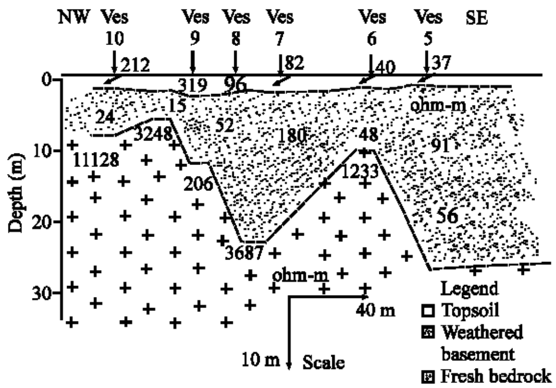

Fig. 11: 2-D geoelectric section along profile A-B of location 1

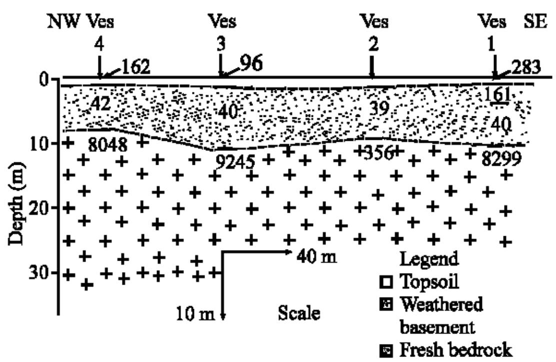

Fig. 12: 2-D geoelectric section along profile C-D of location 1

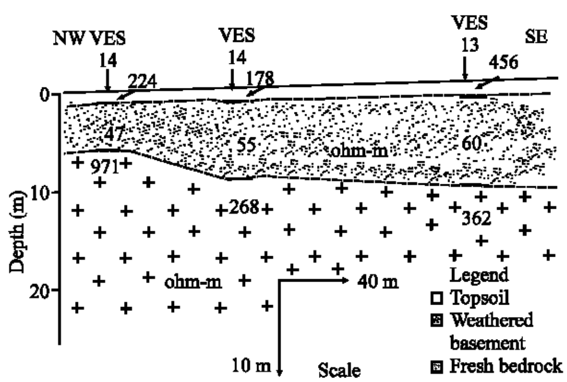

Fig. 13: 2-D geoelectric section along profile E-F of location 2

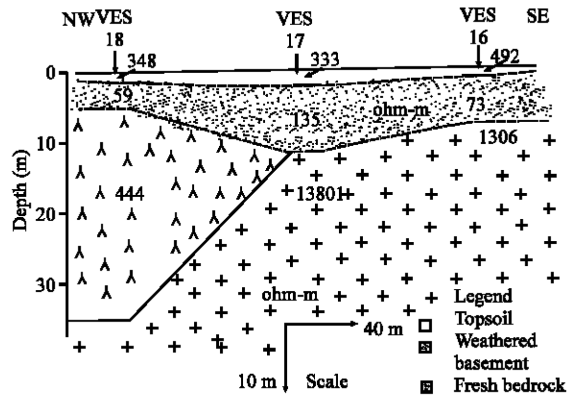

Fig. 14: 2-D geoelectric section along profile G-H of location 2

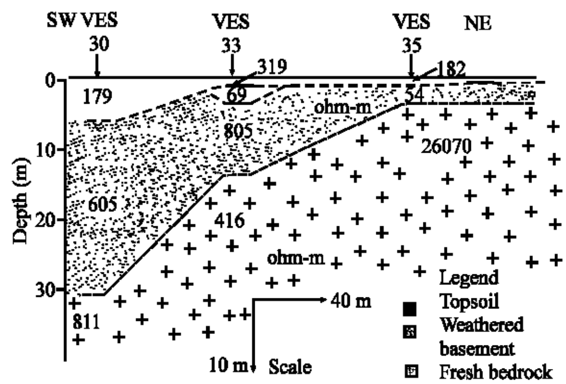

Fig. 15: 2-D geoelectric section along profile N-M of location 3

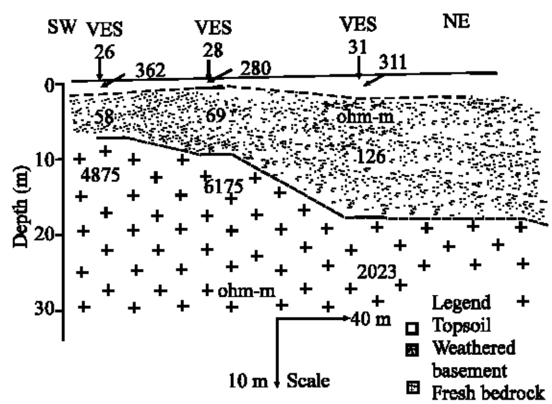

Fig. 16: 2-D geoelectric section along profile O-Q of location 3

1000 Ω-m, beside, where it is fractured/sheared and saturated with fresh water, the resistivity often reduces below 1000 Ω-m (Olayinka and Olorunfemi, 1992).

Overburden thickness map: The overburden thickness map of the study area is presented in Fig. 19. Overburden thickness in the study locations vary from 5-23 m (location 1), 2-35 m (location 2), 6-77 m (location 3) and 2- 26 m (location 4). This map shows area under lain by thicker overbuden materials labeled Z_1 at location 1, Z_2 at location 2, Z_3, Z_4 and Z_5 at location 3, Z_6 and Z_7 at location 4. The works of Okhue and Olorunfemi (1991) and Ike (2001) in similar geologic terrain revealed that areas underlain by thick overburden materials are high Bala groundwater potential zones. Consequently, zones designated Z_1-Z_7 are priority areas for groundwater development in the study locations.

Basement relief map: The bedrock relief map generated for the locations (Fig. 20) shows the subsurface topography of the bedrock across the study locations. The hydrogeologic significance of bedrock relief has been recognized by Okhue and Olorunfemi (1991), Dan-Hassan and Olorunfemi (1999), Olorunnfemi *et al.* (1999) and Bala and Ike (2001).

The map shows series of basement lows/depressions (D) and basement highs/ridges (R). D1, D2, D3, D4 and D5, D6, D7, R1, R2, R3, R4 and R5 are the designated areas for both the depressions and ridges zones delineated at locations 1-4, respectively. The depression zones are noted for thick overburden cover while the basement high/ridge zones are noted for thin overburden cover. Omosuyi and Enikanselu (1999) findings revealed that depressions zone in the basement terrain serves as groundwater collecting trough especially water dispersed from the bedrock crests. Thus, the zones marked D1-D7 are priority areas for groundwater development in the study locations.

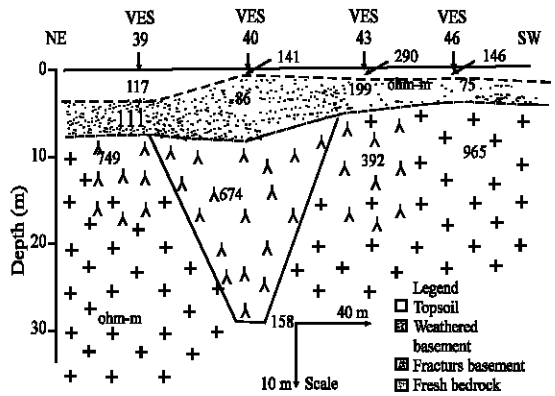

Fig. 17: 2-D geoelectric section along profile R-S of location 4

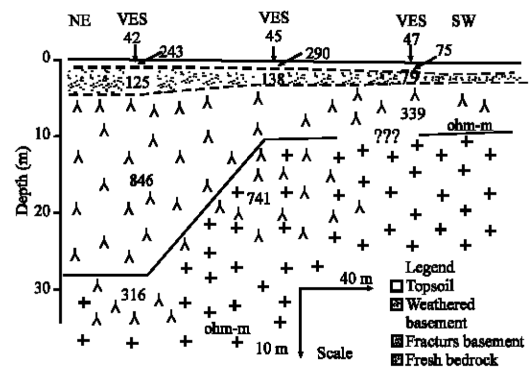

Fig. 18: 2-D geoelectric section along profile T-Y of location 4

Fig. 19: Overburden thickness map of the study area

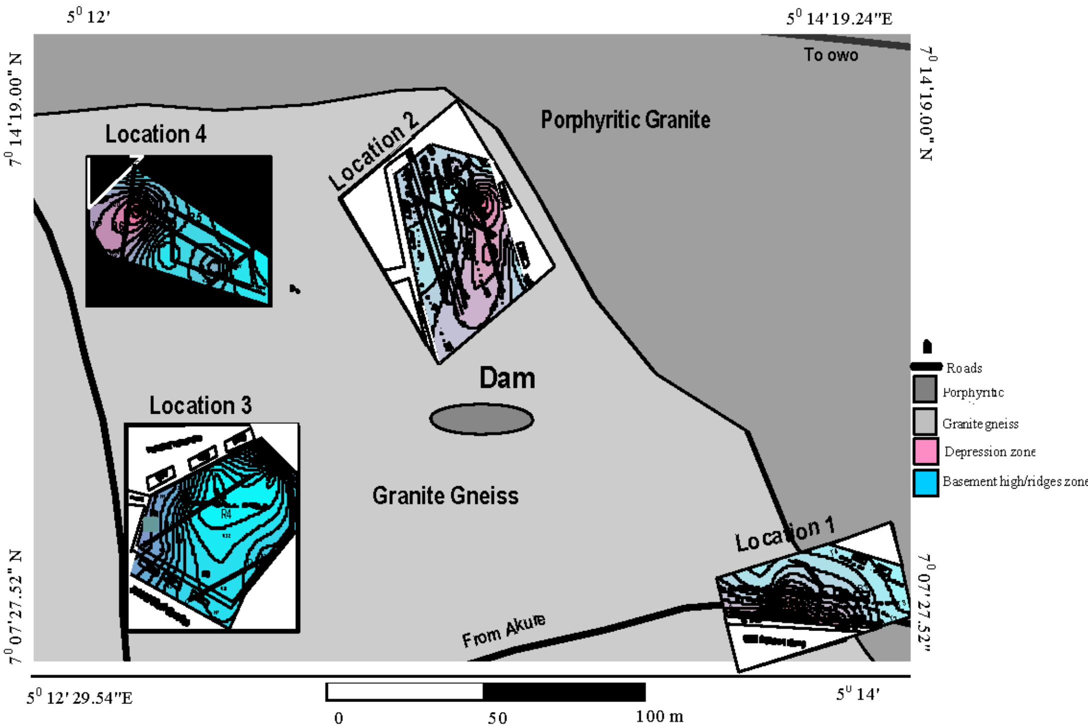

Fig. 20: Bedrock relief map of the study area

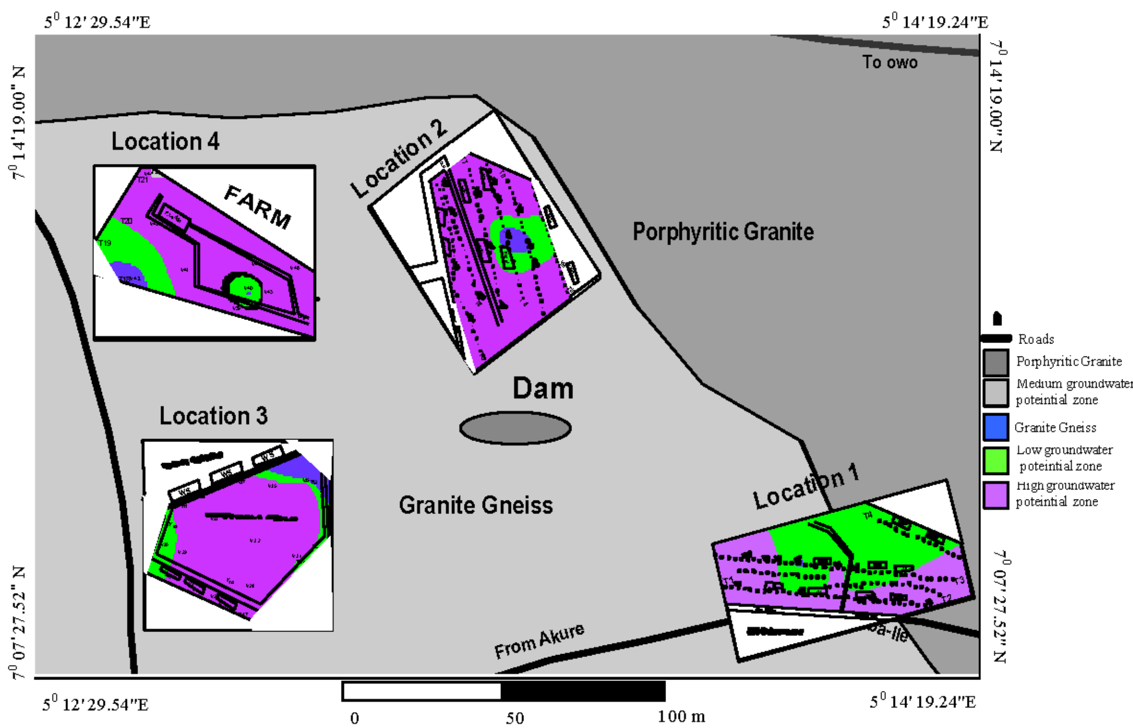

Fig. 21: Groundwater potential map of the study area

GROUNDWATER POTENTIAL EVALUATION

The groundwater potential of the study locations was evaluated based on the maps (i.e. overburden thickness and bedrock relief maps) generated from the characteristics geoelectric parameters, obtained from the VES interpretation results. The characteristic geoelectric parameters enabled the groundwater potential rating at each study locations. These ratings were used to evolve the groundwater potential map (Fig. 21) for the study area. The map present local groundwater prospects of the locations, zoned into high, medium and low potentials.

CONCLUSION

In this study, the groundwater potential evaluation of federal college of agriculture, Akure campus was undertaken. The study revealed that the high and medium groundwater potential zones underlie the northeastern area of Location 1, central area of Location 2, northeastern, western and southeastern areas of Location 3 and southwestern and parts of southeastern areas of locations 4. Northwestern and southeastern parts of Location 1, western and eastern parts of Location 2, central parts of Location 3 and northern and southern parts of Location 4 constitute the low groundwater potential zones. The VES stations underlain by high and medium groundwater zones in the study locations are envisaged to be viable for groundwater development within the College campus.

The results of this research provide reliable background information for elaborate groundwater planning and development in the College campus.

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