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INVESTIGATION OF CONCEALED LINEAMENTS FOR GROUNDWATER EXPLORATION AT THE KOGI STATE POLYTECHNIC, OSARA CAMPUS AND ENVIRONS, USING ELECTRICAL RESISTIVITY METHOD

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ABSTRACT

The electrical resistivity investigation of the Kogi State Polytechnic Lokoja, Osara campus was carried out with a view to providing geophysical information on the different sub - surface layers, depth, nature and thickness, structural trend and distribution of the fractured basement as potential sources of groundwater. Thirty - six vertical electrical sounding stations were established utilizing the Schlumberger electrode configuration. The electrical resistivity data obtained where interpreted using IPI2win (software for interpreting vertical electrical sounding). Results obtained from the interpreted geoelectrical sections indicates the presence of four subsurface layers comprising the top soil, weathered basement, fractured basement and the fresh bedrock. Also, confined and unconfined fracture basement was also noticed within the study area. The weathered basement and the fractured basement constitute the aquifer units. The Isopach maps reveal areas with high basement depressions and zones with basement high. The basement depressions are priority areas for possible groundwater abstraction in the study area. This fractured basement depth ranges from 10-35 metres. The weathered basement indicates high degree of saturation, and may however; fluctuate seasonally due the depth and the clay contents. The depth to the bedrock varies from 8 – 34 metres. Construction or design of foundation structure can also be guided by the depth to bedrock which has been determined.

Keywords: Polytechnic, Osara, Resistivity, Geoelectric

INTRODUCTION

In the Basement Complex area of Nigeria, the flow of groundwater is highly control by the nature and type of fracture that occurs within the basement complexes. However, as a result of overexploitation for groundwater which serve as the most reliable source of non - polluted water, aquifers zone are mostly limited to fractured portion in most of the basement complexes in Nigeria. Delineation and distribution of such fractures is therefore very necessary to exploit and stimulate groundwater. Delineation of thick fractured zones is possible by surface geophysical methods such as resistivity technique. Fracture zones in basement complexes play an important and critical role in fluid flow within the sub-surface, such as the movement and accumulation of groundwater as well as transport of contaminants. Mostly, the minor fractures present in the bedrock, if well-connected, can give copious supply of groundwater. In potential bedrock aquifers, individual boreholes must be targeted to intercept fracture zones or even a fracture that could be from 5–10 ft to less than 1 ft wide. The hydrogeologists need additional, site-specific information to precisely locate boreholes to intercept specific bedrock fracture zones. Delineation of fracture zones in such low permeability rocks is thus a challenging task. Of all the geophysical methods, resistivity method is the most suitable method for investigating fracture aquifers because the localization of fracture zones are based on the fact that they exhibit lower resistivity compared with the undisturbed rocks (Sabnavis and Patangay, 1998).

SITE DESCRIPTION AND GEOLOGY

Figure 1 shows the location of the study area. The geographic coordinates of the study area are latitudes 7^0 $47'$ to 7^0 51' N and longitudes 6^0 $40'$ to 6^0 45' E falling within Geological Survey of Nigeria, 1:250,000 sheet 62 (Lokoja) (1986). The study area is accessible through federal trunk A road from Abuja via Lokoja to Okene.

The study area lies within the basement complex of the North-Central Nigeria. The rocks within this basement complex are grouped into three categories; these are the older granites, gneiss and mignetite; the older metasediments; and the younger metasediments. According to Ajibade and Wright (1980), the rocks of the basement complex are believed to have evolved in at least four orogenic events namely: the pan African (600±150My), The Kibaran (1100±200My), The Eburnian (2000±200My) and the Liberian (2800±200My). The migmatite – gneiss complex dominates the basement complex in the study area consisting of fairly uniform biotite and biotite – hornblende – gneisses with locally intercalated bands of amphibolites and quartzite (Geological Survey of Nigeria, 1986).

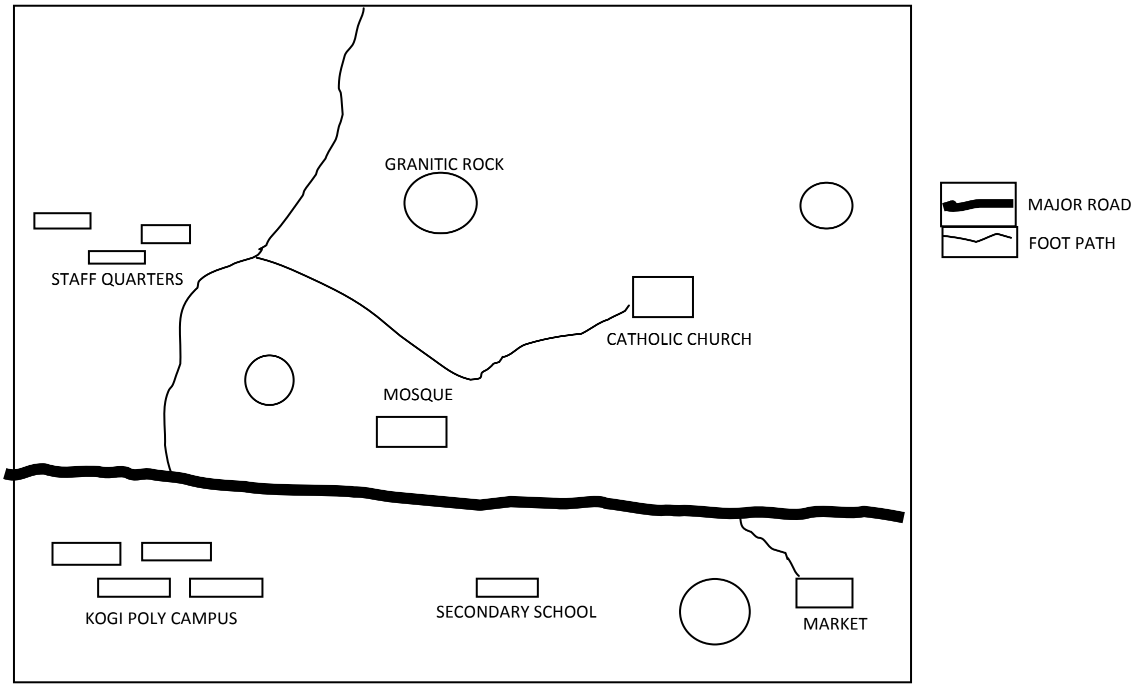


Figure 1: Sketch Map of the Study Area

METHODOLOGY

Geophysical survey involving the vertical electrical sounding (VES) was carried out along six profiles at a separation of 200 metres within the school campus and the surrounding community.

The vertical electrical sounding (VES) was carried out using the ABEM terrameter SAS 1000. A total of 6 vertical electrical soundings spaced at a station interval of 100m were taken on each profile (Figure 2). A maximum current electrode spacing (AB) of 300m was used with the aim of probing a depth of at least 1/3 of AB. A current variation in the range of 0.2-1.0A, found suitable in the basement terrain (Badmus et al., 2005), was used in the survey.

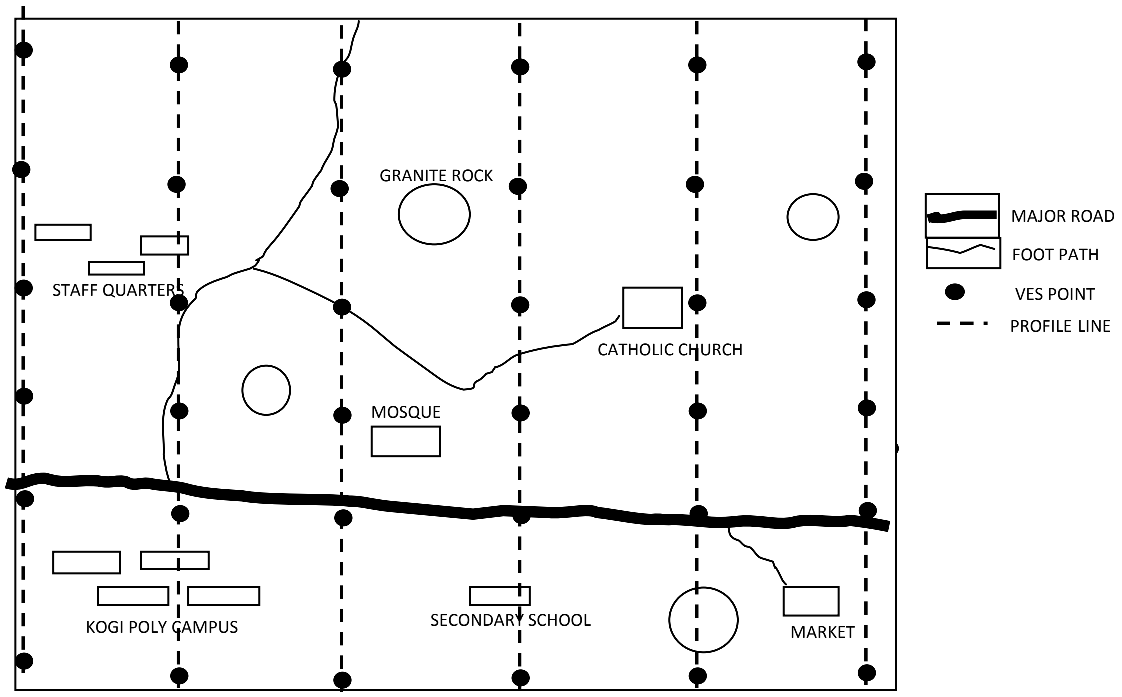
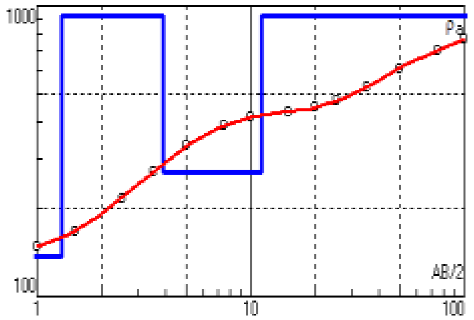


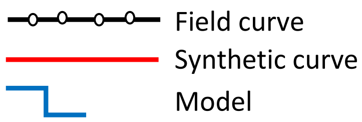
Figure 2 Profile Layout Positions on the Study Area Showing the VES Points

RESULTS AND DISCUSSION

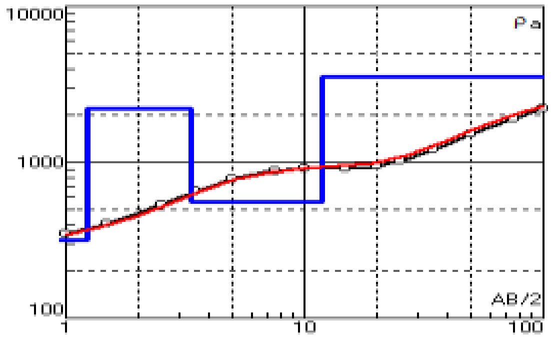
The interpretations of geophysical data involve, expressing the information obtained from the surface measurements into geological section/form from which both qualitative and quantitative deductions can be made.

The apparent resistivity values at each sounding point have been calculated from the resistance values obtained on the field. The apparent resistivity values calculated are presented as sounding curves for all the VES points using IPI2Win, a software designed for interpreting vertical electrical sounding data (Bobachev, 2001). Six curve types have been identified within the study area. These are, AK, HK, HA, AH, KH, and QH. Typical curve types obtained from the field are shown in Figure 3 along with their model interpretations.

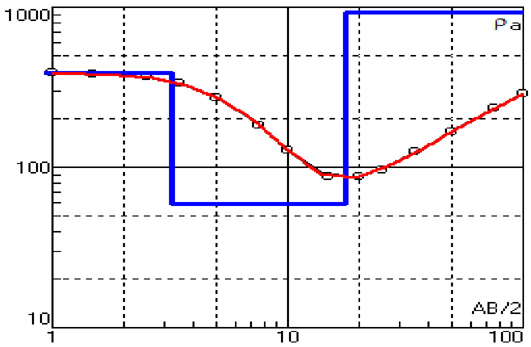




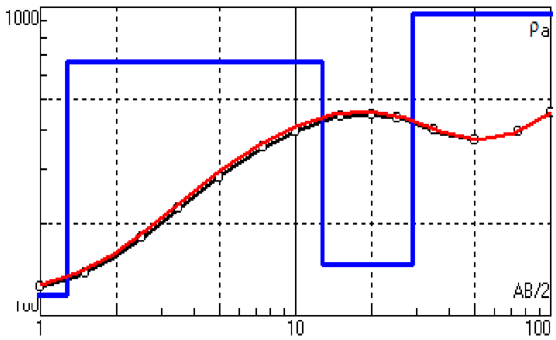
N	ρ	h	d
1	137	1.3	1.3
2	924	2.6	3.9
3	266	7.4	11.3
4	924		



N	ρ	h	d
1	316	1.2	1.2
2	2209	2.1	3.3
3	559	8.5	11.8
4	3542		



N	ρ	h	d
1	389	3.2	3.2
2	59	14.4	17.6
3	927		



N	ρ	h	d
1	116	1.3	1.3
2	665	11.5	12.8
3	145	16.1	28.9
4	950		

Figure 3: Examples of the Sounding Curve Obtained and their Model Interpretation using IPI2Win

The 2D geoelectric/geologic sections along the 6 profiles are shown in Figures 4-9. Four geoelectric/geological subsurface layers comprising the top soil, weathered layer, partly weathered/fractured basement and the fresh bedrock have been delineated.
The top soil is composed of sandy clay or clayey sand with resistivity values of 180-300 Ωm and thickness of between 0.50-4.0 metres. With the exception of profile BB, CC and DD the entire top layer of the others are generally less than 2 metres thick.

The second layer is the weathered basement with resistivity values that vary between 84-170Ωm and thickness of between 0.60-25.0 metres. It indicates a high degree of saturation, suggesting that the layer corresponds to the aquiferous zone in the area. However, due to the low resistivity of some of the VES point for this layer, there is indication of possible clay materials within the weathered basement.

The third layer is the partly weathered/fractured basement with resistivity and thickness values of 200-450 Ωm and 9.0-35 metres respectively. From the 2D Geoelectrical/geologic sections, there are indications of confine fractures within the basement especially in profile A-C.

The fresh basement shows very high resistivity value, greater than 500 ohm-m indicating non porous and permeable media. This forms the bedrock rock of the entire study area.
The prominent fracture zones are restricted within a depth of 8.0 to 35.0 metres below the ground level. Since the study area shows a four layered case, the 2nd and 3rd layers are interpreted as potential ground water horizons from which a good amount of ground water can be exploited. In this case, the second layer represents weathered zone and the third layer represents partially weathered zone or fractured zone.

From the geophysical investigation results obtained, it is inferred that the thickness of the aquifer varies from place to place. In most part of the study area the thickness of the aquifer materials is more than 25.0 metres. The potential aquifers are confined to weathered and fractured migmatite rocks of the basement complex of the North Central Nigeria.

The geophysical investigation of the area reveals that, it has high potentiality for exploitation of ground water through different kinds of groundwater structures. However, depending on the depth to massive bedrock, suitable ground water structures may be developed.

The depth to the fresh basement within the study area was between 8.0 metres to 34.0 metres (figure 12). It was also observed predominantly within the study area that the depth to the fresh bedrock was generally above 16.0 metres.

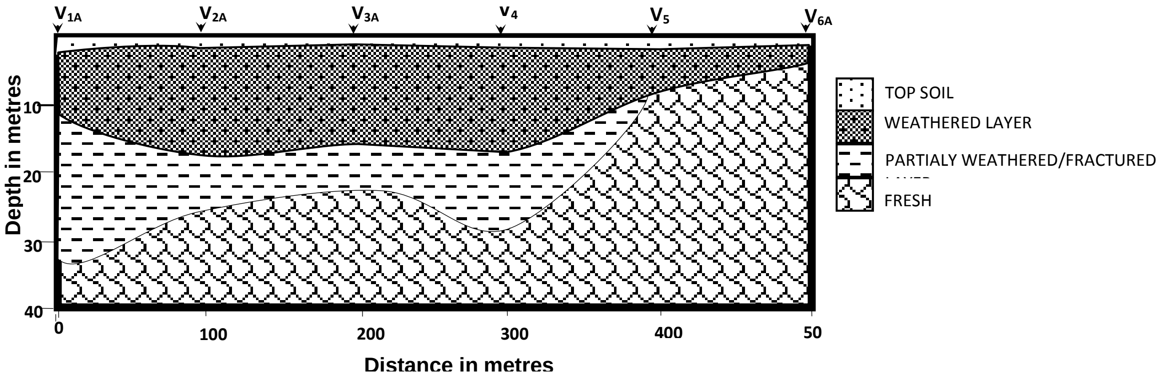


Figure 4 Geoelectric/Geologic Sections along Profile AA

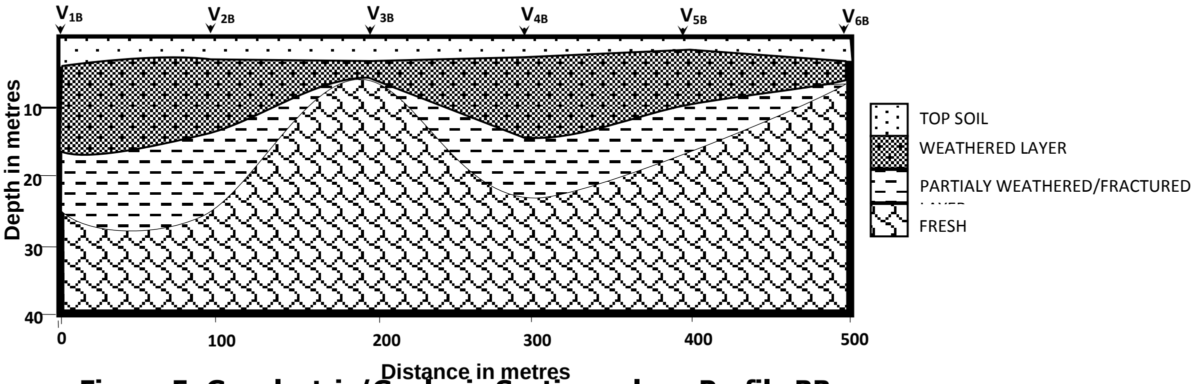


Figure 5: Geoelectric/Geologic Sections along Profile BB

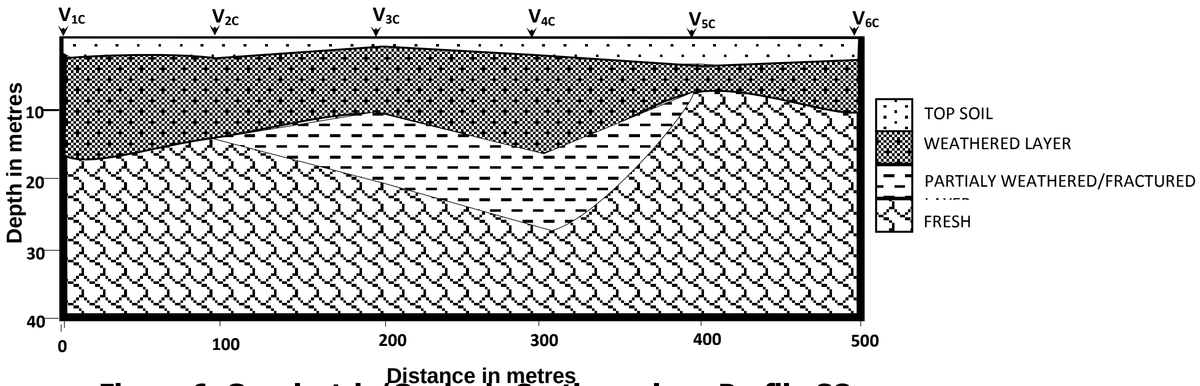


Figure 6: Geoelectric/Geologic Sections along Profile CC

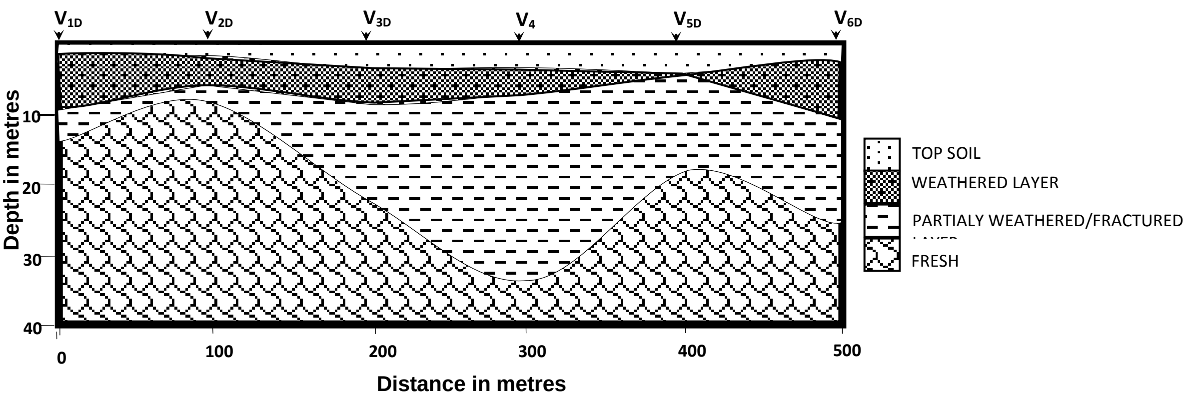


Figure 7: Geoelectric/Geologic Sections along Profile DD

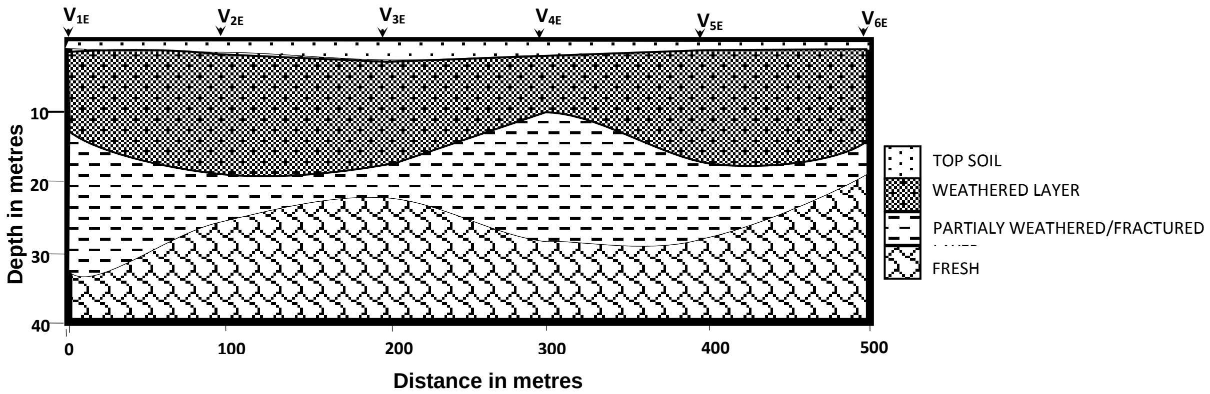


Figure 8: Geoelectric/Geologic Sections along Profile EE

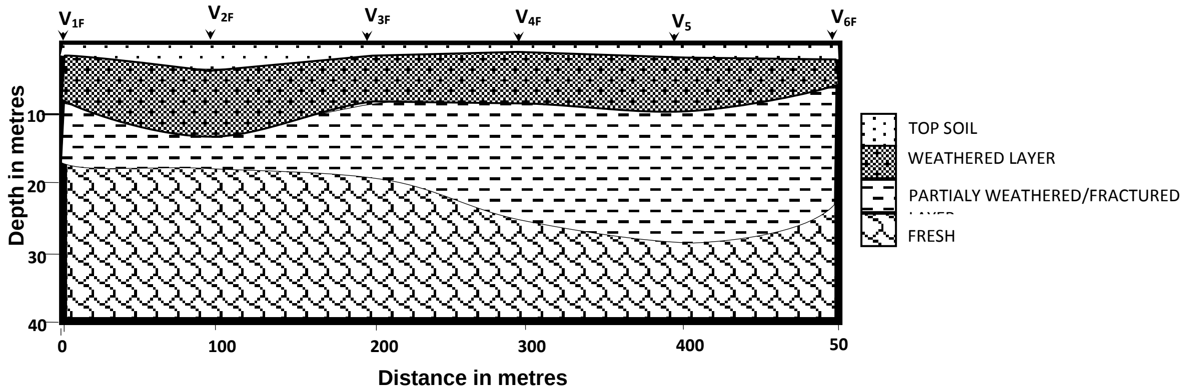


Figure 9: Geoelectric/Geologic Sections along Profile FF

ISOPACH MAP OF THE WEATHERED BASEMENT

The Isopach map of the weathered basement is as shown in Figure 10. From the map, the thickness of the weathered basement ranges from 0 to 26m. This thickness is reliable for groundwater accumulation especially within the areas where the thickness is generally above 12 metres.

ISOPACH MAP OF THE FRACTURED BASEMENT

Figure 11 show the isopach map of the fractured basement. It is clearly seen from the map that the fractures are confined within the study area. However some unconfined fractures exist. These fractures show some North-East South-West trends. Toward the North-West there are virtually absences of fractures.

DEPTH TO THE FRESH BASEMENT

From figure 12 it can be noticed that the depth to basement is generally greater than 16 metres except for the portion where the major road pass through. This shows that the overburden burden covering the fresh basement is thick enough to accumulate enough water for groundwater exploitation activities. Also it can be deduced that the road pavement is been sited on a solid foundation which geotecnically, the road is free from most geological factors that aid road pavement failure.

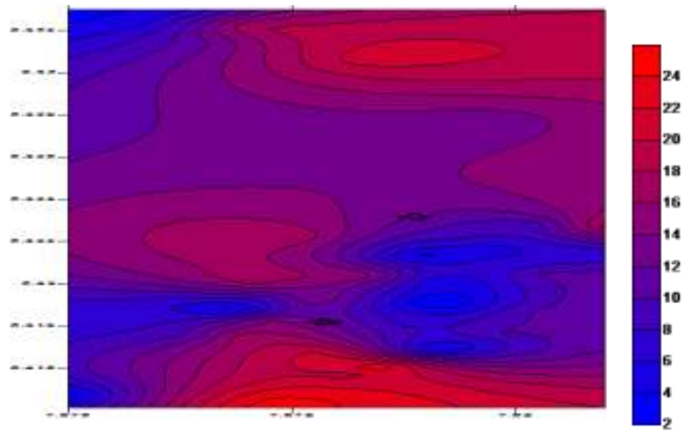


Figure 10: Thickness of the Weathered Basement

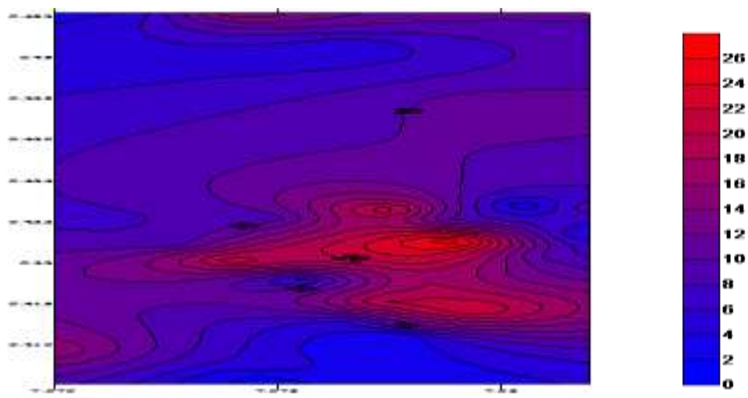


Figure 11: Thickness of the Fractured Basement

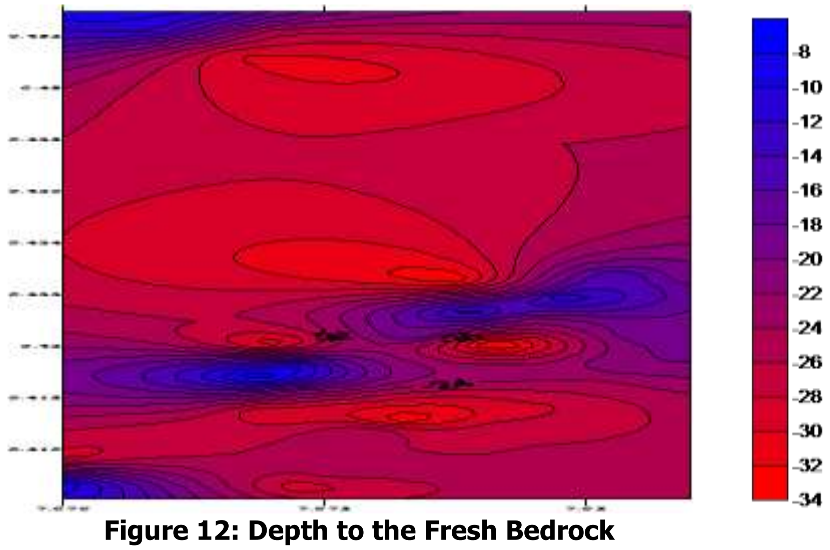


Figure 12: Depth to the Fresh Bedrock

IMPORTANCE OF UNDERGROUND STRUCTURES WITHIN THE STUDY AREA

Within the study area, a variable thickness of weathered material was encountered over migmatite or granite gneiss of the basement complex. The latter was a regolith produced by *in situ* weathering of the basement rocks (Acworth, 1987). The regolith normally grades into solid, unfractured basement over several tens of metres. Often the boundary between the two may be fairly sharp. Hydrogeologically, the weathered overburden has high porosity and contains a significant amount of water, but it has low permeability because of its relatively high clay content. The bedrock on the other hand was fresh but frequently fractured, which gives it high permeability. However, as fractures do not constitute a significant volume of the rock, it has low porosity. For this reason a good borehole, providing long term high yield, is one which penetrates a large thickness of regolith or large areal extent of regolith with fractures, which acts as a reservoir, and one which additionally intersects the fractures in the underlying bedrock. These structures (called concealed lineaments and fractures) provide a rapid transport mechanism from the reservoir and hence the high yield. Boreholes which intersect fractures, but which are not overlain by thick saturated regolith, cannot be expected to provide high yield on a long term. But boreholes which penetrate saturated concealed lineament find fractures in the bedrock are likely to provide sufficient yield for a hand pump.

CONCLUSION

The resistivity investigation carried out delineates the presence of four subsurface layers which comprised the top soil, weathered basement, fractured basement and the fresh bedrock.

The weathered and the fractured basement serve as potential aquifers for groundwater exploration within the area. Also the thickness of the weathered layers were reasonable to support the continuous supply of water from any borehole sank within the area. However the North-West portions of the area lack sufficient fractures and the thickness of the overburden was also thin for groundwater exploration activities.

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