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Fracture Distribution within Bowen University Permanent Site and Its Hydrogeologic Implication

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Abstract

One of the problems that may be facing any community as large as Bowen University is the location of portable sources of water. A combined analysis of VLF data and lineament length density from SLAR (Side Looking Airborne Radar) imagery were used to assess the hydrogeological condition of Bowen University permanent site. The electromagnetic profiling method was employed to delineate fracture zones within the area which aided in the determination of the position of the deepest fracture zones where productive boreholes could be constructed. Prominent lineaments mapped from SLAR imagery varies from 0.72km to 1.39km for long lineaments and 0.11km to 0.56km for short lineaments. The contour map constructed from the VLF data and the lineament density contour map constructed from lineament length values showed the Northeastern parts as feasible and remain the best site for groundwater and any other hydrogeologic development.

Keywords: Side Looking Airborne Radar, Fracture, Lineament, Transverse, Profile, Inflection point.

Introduction

Buildings are expected to have certain characteristics that make them attractive for many uses which may be residential, commercial, educational and industrial to meet people's needs. Characteristics of a good building including provision of security, safety to lives and properties, convenience, in addition to social, psychological and economic satisfaction derived by occupiers[1].

Mapping of bedrock configuration is important for both civil engineering and hydrogeological purposes[2]. In civil engineering, it helps to determine the appropriate and safest depth to place the foundation of our buildings. The geological importance of distribution of fractures in an area cannot be overemphasized. It determines the competency or otherwise of the underline rocks. Areas that is extensively fractured and where the factures are deep are considered as weak zones and are considered best or suitable zones for groundwater development. But areas that is slightly fractured and where fractures are not deep are considered as competent zones and are considered better sites for engineering purposes[3].

The purpose of this study is to use a combined method of very low frequency (VLF) electromagnetic profiling to map and study the bedrock configuration and Side Looking Airborne Radar (SLAR) imagery to study the lineament pattern of the study area. These combined methods of analysis are expected to possibly reveal the distribution of fractures within the area. Fractures are basically defined as a break in a rock or mineral, across which there is a separation, while lineaments are naturally occurring alignment of soil, topography, stream channels, vegetation's or a combination of these features that are visible on remotely sensed imagery aerial photographs.

Materials and Methods

Profiling: The instrument used for the VLF profiling is the Abem Wad; VLF. A total of six transverse were established in either west to east or north to south directions. The reading was recorded at an interval of 20metres. The recorded values of the filtered real from the VLF were used to produce 2D profiling and contour maps of the study area.

Lineament Identification: For the lineament analysis, Side looking Airborne Radar (SLAR) map of sheet number NC31-15S was used. The map was obtained from ministry of Agriculture and Rural Development, Federal Department of Forestry (FORMECU)- idi-Ishin, Ibadan.

The area covered in the study was mapped out from the map sheet and divided into a number of cells. The lineaments observed in each cells were traced out on transparent paper (tracing paper) placed over the images with the aid of a hand lens. Prevalent orientations were noted and compared to known geological structural features in the area. The length of each lineament was determined using tread whose length was measured in a ruler in centimeter which is then converted to kilometer. The summary of the lineament length obtained is as shown in Table 1. On the basis of this, a lineament length density contour map of the study area is produced.

$L_D = \frac{\sum_{i-1} L}{A}$ Lineament length density is defined as the total length of all recorded (mapped) lineaments divided by the area[4].

L_D =Lineament length density (km^{-1}), $\sum_{i-1} L$ = Total length of all lineaments, A =Area under consideration

The Study Area: The study was conducted within Bowen University Permanent site in Iwo Southwestern Nigeria, located between latitude7°50' to 8°00' and longitude 4°00'to 5°00' in south western Nigeria precambrian basement complex comprising predominantly migmatized and undifferentiated gneisses, schist and quartzite. Locally, the rock sequence in the study area consists of fine grained biotite gneiss, quartzite's schist complex of Precambrian age[5].

The gneiss complex underlain the northern and southern part of the study area and constitute a considerable larger area with rock exposures. The rocks appear to be readily weathered and give rise to an undulating topography dipping in a north-south direction and cross cutting by numerous bands and lenses of pegmatites at several locations.

The topsoil association of the site is the Fasola and Ajawa groups with great fertilities, which support good agricultural practice. They have fine texture and are of variety of colour ranging from brown to brownish red, fairly brownish yellow and white clay, and are of average thickness of 50mm[6]. Generally Iwo is located in southwest Precambrian basement complex of Nigeria, predominantly composed of; oldergranite, migmatite gneiss complex, dolorite dykes and charnockitic rocks

Results and Discussion

The results were presented as VLF electromagnetic profiles. The graphs of filtered real values were plotted against distance measured in metres and these revealed variations in conductivity along the profiling lines. The positive peaks represent the conductive (fractured) zones while the negative peaks are indicated of non-conductive zones. The series of positive peaks alternated with negative peaks along the six profile lines revealed that the study area is fractured and that these fractures are well distributed across the area.

The analysis of the SLAR imagery was also used to corroborate the results of the VLF survey, since the main assumption inherent in performing any lineament analysis is that the alignment represents fracture zones or other discontinuities. The result of the VLF profiling were discussed qualitatively while the result of the lineament analysis were discussed both quantitative and qualitatively.

VLF Profiles: Profile 1: The profile has a lateral extent of 350m (figure-1), the station positions 50m, 120, 180 and 300metres exhibit negative peaks which are indicative of competent or non-fractured zones along the profile while the station positions 90,150 and 200 metres exhibit positive peaks which are indicative of fractured or weak zones. The very sharp inflection point at station position 260 metres indicates contact between two rocks along the profile line.

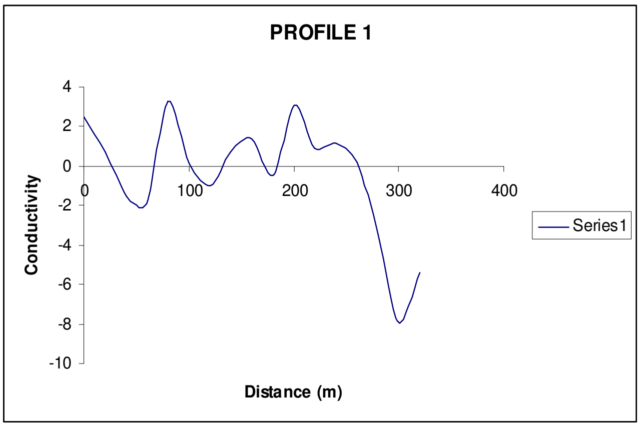

Figure-1
Profile 1

Profile 2: The profile covers a total of 350m (figure-2). The profile shows negative peaks at station position 20, 100, 180, 270 and 320 metres which are indicative of competent zones along the profile. Positive peaks which are interpreted as fracture zones are observed at station positions 50,130, 200 and 300 metres along the profile line.

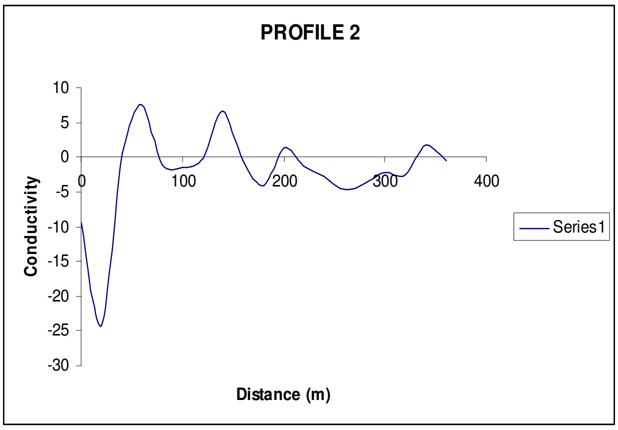

Figure-2
Profile 2

Profile 3: This is shown in figure 3. It covers a length of 300metres. Negative peaks are observed at station positions 30,120, 180 and 120 metres. These points are again interpreted as competent zones along the profile line. Very sharp positive peaks are observed at station positions 50, 150, and 270 metre and these points remains the most fractured zones along the profile line and within the study area.

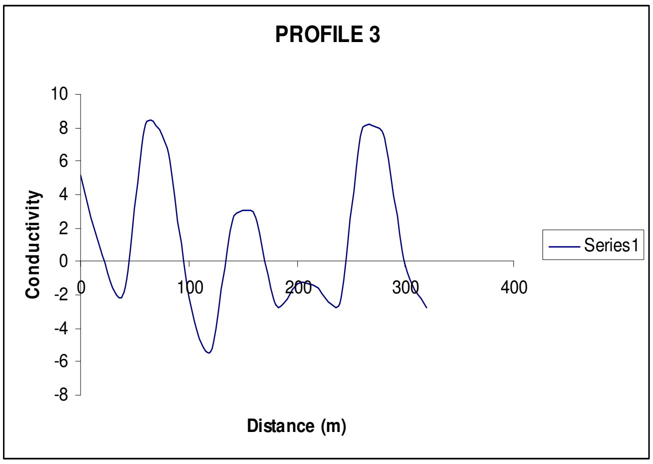

Figure-3
Profile 3

Profile 4: Profile 4 (figure4) has a total length of 380metres. Negative peaks which are indicative of component zones are exhibited at station positions 70, 120, 180, and 320 metres. The broad nature of the negative peaks at station position between 110 and 220 metres is perhaps due to an un-differentiated rock of very large area of extent.

The positive peaks observed at station positions 30, 90, 130, 260 and 360 metres along the profile line are attributed to fracture or weak zones along the profile line. The very sharp positive peaks observed at station points 30 and 260 metres could be an extension of fractures in profile 3.

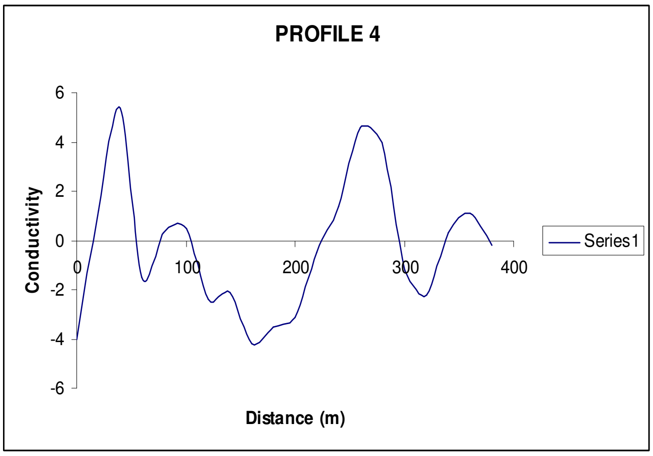

Figure-4
Profile 4

Profile 5: Profile 5 (figure 5) has a lateral extent of 350 metres. The station positions 50, 110 and 280 metres exhibit negative peaks which are indicative of competent zones along the profile line while positive peaks were exhibited at station positions 20, 180, 250 and 320 metres along the profile line and these points are interpreted as competent zones along the profile line.

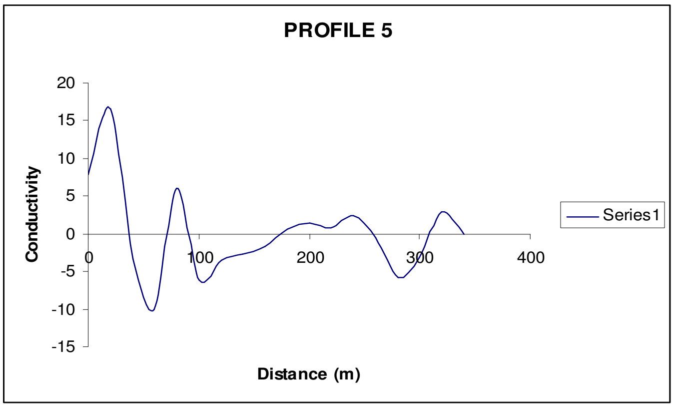

Figure-5
Profile 5

Profile 6: Profile 6 (figure-6) has a total length of 270metres. Negative peaks which are indicative of competent zones are observed at station points 20, 120 and 200 metres. The broad negative peak observed along station 200metres is perhaps an extension of the undifferentiated rock observed at profile 4 (figure 4). The positive peaks are observed at the station points 75, 150 and 250 metres are interpreted as fracture or weak zones along the profile line. The broad positive peaks on profile 6 may not be due to deep fractures, but may be due to shallow fracture of large area of extent while the inflection point at station point 260 metre could be interpreted as contact between two different rocks along the profile line.

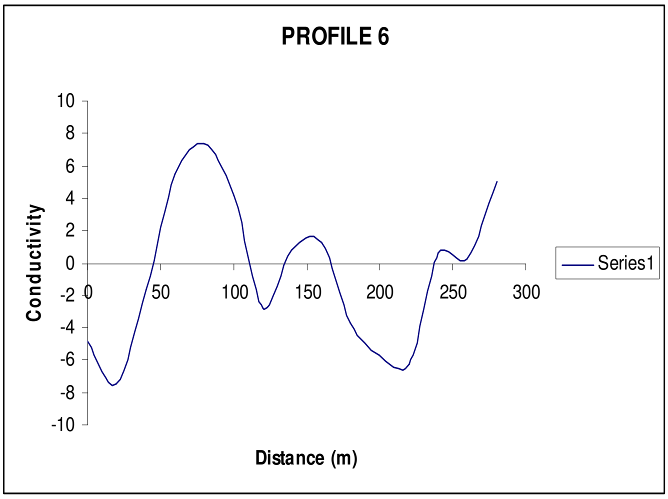

Figure-6
Profile 6

Lineament Analysis: The summary of the length values from the lineament map of the study area is as shown in table 1. The long lineaments ranges between 0.72km to 1.39km while the short ones ranges between 0.11km to 0.56km. The long lineaments are associated with deep fractures while the short ones are interpreted as shallow fractures.

Table-1
Summary of the length Values from the lineament Map of the study area

	1	**2**	**3**	**4**	**5**
A	0.92	0.79	1.04	0.54	0.51
B	0.46	0.46		0.73	1.39
C	0.46		0.11	0.85	0.19
D	0.31		0.42	0.42	0.73
E	0.74		0.56	0.80	0.72

Contour MAPS: Conductivity Contour MAP: The conductivity contour map constructed from the VLF data obtained from the study area is as shown in figure-7. The constructed, colored map showed low and negative conductivities between -24σ to -16σ (green colour), -16σ to -8σ (yellow colour) and -8σ to 0σ; these zones are interpreted as competent zones with probably undifferentiated basement rocks. The zone with conductivity value between -24σ and -16σ (green colour in the Southwestern part of the study area) is observed to have the least conductivity values and so, remain the most competent zone within the study area.

The observed positive conductivities ranges between 0σ to 8σ (blue color) and 8σ to 16σ (cyan color). The highest conductivity is observed between 8 and 16 (cyan color) and in the Southeastern parts of the study area. So, by implication remains the most fractured zone and the best site for groundwater development though might not be a deep fracture as shown in profile 6.

Lineament Density Contour Map: The lineament density contour map (figure-8) was constructed from the lineament values in table1. Zones with very short lineament length values -0.05 to 0.05km (pink color) and 0.05 to 0.25km (red color) are observed in the North central and trends towards the southwestern portion of the study area, with the shortest length values -0.05 to 0.05km (pink color) observed conspicuously in the southwestern portion of the area. The short lineament values are indications of shallow weathering or shallow faults, so by implication, the south western portion remains the most competent zone in the study area and this agrees well with the result of result of VLF conductivity contour map in figure-7. The longest lineament length values 1.25 to 1.35km (dark brown color) was observed in the North Eastern part of the study area and this are associated with deep fractures.

Since low or negative conductivities values and short lineament length values are associated with shallow fractures which are interpreted as competent zones, the South Western part of the study area remain the only feasible zone for the errection of heavy structures. This justified the siting of the university worship center (chapel), new female hostel and the new university library in the Southwestern part of the university permanent site. Other areas that are still good for engineering works includes the Northwestern, central, and some parts of Northeastern parts of the study area. Other zones or parts with long lineament length values and high conductivity values with positive peaks especially in Northeastern and southeastern parts of the study area are better sites for hydrogeological purposes.

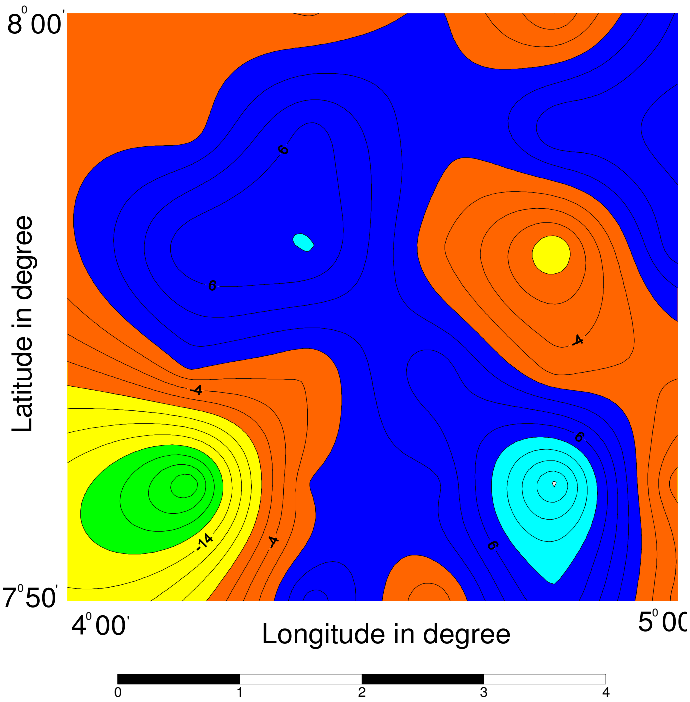

Figure-7
Conductivity contour map of the study area

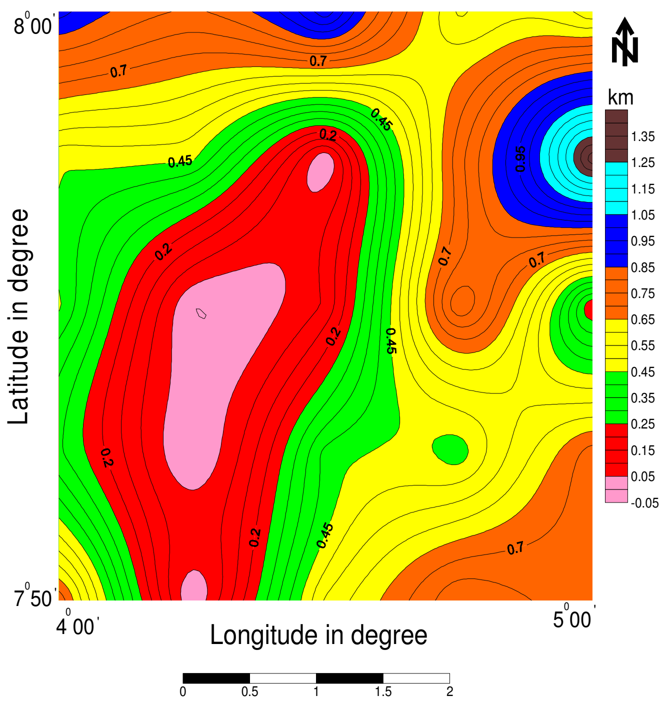

Figure-8
Lineament density contour map of the study area

Conclusion

The combined methods of VLF and lineament analysis of the data from Bowen University permanent site was carried out. The study revealed a network of geologic features which are the reflections of the basement pattern within study area.

The south western, Northwestern, central and some parts of Northeastern parts of the study area are considered feasible for any engineering purposes while the Northeastern and southeastern parts remain the best site for ground water development.

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