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INTEGRATED GEOPHYSICAL INVESTIGATION OF SEQUENCE OF DEPOSITION OF SEDIMENTARY STRATA IN ABAKALIKI, NIGERIA

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ABSTRACT

Both seismic refraction and electrical resistivity surveys were run in Abakaliki, Nigeria along the same profile. The objective was to investigate the sequence of deposition of sediments in the area. Abakaliki is a sedimentary area located geographically within latitude 6^0 17^I – 6^0 20^IN and longitude $8^0 05^I$ – 8^0 10^IE.and situated within the lower Benue trough with a total land mass of about 81km^2. ABEM Terrameter (SAS 300C) and its accessories were used for the resistivity survey while a signal enhancement seismograph (MOD.S79) was the major equipment for the seismic refraction survey. Five geoelectrical layers were delineated by the current in the resistivity survey while only three geoseismic layers were delineated by the compressional waves used in the seismic refraction survey. The three geoseismic layers had average compressional wave velocities of 725m/s, 1994m/s and 3168m/s; for the first, second and third layers respectively. The thicknesses of the first and second layers were 1.70m and 2.78m respectively. These layers were interpreted to be probably made up of lateritic overburden, clay and carboniferous siltstone for the first three layers respectively. The resistivity result however showed that the first five layers of the study area from the surface with resistivities 872.94Ωm, 268.34Ωm, 1169.84Ωm, 176.17Ωm and 80.67Ωm consists of lateritic overburden, ferruginised clay concretions, siltstone bed, well compacted but fissile shale bed and well consolidated and mineralized layer from top to bottom for the first five layers from the earth's surface respectively.

Keywords: seismic, geophones, seismograph, refraction.

INTRODUCTION

Sedimentary rocks form as layer upon layer of sediments accumulate in various depositional environments. These layers called strata or beds are probably the single most characteristic feature of sedimentary rocks. The thickness of beds ranges from microscopically thin to tens of meters thick. Separating the strata are bedding planes. Generally, each bedding plane marks the end of one deposit and the beginning of another. Unconsolidated sediments are transformed into solid sedimentary rocks through a process called lithification. Sedimentary rocks are lithified by compaction, cementation or a combination of both (Tarbuck and Lutgens, 1957). This work aims at investigating the depositional sequence of strata in Abakaliki. Abakaliki is located within latitude 6^0 17^I – 6^0 20^IN and longitudes $8^0 05^I$ – 8^0 10^IE. It is situated in South-Eastern Nigeria and lies within the southern part of the Benue trough. The Benue trough is an intra-continental cretaceous basin about 1000km in length stretching in NE to SW direction and resting unconformably upon the Precambrian Basement (Kogbe, 1989). The oldest sediment in the trough was deposited in the mid-Albian. Outcrops of the Albian age are well developed in the trough where they generally outcrop in the main anticline structure (Abakaliki anticlinorium). The Albian sediment constitute the Asu River group and its lateral equivalent (Kogbe, 1989). This work involves the combined use of the seismic refraction and electrical resistivity methods. In the refraction method, the detecting instruments record seismic signals at a distance from the shot point that is large compared with the depth of the horizon to be mapped. The explosion waves travel large horizontal distances trough the earth and the times required for the travel at various source - receiver distances give information on the velocities and depth of subsurface formations along which they propagate. The method thus provides data on the velocity of the refracting beds which allows the geophysicist to identify them or specify their lithology (Dobrin, 1976).

The electrical resistivity method on the other hand gives information on formations or bodies having anomalous electrical conductivity. The resistivity of a formation is the reciprocal of the electrical conductivity.

Both methods, seismic refraction and electrical resistivity, has been jointly used to investigate the sequence of deposition of sediments in Abakaliki.

MATERIALS AND METHOD

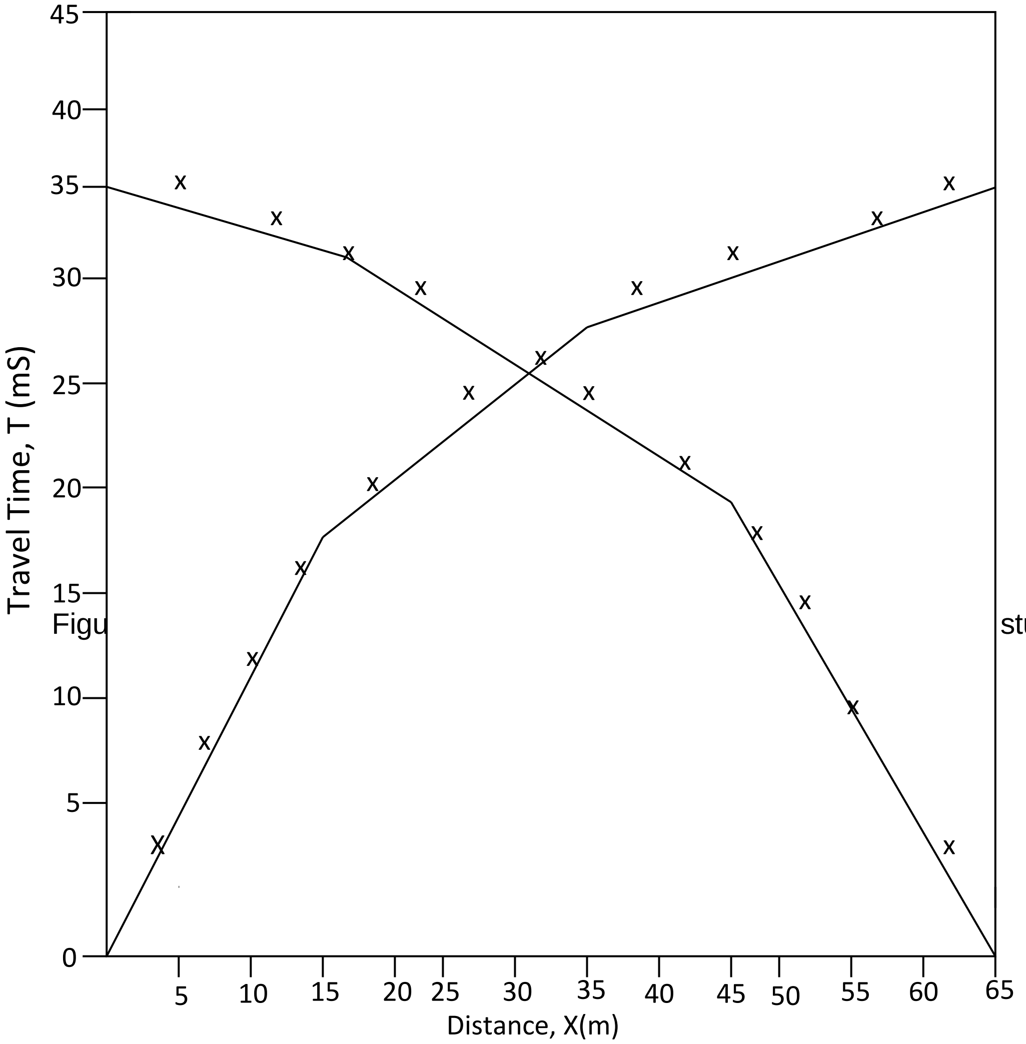
MATERIALS: The instruments used in the seismic refraction survey were a 3-channel seismograph, Compressional/P-wave source and sensors, with connecting cable. The P-wave source was mechanical while the sensors were of the electromagnetic type. The materials used for the electrical resistivity survey include ABEM Terrameter (SAS 300C), potential and current electrode pairs and connecting cables, measuring tape, pegs and a global positioning system (GPS).

METHOD: Both the seismic refraction survey and the direct current resistivity survey were run along the same profile line one after the other. In the refraction survey, the profile length was 65m and the inter-geophone spacing was 5.0m. Forward and reverse profiles were carried out and arrival times, T (ms) of the waves reaching the sensors from the shot were recorded against corresponding offset distances of sensors, X (m).

In the resistivity survey, the profile length was 300m. The electrode array used was the schlumberger and the approach was vertical electrical sounding (VES).

RESULTS AND DISCUSSION

RESULTS: Fig. 1 is the T-X plot of the seismic refraction survey while Fig. 2 is the vertical electrical sounding (VES) curve of the resistivity survey.



Figu study area

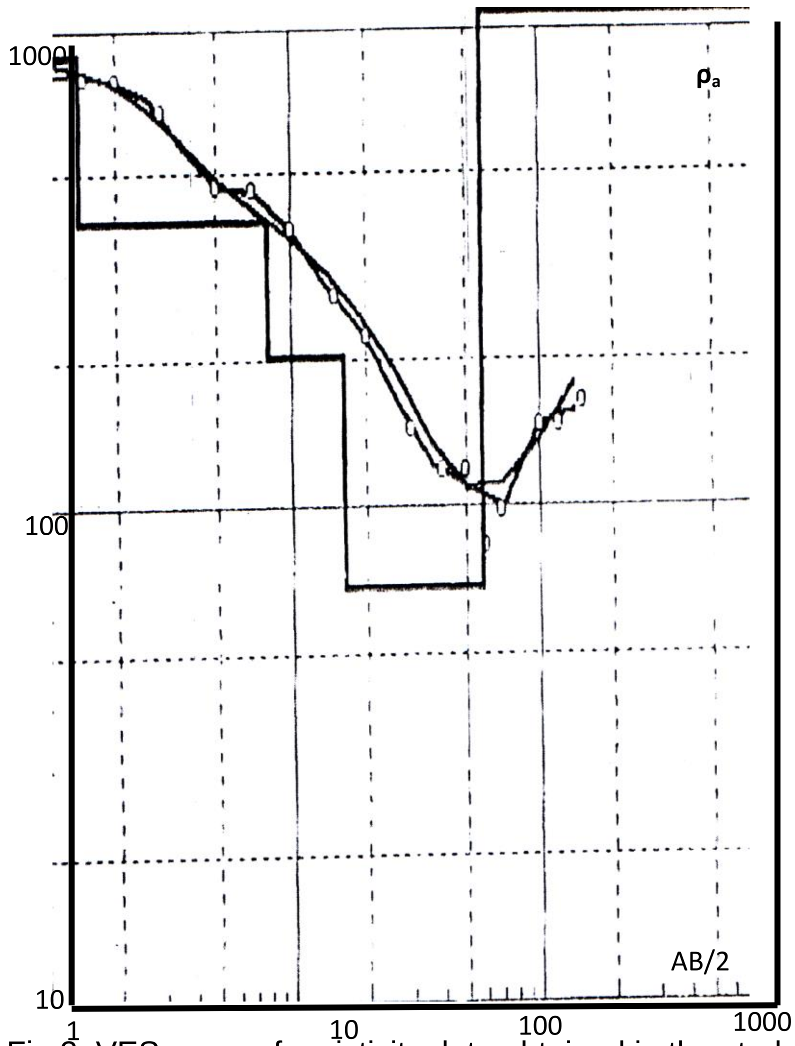


Fig 2: VES curve of resistivity data obtained in the study area

DISCUSSION: In Fig. 1, three layers of the subsurface were delineated by the P-waves used in the seismic refraction survey. The average P-wave velocities were 725m/s, 1994m/s and 3168m/s; for the first, second and third layers respectively. The thicknesses of the first and second layers were 1.70m and 2.78m respectively. These layers were interpreted to be probably made up of lateritic overburden, clay and carboniferous siltstone for the first three layers respectively.

In Fig. 2, the VES graph shows that the direct current used in the electrical resistivity survey delineated five layers of the earth's subsurface. The apparent resistivities of the layers were 872.94Ωm, 268.34Ωm, 1169.84Ωm, 176.17Ωm and 80.67Ωm respectively. The thicknesses of the first four layers were 1.1m, 4.7m, 6.0m and 30.8m respectively. These layers were interpreted to be made up of lateritic overburden, ferruginised clay concretions (probably wet), siltstone bed (probably dry), well compacted but fissile shale bed (probably fractured and wet) and well consolidated and mineralized layer from top to bottom for the first five layers from the earth's surface.

CONCLUSION

Comparing the two results (seismic and electrical resistivity), it is observed that both methods reveal about the same lithology although the seismic refraction method due to limited seismic energy source could only reveal the first three lithologic units. The results by the two methods for the first three layers from the surface are in agreement. Hence, the lateritic top soil overlies the clay deposits (second layer) which are underlain by a siltstone bed (third layer). The sequence of deposition of sediments is from bottom to top and not the reverse. That is the siltstone bed is older than the clay deposits and the clay deposition occurred before the laterites were deposited. Therefore, the youngest sediments in the area are laterites.

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