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Resistivity and Magnetic Mapping of Sediment Basement Contact Between Calabar Flank and Oban Massif South – South Nigeria.

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ABSTRACT

Geophysical surveys involving magnetic profiling, horizontal resistivity profiling and vertical electrical sounding were carried out along Calabar –Ikom Highway to determine the location of contact between the Cretaceous – Tertiary sediments of the Calabar flank and Precambrian basement rocks of Oban massif. These were performed in conjunction with surface geological mapping and interpretation of aeromagnetic data of the area. Twenty seven magnetic stations were established using Geometric G 826 proton magnetometer. The horizontal resistivity profiling involved the establishment of 24 and 36 stations using GG 30 Bodenserwerk DC Resistivity meter. The horizontal resistivity profiling utilized Half Wenner, Schlumberger and Dipole-dipole arrays. The digitized aeromagnetic data were used to produce total magnetic field intensity of the area. The result showed that the contact is located at km 26.48 – 26.50 along Calabar –Ikom Highway.

Keywords; Basement, flank, resistivity, profiling.

1. INTRODUCTION

Geological traversing can be used to map sediment basement contact in outcrops. Geophysical surveys such as magnetic profiling and resistivity survey can also be used to map sediment basement contacts. The Precambrian geology of the Nigerian basement complexes and the sedimentary framework of Nigeria show that nearly all the basement complexes are overlain by sediments or weathered basement materials. (Effiong et al 2017). This is applicable to Oban massif. To the south of Oban massif is the Calabar flank, a sedimentary basin of Cretaceous – Tertiary sediments (Effiong et al 2017). Magnetic profiling the oldest method of geophysical exploration is used to explore for both oil and ore bodies. It is sometimes employed in mapping topographic features on the basement surface that influence the structure of the overlying sediments (Aka et al 2022). Sedimentary rocks exert such a small magnetic effects compared with igneous rock that virtually all variations in magnetic intensity measureable at the surface result from topographic or lithologic changes associated with the basement or from igneous intrusions (Opara, 2011). In prospecting for oil, gas and solid minerals, magnetic is used in reconnaissance surveys. As resistivity is a fundamental property of a rock materials closely related to their lithology, the determination of the subsurface distribution of resistivity from measurement on the surface can yield useful information on the structure and composition of buried formations (Aka et al 2022). Electric current injected into the ground by means of two electrodes reveals subsurface resistivity variations. These variations which affect subsurface pattern can be mapped by raising a second pair of electrodes to take surface potential measurement at a series of sites that cover the section of area of interest. The data thus gathered is then interpreted to reveal the subsurface anomalies.

2. LOCATION AND GEOLOGIC SETTING.

The study area is located within Akamkpa and Odukpani local government areas of Cross River State. It lies between latitude 5^0 15' to 5^0 20'N and longitude 8^0 15' to 8^0 20'E. It covers part of the sedimentary terrain of the Calabar flank and basement complex of Oban massif (Fig 1)

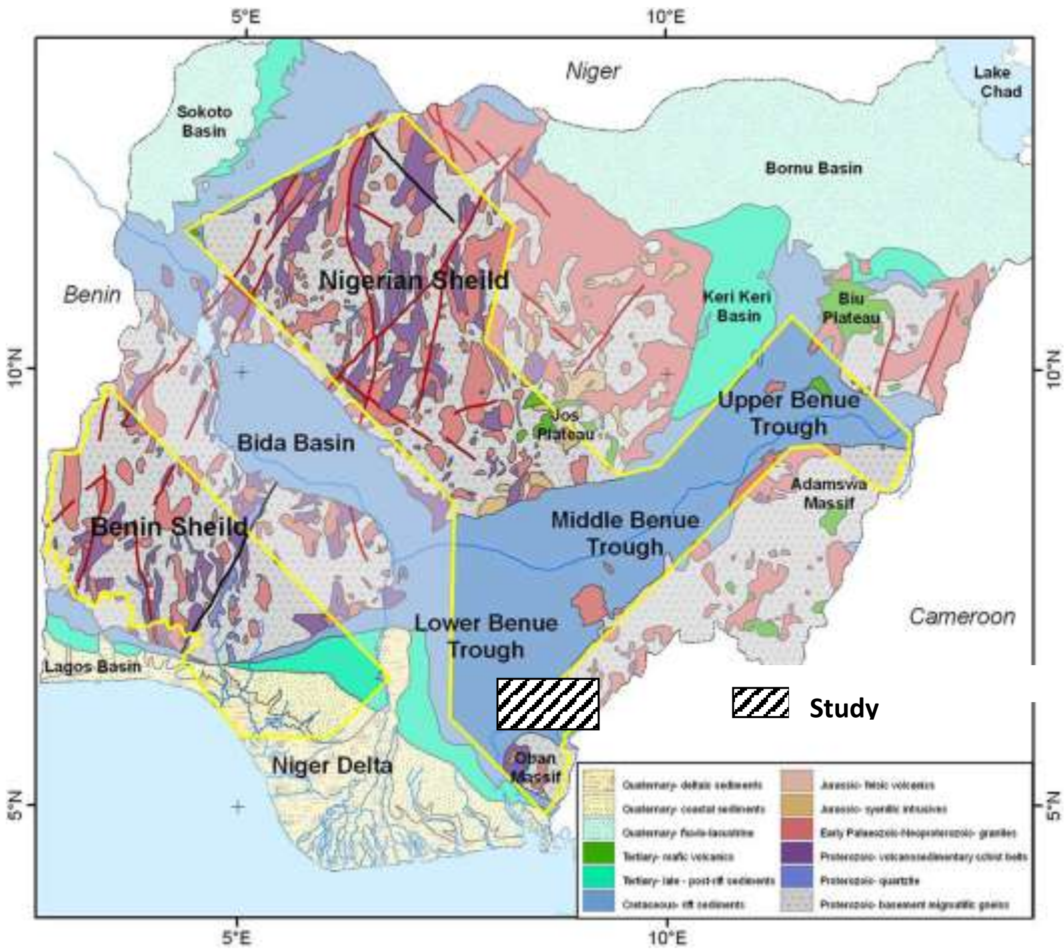


Fig. 1: Geologic Map of Nigeria Showing Study Area (Adapted from Helmer and Hespanhol 1997)

The Oban massif which is the basement part of the study area include metamorphic rock unit as phyllites, schists, gneisses and amphibolites. These rock are intruded by pegmatites, granites, granodiorites and dolorites (Ekwueme and Nganje, 2000). It has a complex lithology. Outcrops are generally intensely weathered. This made it difficult to obtain fresh samples for geological studies. The schists are highly deformed and display conspicuous segregation into light and dark portions. The light band contains porphyroblasts of garnet, cyanide, sillimanite. On the other hand, the dark portion of the schist is highly foliated and consist of mafic minerals dominantly phyllosilicate (Ekwueme and Nganje 2000).

The geology of southern Nigeria is dominated by Cretaceous – Tertiary sediments which make up the Lower Benue Trough. These Cretaceous -Tertiary sediments lie conformably on rocks of the crystalline basement as seen in figure 2. The Calabar flank represent that part of the foundered southern Nigerian continental margin dominated by a system of NW-SW trending step fault system that resulted in the formation of horst and graben structure within the area (Petters 2010). Subsequent stratigraphic development of the flank was controlled by the vertical tectonics of this fault blocks.

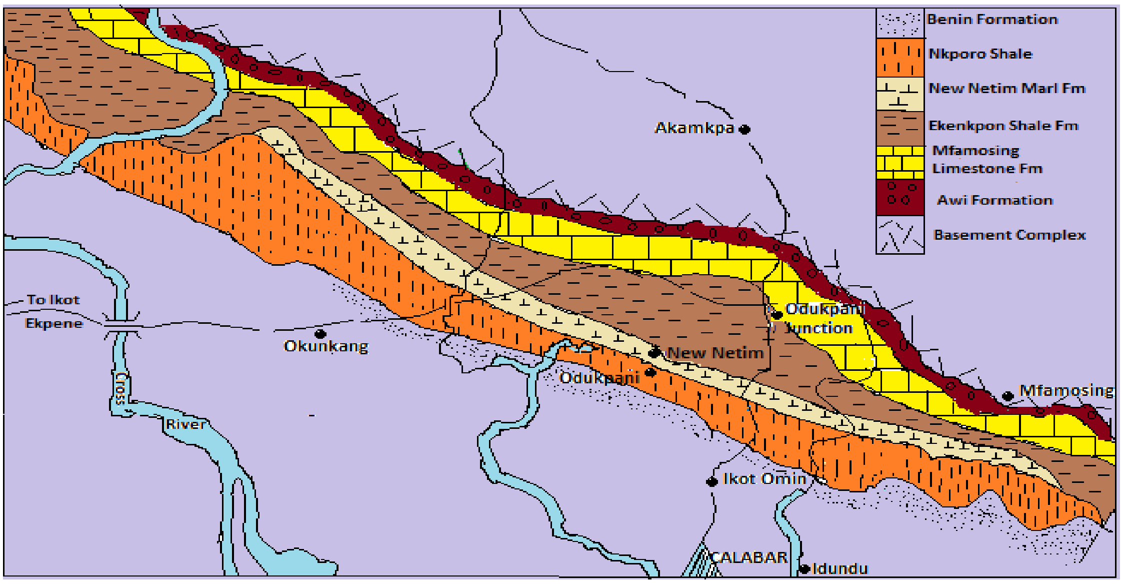


Fig.2 Geology outline map and stratigraphy unit of the Calabar flank(Aka et al 2022).

Sedimentation in the Calabar Flank started with the deposition of fluvio-detaic clastics of Early Cretaceous age accumulating in a prograding deltaic margin as deltaic and non marine sediments. These sediments belong to the Awi Formation as seen in figure 2. Enhanced subsidence of the faulted blocks resulted in the initiation of series of marine transgression. The earliest of such transgression in Mid-Albian resulted in the deposition of platform carbonates (Mfamosing Limestone Formation, Petters 2010). In some localities the limestone can be observed to lie directly on weathered basement.

The Mfamosing Limestone is overlain by a thick black to grey fissile shale unit. The shale unit is separated from the underlying carbonate body by a 10m-thick hard ground which can be seen at the Mfamosing quarry. This represent hiatus during Late Albian times. These fossiliferous black shales are carbonaceous. They grade upward into bedded mudstone of the overlying major Mid-Cenomanian regressive unit with well displayed parasequences.

The Ekenkpon Shale is characterized by bioturbated gray shales with intercalations of fossiliferous marls, calcareous mudstone, two major thick oyster beds; the shale being rich in planktonic foraminifera indicative of paleo-anoxia with frequent oscillation of oxic and anoxic depositional environments.

The Ekenkpon Shale is overlain by a thick marl unit, the New Nnetim Marl. It is nodular and shaly at the base and is interbedded with thin layer of shales up section. The New Nnetim Marl can be correlated with other regional carbonates units, notably the Nkalagu and Wadatta Formation in the Benue Trough.

The New Nnetim Marl is uncomformably overlain by carbonaceous dark grey shale, Nkporo Formation. This shale unit contains interbedded thin bands of limestone towards the base where gypsum also occurs. The Nkporo shale were deposited in a variety of environment ranging from open marine to anoxic and paralic conditions (Petters 2010). The various unit in the Calabar Flank is summarized in figure 2.

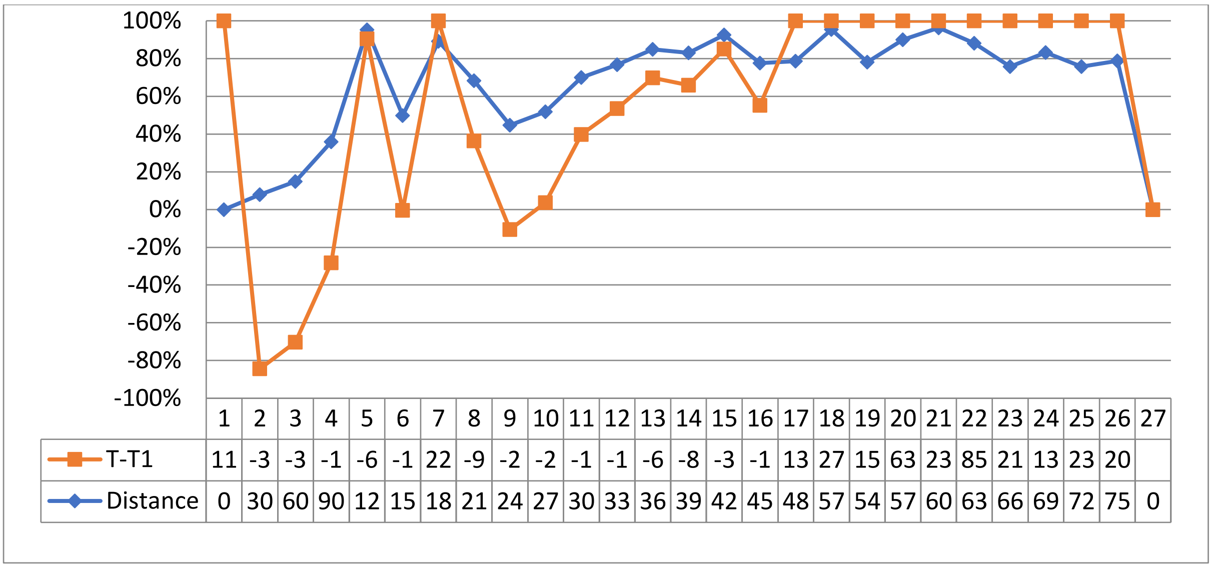
3. METHODOLOGY

The entire area was subjected to an intensive surface outcrop mapping for possible assumption of the contact location and to determine the regional trend of the rocks. Base on the regional trend of the rocks, profile lines were delineated. With the use of proton 826 magnetometer, magnetic profiling was carried out . Twenty seven magnetic stations were established at station interval of 30m. The magnetic data were processed and a graph of magnetic anomaly against stations is shown in figure 3

With GG30- Resistivity meter, horizontal resistivity profiling (HRP) was carried out in the area. Horizontal resistivity profiling gives information on the lateral variation in the resistivity of the ground (Effiong et al 2017). Three electrodes arrays were used. The Schlumberger, Wenner and Dipole-Dipole arrays.

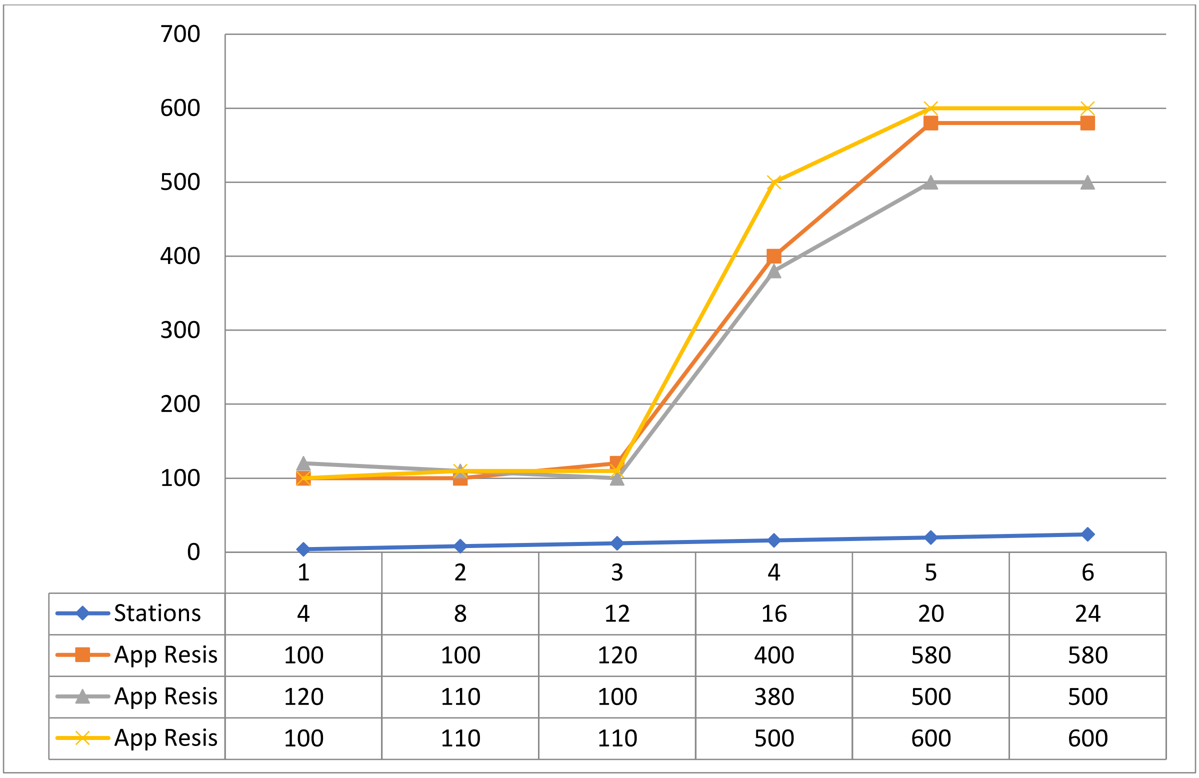
Apparent resistivity for each of the arrays were calculated using their Geometric factors. Figure 4 and 5 are graphs of apparent resistivity against stations.

With GGA30 Resistivity meter, 20 soundings were carried out in the area using Schlumberger array at different locations.. The electrode movement in the field is relatively easy for the Schlumberger, hence its choice for the study. Figure 8 shows a typical computer interpretation curve for the area. Figure 6 is a geoelectric section of the area obtained from vertical electrical sounding data from the area.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
T-T1	11	-3	-3	-1	-6	-1	22	-9	-2	-2	-1	-1	-6	-8	-3	-1	13	27	15	63	23	85	21	13	23	20	
Distance	0	30	60	90	12	15	18	21	24	27	30	33	36	39	42	45	48	57	54	57	60	63	66	69	72	75	0

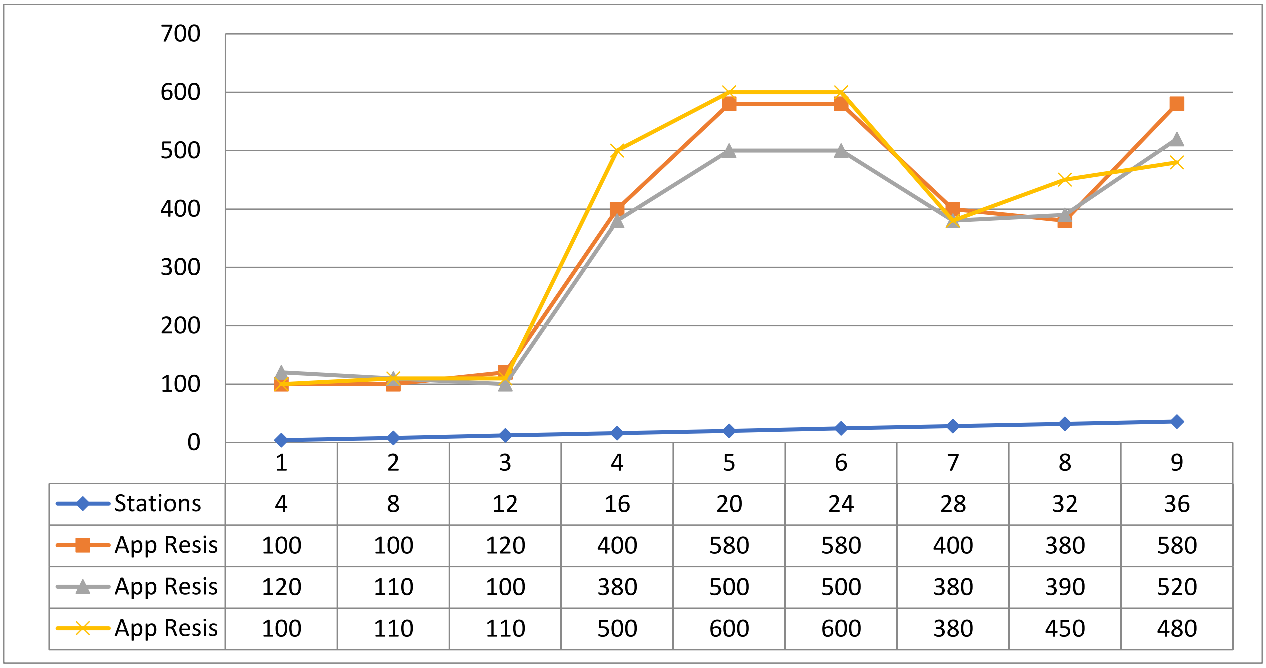
Fig. 3 Graph of magnetic anomaly against stations



	1	2	3	4	5	6
Stations	4	8	12	16	20	24
App Resis	100	100	120	400	580	580
App Resis	120	110	100	380	500	500
App Resis	100	110	110	500	600	600

a = 20m, a = n, a = 60m

Fig. 4. Graph of apparent resistivity against stations for Half Wenner array for a=20, 40 and 60m



= Dipole-Dipole Array, = Wenner A y, = Schlumberger Array

Fig. 5. Graph of apparent resistivity against stations for Dipole-dipole, Wenner and Schlumberger arrays.

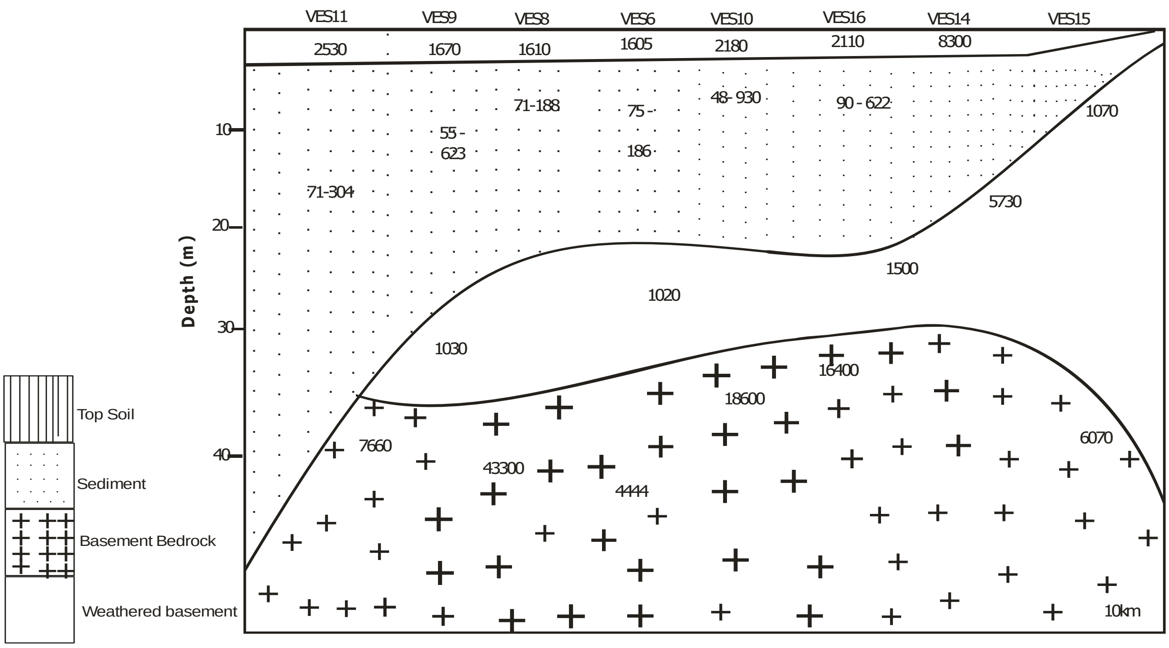


Fig. 6. Geoelectric section of the area.

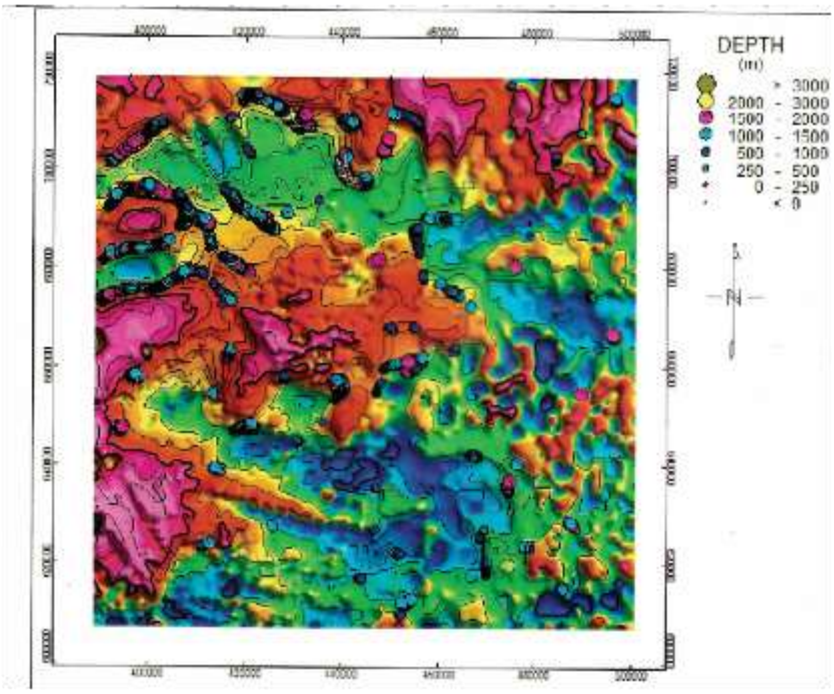


Fig. 7. Total magnetic anomaly map of the area.

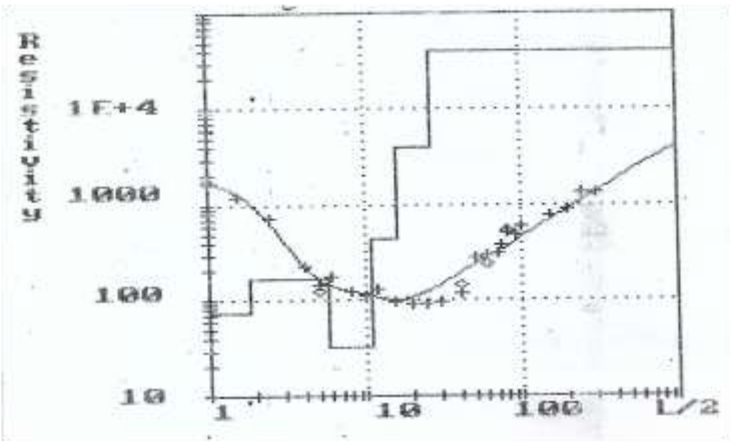


Fig. 8. A typical computer interpretation depth sounding curve

4. Result and Discussion

In the qualitative interpretation of magnetic anomaly graph, igneous rock with high mafic content has high positive anomalies. Sedimentary rocks have negative anomalies (Grauch et al 2006). Undoubtedly, the low magnetic anomalies in figure 3 between 2 and 16 is indicative of sedimentary rocks and high magnetic anomalies thereafter is basement. From figure 4 (Graph of apparent resistivity against station for Half Wenner array of a=20, 40m and 60m, it is clearly seen that low resistivity values are obtained for sedimentary rocks of Calabar flank occurring between stations 1 -12. There is gradual increase between stations 12 and 16 which is the contact location. Between stations 17 and 41 we have high resistivity values depicting a typical basement rock. Figure 5 is another plot of apparent resistivity against stations for Schlumberger, Wenner and Dipole-Dipole arrays. They show similar and consistent resistivity curves pattern over the sediment and basement areas of the traverse. Interpretation of these profiles for delineating lateral variations in the sub surface is largely qualitative. It could be observed that stations 1 -12 are characterized by generally low resistivities values. This is reflective of water contained in the pore spaces of the underlained rock unit of sedimentary rocks (Effiong et al 2017). It is observed that there is increased in resistivity values at stations 12 and 14. This indicate a transition from sedimentary rocks to basement rocks. Beyond this zone there are high resistivity values which is the basement complex. Within the basement, there are stations with surprising low resistivity values. This may be associated with weathering, faulting, fracturing or intrusions and may be filled with water. The vertical electrical sounding data were then subjected to interactive computer modeling as seen in figure 8 to delineate zones with anomalous resistivity in relation to the local geology. Four major layers were delineated; top soil, sediments, weathered basement and basement bed rock as seen in figure 6 which is a geoelectric section of the area..

The total magnetic map anomaly of the area from aeromagnetic data indicates clearly the sedimentary wedge of the Calabar flank and basement complex of the Oban massif. This is clearly seen in figure 7 which is the total magnetic anomaly map of the area.

5.CONCLUSION

Geophysical survey is by far the most widely used method in subsurface studies. From the study, the basement complex of the Oban massif and the sedimentary wedge of the Calabar flank formed a contact located at kilometer 26. 48 – 26.5km along Calabar –Ikom Highway.

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