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In search of clay deposit in a dual geological environment in the South-Southern part of Nigeria.

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Abstract

The presence of clay deposits in the south-southern part of Nigeria was investigated using the electrical resistivity methods. The Vertical Electrical Sounding (VES) was adopted for the investigation using the Schlumberger electrode arrangement. Resistivity soundings were collected from several locations which were evenly distributed within the study area. Models were generated for computer iterative technique. Borehole data were also collected using spontaneous potential logging method as well as driller's log in some selected sites within the study area so as to correlate surface measurement with borehole records. Analysis based on five depth related resistivity contour maps as well as sellected cross sectional profiles confirm the existing dual regional geological environment of the area. Finally, it was established that the quantity of clay deposits is more in the sedimentary environment than basement complex area.

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1.0 Introduction

The mining and production of individual minerals for the use of various industries is an activity that has not received adequate entrepreneurial attention in Nigeria. This has its historical basis in the fact that virtually all-Nigerian industrialists depend on foreign sources for both the plants and equipment as well as the raw materials for their industries. With the current drive towards the attainment of self-reliance in the local sourcing of industrial raw materials, it is thus possible to set up profitable venture for the supply of raw materials as feedstock to industries without direct involvement in actual manufacturing.

There are hundreds of various non-metallic minerals that have applications in the industrial sector, clay falls into one of the industrial minerals that are needed for the manufacturing of industrial products.

The study of ground resistivity is commonly used in shallow depth geophysical prospecting where the electrical property of rocks and soils, which varies over a wide range, is measured. This electrical exploration method utilizes artificial electric currents to explore the properties of the earth's interior and to search for natural resources such as water, clay and other minerals.

Zodhy (1973) [10] and Zodhy et.al (1974) [11] gave details on the use of resistivity method for obtaining information on subsurface geology. Chilton and Faster (1995) [2] have successfully utilized the resistivity techniques in assessing water supply potential in basement aquifers. Ujuanbi and Asokhia (2000) [8] and Ujuanbi and Asokhia (2001) [9] have successfully used the Vertical Electrical Sounding as a viable geophysical tool for mapping clay deposits at Afuze and Eme-Ora. The bane of this paper therefore, is to use this method to delineate the presence and continuity of clay deposit in a basement and sedimentary environments in the Northern part of Edo State.

2.0 Location of study area

The study area lies within latitude 6^0 47^1N and 7^0 35^1N and longitude 5^0 46^1E and 6^0 45^1E. Resistivity sounding data were collected from 24 towns and these locations were evenly distributed within the study area as shown in the base map of Figure 1.

The topography of the area can generally be described as "rugged". It is characterized by irregular depressions and elevations. In general, the western and eastern portions are characterized by undulating hills and ridges, more especially the western portion, which is, aligned to the course of river Ule and its tributaries. The central portion is characteised by fairly lowland with an average elevation of 122m above the sea level. The eastern part of the study area is bounded by river Niger. However, other major rivers within the area are Onyami, Orle, Edion Obe and Udo. The rivers appear to be structurally controlled and their down cutting action has given rise to deep valleys and gullies especially along out crops of weak lithologies.

3.0 Local geology

The area under study is underlain by basement complex rocks of precambrian to upper cambrian age and cretaceous to tertiary sedimentary rocks as shown in Figure 2

The basement complex comprise chiefly of undifferentiated basement rocks, undifferentiated meta sediments and older granite. In the sedimentary area there are five lithostratigraphic units observed. These are:

i. Nkporo shale group consisting of shale and mudstone.
ii. Upper and lower coal measure- coal, sandstone and shale.
iii. Ajali formation – false bedded sandstones.
iv. Imo clay – shale group – clays and shales with limestone.
v. Bende ameki group – Clay, clayey sands and shale.

4.0 Theory

The resistivity transform function is usually preferred to the apparent resistivity as a basis for interpretation because it has a significant advantage, in that; it may be calculated more easily for theoretical models. Koefoed (1965) [5] decomposed the field curve into a sum of partial apparent resistivity functions and then obtained the equivalent transform curve as a sum of corresponding partial transform functions. Chan (1970) [1] calculated the resistivity transform directly by numerical integration. Glosh (1971a) [3] used electric filter theory to determine a digital filter, which allowed each transform value to be expressed simply as a weighted sum of field apparent resitivity values.

$$T(i) = \sum_i a(j)\rho_a(i-j), \quad i = 1,2,\cdots,m$$

where $a(j)$ are filter coefficients and m is the number of field data. Ghosh published forward filter coefficients for both Schlumberger and Wenner arrays at a sampling interval of: $\Delta x = \frac{1}{3}\ln(10)$.

The field curves were sampled at

x = 1, 2.15, 4.64, 10, 21.5, … etc.

where x = half current spacing for Schlumberger configuration and
x = distance between adjacent electrodes for Wenner spread.

Subsequently, Ghosh (1971b) [4] used linear filter theory to solve the inverse case of obtaining apparent resistivity data from transform data:

$$\rho_0(i) = \sum_i b(j)T(i-j), \quad i = 1,2,\cdots,m$$

where $b(j\ )$ are inverse filter coefficients. Again, the sampling interval was 1/3ln10. However, the significance of this inverse filter is that theoretical apparent resistivity curves may be calculated quickly and easily for horizontally – stratified models of the earth by using theoretical transform data generated by a recursion formula.

5.0 Experimental work

This work was carried out in parts of south-southern part of Nigeria. Resistivity sounding data were collected along many profiles scattered in position to give good geophysical knowledge of a region that has a dual geoglogical setting. The Schlumberger array system was adopted in view of its reliabity and cost effectiveness. Osemeikhian and Asokhia (1994) [6] gave detail on field procedure and practice. The direction of expansion of the cables was however constrained by topography though it is desirable that array should be expanded parallel to probable strike so as to minimize the effect of non-horizontal bedding. The ABEM TERRAMETER SAS 300B was used for surface investigation as well as for logging. Non-polarizable copper electrodes in copper sulphate solution were used in logging while stainless steel electrodes were used for surface investigation.

6.0 Identification of field curves

The major observed apparent resistivity curves within the study area are H- curve, Q-curve, KQ-curve, HK- curve, QH- curve, KH-curve, HA-curve and KHKH – curve type respectively. Ujuanbi (2000) gave detail description of the curve types.

7.0 Geological interpretation of VES results correlated with borehole records

In the sedimentary southwestern part of the study area, clay deposits, which have been mapped into different-geological formation, were encountered. Cross section B-B of Figure 3 shows some of the locations within this sedimentary environment. At Eme-ora, this clay out crop at the surface. They are overlain by superficial sand layers of thickness ranging between 0.6m and 0.7m at (Oke-ora and Uhonmora) and 4.6m at Agbede and Ogonmeri in South eastern part of the study area. However, Agbede is on the cross section A-A profile of fig 4. Other locations in this section are Aviele, Auchi, Ikpeshi, Igarra and Ososo.

At Ozalla, the overburden sand presents a much higher thickness of over 35m. It is worthy of note that at Eme-Ora and Agbede, the clay deposit was not fully penetrated because of the large thickness of the clay and the fact that accuracy decreases with depth in resistivity sounding. After probing into a depth of about 55m at Eme-ora and at Agbede, the clay layers were still continuous. This was corroborated by borehole log at Eme-ora as shown in Figure 5. This Agbede clay tagged Imo clay/shale have a southern dip and was also encountered in the southern portion of the study area at Ogonmeri.

At Afuze and Aviele, the surface is underlain by a resistive (sandy) material of thickness 5*m* and about 3m respectively. This surface sand layer is underlain by clay body whose thickness is well over 30m at Aviele-where it bears a sand mixture in the lower depth.

At Afuze, this clay exists to the substratum above a thickness of 40m. Borehole information from Auchi as shown in fig 6 confirms the interpreted subsurface stratification in these sites.
Note however that geologically, the Afuze sand/shale bodies belong to the false bedded sandstone and upper coal measure formation which directly underlies the Imo clay/shale formation.

Auchi, Fugar and Agenebode are indicated in cross section C-C of Figure 7. Other locations in this cross section profile are Sabongida-Ora, Oke-ora, Afuze, Ikabigbo, Fugar and Agenebode. At Auchi, Fugar and Agenebode, the surface material is clayey. However, at Auchi where this surface clay/shale material is being mined, the thickness is about 4.2m, whereas at Fugar and Agenebode, the thicknesses are 13.4*m* and 8.5*m* respectively. It is also noteworthy that this clay/shale material found at Auchi and Fugar is underlain by false bedded sandstone (Ajali) formation exposed at Afuze and Aviele.

At Ikabigbo, this surface clay layer is completely absent, possibly due to erosion. This exposed clay presents shale condition at Auchi that assumes very plastic behaviour at its exposure at river Ojo valley between Ikabigbo and Fugar. Although road failure in this area is ascribable to the

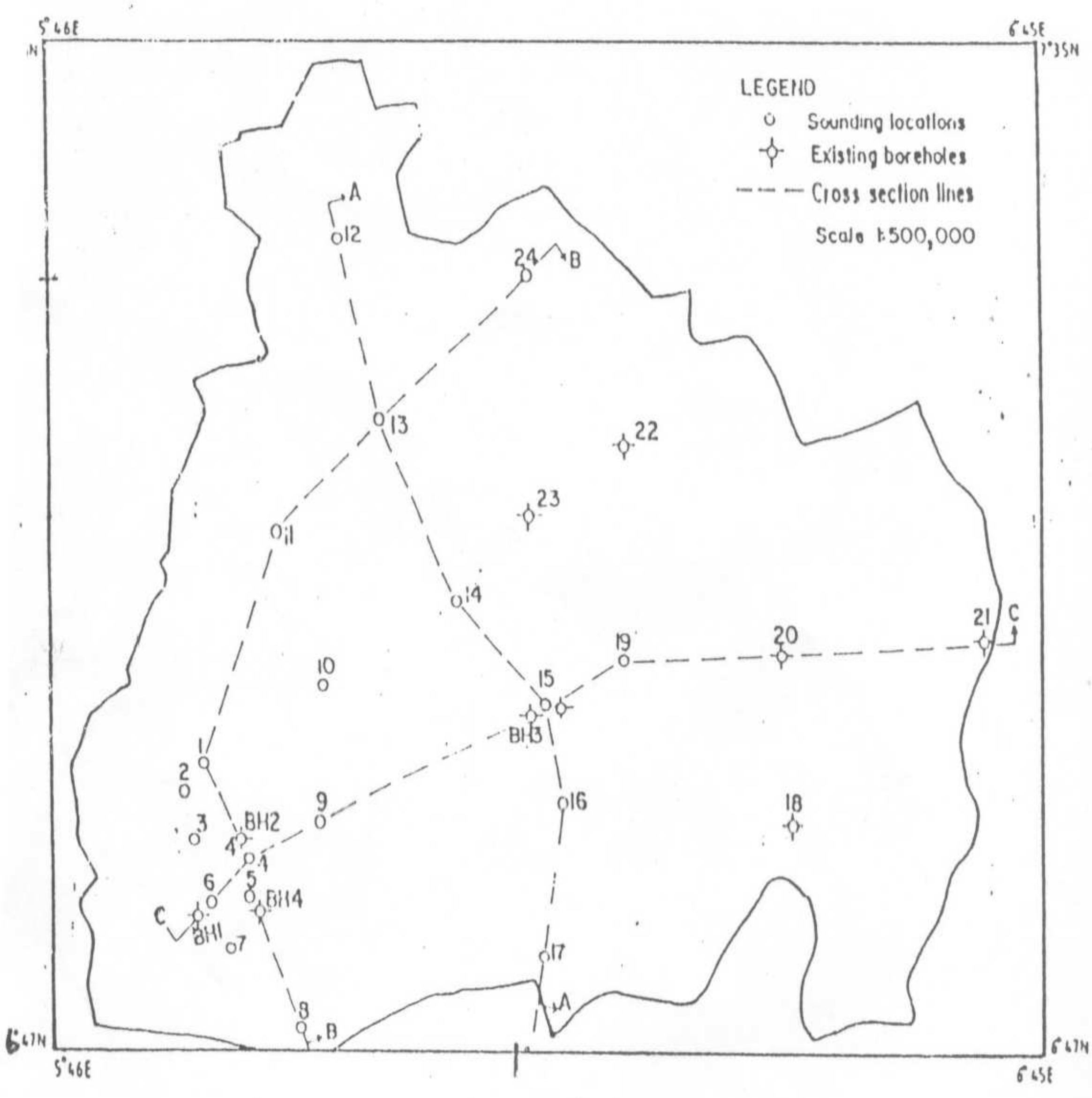

Figure 1: Basement of study area showing sounding points, existing boreholes and cross sectional lines

presence of this plastic clay, it is also believed to be of an economic occurrence that could sustain the production of bricks and other clay related products.

At Uzebba, within the depth of 47.2 penetrated no clay layer of appreciable thickness was encountered. At Ukhuse conductive clayey material of up to 5m were encountered from the surface, which was immediately underlain by a very resistive layer believed to be dry sand below which lies fairly conductive layers which together with the substratum could be interpreted as clay sand.

Within the basement area, namely Ikpeshi, Okpella, Atte, Otuo, Igarra, Ososo and Ibillo distinct clay layers of thickness between 3.1m to 13m were encountered from the surface.

These results presented are also expressed in the resistivity contour maps of depth horizon 1m, 3m and 10m as shown in Figure 8 to Figure 10 respectively. However, contour maps of Figure 11 and Figure 12 show the depth horizon 30m and 50m, which are mainly applicable to locations within the sedimentary environment. In addition, within the basement area the surface clay layers directly overlie the weathered or fractured basement zone which in turn precedes the unweathered basement environment and are by no means continuous over the entire area since their occurrence is frequently interrupted by fresh intrusions. In parts of the study area between Igarra and Ososo economic exploitation of this clay body by local inhabitants for pottery is a common sight.

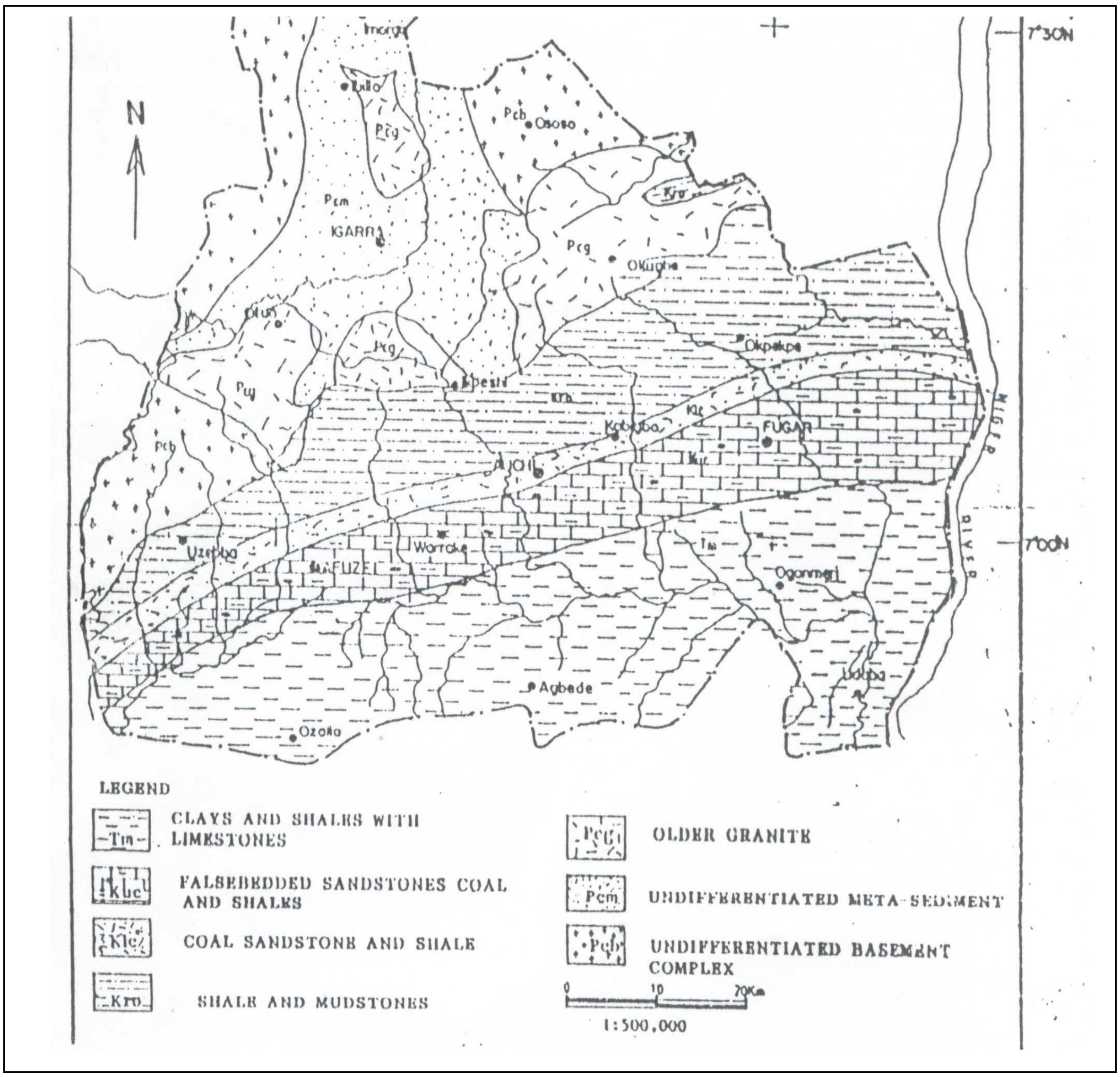

Figure 2: Geological map of Edo North (adapted from Geological map of Nigeria by Okezie, 1974)

8.0 Conclusion

This research has confirmed the use of electrical resistivity method as a viable tool in mapping clay deposit in a sedimentary and basement geological setting

9.0 Acknowledgement

We thank the authority of Ambrose Alli University, Ekpoma for the financial support

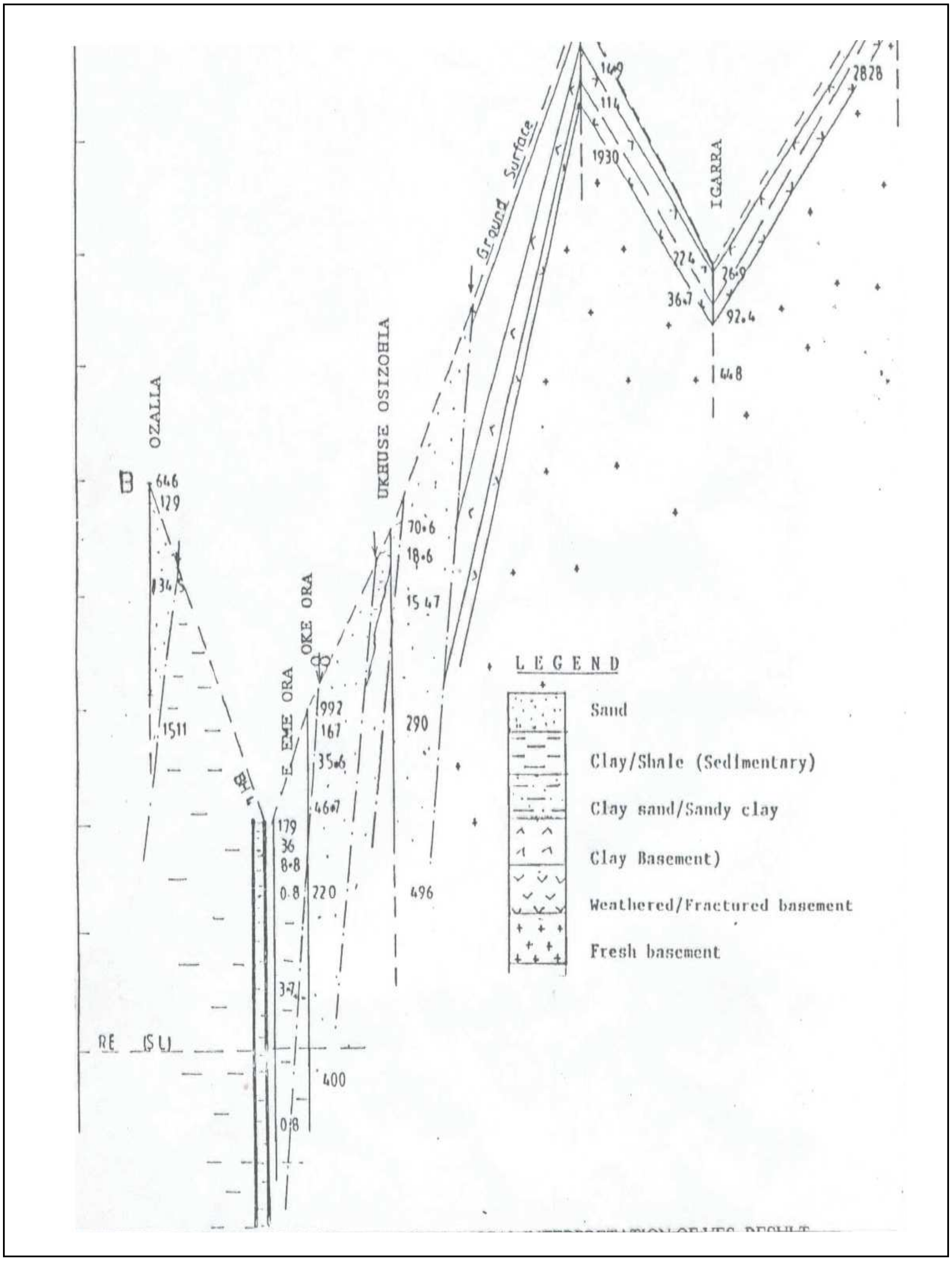

Figure 3: Cross section B-B showing geological interpretation of VES result correlated with borehole records.

Note: Vertical scale applies to surface points at VES and borehole locations only. Subsurface depths are exaggerated by factor 2

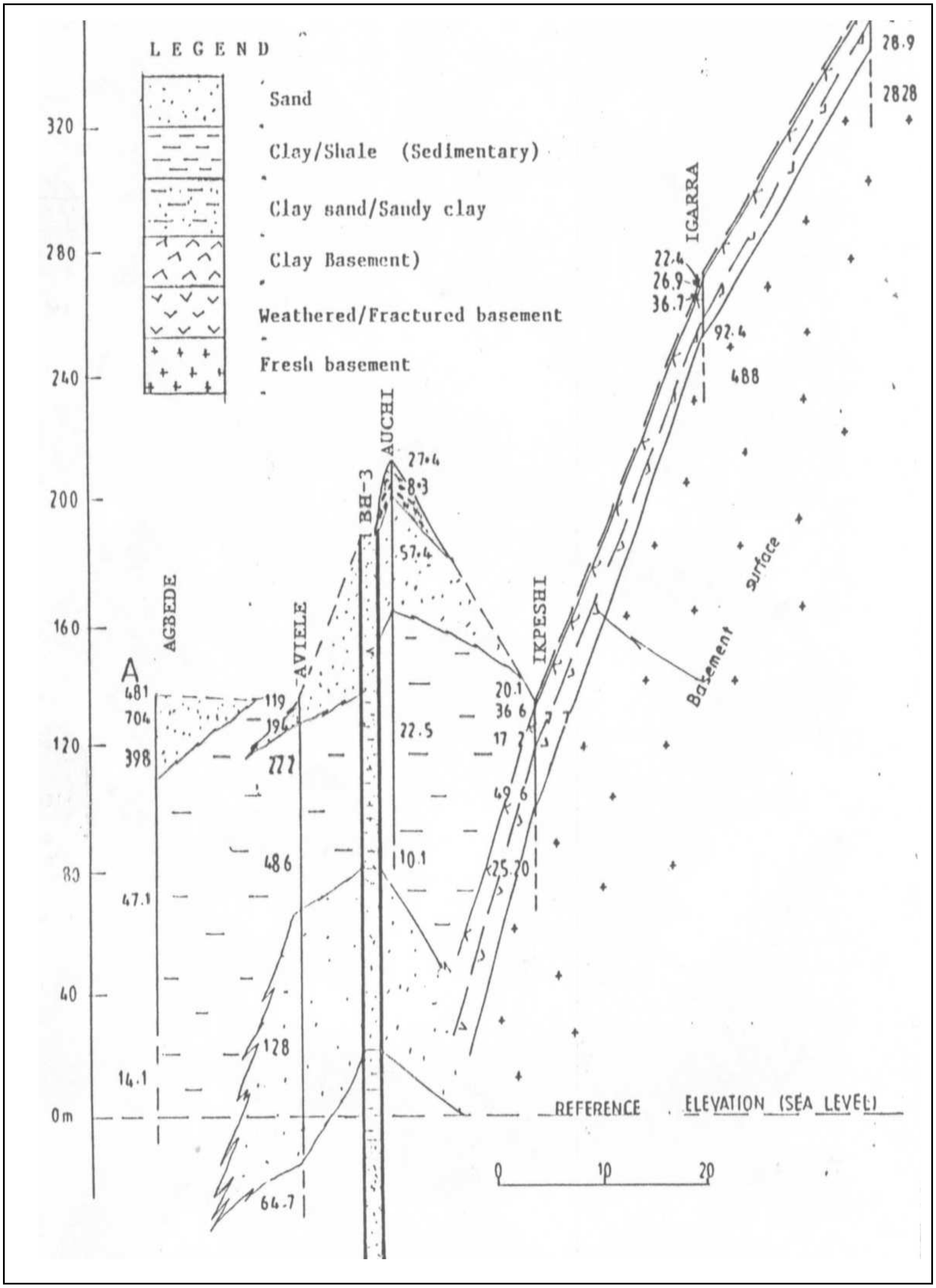

Figure 4: Cross section B-B showing geological interpretation of VES result correlated with borehole records.

Note: Vertical scale applies to surface points at VES and borehole locations only. Subsurface depths are exaggerated by factor 2

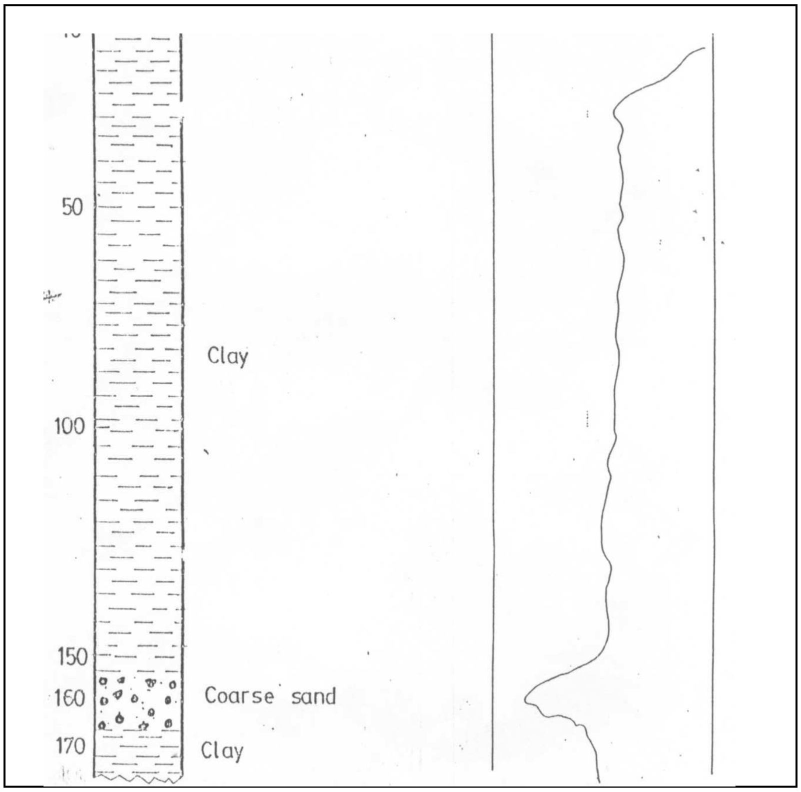

Figure 5: Driller's/SP log in Eme-Ora

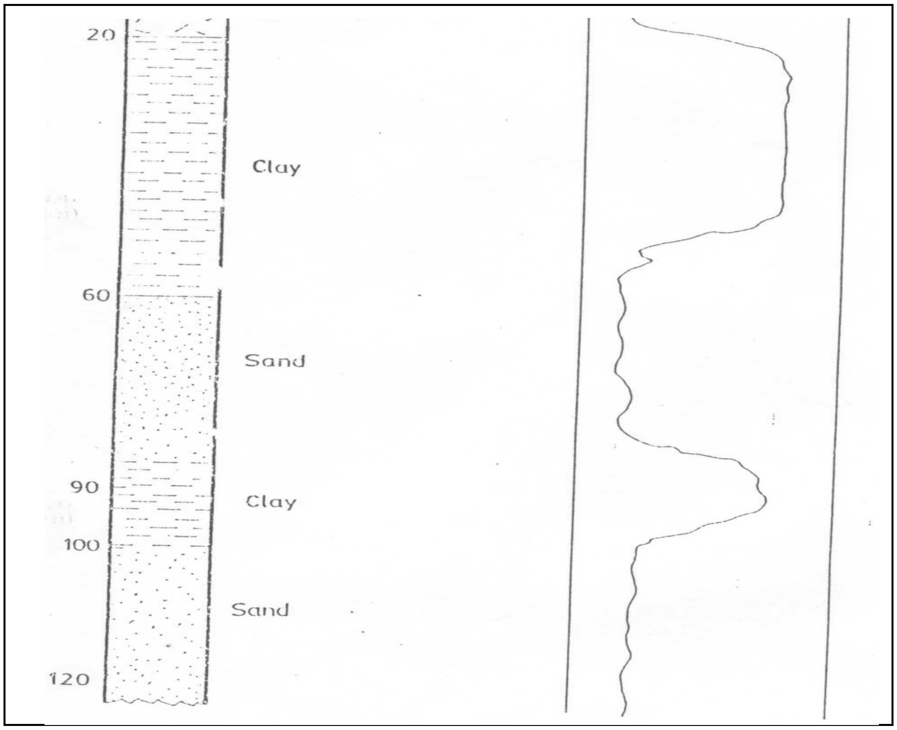

Figure 6: Driller's/SP log in Auchi

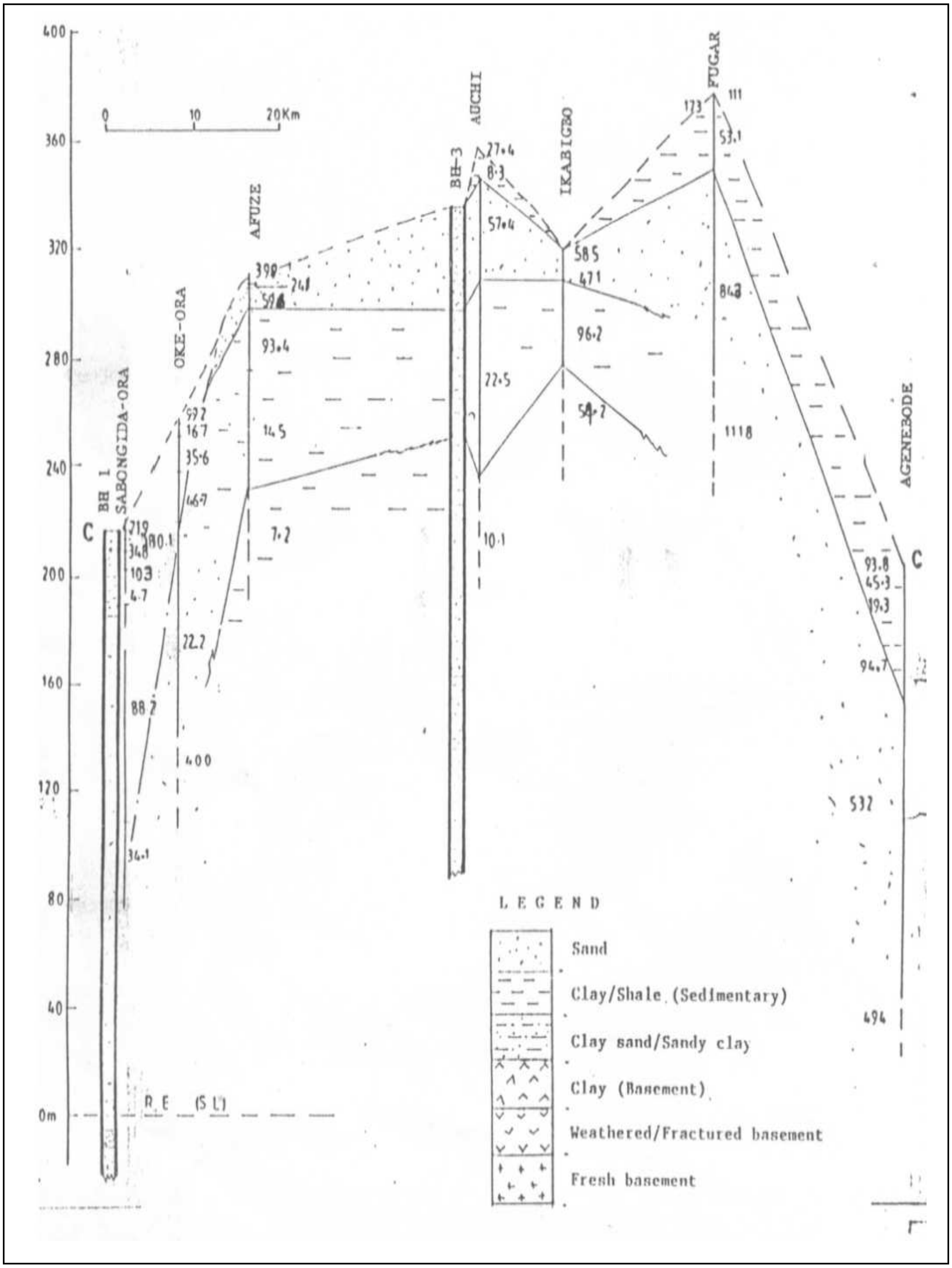

Figure 7: Cross section C-C showing geological interpretation of VES result correlated with borehole records

Note: Vertical scale applies to surface points at VES and borehole locations only. Subsurface depths are exaggerated by a factor 2.

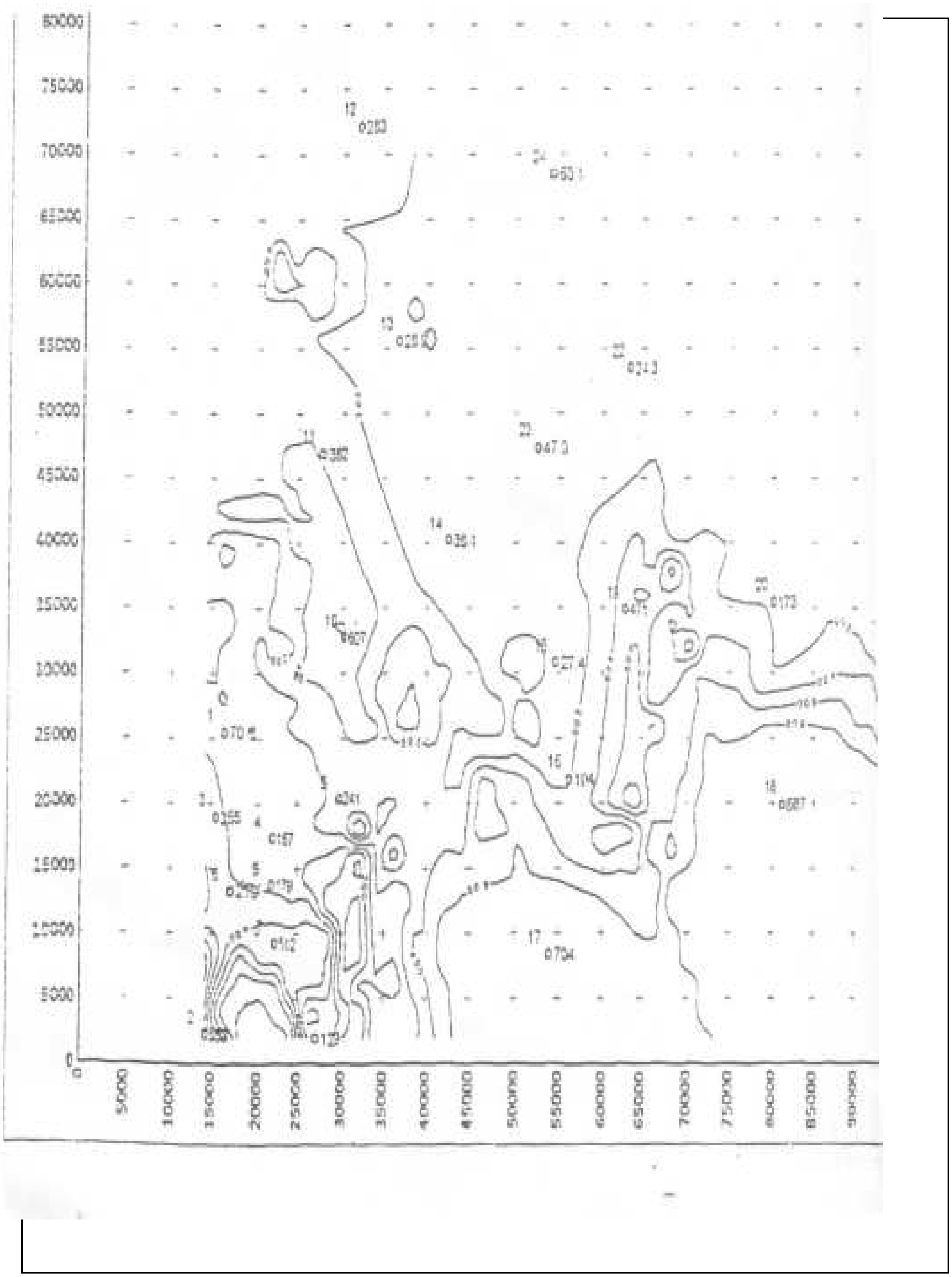

Figure 8: Resistivity contour map of depth horizon of 1*m*

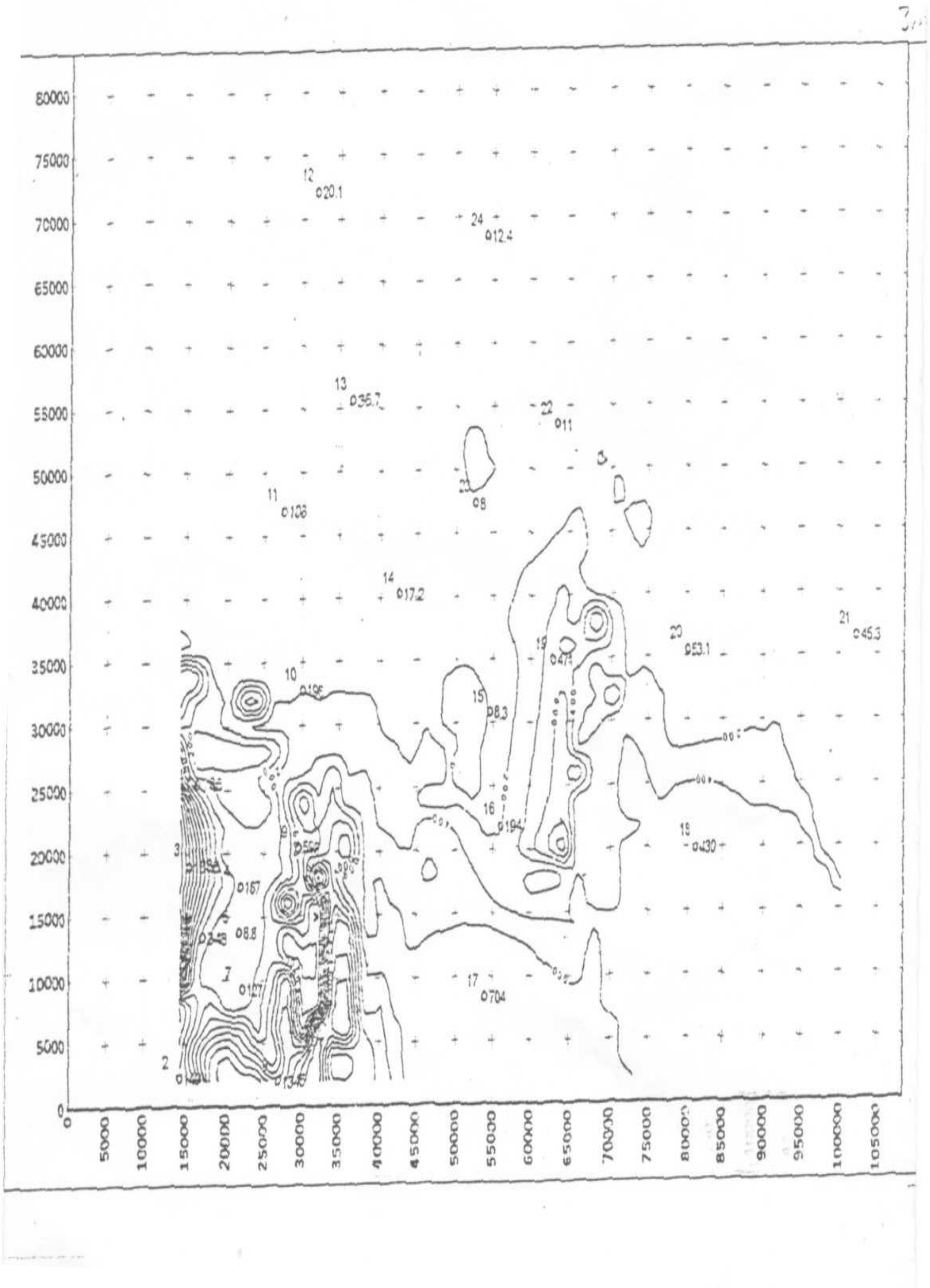

Figure 9: Resistivity contour map of depth horizon of 3*m*

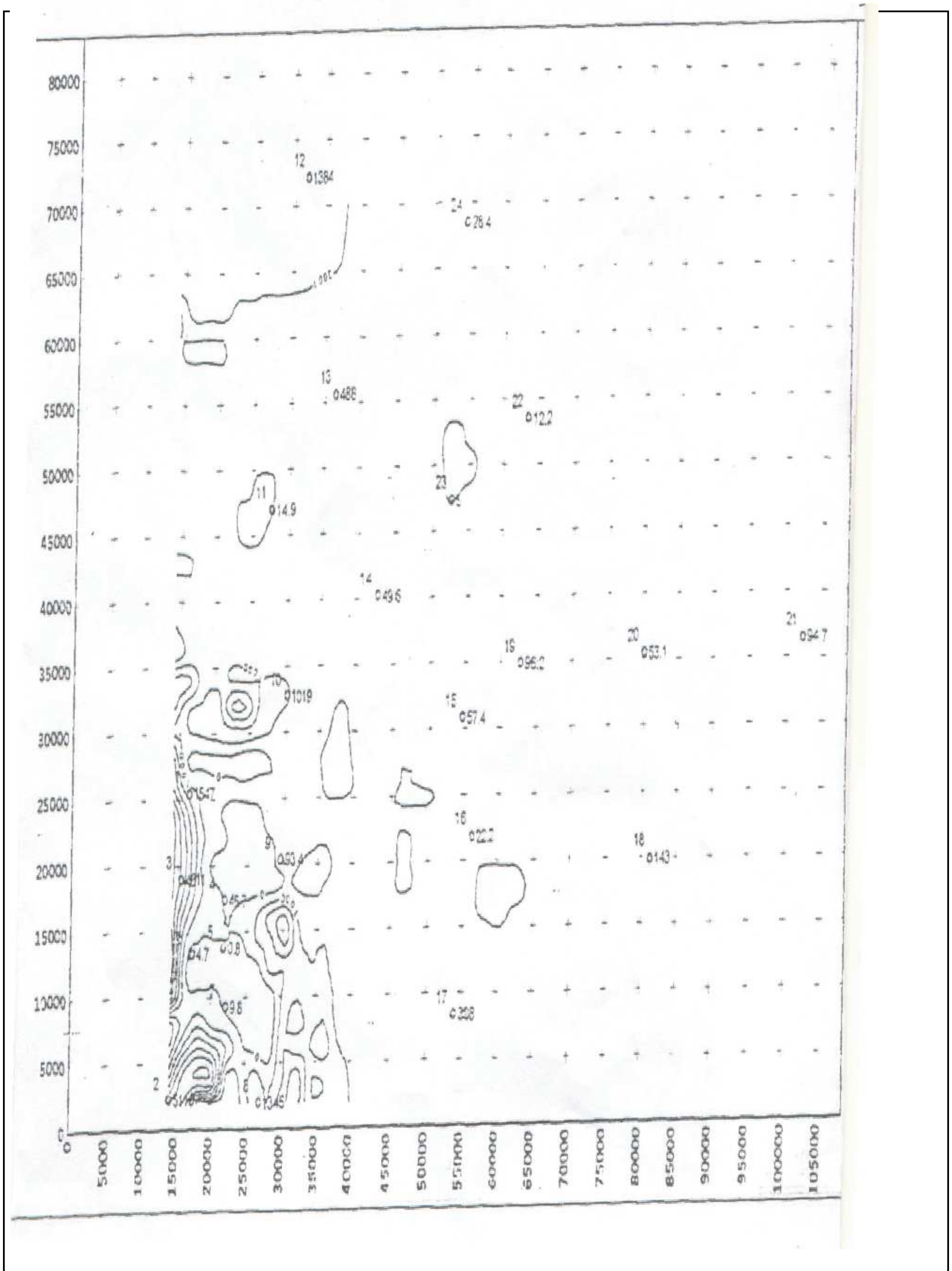

Figure 10: Resistivity contour map of depth horizon of 10*m*

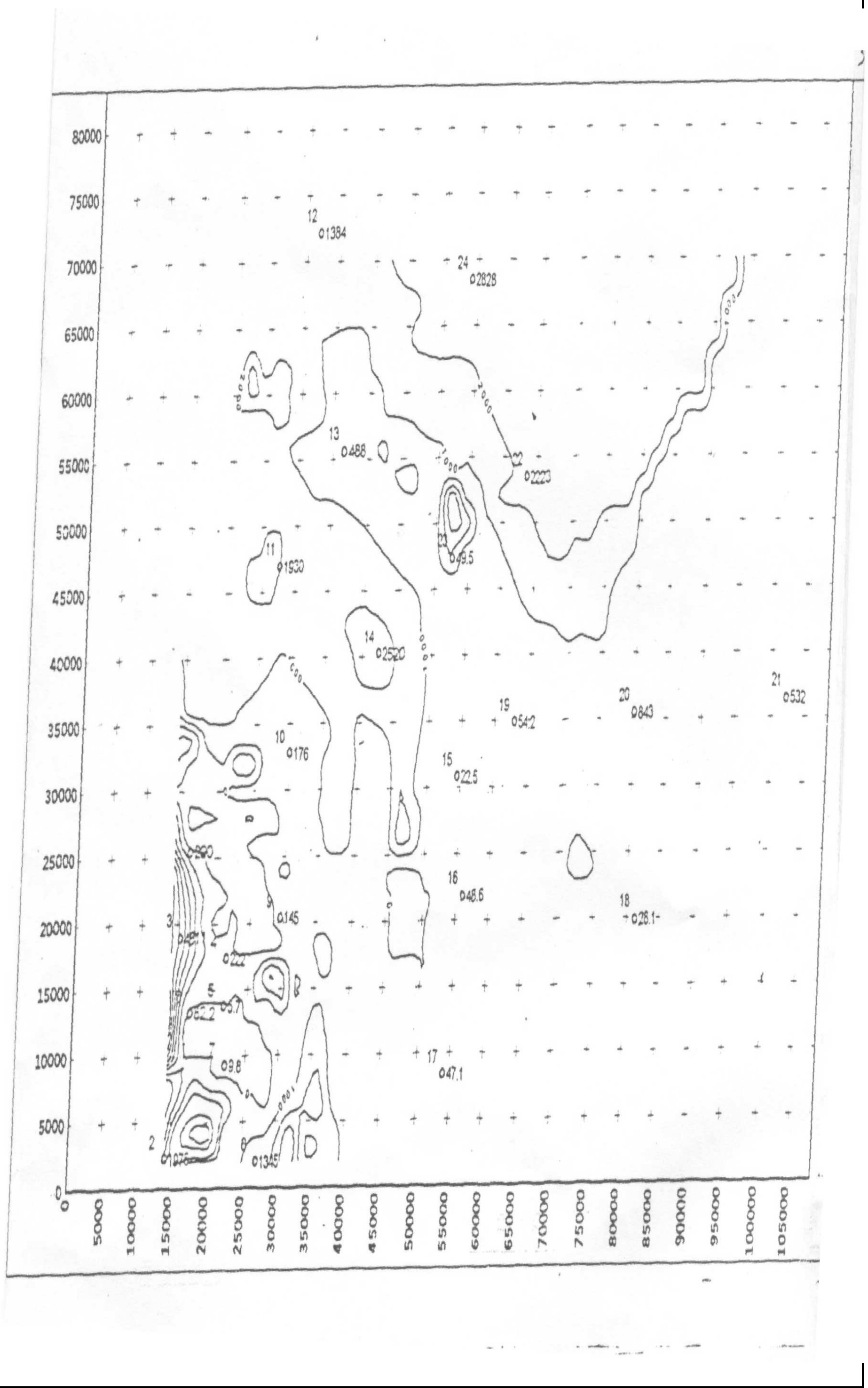

Figure 11: Resistivity contour map of depth horizon of 30*m*

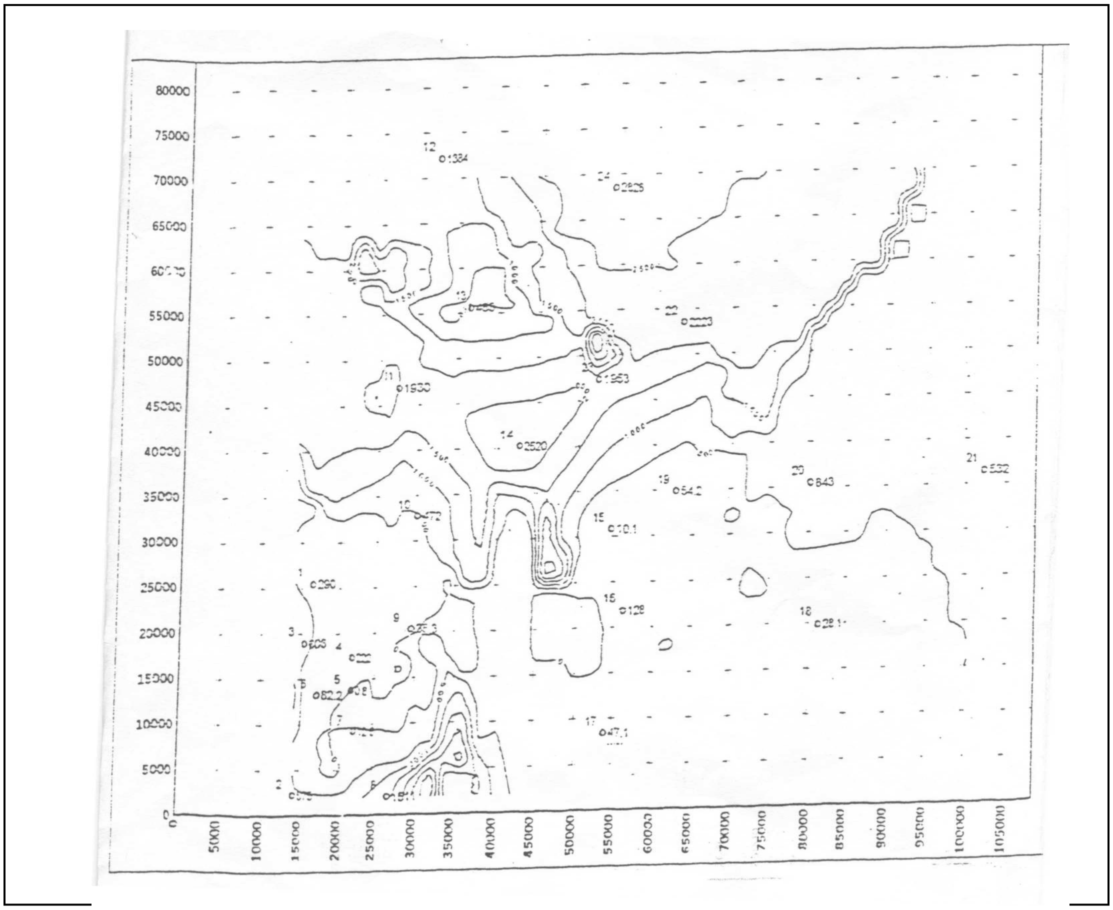

Figure 12: Resistivity contour map of depth horizon of 50*m*

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