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GEOPHYSICAL EXPLORATION FOR GROUNDWATER IN A SEDIMENTARY ENVIRONMENT: A CASE STUDY FROM NANKA OVER NANKA FORMATION IN ANAMBRA BASIN, SOUTHEASTERN NIGERIA

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ABSTRACT

The interpretation of five restivity curves over Nanka town within geologic terrain often referred to as Nanka Formation in Anambra Basin, south-eastern Nigeria indicates that the area has a great groundwater potential. A correlation of the curves with the lithologic log from a nearby borehole suggests that the major lithologic units penetrated by the sounding curves are Laterite, Clay Sandstone and clay.

The sandstone unit which is the aquiferous zone has a resistivity range of between 500 ohm.m and 960ohm.m and thickness in excess of 200m. The depth to the water table is at least 1 00m.

KEYWORDS: Vertical electrical Sounding, groundwater potential, aquifer thickness, Nanka Formation, Anambra Basin.

Introduction

This paper describes a geo electric investigation undertaken in Nanka, a type area of Nanka Formation in Anambra Basin, South/East Nigeria. The aim is to explore the groundwater potential of the area. Generally, a number of geophysical exploration techniques are available which enables an insight to be obtained rapidly into the nature of water bearing layers. These include: geo-electric, electromagnetic, seismic and geophysical borehole logging. The choice of a particular method is governed by the nature of the terrain and cost considerations.

The superiority of geo-electric method over others in the groundwater research is confirmed by the work of Pulawski and Kurth (1977). Zohdy (1973) and Zohdy et al (1974) reported on the ability of resistivity method to furnish information on the subsurface geology unattainable by other methods in groundwater studies. For example they attested to the ability of electrical method to provide information on the depth of the fresh/salt water interface. The resistivity techniques have been successfully utilised in assessing water supply potential in basement aquifers. (Chilton and Foster, 1995); in exploring aquifer boundaries in the plains of Yemen (Van Overmeeren 1989) and the assessment of the groundwater resources potentials within Obudu basement area of Nigeria (Okwueze, 1996).

In general geo-electric measurements enable the electrical resistivity of the subsurface to be determined. In a sedimentary environment high resistivities may broadly be associated with the presence of fresh groundwater in porous medium (aquifer), while low resistivity may be due to the presence of clays and/or brackish water.

Apart from the investigation of the groundwater potential of the area, it is envisaged that this work will provide information on the thickness of Nanka Formation within the study area.

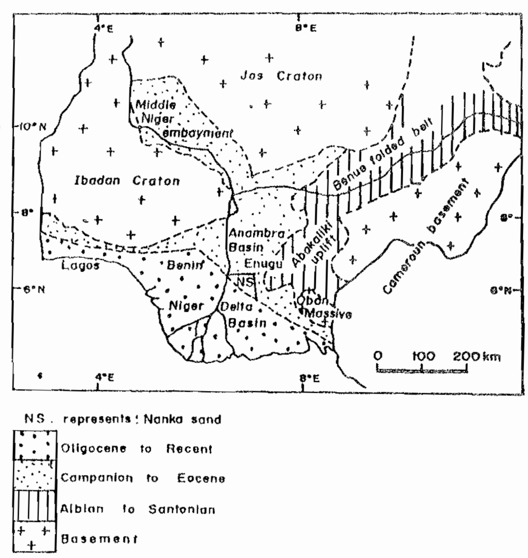

FIG. 1. Generalised geology and Tectonic features of south eastern Nigeria (Adapted from Murat, 1970)

BRIEF GEOLOGY OF THE STUDY AREA

The study area (fig 2) falls within the Nanka Formation, a zone that has been seriously affected by gully erosion. The extensive nature of the gullying has attracted a good number of workers to the area over the years. Notable among these are Grove

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(1951), Ogbukagu (1977), Nwajiᴗa and Hoque (1979) and Egboka (1985). These investigations were broadly designed to identify the major lithological units and the factors responsible for the intense gully erosion. As far as is known, there are no published geophysical studies in the study area.

According to Nwajide (1977) three main lithological units, namely, Nanka Formation, Ameki

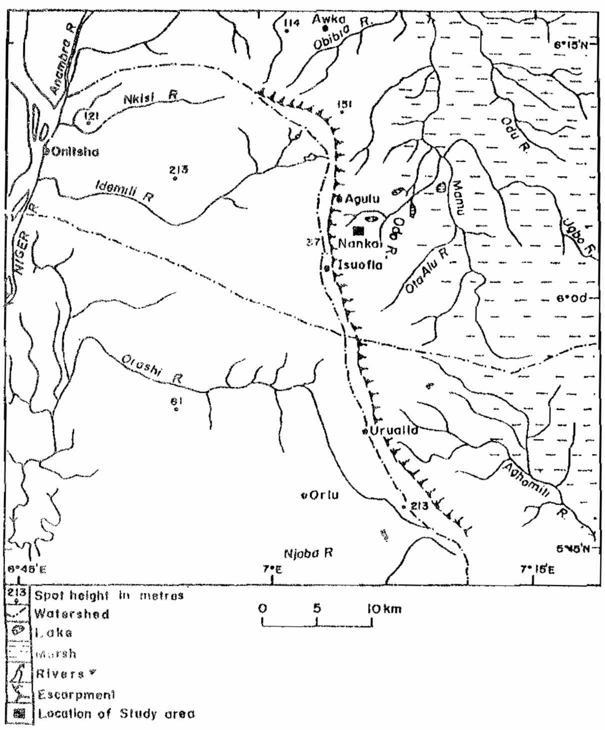

FIG. 2 Drainage and other physical features of the Study Area. (After Nwajide, 1977)

Formation and Imo Formation have been identified in the study area (fig. 3).

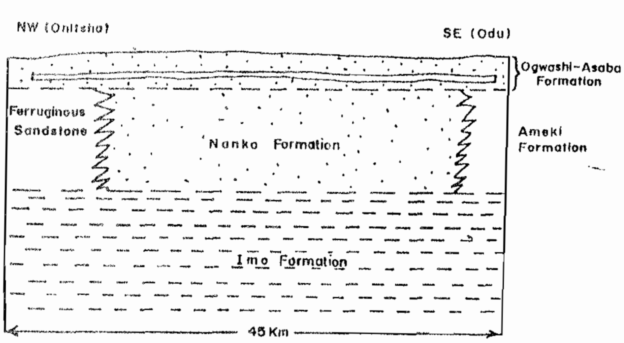

FIG. 3. Sk... showing the presumed contact of Nanka Formation with adjacent lithologic units (After Nwajide, 1977).

Nanka Formation is of Eocene age and the youngest lithologic unit of the Anambra Basin. According to Murat (1970), the basin is the direct consequence of the folding and uplift of Abakiliki/-Benue area during the Santonian (fig. 1). Grove (1951) recognised Nanka Formation as a distinct mappable unit and Kogbe (1976) maintained that the formation is the lateral equivalent of the Ameki Formation. Both Orajaka (1975) and Ogbukagu (1976) consider Nanka Formation a member of Ameki Formation. According to Nwajide (1977), Nanka sediments were derived from Cameroon basement and Abakiliki/Benue fold belt and were deposited in a tide dominated marine shoreline environment.

Nanka Formation is composed of loose to very weakly consolidated quartz arenite completely devoid of cement, which helps to explain the high rate of gully erosion. Minor amounts of shale, mudstone, ferruginous sandstones intercalate the formation (Nwajide, 1977). The sandstone is medium to coarse grained occasionally pebbly and highly porous and permeable. Egboka (1985) suggested that the sandstone deposit exhibit a systematic pattern of alternating gross-bedded sand thin dark grey shales with sand horizon thicker than the shale siltstone.

Nanka Formation is overlain by the lignite-clay seams of the Oligocene Ogwashi - Asaba Formation and underlain by Imo Formation (fig3). Imo Formation (Paleocene) consists of thick dark grey to bluish shale with occasional intercalation of thin bands of calcareous sandstones, ironstones and limestone. Simpson (1954) found that Imo Formation underlies the valleys of Aghomili and Mamu rivers (fig.2). Good exposure of the Imo Formation is rare and most outcrops occur in small tributaries of Mamu and Aghomili rivers. It has been suggested (Orajaka, 1975) that Imo Formation succeeds Nanka Formation conformably.

GEO-ELECTRIC INVESTIGATION

For the purpose of the geo-electric survey, five locations for depth probe were chosen after hydrogeological observations of the area. The lines were at intervals of 250m from each other and oriented perpendicular to the perceived structural trends which are broadly north-south. The lines were cut through bush of predominantly elephant grass that is devoid of human settlement. It was only for one of the profiles (VES 2) that a shift of 50m was made at some point to avoid a yam farm. It was found convenient to adopt the Schlumberger electrode arrangement for the survey.

DATA ACQUISITION AND INTERPRETATION OF SOUNDING CURVES

The ABEM Terrameter SAS 300 was utilised in data gathering. A total of five vertical electrical soundings (VES) were undertaken in Nanka town, each sounding point being approximately 250m from each other. The Schlumberger electrode arrangement was used for the measurements. The maximum current electrodes distance was 1000m for all five sounding points.

The apparent resistivity values obtained from the measurements were plotted against half the current electrode spacing (Figs 4, 5a, 5b). The sounding curves (VES 1-5) are shown in figures 4-8.

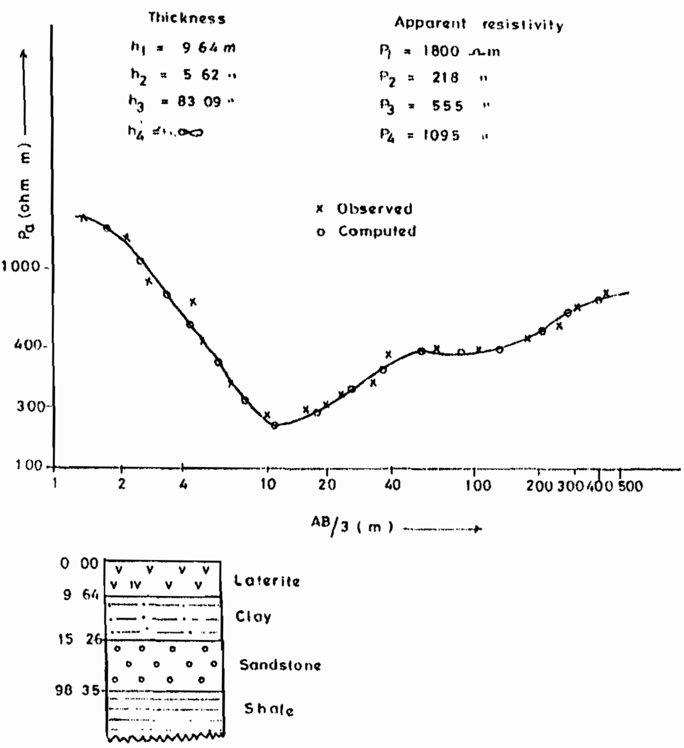

Fig. 4. Observed and computed resistivity curve for VES 1

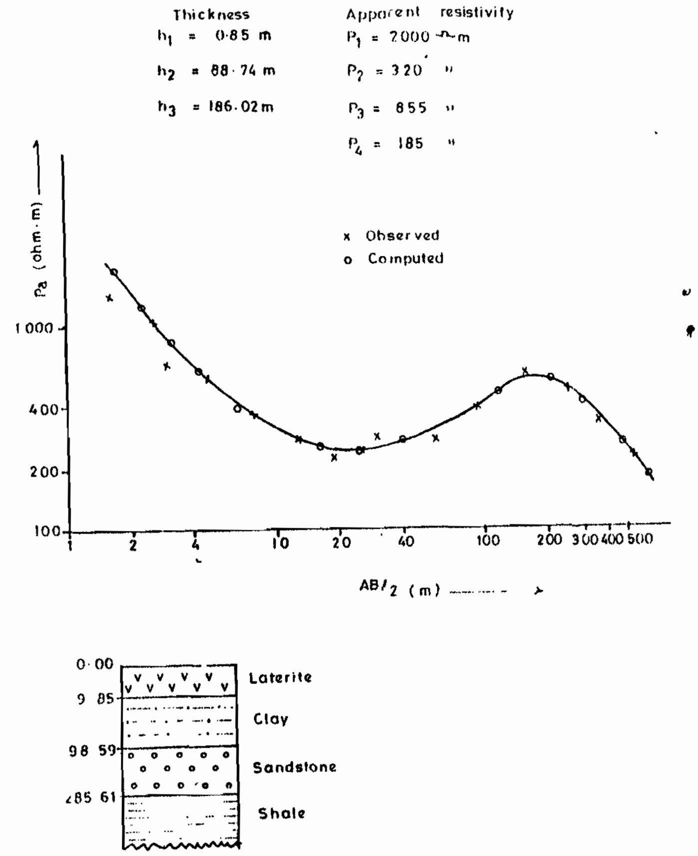

Fig. 5a Observed and computed resistivity curve for VES 2

The early method of interpreting sounding curves used curve matching techniques. The method involves matching small segments of field curve with appropriate theoretical curve which enables one to determine both the thickness and apparent resistivity of a particular layer. This method has the disadvantage that it can only be usefully handled by experienced personnel, particularly where the layering exceeds two. In these studies, a computer program (Mooney, 1974) is used to compute a layered earth model using least square techniques to match the theoretical apparent resistivity curve as close as possible to the field curve. Initial input to the computer program was obtained by sampling the field curve at specific intervals.

RESULT AND DISCUSSION

The interpreted sounding curves (VES 1-5) along side the computed earth models are shown in figures 4-8. The sounding curve I (VES 1) in figure 4 is a 4-layer HA type section while sounding curve (VES 5) in figure 8 is a 3-layer H-type section.

The lithologic information from a producing borehole some 2km from the VES 2 (fig. 5a), in conjunction with the geology of the area were utilised in the constructing the various earth models. It is necessary to point out that because of the inherent ambiguity in interpretation of this nature, other earth

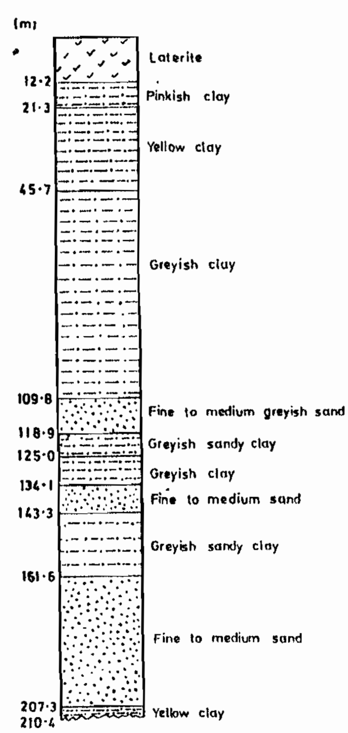

Fig 5 b Lithologic Log from a borehole in the vicinity of study area

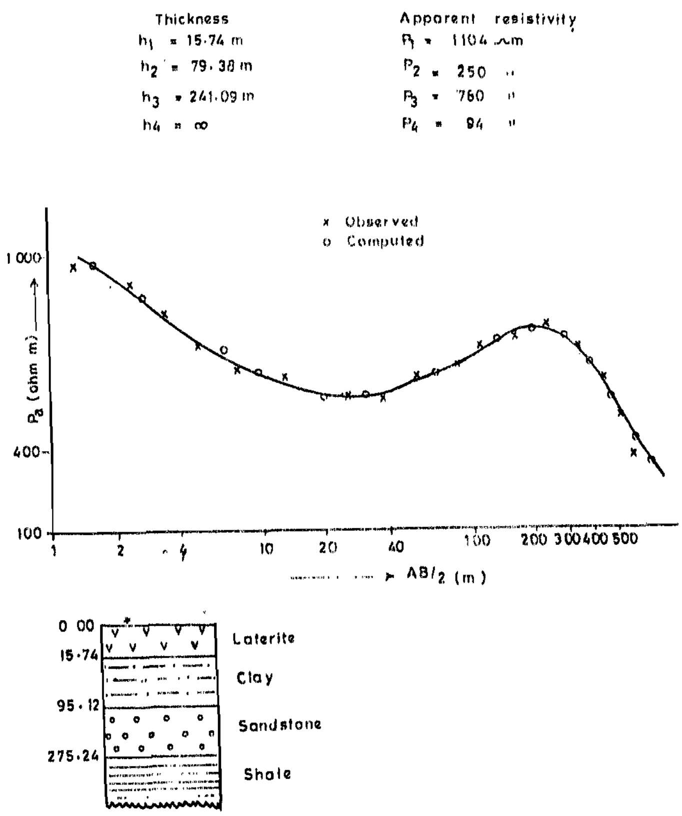

Fig. 6. Observed and computed resistivity curve for VES 3

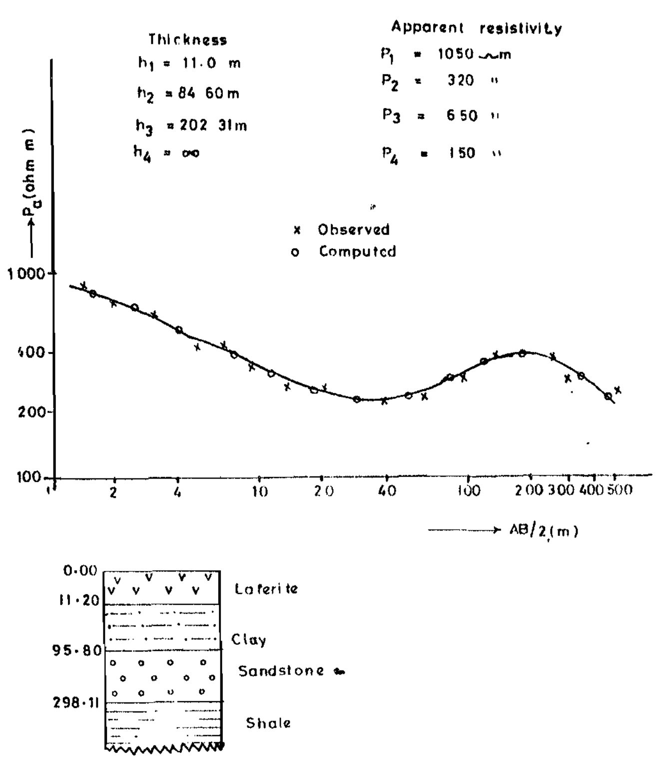

Fig. 7. Observed and computed resistivity curve for VES 4

models may equally fit the data. The borehole lithologic log (fig. 5b) indicates broadly that within the depth penetrated, the lithologic succession is

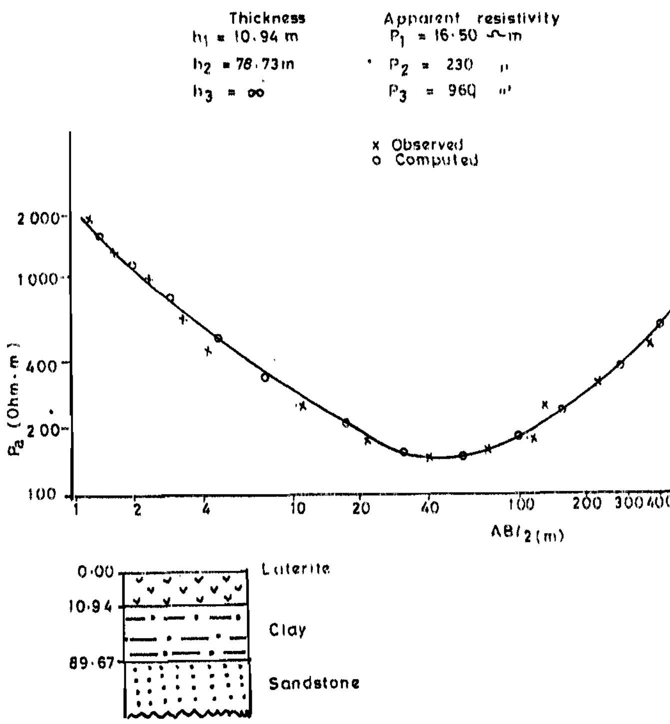

Fig. 8. Observed and computed resistivity curve for VES 8.

laterite-clay-sandstone-clay. The borehole apparently did not penetrate the shale unit.

Generally the sounding curves indicate a high resistivity (>1000ohm.m) for the top weathered lateritic layer of varying thickness and dryness. It appears that that VES 2-4 (fig. 5a-7) penetrated Imo Formation (Shale) at a depth of at least 270m. For VES I and 5 (figs. 4 and 8), at the maximum current electrode spacing (l000m) used, the rising part of the resistivity curves are not well developed to enable the resistivity of the basal rock unit to be determined. The high resistivity third layer (500-960 ohm.m) in figures 4-8 is probably a sandstone bearing freshwater zone. In all the sounding curves this zone is overlain by a low resistivity layer (2.00-320ohm.m) interpreted as clay. A freshwater aquifer thickness of about 200m is indicated along the sounding curves in figures 5-7 while in figures 4 and 8 the rising nature of the resistivity curves makes it difficult to determine the thickness of the freshwater zone. However, since at the same current electrode spacing the shale bed (Imo Formation) is yet to be penetrated along the sounding curves in figures 8, it follows that from the point of view of groundwater potential, the neighbourhood of this sounding point may be the most promising.

CONCLUSION

This study shows that Nanka Formation is an extensive sand unit which is at least some 250m thick in the study area. The interpretation indicates that the water bearing formation (sandstone unit) is in excess of 200m in thickness. The implication is that the area has a great freshwater potential but any production well for that purpose will be in excess of 100m depth.

The area is therefore a potential recharge zone for Odo river in the vicinity which flow into the Mamu River (fig. 3). The presence of Awka-Orlu highland standing over 300m above sea level at Isuaofia but which falls to about 200 metres at Nanka implies the existence of large hydraulic gradient and attendant increase in the velocity of water down the Odo River within the Nanka town. This has caused the "quick sound" responsible for the extensive gully erosion in the area.

This study has provided information on the depth to the groundwater and probably thickens of the aquiferons unit in Nanka, a type locality of Nanka Formation. This information is going to be relevant to the development of effective water scheme for the area and possibly beyond over areas underlain by Nanka Formation.

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