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SUBSURFACE SEQUENCE DELINEATION AND SALINE WATER MAPPING OF LAGOS STATE, SOUTHWESTERN NIGERIA.

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ABSTRACT

A subsurface sequence delineation and saline water mapping of Lagos State was carried out. Ten (10) deep boreholes with average depth of 300 m were drilled within the sedimentary basin. The boreholes were lithologically and geophysically logged.

The driller's lithological logs aided by gamma and resistivity logs, showed that the area is underlain by clays, sandy/silty clays, clayey sands and sands with shale and limestone in places.

The resistivity logs delineate saline water at shallow depth at Lekki wells I and II, Lakowe and Akodo with fresh/saline water interface at depths ranging from 8 - 15m. Confined saline water was delineated at deep levels at Eredo and Akodo. Saline seawater incursion has extended in land to within 2.5 - 12.5km from the coastline.

KEY WORDS: Subsurface Sequence, Saline Water Mapping

INTRODUCTION

Lagos State is situated in the Southwesterr part of Nigeria, and is made up of a low-lying Coastal region of mangrove swamps coving 60% of the total landmass. It is bounded by the Republic of Benin to the West, Ogun State to the North and East and the Atlantic Ocean to the South (Fig. 1). The State occupies an area of some 5,000km^2 with an estimated population of 10 million inhabitants. Water supply in some parts of the state is inadequate with many inhabitants having either no access or limited access to potable water supply. The major drinking water sources in the state are surface and groundwater. In some parts of the state that are closer to the coast, surface water is abundant.

The water is however not usually potable due to urban waste disposal and sea water intrusion. The shortage of public potable water areas have led to the exploration of fresh groundwater by local and international organizations.

Most boreholes in Lagos State obtain water from aquifers within the Coastal Plain Sands. Kampsax - Kruger and Sshwed (1977) carried out extensive study for the Ministry of Works and Panning on the hydrogeology of Lagos metropolis and grouped the aquifers encountered in the boreholes into four. The aquifers are separated from each other by alternating sequences of clay and sandy clay layers of varying thicknesses. The fourth aquifer is the deep and highly productive Abeokuta Group. The water from this aquifer is hot with temperature of 80^{0}C recorded from borehole discharge at Guinness borehole, Ikeja.

A fresh water lens overlying brackish water is found in the coastal areas of Lagos State within the Recent Sediments aquifer. Oteri (1985, 1988) found brackish water in hand dug wells in Aguda and Tin Can Island near Apapa and in a borehole by Badagry beach respectively. Interpretation of gamma ray and resistivity logs of water wells in Apapa, Victoria Island and Lekki Pennisula also reveal the existence of a shallow salt water bearing sand overlying the main fresh water aquifer (Oteri and Atolagbe, 2003).

This paper presents the lithological logs from ten (10) deep boreholes drilled between late 1995 and through 1996 at Lekki, Ijanikin, Igando, Itoikin, Eredo, Lakowe, Ikorodu Badore and Akodo area of Lagos State. The boreholes were drilled on behalf of the Lagos State Water Corporation. The logs in addition to some wirelogs will be used to delineate the subsurface lithologies and establish fresh/saline water interface.

GEOLOGICAL SETTING

Lagos State lies within Dahomey Sedimentary Basin. The basin extends from the eastern part of Ghana through Togo and Benin Republic to the Western margin of the Niger Delta. The eastern half of the basin occurs within the Nigerian territory. The base of the basin consists of

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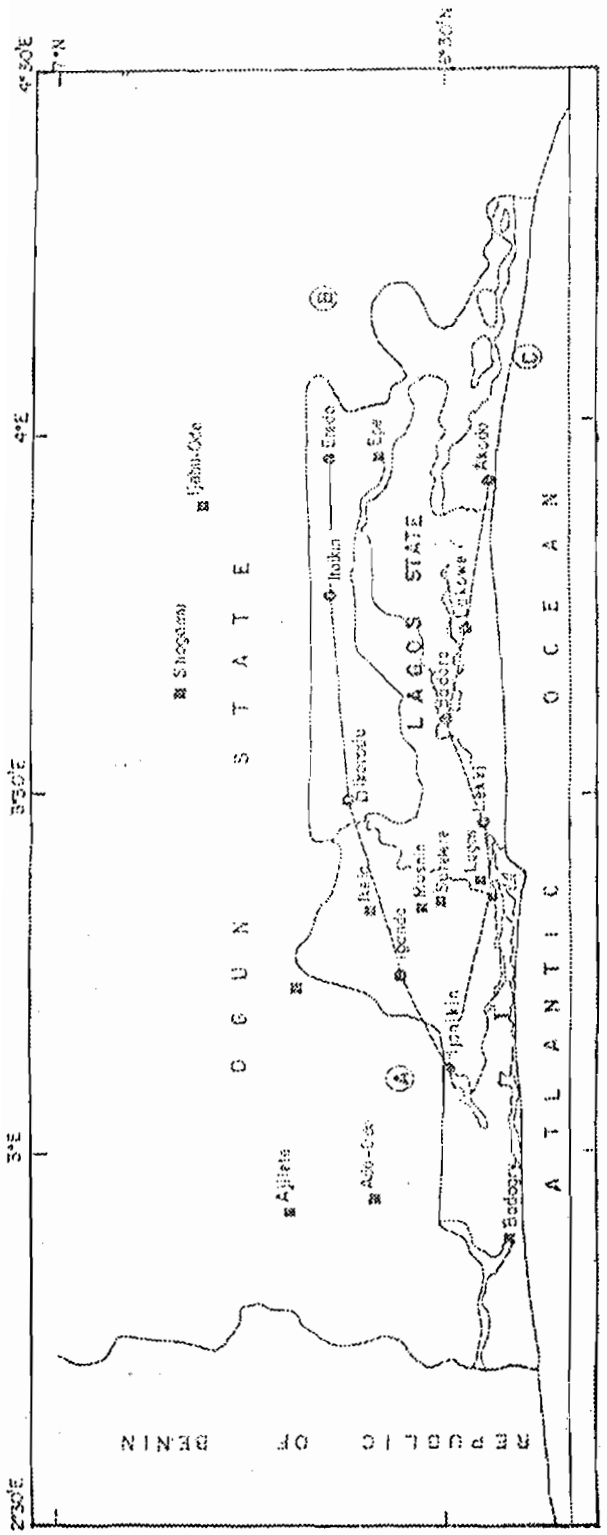

FIG. 1: MAP OF LAGOS STATE SHOWING LOCATIONS OF BOREHOLES.

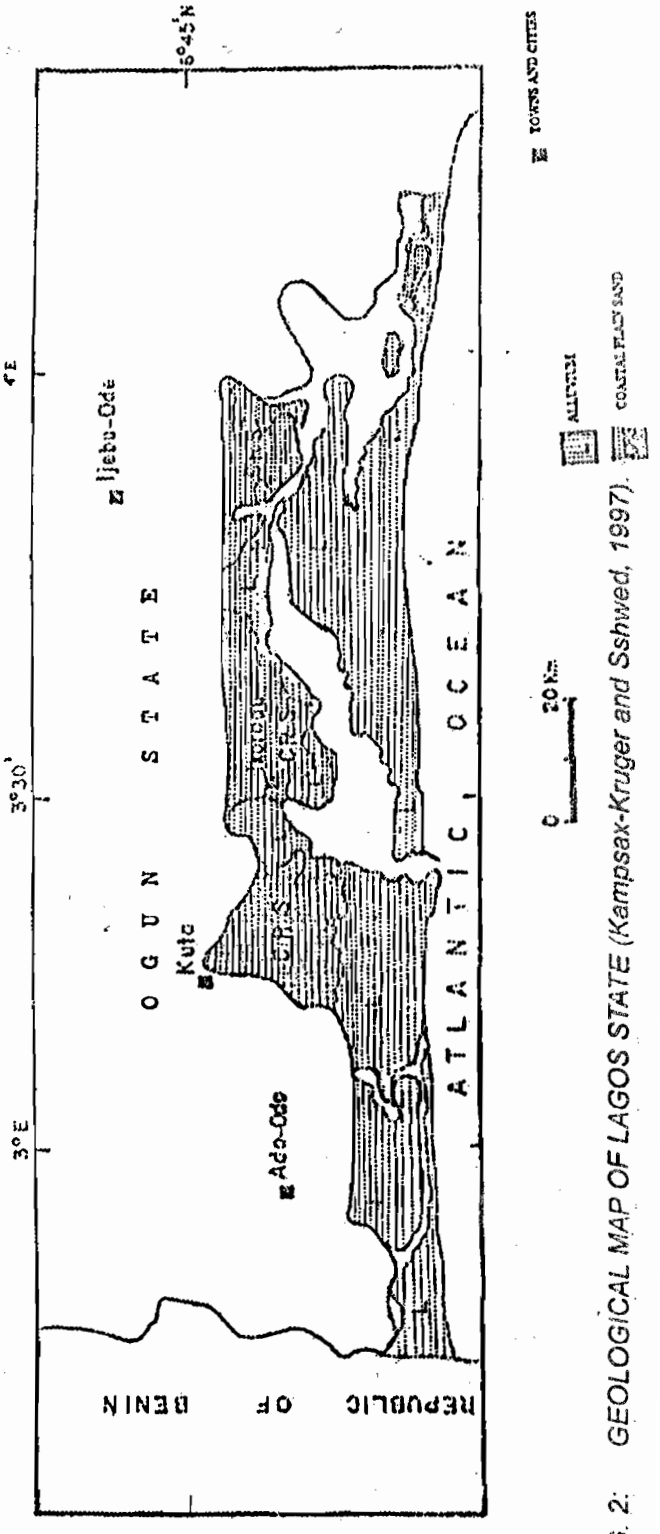

FIG. 2: GEOLOGICAL MAP OF LAGOS STATE (Kampsax-Kruger and Sshwed, 1997).

unfossiliferous sandstones and gravels weathered from underlying Precambrian basement. On top of these are marine shales, sandstones and limestones of Albian to Santonian ages deposited prior to the Santonian tectonic episode.

Jones and Hockey (1964) grouped all the Cretaceous sediments under the Abeokuta Group. Omatsola and Adegoke (1981) subdivided the cretaceous sequence into three: Ise, Afowo and Araromi Formations under an Abeokuta Group. Similarly, the Ewekoro Formation has been subdivided in Ewekoro and Oshosun Formation.

Ogbe (1972) subdivided the Ewekoro formation into Ewekoro and Akinbo Formations. In Lagos State and some parts of Dahomey Basin, the Ilaro

Formation is overlain by Coastal Plain Sands and Recent sediments (Fig. 2).

MATERIALS AND METHOD OF STUDY

The materials used in this study are lithological logs and geophysical logs from ten (10) boreholes from the sedimentary basin of the Lagos State. The average depth of the boreholes was 300m. (984ft). The deep borehole were drilled at Lekki (I&II), Ijanikin, Igando, Itoikin, Eredo, Lakowe, Ikorodu, Badore and Akodo.

The lithological logs consist of the driller's description of the borehole lithology at every 3 metres interval. Samples were collected while drilling was in progress and subsequently logged.

Borehole geophysical logging was undertaken in all the boreholes using Robertson Geologging equipment (RG PC - LOGGER SYSTEM II), a digital borehole logging equipment. Resistivity and gramma-ray logging were carried out.

The resistivity logging devices measure the

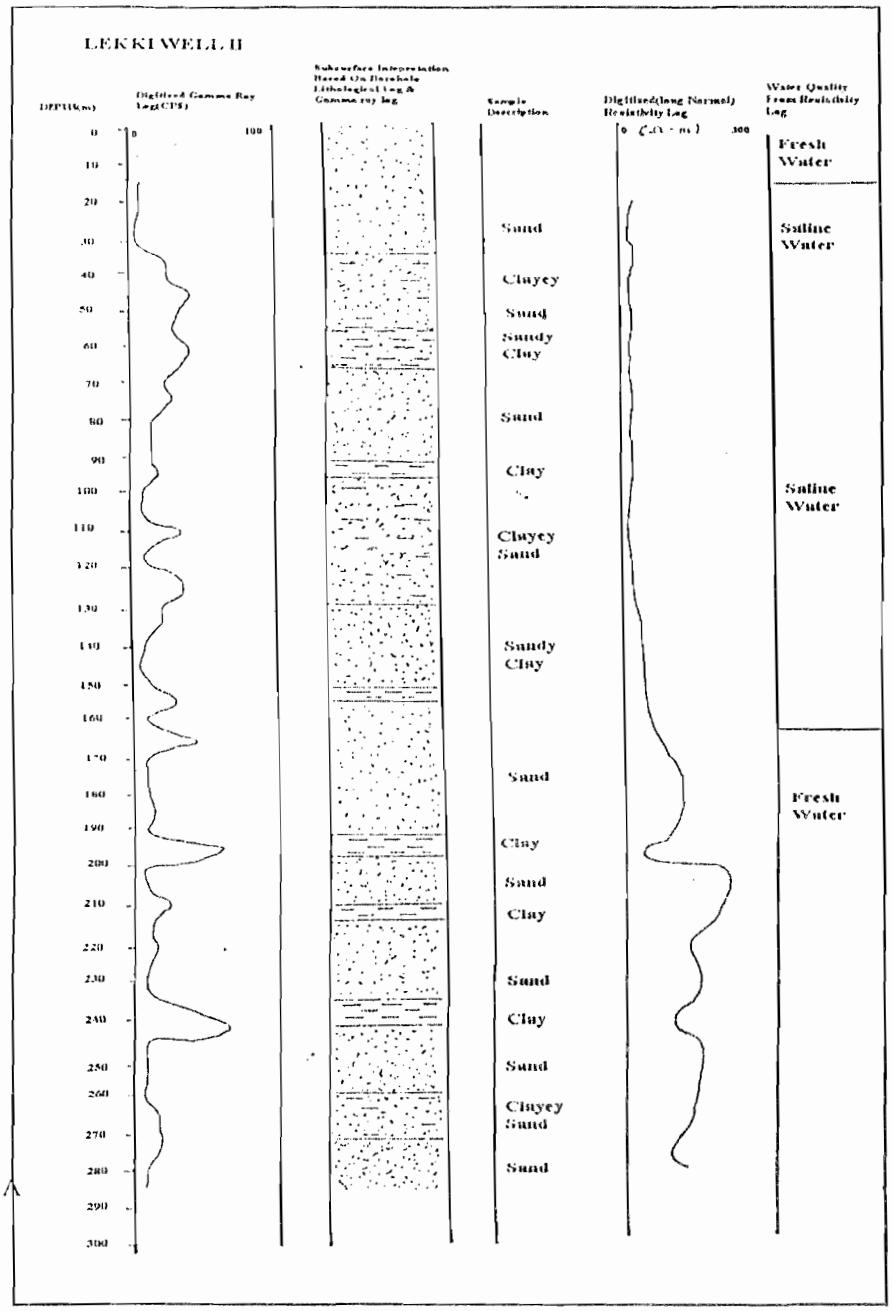

Fig. 3: GEOPHYSICAL AND LITHOLOGICAL LOGS OF LEKKI WELL II

electrical resistivity of the earth materials within the borehole. Two resistivity curves corresponding to increasing radii of investigation from the center of the borehole were obtained. Theses are the Short Normal with radius of 16" and Long Normal with a radius of 64". In this study only the Long Normal logs were used. The Long Normal measures the resistivity of the un-invaded zone (undisturbed formation). The measured resistivity is a function of the resistivity of the borehole formation and interstitial fluids.

In gamma-ray logging, the natural radioactivity of the borehole formation was measured. The logs were used as qualitative guide for lithological identification since the radioactive materials are more concentrated in clays and shales. Mature sands and gravels, on the other hand, contain primarily silica, a stable substance emit only very low level of radiation.

RESULTS AND DISCUSSIONS

The borehole lithological logs as digitized geophysical logs are presented in Figures 3-12 and are subsequently discussed.

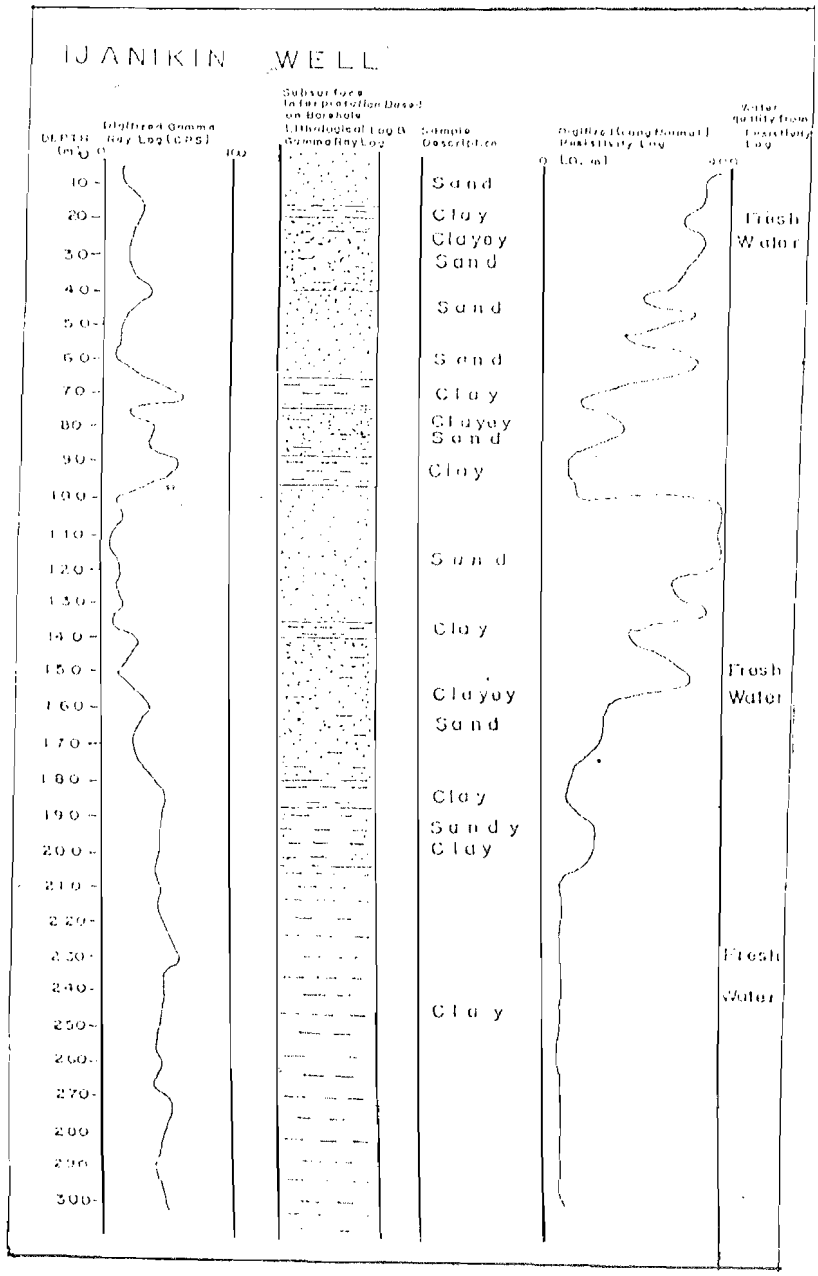

FIG. 4: GEOPHYSICAL AND LITHOLOGICAL LOGS OF IJANIKIN WELL.

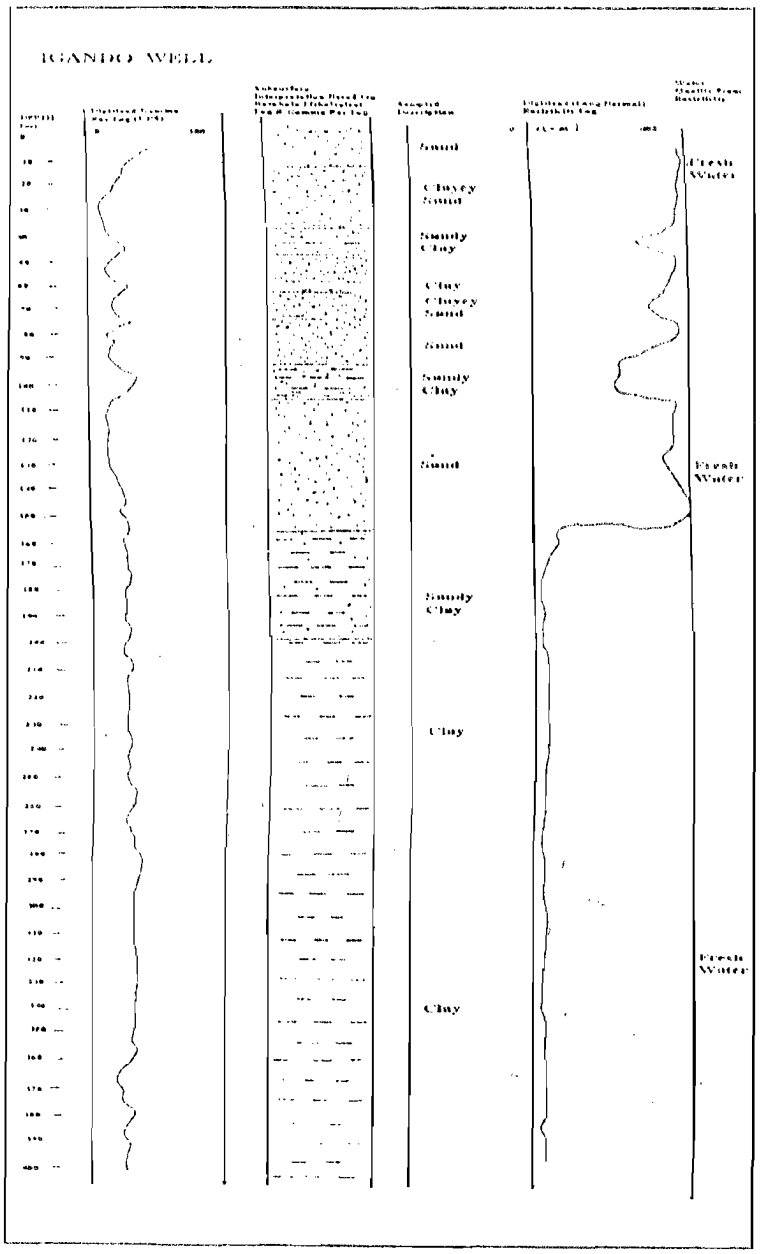

Fig. 5: GEOPHYSICAL AND LITHOLOGICAL LOGS OF IGANDO WELL.

LEKKI WELL II

The geologic sequence consists of thick sand and clayey sand layers with interbeded thin clay layers from surface to the bottom of the borehole (Fig.3). . An upper and lower fresh/saline water interfaces were encountered at depths of 15m and 170m respectively.

IJANIKIN WELL

Alternation of sand and clay occurs from the surface to a depth of 180m.

Below this depth the lithologies are clay and sandy clay (Fig.4). The resistivity log does not show any indication (marked deflection within sand) of saline water bearing formation.

IGANDO WELL

From the ground level to a depth of 155m, there is thick sequence of sand and clayey sand with thin bands of sandy clay layer. Below this depth, the lithology is predominantly clay formation (Fig. 5). Fresh water was encountered in this well form top to bottom.

ITOIKIN WELL

The lithology from ground level down to 280m is

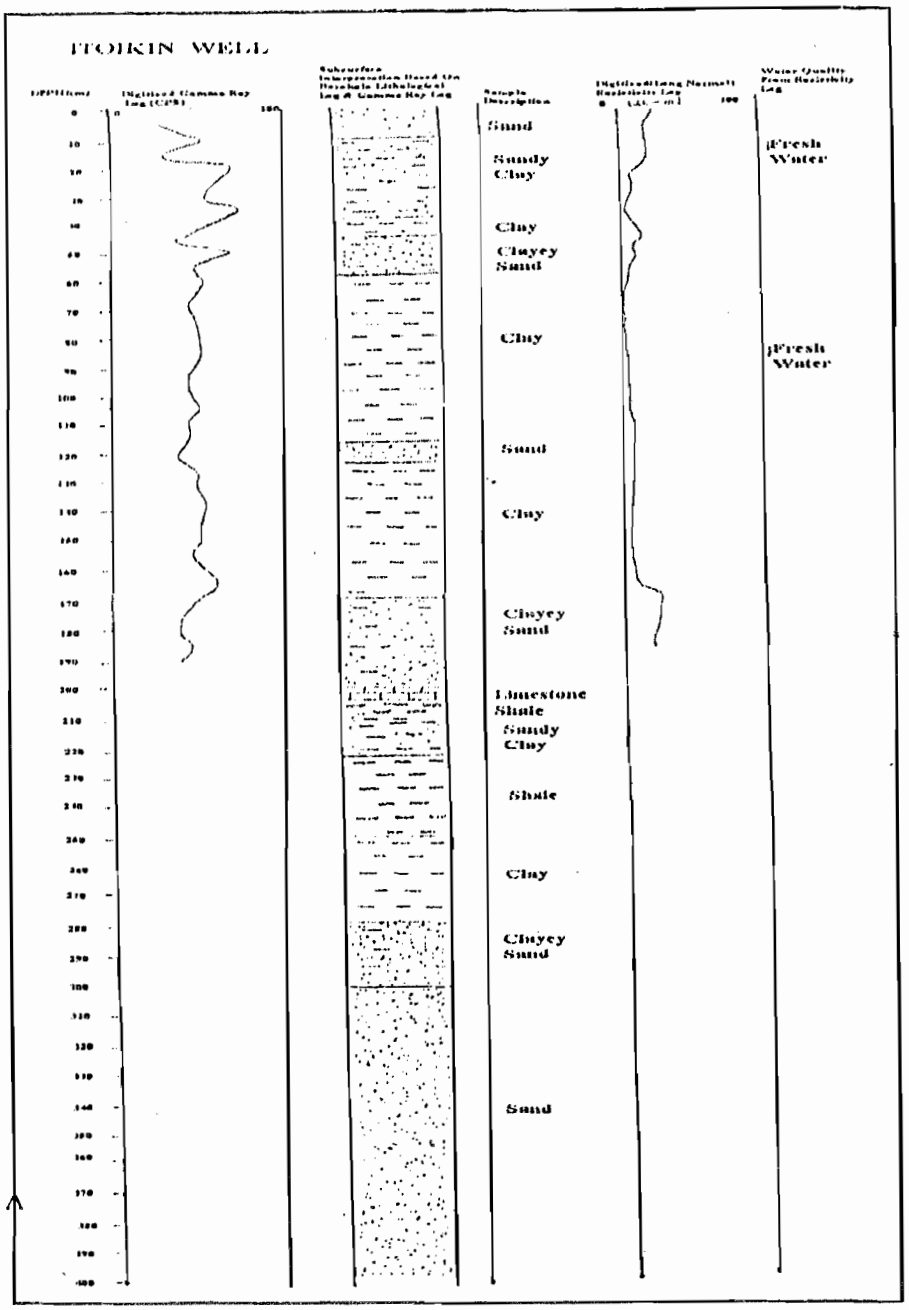

Fig. 6: GEOPHYSICAL AND LITHOLOGICAL LOGS OF ITOIKIN WELL.

predominantly clay with bands of sand, clayey sand and limestone. From 280 m to 400 m, the lithology is predominantly clayey sand /sand formation (Fig. 6). The borehole is fresh water bearing.

EREDO WELL

The upper 210m is composed of predominantly clay/shale with sands of limestone and clayey sand in places. Beneath this depth, the formation is composed of sand/clayey sand with clay intercalations (Fig. 7).

Borehole geophysical logging was carried out between 160 and 400m. The resistivity log indicates fresh/saline water interface at a depth of 325m

LEKKI WELL 1

The geologic sequence up to a depth of 290m beneath this site is composed of sand and clayey sand inter-bedded by thin bands of clay. Below this depth, clay formation occurs (Fig. 8).

The resistivity log indicates fresh/saline water interface at a depth of about 15m. Fresh water

occurs from a depth of about 120m with a thin band of overlying clay acting as a sealant for the overlying saline water. The borehole correlates well with that of Lekki Well II, which is located within the same locality.

LAKOWE WELL

Lakowe well is different from all the wells in the study area in that it has no substantial sand formation below 25m where the sequence is composed of predominantly clay/shale with thin bands of sandy clay and clayey sand (Fig.9).

The resistivity log shows that fresh water bearing formation occurs from the surface to a depth of 12m while the formation below this contains saline/brackish water.

IKORODU WELL

The upper 110m of the geologic sequence beneath the Ikorodu site consists of sand, sandy clay and clayey sand interbedded by thin clay layer (Fig. 10). The underlying formation is composed of clay/shale. No resistivity log was recorded from the borehole hence the quality of the groundwater could not be established.

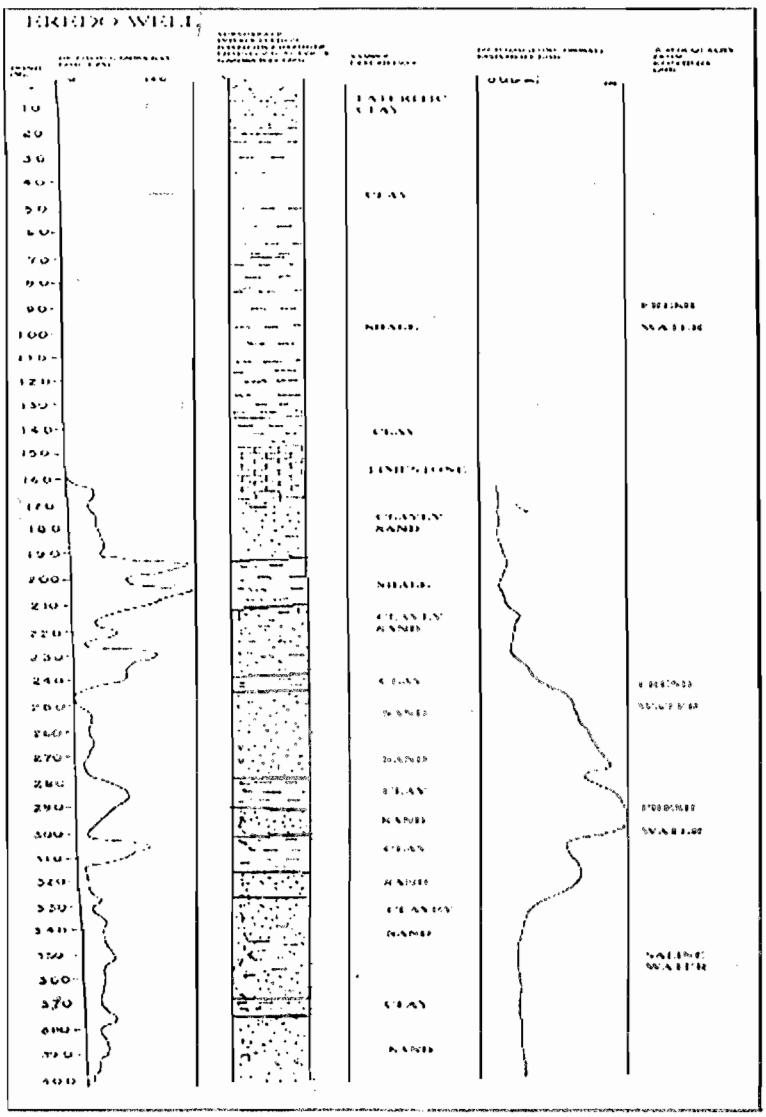

Fig. 7: GEOPHYSICAL AND LITHOLOGICAL LOGS OF EREDO WELL.

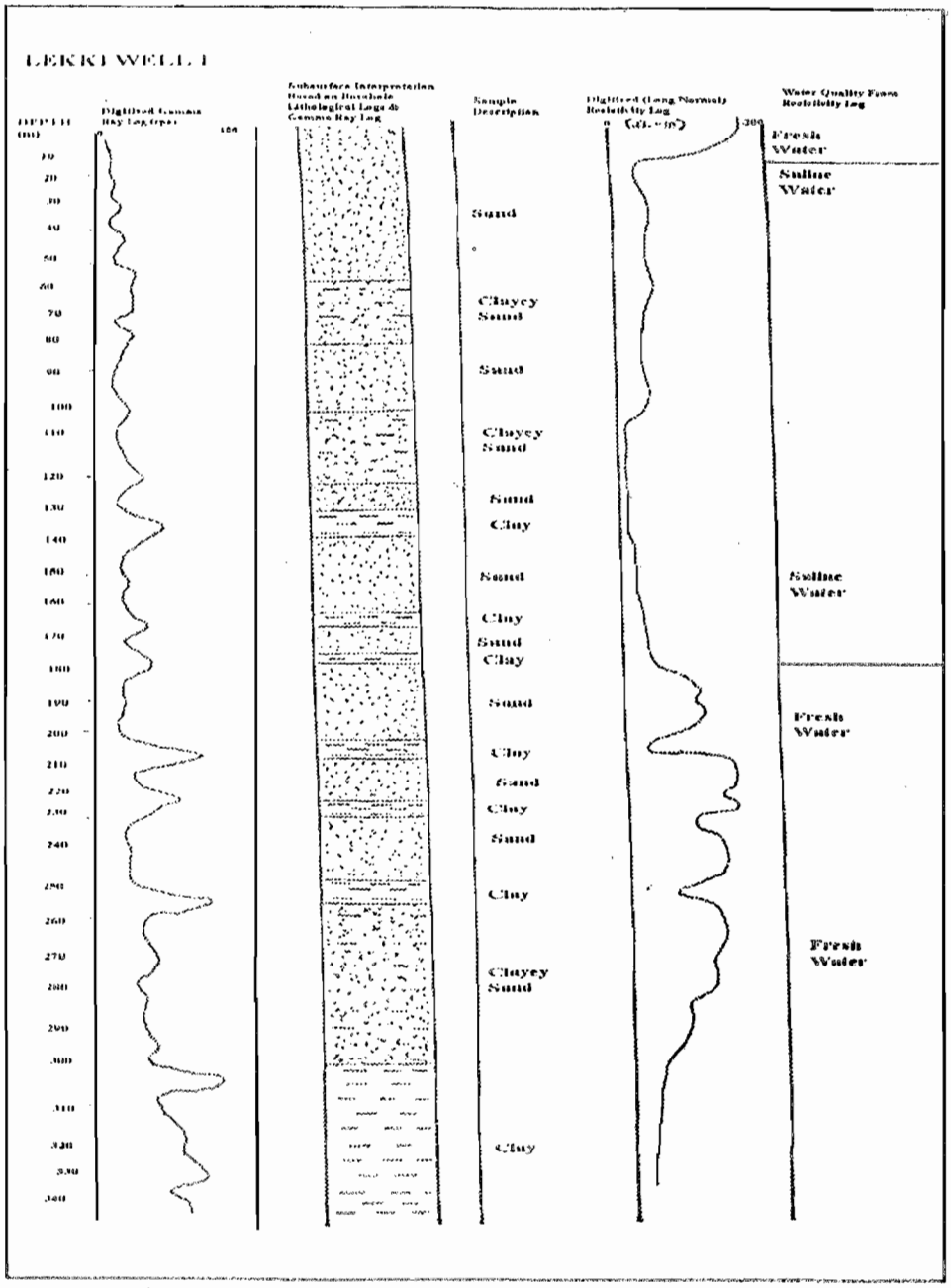

Fig. 8: GEOPHYSICAL AND LITHOLOGICAL LOGS OF LEKKI WELL 1.

BADORE WELL

The lithologies beneath Badore borehole consist of sand and clayey sand with intercalation of clay/sandy clay from surface to a depth of 212m. Beneath this depth, the sequence is composed of clay (Fig.11). The borehole is fresh water bearing.

AKODO WELL

The lithologies beneath Akodo Well are composed of alternations of sand, clayey sand and clay. (Fig. 12)

The resistivity log shows that in Akodo Well, the fresh water bearing formation starts from the surface to a depth of about 8m. Below this depth, saline water is encountered up till a depth of 110m. Fresh water occurs in the formations between 110m and 190m where saline water is presumed to occur. Fresh water sands are encountered within depth intervals of 0-8m. 120 - 192m.

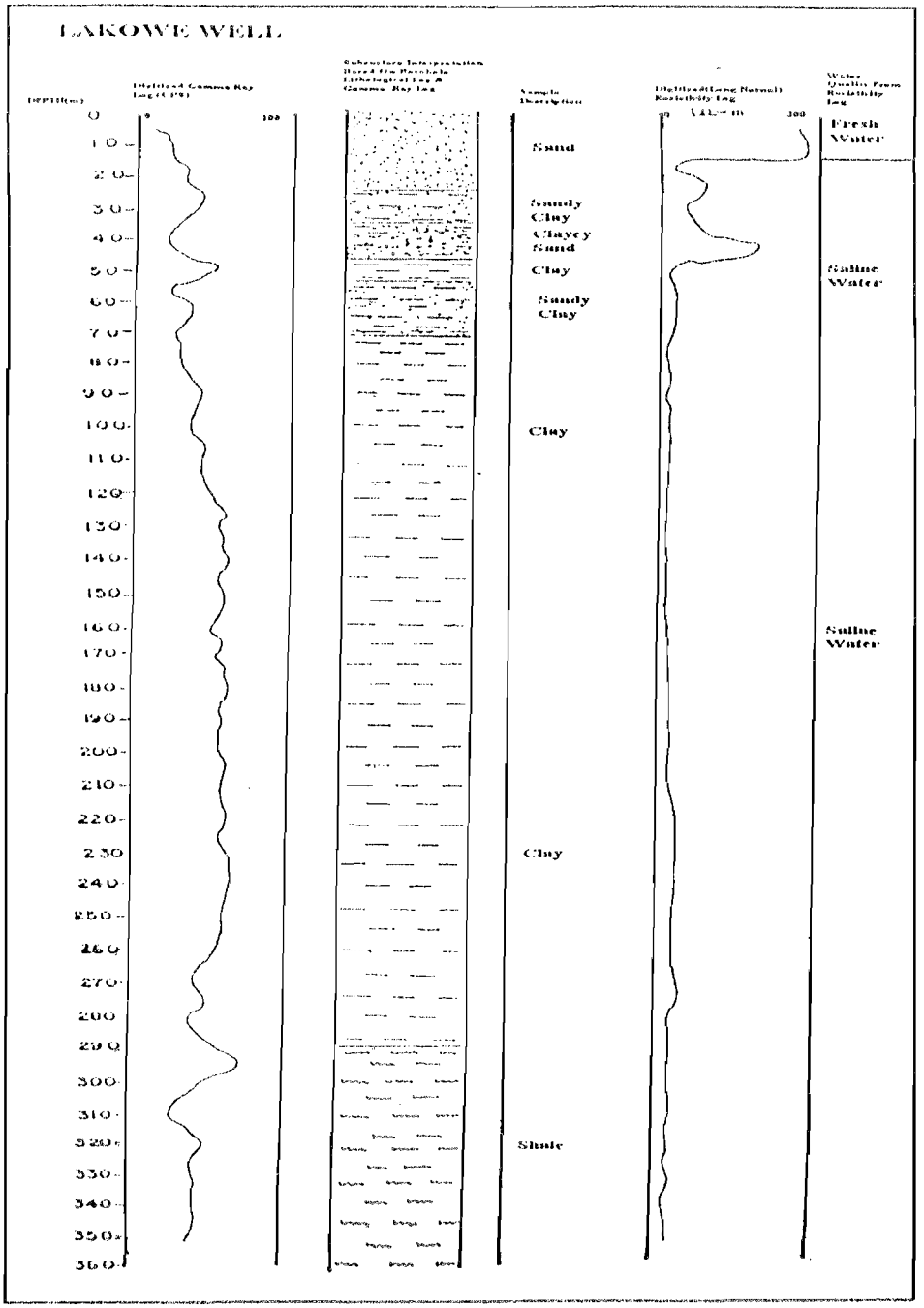

Fig. 9: GEOPHYSICAL AND LITHOLOGICAL LOGS OF LAKOWE WELL.

SYNTHESIS

Lagos sate is underlain by a geologic sequence composed of sands, clayey sands, clay/shale, and sandy clay typical of Alluvium and Coastal plain sands. The bands of limestone use delineated beneath itoikin and Eredo, in the north.

Figure 13 shows the lateral extent of the saline water zone in the study area as determined from the geophysical logs and boreholes records. Saline water intrusion in Lagos is precipitated and

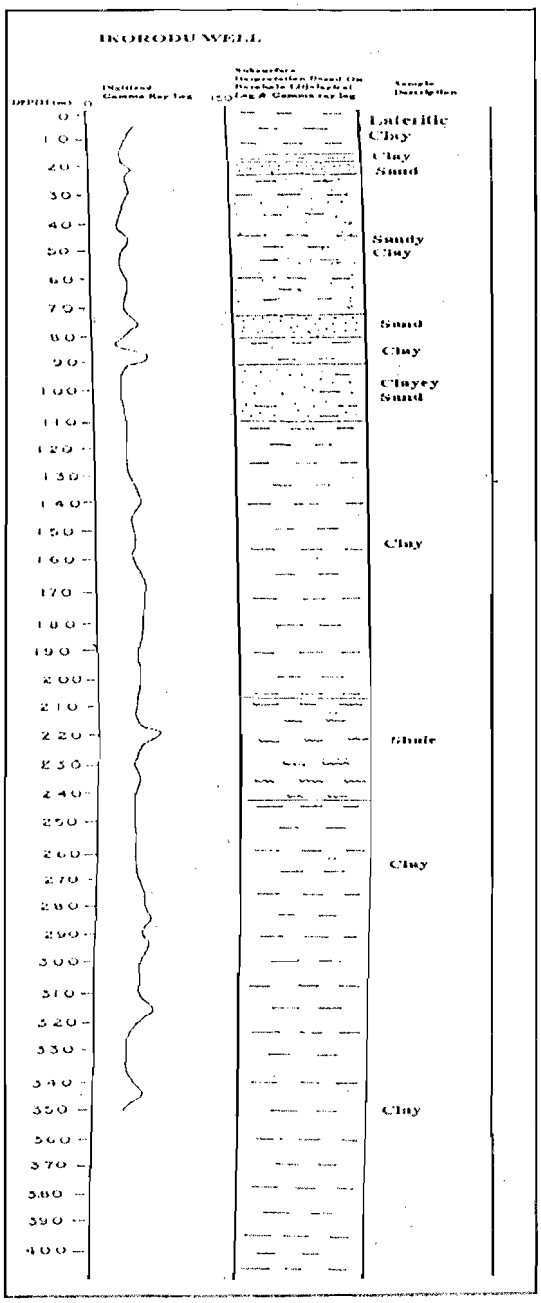

Fig. 10: GEOPHYSICAL AND LITHOLOGICAL LOGS OF IKORODU WELL.

sustained by natural saline sea water incursion and upconing of basal saline water due to excessive groundwater abstraction in areas like Lekki, Apapa and Surulere. If the groundwater exploitation in these areas is not controlled, the incursion of seawater will continue to extend inland.

CONCLUSION

Lithological and geophysical logs from ten (10) deep boreholes from the sedimentary basin of the Lagos State were studied for delineation of the subsurface geologic sequence and mapping of saline water zone and fresh/shale water interface

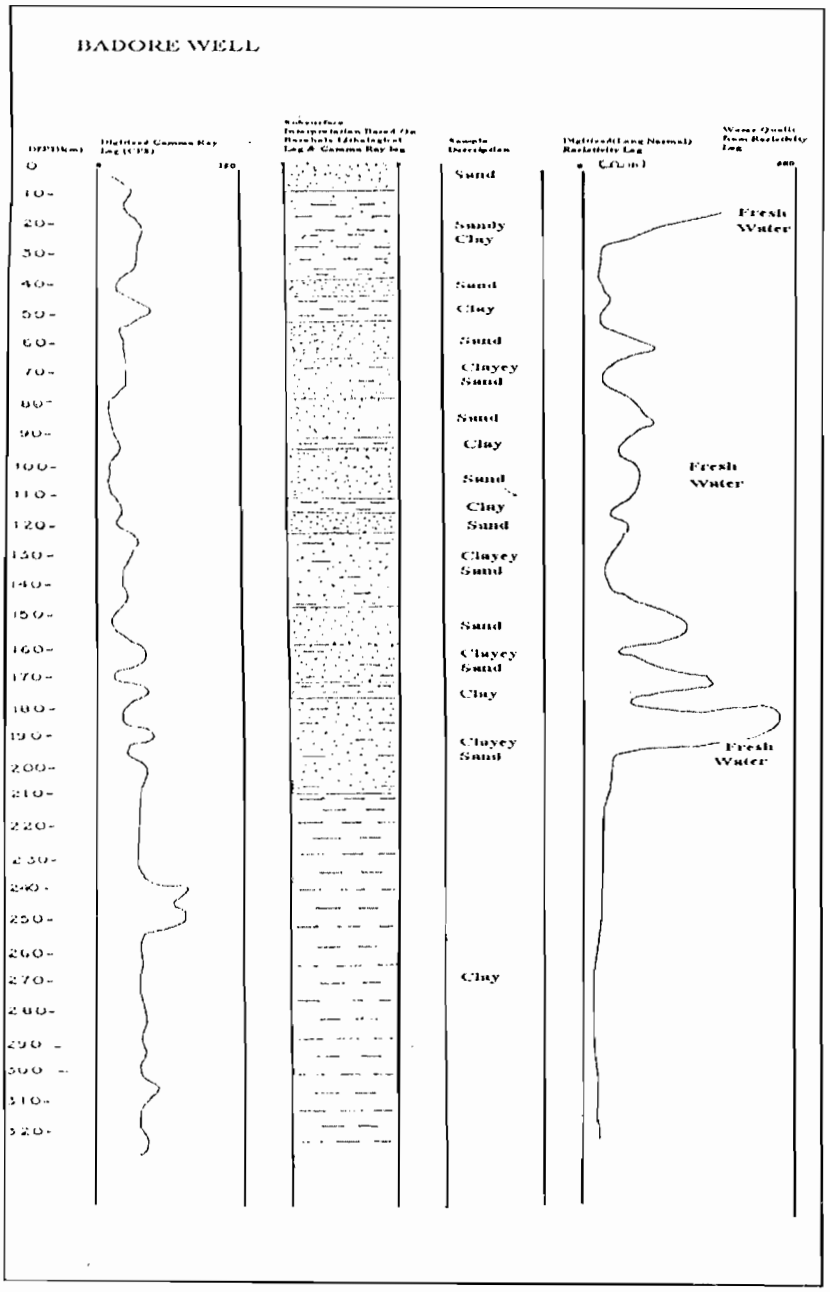

Fig. 11: GEOPHYSICAL AND LITHOLOGICAL LOGS OF BADORE WELL.

The geologic sequence is composed of clays, sandy/silty clays, clayey sands and sands with shale and limestone in places. The sands and clayey sands constitute the aquifer units.

The resistiivty logs show that saline water is present at shallow depth at Lekki I and II, Lakowe and Akodo borehole locations. The fresh/saline water interface ranges in depth from 8-15m below

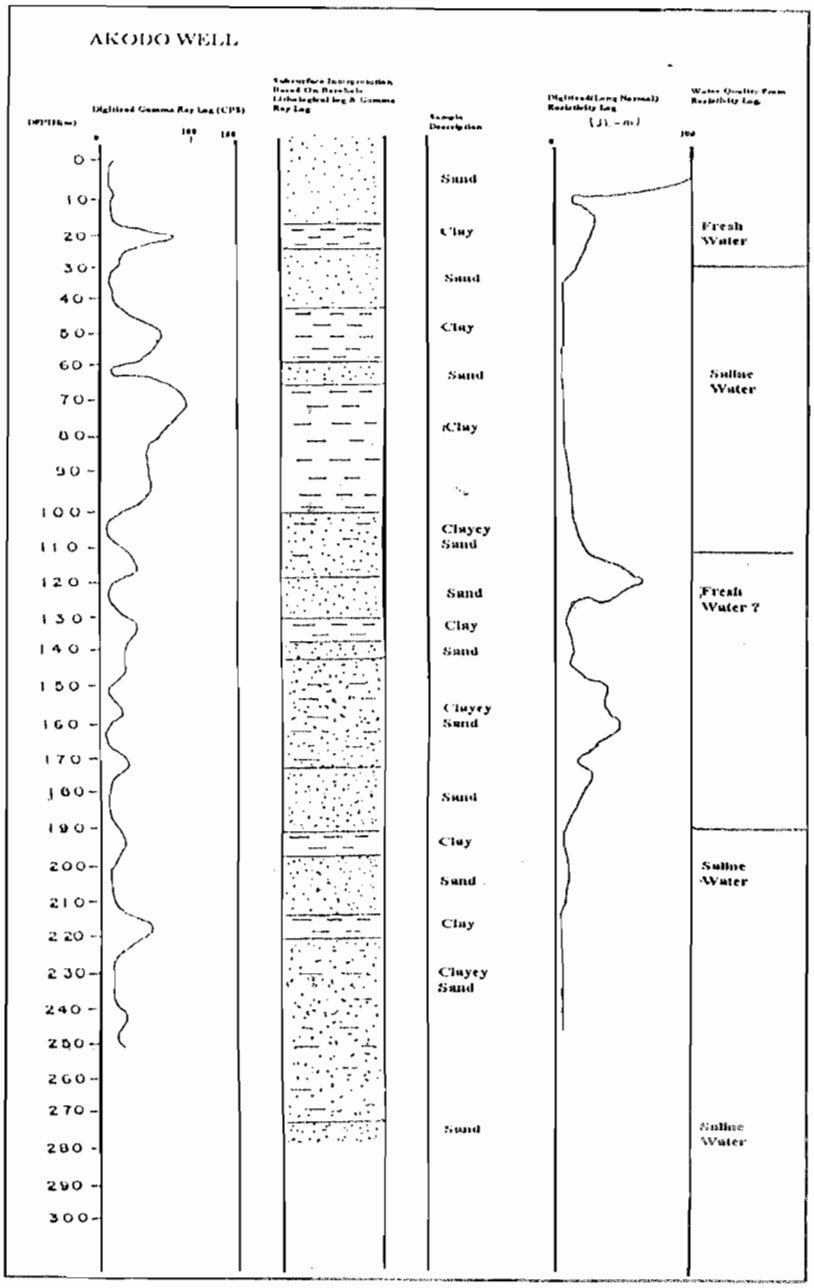

Fig. 12: GEOPHYSICAL AND LITHOLOGICAL LOGS OF AKODO WELL.

the ground level. Confined saline water is also delineated at deep depth at Eredo and Akodo. Delineated saline water zone extends from about 2.5km from the coast in Lakowe/Akodo area to 12.5km within metropolitan Lagos (up to Surulere area) where excessive groundwater abstraction has led to the upconing of the basal saline water.

ACKNOWLEDGEMENT

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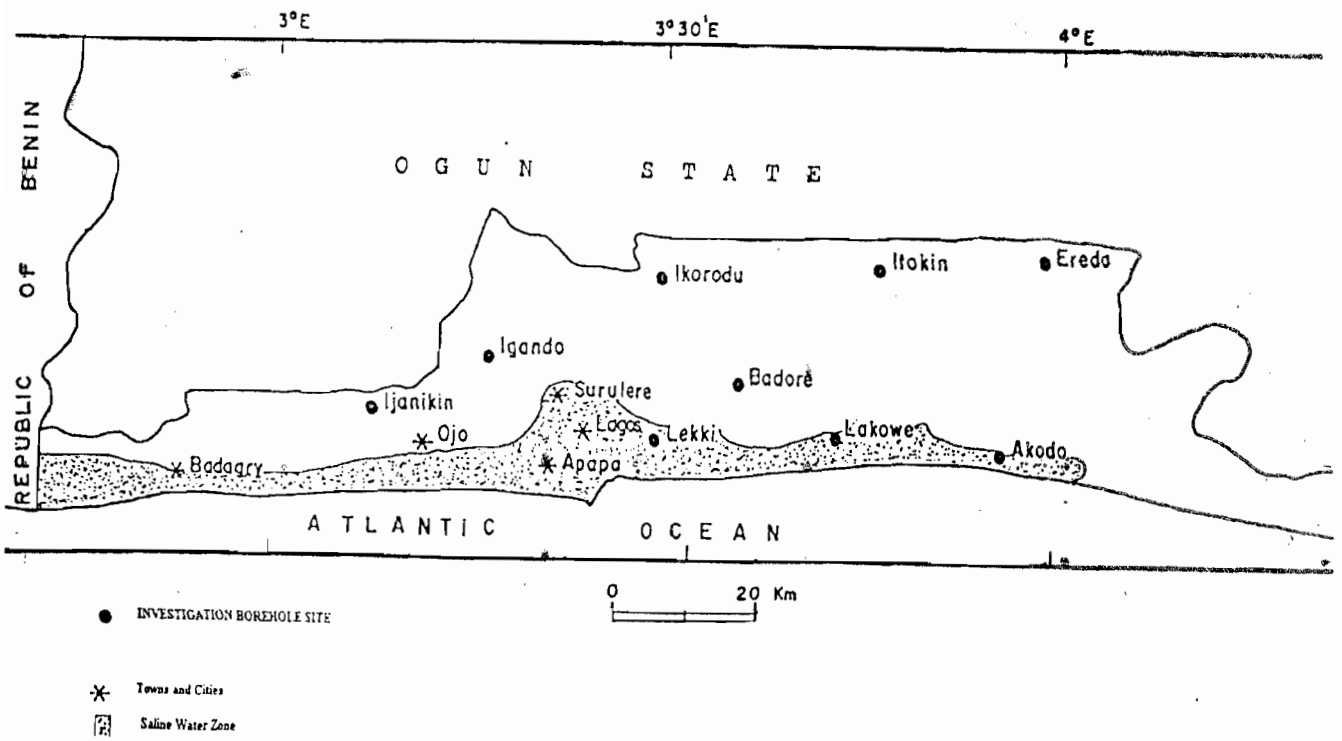

FIG 13: MAP SHOWING NEAR SURFACE SALINE WATER ZONE.

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