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INTERPRETATION OF GOELECTRICAL DATA TO IDENTIFY AQUIFERS AND PALEO -CHANNEL OF RIVER NILE IN ESNA AREA, UPPER EGYPT.

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Abstract

The region under consideration lies between latitudes 25 ^{0} 10` and .25$^{0}$ 40` N and longitudes 32^{0} 20` and 32$^{0}$ 50` E. With the objective of detecting lateral shift in the Nile channel that might have occurred during Quaternary times and identification of groundwater aquifers. The study area is covered with Quaternary deposits of sand and gravel with thin clay interbeds. The study reveals that the typical stratigraphic column and geophysical survey (geoelectric) in the region shows various aquifers. Distinction can be made for the Quaternary and Plio-Pleistocene. The maximum thickness of the first aquifer is 180m, while for Plio- Pleistocene is 90m. The Plio-Pleistocene aquifer is vertically recharged from infiltration of irrigation water in the reclaimed areas, and some from wadis and rainfall during the occasional cloud bursts. It is rechargd also by lateral inflow from limestone aquifer and vertical one from deeper aquifer. The maximum later displacement between the old and present courses seem to be rane between 11 km and 6 km. It can be concluded that also the study area has a groundwater potentiality for the sustainable development .

Introduction

The studied areas are located along the Nile Valley between latitudes 15° 20′ and 25° 30′ N and longitudes 32° 20′ and 32° 50′ E. Esna covers an area of about 380 km2 on the west bank of the Nile River

The purpose of this paper is to establish an integrated hydrogeological study on the investigated area, in order to detect the main aquifers and the old channel of the Nile.

Geological Setting

The exposed rock units in the study areas are of sedimentary origin ranging in age from Paleozoic-late Cretaceous to Recent, where the lower part is mainly composed of sandstone facies belonging to Paleozoic-Early Cretaceous age, while the upper part of the sedimentary section is dominated by carbonate and shale rocks, belonging to the Late Cretaceous- Eocene age, This sedimentary section is overlain by Pliocene-Quaternary deposits, which fill the Nile gorge. The Pliocene deposits consist of clay with some interbeds of sand, and show uncomfortably resting on the Eocene carbonate or

Paleocene rocks (. Said, 1981) The Quaternary deposits are distinguished into two fancies, Holocene silt and clay for the young alluvial plain, and sands with gravels of Pleistocene age which is covering the old alluvial plain (Quaternary aquifer) (Fig 2)

The subsurface stratigraphic sequence ranging in age form Pre-Cambrian to Quaternary. The oldest Pre-Cambrian rocks consist mainly of igneous rocks, having generally a granitic composition. The sedimentary section overlying the basement complex ranging in age from Cretaceous to Recent.

Geologic Structure

From the surface structural map it can be noticed that, the Nile Valley crosses Cretaceous and Paleocene sediments, which form this platform cover. The essential role of structure of the platform cover are faults and folds. The prevailing trends of the faults are NW-SE: ("Erythream) and NE~-SW Aqaba trend" The NW-SE: fault system is more predominant, while the NE-SW fault system is represented by a number of minor faults of lesser extensions. These faults make several grabens and horsts. The other important group of faults is that which coincides with the location of the Nile Valley, and run parallel to the Nile Valley takes northwest trend and have close relation to its origin, this group of faults, are bordering the Quaternary aquifer, while the fold are gentle synclinal and anticline, follow the general prominent

NW-SE fault trend. These simple folds are either the surface reflection of deeper normal faults or the result of local secondary compression resulting from major tension. (Abd el Razi et al, 1972)(Fig.3)

Geophysical Survey

Geophysical surveys are good tools for a regional estimation of aquifer (vertical and lateral geologic boundaries). A computer program (Hemeker, 1988) was used to analyzed the field data

A geophysical survey has been performed in the study area along 7 traverses (Fig.4) to enable a better identification of the various aquifer systems. Measurements are calibrated with the help of available lithological and hydrochemical data.

A numerical package (30) has been used in the interpretation of field measurements. Results are summarized in the following paragraphs.

Traverse (a):

Eight Veses were measured along this traverse (Fig.5) they confirming the presence of three geoelectric units:

(1) A thin layer superficial unit of low ohmic values (4-10 ohm.m.). this represents the silt and clay of the fertile soil.

(2) A thin layer of graded sand-gravel, with moderate ohmic values (19-66 Ohm. m). This represents the main aquifer. Its thickness varies greatly

from east to west, being very thin in the east and becoming thicker to the west; the maximum thickness is at No. 2

(3) A basal unit of very low ohmic values (4-8 ohm. m.). this could represent the Pliocene clay which acts as the lower aquiclude for the aquifer. The upper surface of this unit becomes very shallow to the east and attains a maximum depth to the west.

Traverse (b):

Includes 8 VESs in an E.W direction crossing the Nile valley. The study of this traverse (Fig.5) shows that 3 geoelectric units are present.

(1) Surface clay layer of low resistivety (2-8 ohm.m.) with a thickness ranging between 3 and 11m.

(2) Surface sandy layer with high receptivity values, ranging from 15 to 2000 ohm.m. with a thickness varying from 1 to 15 m.

(3) A formation with a resistivity ranging between 12 and 40 ohm.m and a thickness ranging from about 50m. 90m. This constitutes the main aquifer. The base of the aquifer is made up of clay with resistivity ranging from 1 to 4 ohm.m., that can be interpreted as the Pliocene clay.

Traverse (c):

It is about 9 km. long east. The study of the geoelectric section reveals the following:

(1) A superficial thin unit Nile silt with low ohmic values ranging from 1 to 8 ohm. m becoming dry sands and gravels in the desert fringes.]

(2) A subsurface unit formed of graded sand-gravel (21 to 58 ohm). followed by a deeper layer, also of graded sand-gravel but contaminated with more clay intercalations or lenses (7-19 ohm. m.).

(3) A basal unit of Pliocene clays (< 5 ohm.m.) that forms the base of the Quaternary aquifer.

The interpreted geological section (Fig.5) reveals the presence of faults at both the western and eastern sides of the Quaternary aquifer.

Traverse (d):

It extends about 10 km. In which ten VESes were measured along this traverse (Fig.5) the geoelectric measurements along this traverse indicates the following:

(1) A subsurface unit of Nile silt with low ohmic values 6-12 ohm. m.It changes to dry sand and gravel on the fringes.

(2) A superficial unit of graded sand-gravel. Its upper layer shows moderate ohmic values (30-63 ohm.m.) and is underlain by a deeper layer contaminated with clay or intercalated with clay

lenses. It shows relatively lower electric resistivity values (5-9 ohm.m.).

(3) A basal unit, probably of Pliocene clay with very low ohmic values (4-7 ohm.m.). This Pliocene clay is considered as the basal part of the Quaternary aquifer. This section confirms the presence of the faults bounding the cultivated lands from east and west.

Traverse (e):

It lies to the south of traverse 4. The survey along this traverse (Fig.5) shows that the desert areas at the extreme west are characterized by superficial zones having very high ohmic values. These areas are covered by fanglomerate consisting of pebbles of chert and dolomitic limestone, gravels. Three geoelectric units are distinguished:

(1) Superficial thin unit of Nile silt with low ohmic values (2-8 ohm. m.)

(2) A subsurface unit which includes a layer of graded sand gravel with moderate electric resistivity values (22-55 ohm.m), underlain by a layer of graded (gravelly sand) with clay intercalations and is characterized by relatively lower ohmic values (2-8 ohm. m.).

(3) A basal unit which is very low ohmic values (5-16 ohm.m.) it consists of Pliocene clay, and forming the bases of the Quaternary aquifer. The Quaternary aquifer is bounded from the east and the west by a fault system.

Traverse (f):

It is to the south of traverse 5,. Three VESes were measured along this traverse. Study of the section along this traverse confirms the presence of the three geoelectric units identified before, namely.

(1) A thin superficial unit of low resistance values (3-6 ohm.m), representing the silt and clay layer.

(2) A subsurface unit of graded sand gravel; Its upper layer has a resistivity ranging from 35 to 105 ohmm m., It is underlain by a deeper layer intercalated with clay.

(3) A basal unit has with very low ohmic values (2-6 ohm.m) .

Traverse (G):

It takes a W-E direction, crossing the Nile valley. The study of this traverse (Fig. 5) shows that 3 geoelectric unit are present.

(1) Surface clay layer of low resistivity (2-8 ohm. m.) and of thickness ranging between 5 m to 15 m.

(2) Surface sandy layer of high resistivity values (908 ohm. m.,). The average thickness of this unit is 30 m. this layer is underlain by the main water bearing formation of resisivity ranging between 23 to 55 ohm. m., and a thick ness from about 30-80 m.

(3) The base of the aquifer is made up of a layer with resistivity ranging from 2-12 ohm. m. that can be interpreted as the Pliocene clay which serves as the basal aquiclude for the aquifer.

Longitudinal Cross Sections

Three longitudinal cross sections in the Esna area could be traced Fig. (6) these sections show detected Previously mentioned geoelectric units and the following can be concluded.

1. The maximum thickness of the superficial geoelectric unit appears near the Nile River and decrease away from it, where it is replaced with dry sand and gravel at the fringes.
2. The maximum thickness of the water bearing formation appears mainly in the southern part and northern part at Esna.
3. The basal unit, representing the base of the Quaternary aquifer (aquiclude) and has its maximum thickness near the fringes.

The study of the above mentioned previous geoelectric sections shows that the probabilities of finding groundwater increase along the Nile Valley at which the Quaternary sands and gravels are expected and have their maximum thickness.

The lateral variation of different geoelecterical units

Based on the results of the VESes interpretation three contour maps for the thickness of the surface clay layer and the thickness of the water bearing formation have been prepared Fig. (7,8).

Ancient and Present River Nile Courses:

(Fig.5) through 30 constitute the basic information in locating the Paleo-channel of the Nile during the Quaternary. The sediments characterizing the channel are mainly sand and gravel (23 to 55 ohm). Tracing and connecting these formations along the successive cross sections as shown in Fig. 7 indicates the presence of essentially 2 channels. is a final integration of the previous figures showing the 2 main channels of the river.

The maximum lateral displacement between the old and present courses seem to be ranging between 11 and 6 km . The eastward displacement of the present channel can be understood in view of the theory that in the northern hemisphere, rivers tend to shift their courses towards the East, affected by the rotational movement of the earth around its axis (shata, 1988). What needs to be explained, in fact, is the slight westward displacement. This may be explained as being due to the Eocene Limestone plateau obstructing the flow of the old river north-eastward which modified the river course in such a way it gradually migrated westward to the course it has now.

Hydrogeologic Setting

On the basis of geological geomorphological, structural and geophysical as well hydrological data three aquifers are suggested in the study areas (Faid, 1990). The Quaternary alluvial aquifer is the most important aquifer in the study areas, where there are two other aquifers of less important to the present work, namely Eocene fissured limestone aquifer and the Pre Tertiary Nubian sandstone aquifer (Fig.9).

The Quaternary alluvial aquifer

It is in the Nile Valley and the Nile Delta and is considered as one of the most important and huge aquifer in the world. It has a very wide distribution in the Nile Valley and in the adjacent desert valley fringes. The aquifer deposits are of continental origin and comprise mainly gravels and sands of different sizes, with some intercalation of clay lenses limited in thickness and extension. The thickness of the aquifer varies from place to place but generally ranges from 34.5 m to 122.5 m at Esna. The main Quaternary aquifer can be subdivided according to its age and formation into two sub-aquifers, name the Pleistocene aquifer and Plio-Pleisticene aquifer. (Fig. 10).

1- Pleistocene aquifer:

This aquifer is widely distributed when it is compared with the Plio-Pleistocene one. It is composed of sands and gravels interrelated with clay lenses Such aquifer lies under the semi-permeable silty clay layer (Holocene), which characterizes the Nile Valley, So it can be considered as a semi-confined aquifer. It is connected with the water body of the Nile River either by feeding from the surface water canals to the Pleistocene aquifer or seepage from the aquifer to the Nile River as drain.

2- Plio-Pleistocene aquifer:

This aquifer is represented underneath the old alluvial plain, and is underlained by thick Pliocene clay facies It cover's a considerable area at the footslopes of the carbonate scarp along the Nile Valley fringes. This aquifer is considered as unconfined aquifer (phreatic). It consists of clayey sand and gravel and is locally capped by breccias or loose sand and travertine beds on the surface; it is dominated by clay and sand beds on the subsurface. This unit forms an aquifer of secondary importance, because of its low productivity and relatively high water salinity. Regarding to the geometry of this aquifer, it can be noticed that its thickness exhibits unconsiderable values.

The hydrogeological conditions of the Quaternary aquifer will be discussed in the present work in the following items.

1. The hydraulic properties parameters.
2. Groundwater flow
3. Groundwater recharge and discharge
4. Depth of the groundwater level.

For the Quaternary aquifer, pumping tests are used for estimation the vertical leakage factor and the vertical hydraulic conductivity of the top Holocene aquifer, also beside the transmissivity, storativity, hydraulic conductivity and porosity of the Quaternary aquifer.

Isopach map of the water bearing formation and the hydraulic parameters of the top Holoccne acquitter reflect variation in the vertical leakage factor from low to high. This indicates that the hydraulic connection between the top aquitard and the main aquifer changes from place to other depending on lithological variations.

The vertical hydraulic conductivity varies from 0.033 to 4.01 m/day due to the predominance clay dominant and the high value associated with the sands and gravels facies (RIGW 1997) fig. 11

The hydraulic parameters of the Quaternary aquifer reveals that the transmissivity values range between 3138.85 and 6726.11 m2/day, the hydraulic conductivity values range between 25.2 and 54.9 m/day, the storativity values vary from 0.00099 to 0.0049 and the effective porosity varies from 9.64% to 13.08%. These parameters value are associated with sands and gravels deposits and is indicatives to the semi-confined to confined aquifer. RIGW 1996.

The groundwater flow in the Nile Valley aquifer generally takes a longitudinal movement from the south to north, parallel to the river. In the study areas, and based on the piezometric levels of the groundwater in the studied wells with the calculated hydraulic gradient, the groundwater flow is from the west and southwest to the east and northeast direction at Esna and from east and southeast to the west of the area (Fig. 12) where Generally the groundwater flow direction is towards the Nile River.

Recharge of the Quaternary aquifer in the investigated area, mainly, takes place from the infiltration of the surface Nile water after the both lateral and vertical in flow from the irrigation canals. The second recharge is the upward leakage from the deep Nubian Sandstone aquifer through the fault planes present in the region.

Discharge from the alluvial aquifer in the Nile Valley occurs through, the lateral outflow to the Nile, the drainage system outflow, the vertical discharge through the wells drilled for drinking and irrigation purposes and evaporation of the groundwater.

Most of the studied wells in the areas under investigation are partially penetrating the aquifer. They tap less than the full thickness of the aquifer these wells varies from 15m to 50 m at Esna (fig. 10). The groundwater of the Quaternary aquifer is available at depths varying from 1.0 m to 33.5 at Esna.(Fig. 13)is a map showing the location of wells

Groundwater Potentiel

Groundwater potential in various systems was determined from various factors namely the source of recharge, groundwater quality, productivity of the aquifer and depth to groundwater. Results indicate that, the high potential areas are those located in the central part of the flood plain (Pleitocene aquifer) (Fig.14).

Conclusions

Interpretation of vertical electrical sounding curve using program of HEMKER (1988). Construction and analysis of the geoelectric cross section (transversal), that when correlated with available geologic information can reflect the picture of the subsurface geology and water bearing formation construction of two isopach maps for the upper surface silty clay layer at Holocene age and for the water bearing formation.

The area under investigation consists essentially of three geoelectric units. The low resistivity values of the surface geoelectric unit can be originated from silty clay layer, having resistivity ranges between1.5-17 Ohm.m and the second geoelectric unit represents the water bearing formation ranges between 130-600 .the high resistivity values the superficial, which found only in the fringes of the western or eastern desert.

For direction of quaternary poleo-courses, a contoured true resisivity cross sections .the eastward displaced of present channel can be understood in view of theory that in the northern hemisphere, river lend to Shift their courses towards the east, affected by the rotational movement of the earth around its axis

The main quaternary aquifers can be subdivided according to its age and formation into two subdivisios according to its age and formation into two sub-aquifers named Pleistocene aquifer and plio-pleistocene aquifer

The recharge of the quaternary aquifer in the investigated area, mainly, take place from the infiltration of the surface Nile water after the Irrigation processes and both lateral and vertical inflow from the Irrigation canals. The second recharge from deep aquifer along fault planes

Groundwater potential in various aquifers system was determined from various factors namely sources of recharge, groundwater quality, productivity of the aquifer and depth to groundwater results indicate that, the high potential areas are those located in the central part of the flood plain(Pleistocene aquifer).on the other hand medium potential areas area dominating at the edge of the flood plain.

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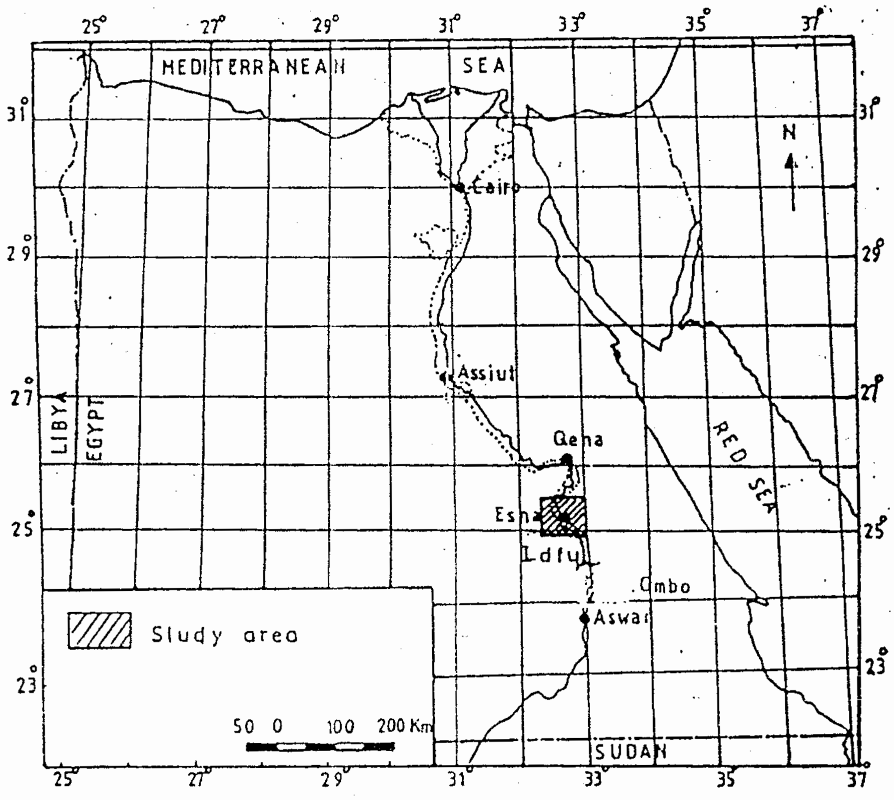


Fig(1) Location map of the study areas

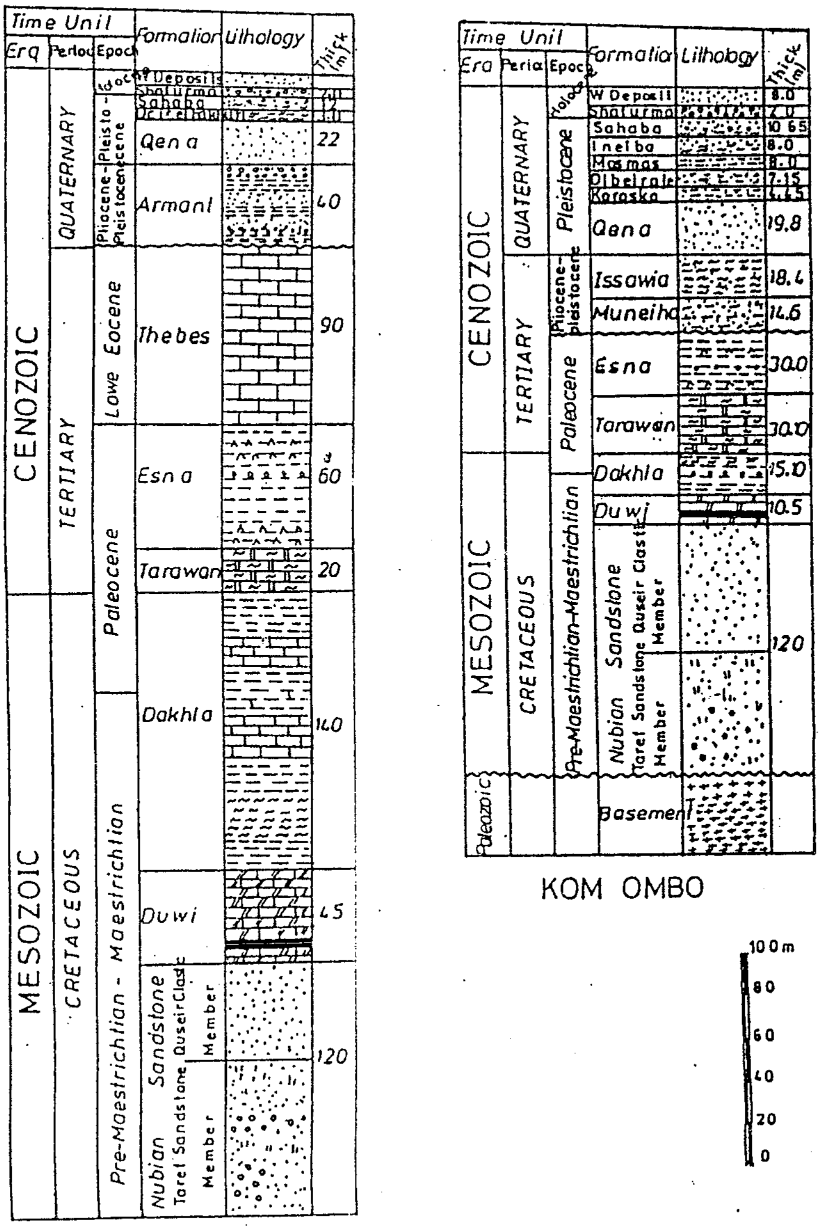
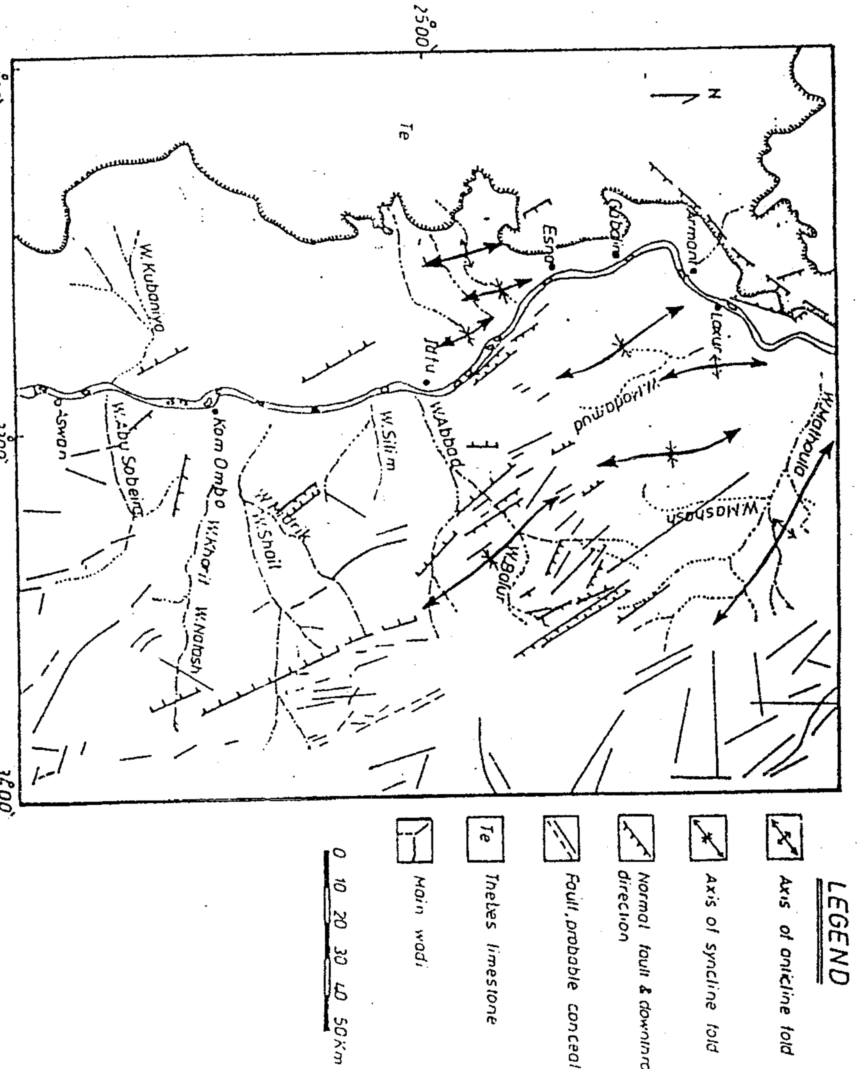


Fig. 2 Generalized stratigraphic successions at Esna and Kom Ombo areas
(Composited from Said, 1962 and 1981)



Fig(3) Structural pattern of the study areas and their vicinities
(Compiled after Abd el Razik et al.,1972 and Geological Survey,1979)

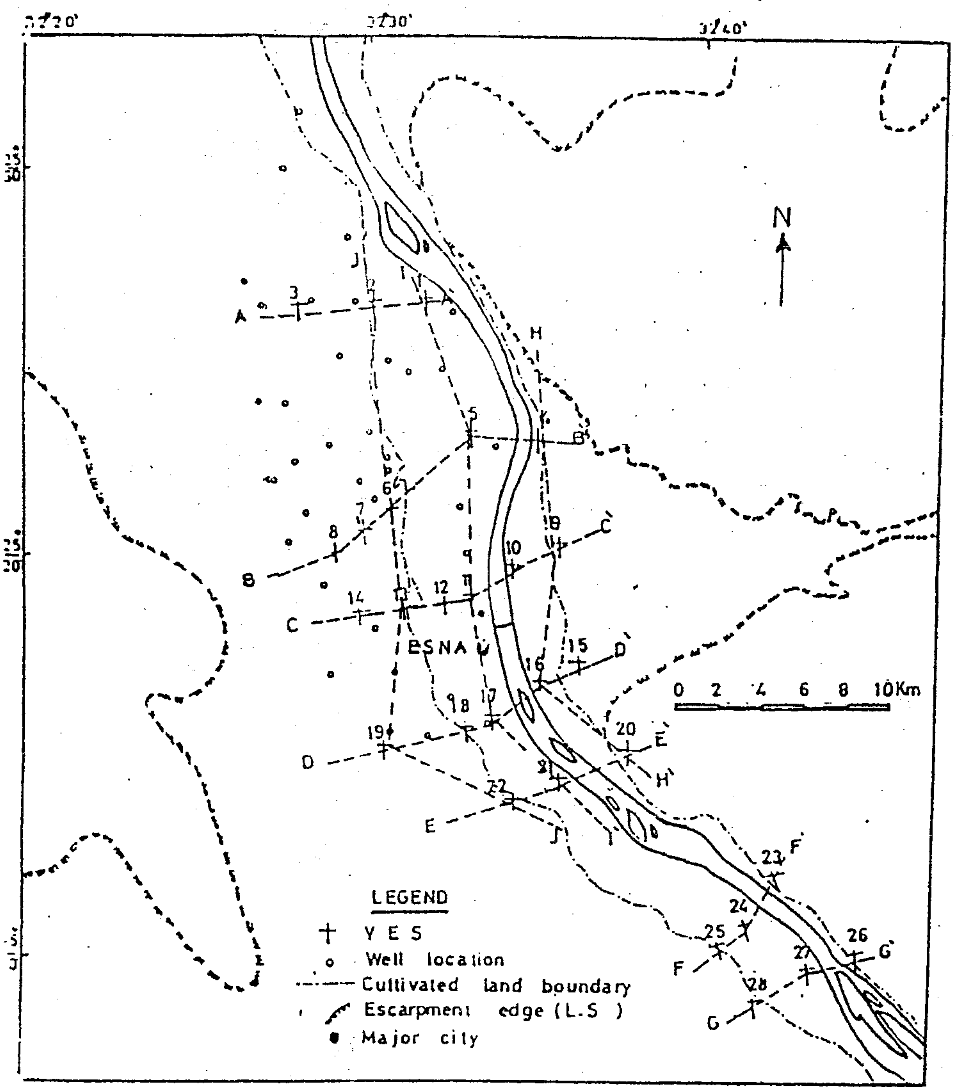
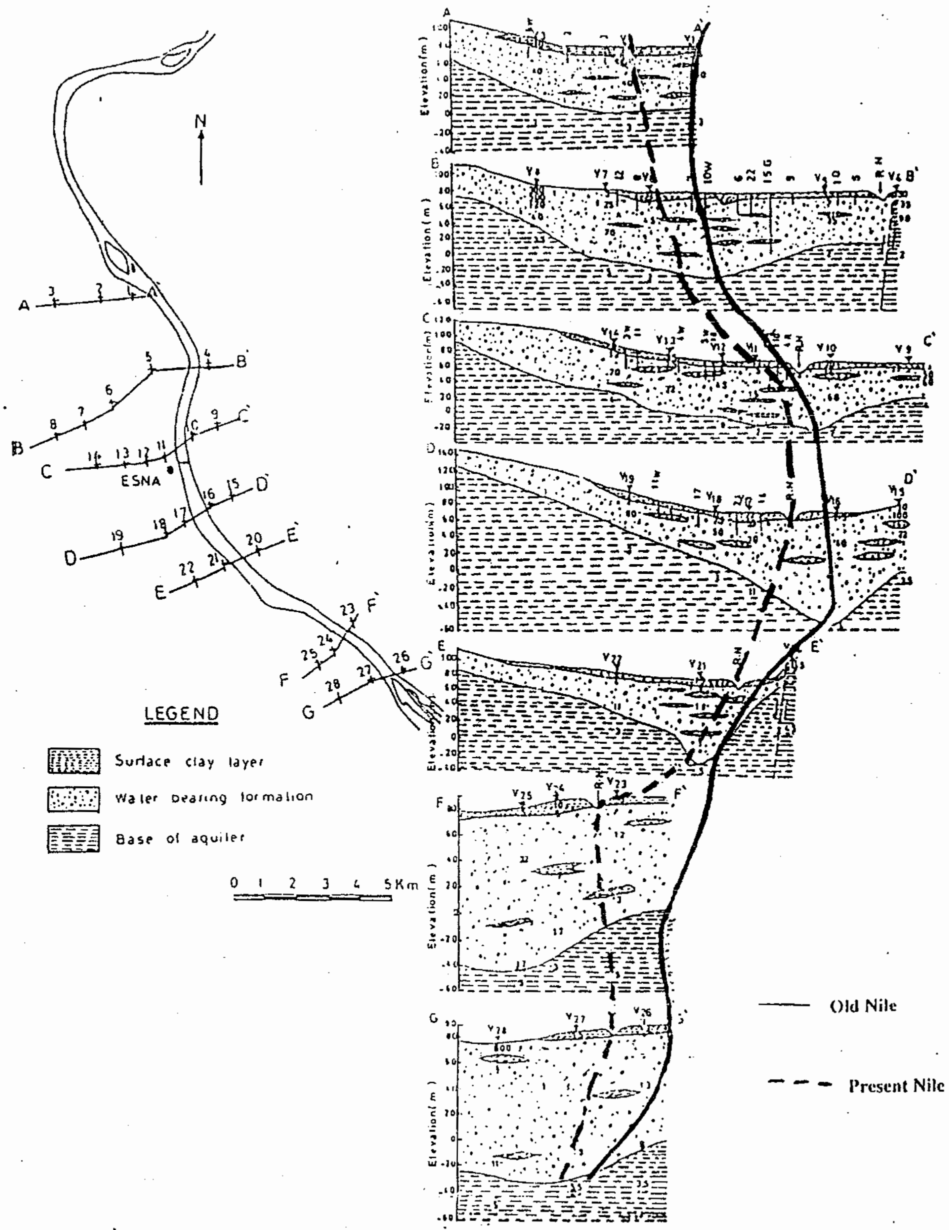


Fig. 4 Transversal and longitudinal geoelectrical profiles, Esna area



Fig(5 Transversal geoelectrical cross sectio·

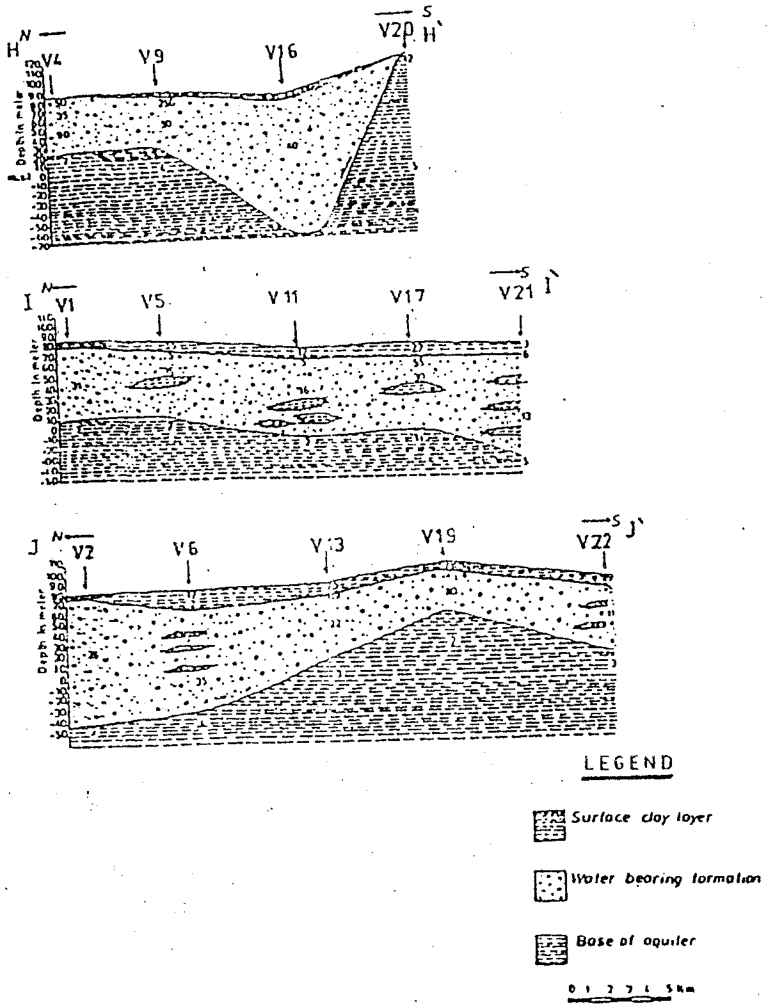


Fig.(6) Longitudinal geoelectrical sections, Esna area.

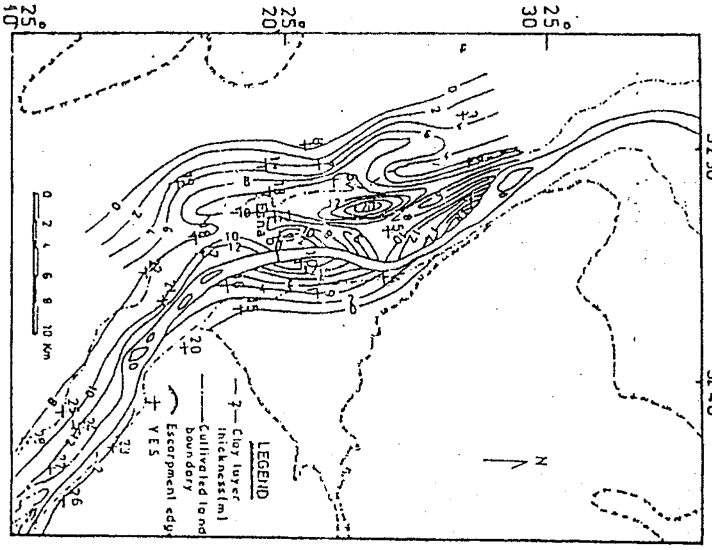


Fig. 7 Isopach map of surface clay layer, Esna area

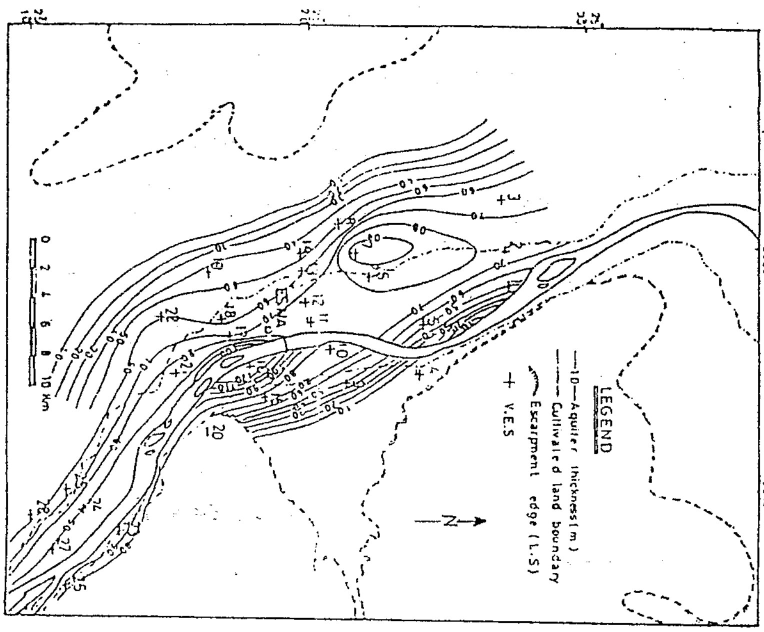


Fig 8 Isopach map of the water bearing formation, Esna area.

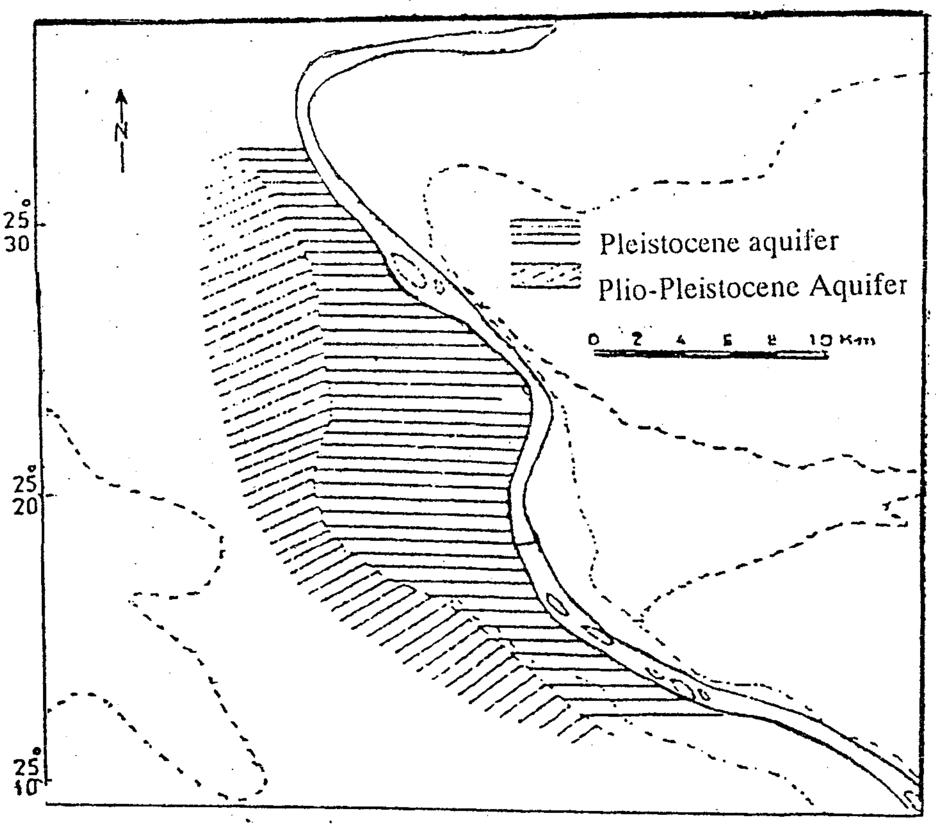
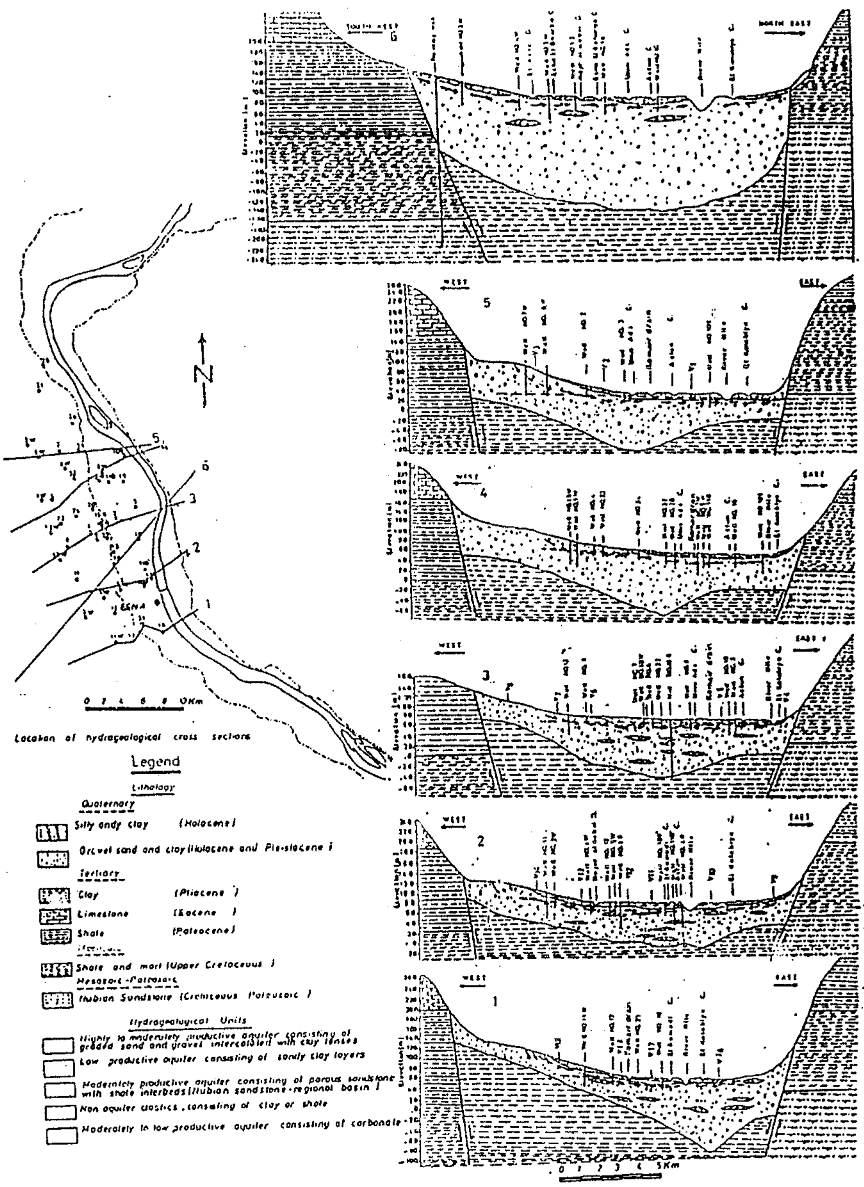
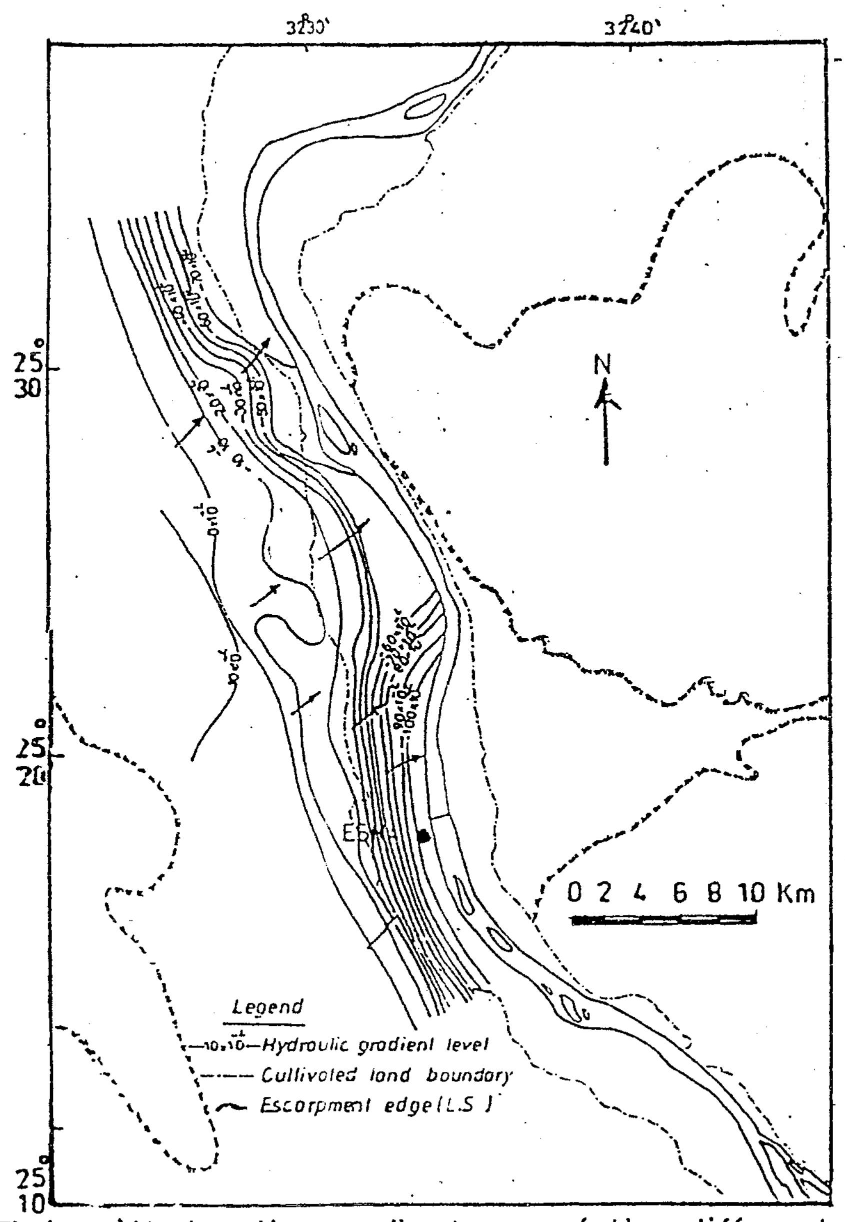


Fig. (9) Aquifer Distribution Map, Esna Area.



Fig(10)Hydrogeological cross sections of Esna area



Fig(11)Hydraulic gradient map of the different wells relative to the Nile River level Esna area

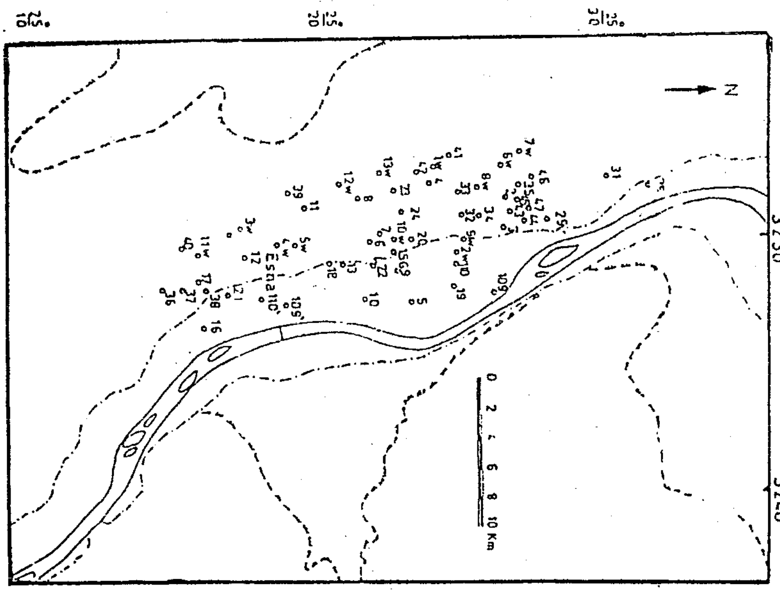


Fig (13) Well location map , Esna area

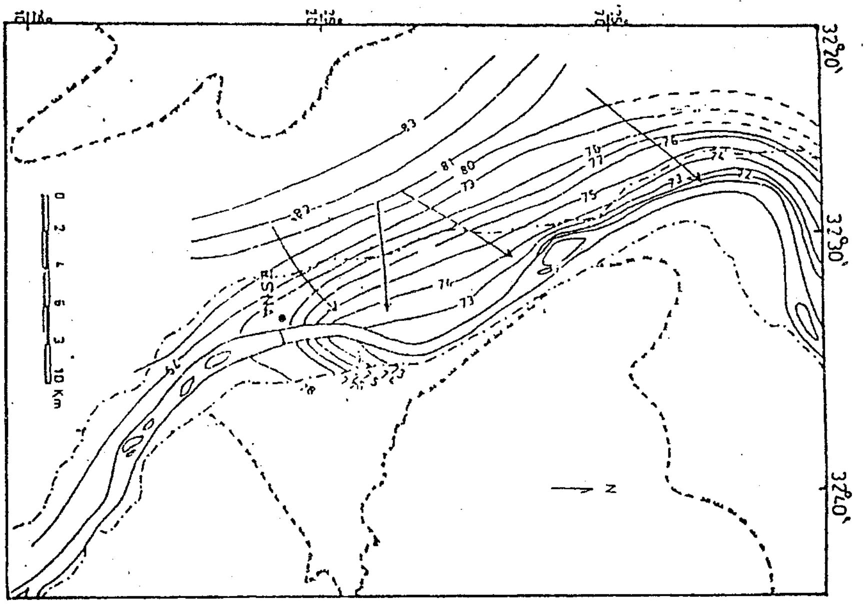
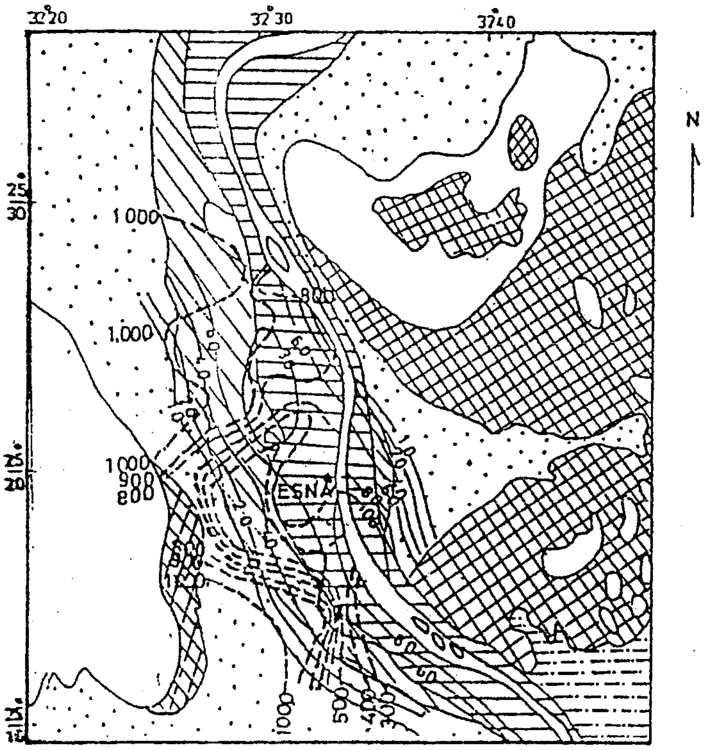


Fig (12 Iso-piezometric map of the Quaternary aquifer , Esna area



Fig(14) Aquifer potentiality map of Esna area

LEGEND

0 4 8 12 16 Km

High potential

High to moderate potential

Moderate potential

Moderate to low potential

Low potential

Non aquifer

—1000— Salinity contour

—10— Aquifer thickness

تفسير بيانات الاستكشاف الكهربي لتحديد خزانات المياه الجوفية ومجرى نهر النيل القديم فى منطقة إسنا ، مصر العليا.

عبد الله فايد

هيئة الاستشعار عن بعد وعلوم الفضاء

تقع منطقة الدراسة بين خطى عرض ١٠' ٢٥° و ١٠' ٢٥° شمالا وخطى طول ٢٠' ٣٢° و ٥٠' ٣٢° شرقا . تهتم الدراسة بتحديد خزانات المياه الجوفية ومجرى نهر النيل القديم بمنطقة إسنا وذلك بناءا على تفسير بيانات الاستكشاف الكهربي. وقد تبين من الدراسة وجود خزانان للمياه الجوفية هما خزان الرباعى وخزان البليو- بليستوسين. يبلغ أقصى سمك لخزان الرباعي ١٨٠م بينما خزان البليو- بليستوسين يصل إلى ٩٠م. وتكون تغذية خزان البليو- بليستوسين رأسيا من خلال مياه الري فى مناطق الاستصلاح بالإضافة الى الى مياه السيول والانسياب الجانبي من خزان الحجر الجيرى وراسيا من الخزانات العميقة. وقد تبين من الدراسة أيضا ان أقصى إزاحة بين المجارى المائية القديمة والحديثة ما بين ٦كم و ١١ كم. ويمكن استخلاص القول بان هناك كميات من المياه الجوفية تسمح بتنمية محتملة لمنطقة الدراسة.