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Full Length Research Article

Evaluation of Carbonate Aquifer Potentiality in Beni Suif-Minya area, Eastern Nile Valley, Egypt

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ABSTRACT

This study deals with new reclamation areas in East Beni Suef and El Minya governorates, Its identified by two types of aquifers, top one Quaternary aquifer and deeper one Eocene aquifer. The study confirmed the relationship governing the groundwater movement with geological structures. Where faults trends coincided with the groundwater movement. The hydrogeological survey of the area indicated that the aquifer discharges its waters through hundreds of existing wells for irrigation and agriculture. Eocene aquifer consists of deposits of limestone, groundwater depths ranges between 70 m to 95 m, the discharges range between 6 m^3/hour and 30 m^3/hour, The mean depths for drilling wells range between 180 m and 200 m., The transmissivity ranges between 2.47 m2/day and 1248.7 m^2 / day. Groundwater salinity ranging between 1000 ppm. and 3300 ppm. , the highest groundwater salinity in the central region and near the River Nile, while decreases as we go north, south and east. The prevailing salt in groundwater is sodium sulphate which represents 43% of the total salts in groundwater .Interpretation of chemical analysis indicated the presence of groundwater source deeper than Eocene aquifer, it may be Nubian Sand Stone Aquifer (NSSA).

Key words: Reclamation, Quaternary Aquifer, Eocene Aquifer, Groundwater

INTRODUCTION

The Eocene (Fissured L.S) aquifer is the main source for groundwater in the Eastern Desert of Egypt which includes the study area. It appears in the Eastern side of The Nile. The study area lies between Beni-Suef and El-Minya governorates. Intensive hydrogeological, hydrogeochemical and geoelectrical studies were carried out through the present work. Also, huge quantities of data were collected from many boreholes drilled for groundwater exploration, which were used to interpretate the groundwater aquifer characteristics in the study area.

Geomorphology of the area

The main geomorphologic units in the study area are:-

Fanglomerates (Unit B)

They occupy the areas of Pre-Nile deposits. The fans are in the form of elongated strips carried by the wadi waters which drained the water of Eastern and Western Plateaux and deposited their load before reaching the River Nile. The sediments are mainly composed of subordinate cobbles and pebbles, and predominant loose sand and silt sand (Hassan *et al*., 1978).

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Calcareous plateaux (Unit D)

It occupies wide tracts bounding the studied area to the east and the west of the Nile Valley to the east of El-Fayaum depression. The Plateau have a more less parallel drainage patterns acting as the base level of erosion. Some of these drainage courses are filled with deposits of Pliocene and Pleistocene times (Tamer *et al*., 1975). The western Eocene tableland (plateau) is of lower altitude and attains more even surface compared with the Eastern one.

Drainage lines and hydrographic Patterns (Unit F)

Several dry wadis are distinguished in the Eastern plateau. They were developed through several flows of water during the pluvial periods of Pleistocene times. The running water engraved exposed rocks and patterns of channels and tributaries were developed. The present dry climate introduces the action and modifications by winds. Meanwhile, these wadis receive the occasional storms and have flash floods several times. They are filled by Recent sand, clay and silt accumulations (wadi fillings) which are carried by water during the floods. The main wadis have alluvial fans of good soil accumulations along the downstream portions close to the Nile Valley. They are subjected to reclamation during the last few years. Figure (2) shows the hydrographic patterns in the eastern River Nile where the study area is located. The River Nile and irrigation canals are the main perennial stream, which

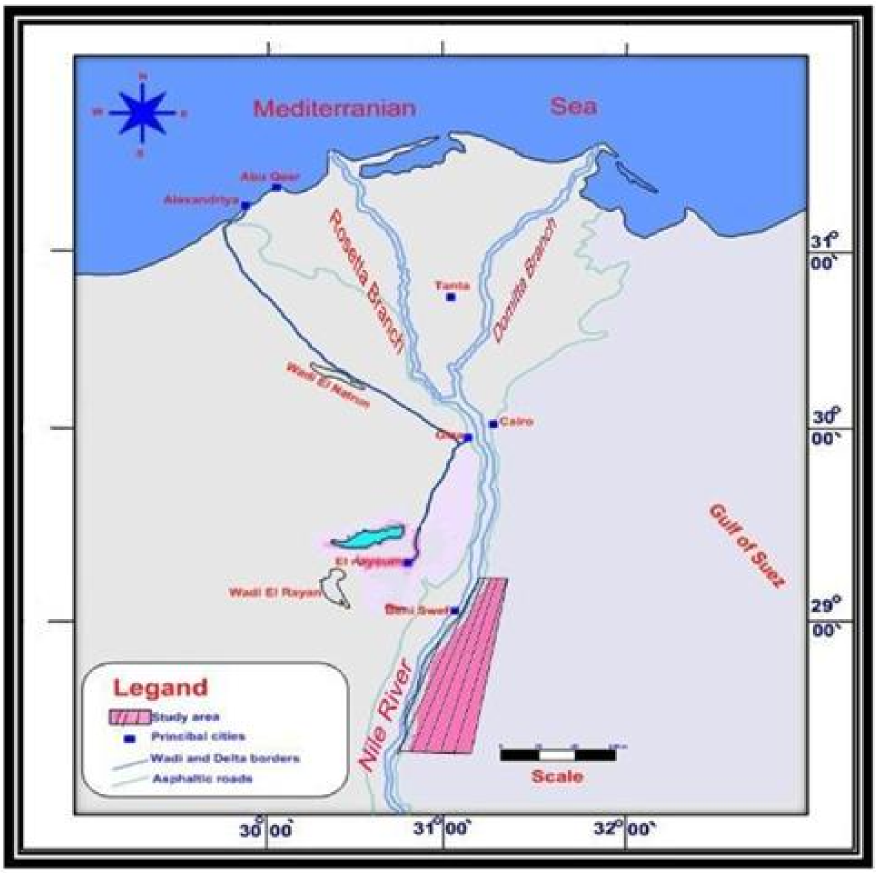


Fig. 1. Location map of the study area

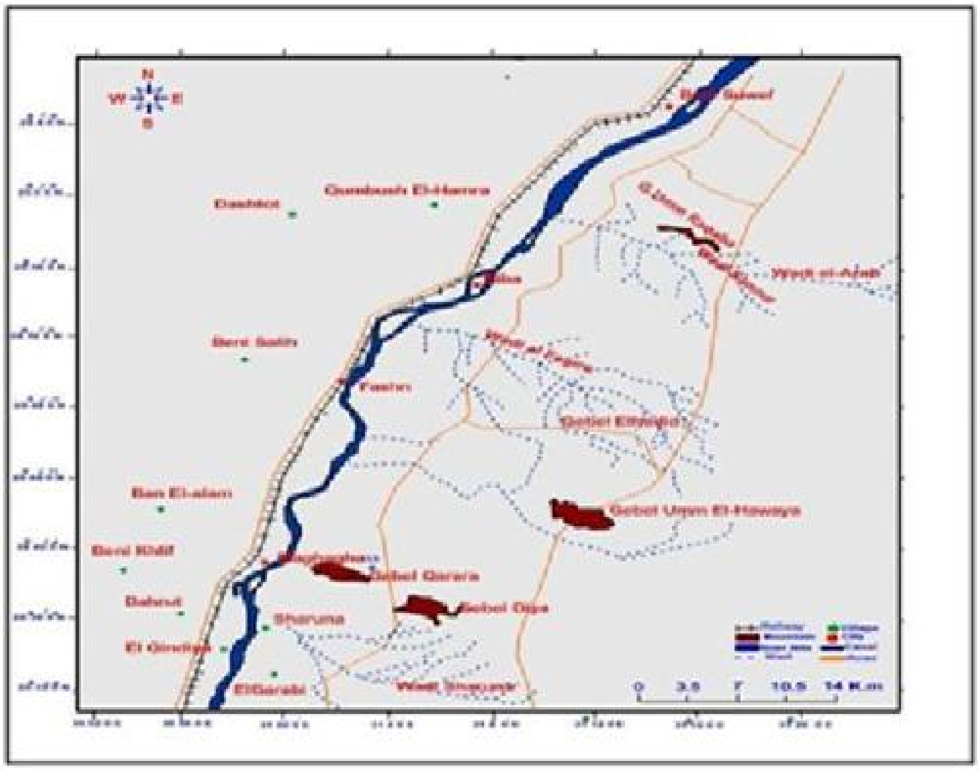


Fig. 2. Map of hydrographic patterns in the study area

flow all over the year while the natural basins comprise an ephemeral streams flowing after short showers. The hydrographic patterns and their interconnection with groundwater represent the direction and patterns of surface water distribution.

Geologic setting

The geology of the Nile Valley was summarized by many authors, among them Beadnell (1900), Said (1962), El-Hemally (1991), El-Sayed and Mabrouk (1991), Abdel-Rhamn (1992), RIGW (1989-1992), El-Sayed (1993), Abdel-

Mageed (1998), Abdel-Mageed (2002) and Morsy (2002).The lithostratigraphic sequence is formed of the rock units which belongs to Upper and Middle Eocene, Pliocene and Quaternary times (Fig. 3).

El-Fashn Formation (Middle Eocene)

It was defined in most of the exposed section lying east and west of Beni-Suef area. Its maximum thickness (90 m. thick) was described by Omara *et al*. (1978).

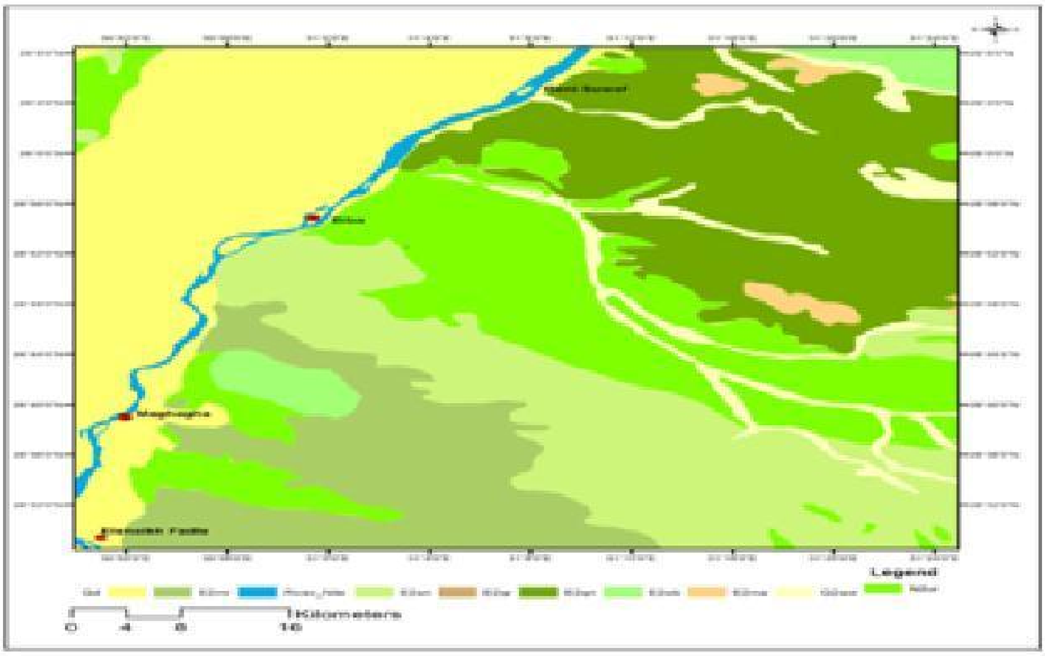


Fig. 3. Distribution of surface geological units. CONCO/EGPC, (1987)

Eocene rock units

The Eocene rocks have a wide distribution and are mainly represented by extension of Middle Eocene rocks. Upper Eocene rocks were reported in Gebel Homeret Shaibun lying east and Gebel El-Naalum lying west of the Nile Valley (Hassan *et al*., 1982, Strougo *et al*., 1984 and Abdel-Rahman., 1992). The sequence of the Middle Eocene in the study area is formed of four rock-units from base to top as following are summarized in from base to top as follow

Qarara Formation (Middle Eocene)

It has a thickness of 170 m. thick and is composed of shale, marl, sandstone and sandy limestone. The Qarara Formation at Beni-Suef area is characterized by fractures, partings veins, veinlets and geodes filled with calcite.

Beni Suef Formation (Lutitian to Early Bartonian)

Its maximum thickness was described by Omara *et al*. (1978) at Gabel Sath El-Hadid lying west of Beni-Suef area (100m thick). This formation is made of thick-bedded argillaceous limestone interbedded with clay. Its upper part is composed of laminated clay unit (25-30m thick) and ends with a Wall-forming thin bedded argillaceous limestone unit rich in Lucinia sp. (12m thick).

Shaibun Member (Middle-Upper Eocene).

Shaibun Member for the upper part of the sequence exposed at G.Shaibun (attaining 62m.) quarries having longitudinal shape with ideal stalactites and stalagmites (Abdel-Magged, 1998).

Furthermore, its facies change into marly limestone intrbedded with shale at G. El Mashash and into limestone and marl sequence at G. Shaibun.

Maadi Formation (Upper Eocene)

Maadi Formation rests on the Shaibun Member and overlaid by calcareous conglomerates and fanglomerates followed upwards by bed of grey white crystalline limestone (10m thick) which is exploited in small quarries as an ornamental stone.

Pliocene Rocks Units

The marine Pliocene includes the rocks which crop out in the Nile Valley region along both banks of the Nile Valley from Giza to El-Fashn from north to south respectively. The Pliocene deposits were recorded in subsurface in different deep boreholes scattered over several parts of the Nile Valley. These deposits are represented by a thick impermeable to semi permeable dark colored clays underlain by the Eocene limestone (Tamer *et al*., 1975).

Quaternary Rock Units

The Pliestocene and Holocene deposits in The Nile Valley particularly in Upper Egypt, are dealt by innumerable. These Quaternary deposits unconformably overlie generally the Middle Eocene rocks and underlie unconformably the Holocene sediments. It consist of sand and gravels and constitute thin thickness reaches about 10 meters in some parts. The Pleistocene aquifer is covered directly with an aquiclude layer of Holocene silt, sands and mud. This reflects the present geohydrologic profile in the studied area. The fracturing intensities control the hydraulic connections between the Pleistocene aquifer and the underling Eocene and deeper aquifers. While the lithological properties of the topmost aquiclude layer control the downward infiltration and perocolation into the aquifer.

Geoelectrical investigation

The field geoelectrical survey comprises (92) VES,s in the area of the study using Schlumberger electrode configuration. These VES,s and profiles drown to bind them and enable to imagine and describe what is present in the area are shown in figure (3-7).

The first unit comprises high resistivity values and thickness varies between 1.6 to 5.9 meters. These height reflects resistivity values ranges from 258 to 588 ohm. m. These resistivity values reflect a thin dry, friable sandy layer.

The Second Unit reflects resistivity values ranges between 99 and 356 ohm.m and thickness ranges between 7.9 and 35.8 meters. It represents an extension of the sand dune layer. This unit doesn't contain groundwater along most of the sections, where the lower resistivity value reflects the probability of groundwater occurrence at this depth.

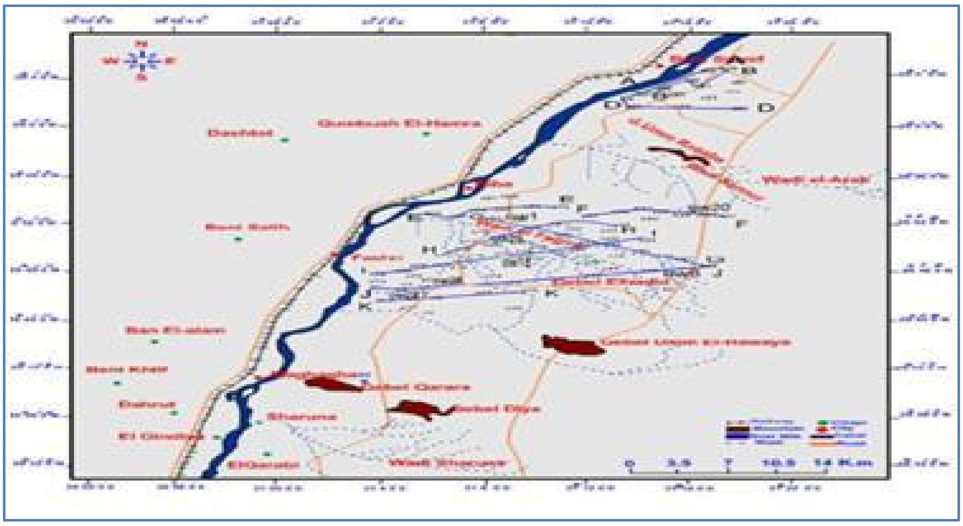


Fig. 4. Geoelectrical profiles

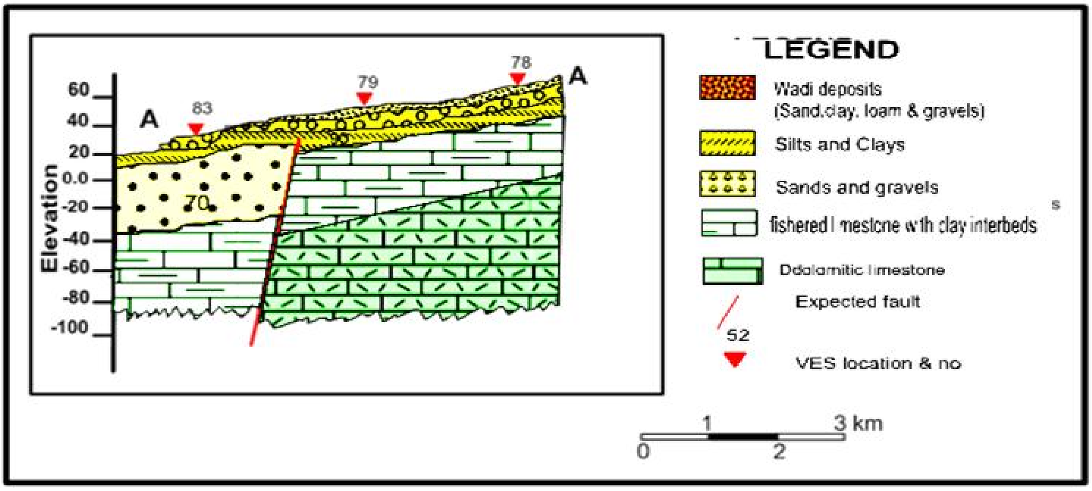


Fig. 5. Geoelectric cross-section A-A' in the northern part

The software of RESIST-PLUS, ver.2.3 (Inter pex, 1996) has been used to demonstrate the distribution of the calculated resistivity parameters (true resistivity and thickness) in the vertical plane across the study area, (11) geoelectric resistivity cross-sections are constructed covering the study area. The geoelectric cross sections indicated the following

The lithologic succession of the study area can be classified into six geoelectric units of different thickness and resistivity.

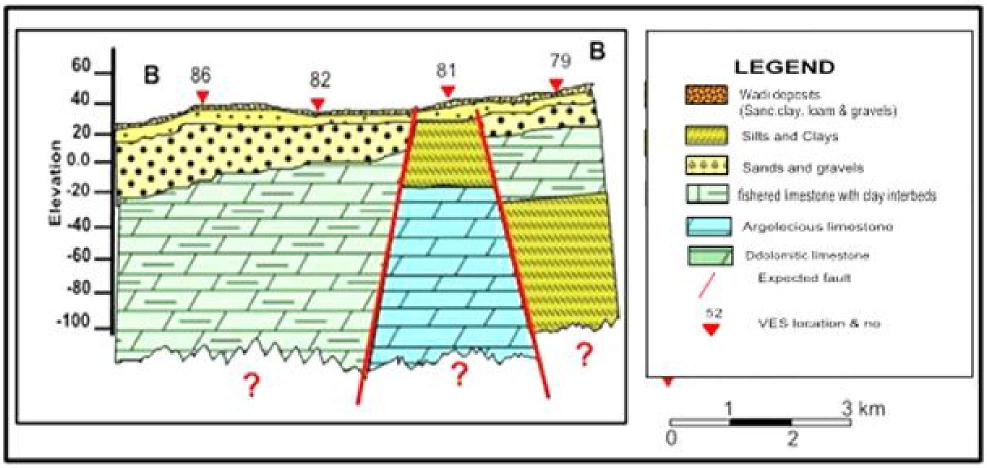
Third unit of low resistivity values range between 11 and 75 ohm.m. This decreasing of resistivity values may be due to the effect of saline water contamination. This unit has high groundwater potentiality but with a relative salinity.

The fourth unit comprises high resistivity values and relative to the fissured limestone as indicated from calibration with the lithological data.

The fifth unit in this section is interpreted as argeliceous; limestone and dolomite of relatively high resistivity values.

It has a thickness ranging from 40 to 65 m. The sixth unit is the base of the investigated interval and has also high resistivity values due to its dryness and conductivity. It was interpreted as dolometic limestone.

In the study area the mean depth of the aquifer reaches about 20 m. while, in the southern part the thickness ranges from 20 to 80 m. and reached about 100 m in the southeastern part of the area.



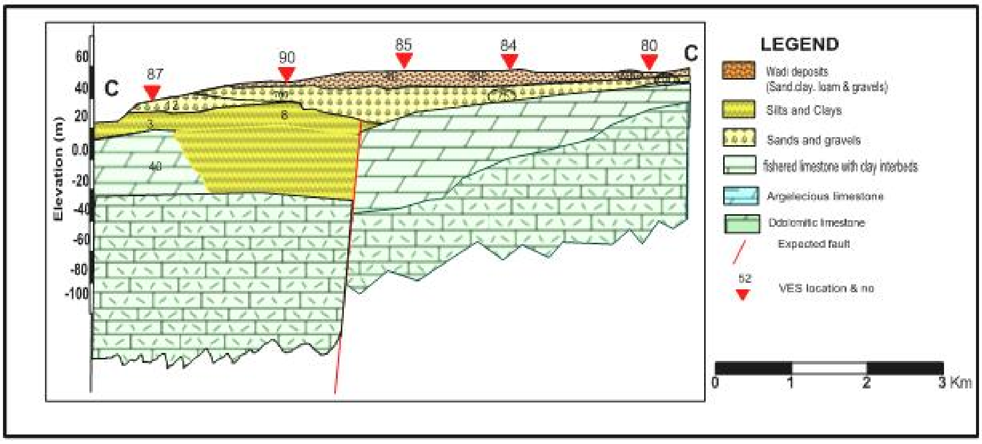


Fig. 7. Geoelectric cross-section C-C' in the northern part

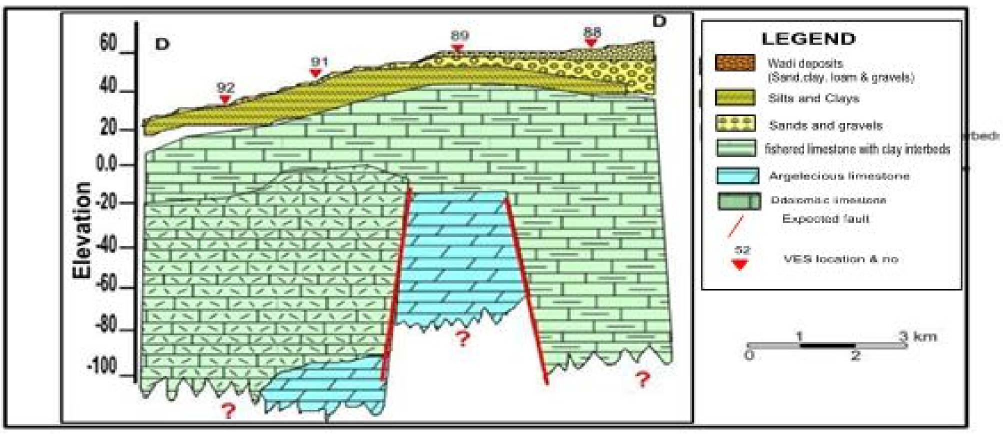


Fig. 8. Geoelectric Cross- Section D-D

Depth map of the aquifer

This map was constructed considering the depth to the first water bearing zone at each VES whatever it was the third or fourth layer. It reflects that the depth to the aquifer increases at the southern part of the study area and decreases in the northern part as shown in Figure (9). In the northern half of

Thickness map of the aquifer

This map was constructed considering the thickness of the third and fourth layers at all VES locations in areas of two water bearing zones and the third layer in areas where the third layer was considered as the main water bearing layer (Fig. 10).

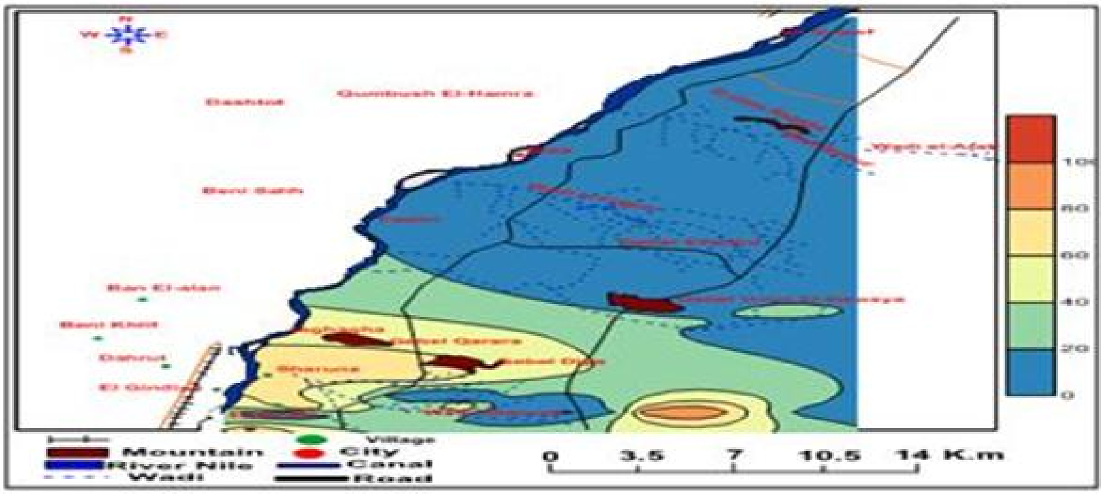


Fig. 9. Depth map of the aquifer

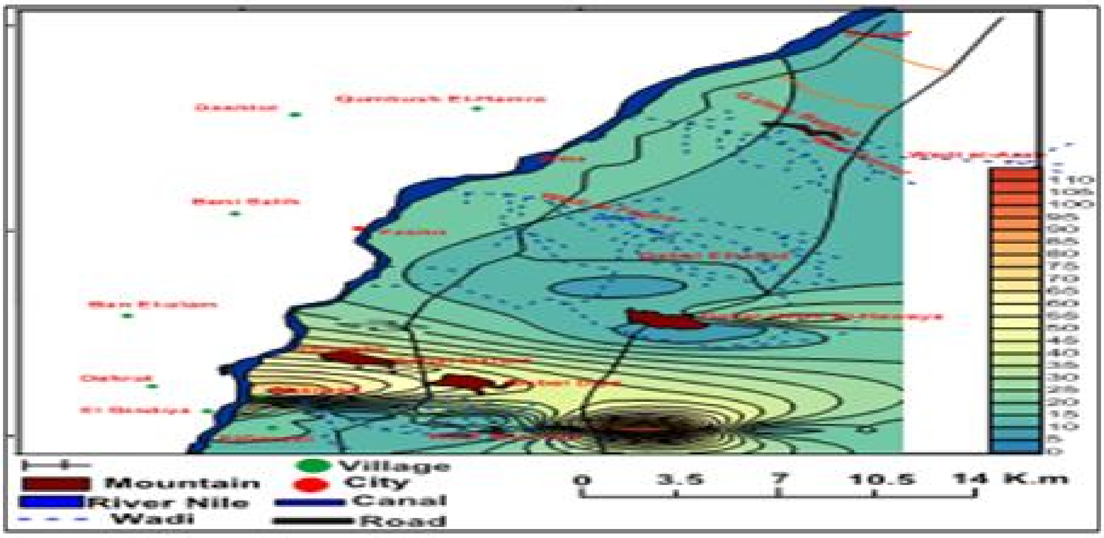


Fig. 10. Map of the aquifer thickness

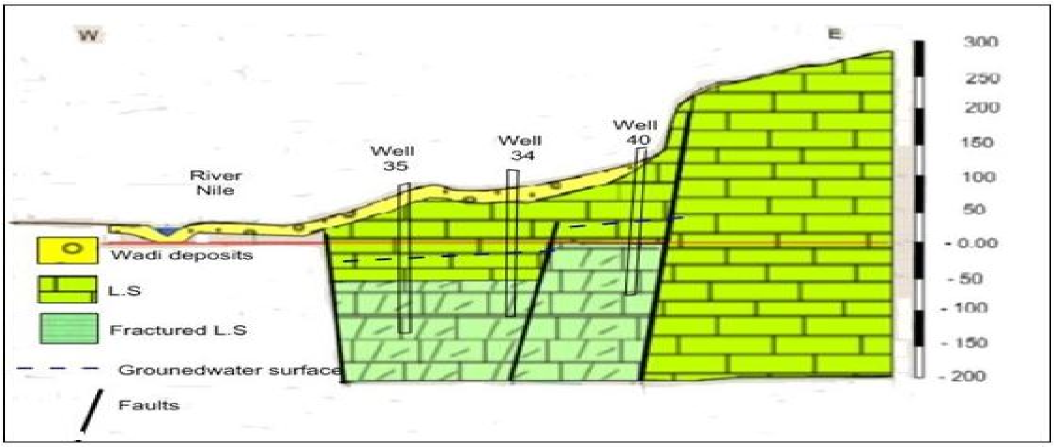


Fig. 11. Hydrogeological cross section of Eocenc aquifer in the southern portion of study area (W-E)

It represents that the thickness of the aquifer varies along the area and the mean value of it ranges from 20 to 30 meters. The contour values indicate that the aquifer in the southern part of the study area has great thickness. The map also, indicates that there are some localities at which the aquifer thickness decreases to less than 15 meters as in the central part of the study area.

Hydrogeologic conditions

The Eocene limestones, marl and fissured limestone underlying shale represent the main aquifer in the area east of the Nile Valley. (Fig. 11) indicates that the thickness of Eocene aquifer increases toward south portion (Wadi Sharouna) and decreases towards the Nile River and at the central portion (east El Fashn area).

Groundwater flow

The depth to groundwater increases eastward of the River Nile to the Eastern Plateaux. The measured water levels are used to construct the water table contour maps for the study area (Figure 12). The groundwater movement is controlled by the difference in groundwater level and the hydraulic gradient. the groundwater level ranges between 8 to 25m. from the River Nile to the plateau (east words). From the groundwater level contour maps in the study area, Figure (13), shows that the groundwater levels near the River Nile increases to east ward to the limestone plateau.

The Aquifer Hydraulic parameters

The hydraulic parameters of the water bearing formations affecting its ability to take in to storage and release water together with its ability to transport water. These paramerters are hydraulic conductivity (K) and storage coefficient (S) and the transmissivity (T). The methods for interpretation of data of pumping tests have conveniently be arranged in a text book (Krueseman and de Ridder, 1979). In the study area, pumping tests have been carried out at two difference locations. In the central portion of the study area, in El Shork and El Kwetia agricultural companies by the teamwork of RIGW and Beni Suef University.

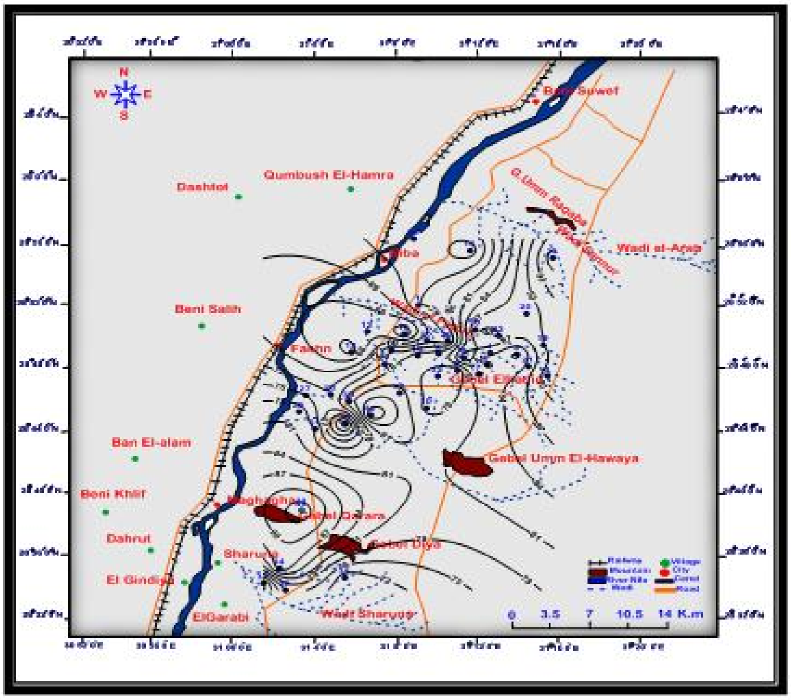


Fig. 12. Depth to water contour map

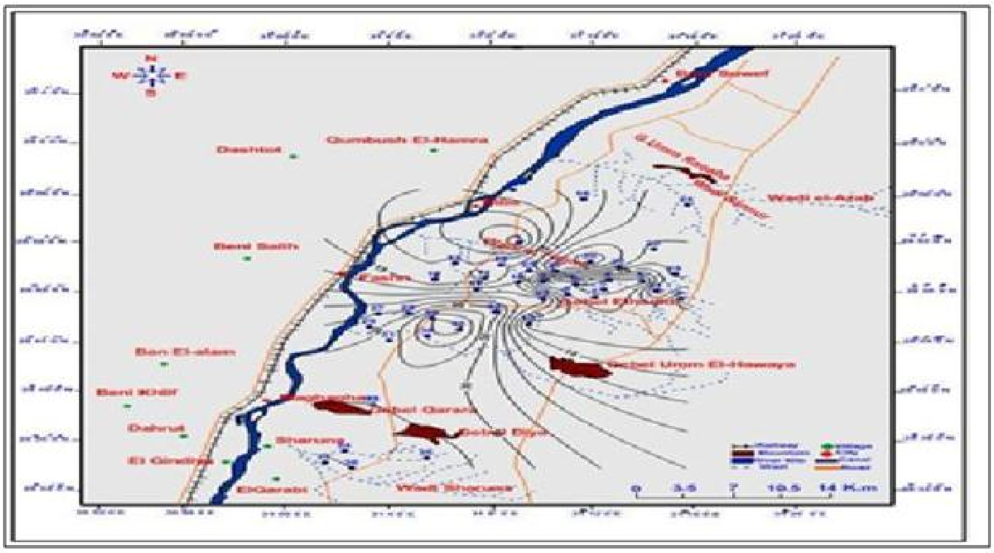


Fig. 13. Groundwater level contour map

Consequently the groundwater flow from east to westward to River Nile direction. Fig. (14). There are many flow directions, from the southern portion to the north-east and from south to north near the Nile River and from the east to west at the middle study area.(Fig. 14).

The tests were carried out under constant discharge and The measured values are analyzed by Aquifer Test Model no. 4. program using Papadoplus – Copper method (1959), method The aquifer parameters including the hydraulic conductivity (K) and the transmissivity (T) were estimated.

The transmissivity (T) values of the Eocene aquifer were determined through one conduct long duration pumping test and recovery test of productive well No. 4 (Kewit-Egypt Company) and Well, No. 1 (El Shrok Company).

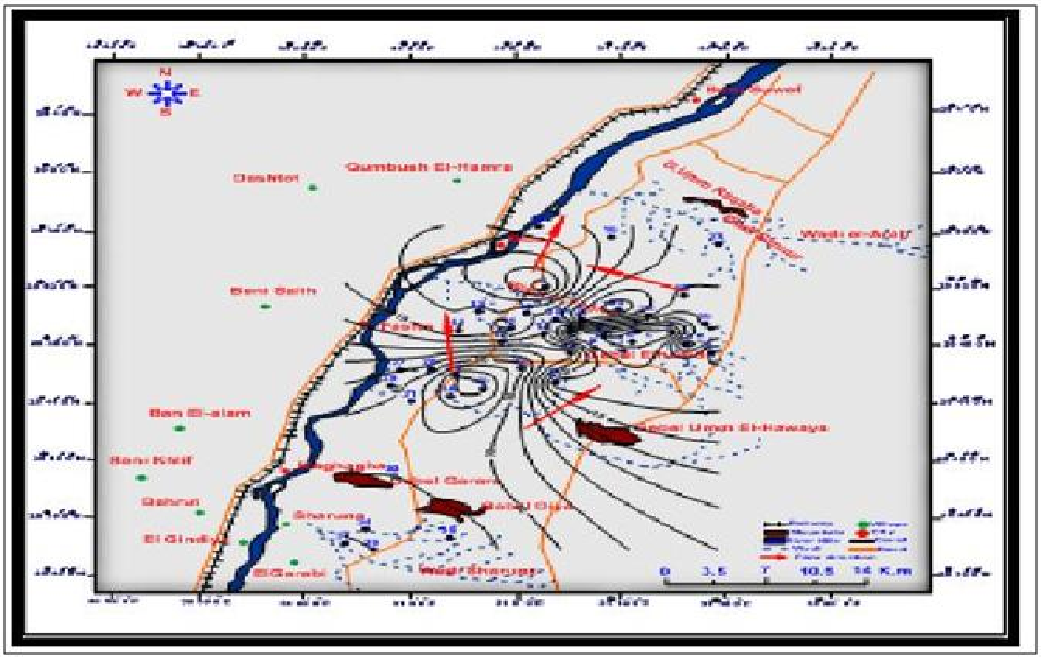


Fig. 14. Groundwater flow map

The determined values of transmissivity are of order 2.47 and 1248.7 m^2/day in the study area. Very low tarnsmissivity values (2.47 m^2/day) represent some localities reflecting change in lithological facies. According to Cheonhag classification (1979) the potentiality of the Eocene aquifer is ordered as Low (Table, 1). Hydraulic parameters of Eocene aquifer in the study area are tabulated in Table (2).

Table 1. Aquifer potentialities classification (Cheonhag, 1979)

Potentiality	Transmissivity m^2/day
High	> 500
Moderate	50-500
Low	50-5
Very low	0.5-5
Negligable	< 0.5

Table 2. The results of the hydraulic properties in the study area

Location	T (m2/d)	K (m./d)
Kewit-Egypt Company	2.47	0.035
ElShrok Company	1248.7	17.84

The Eocene aquifer in this area is characterized by the following results

- Generally of low to very low potential.
- The hydraulic conductivity (K) ranged from 0.035 to 17.64 m/day.
- The transmissivity (T) ranged from 0.035 to 1246.7.
- The variations of the hydraulic properties is related to the lithology and structures such as faults, fissures, cracks and presence of some caves.

Conclusion

Interpretation o the geoelectrical VES's for the resistivity data in terms of true resistivity of subsurface geoelectrical units and true thickness helped in constructing vertical geoelectric sections and isopach maps. The vertical electrical cross sections indicated that the northern part of the study area has no groundwater potentiality and was represented by six units:

- The first surface layer have a true resistively values ranges from 145.4 to 417.1Ω.m. and thickness of about 4m. This unit can be interpreted as the uppermost friable, dry part of wadi deposits.
- The second unit has a true resistivity ranging from 80.7Ω.m. to 851.8Ω.m. and can be interpreted as dry sandy layer.
- The third geoelectric unit, which comprises true resistivity values ranging from 150 to 176Ω.m. and thickness ranges from 15 to 40m, is equivalent to the sandy layer. This unit appeared only beneath VES's 87 and 90.
- The fourth unit comprises high esistivity values and relative to the fissured limestone as indicated from calibration with the lithological data.
- The fifth unit in this section is interpreted as argeliceous ; limestone and dolomite of relatively high resistivity values. It has a thickness ranging from 40 to 65 m.
- The sixth unit is the base of the investigated interval and has also high resistivity values due to its dryness and conductivity. It was interpreted as dolometic limestone.

While, the southern part represents high groundwater potentiality and consist also of the same geoelectric units of different resistivity ranges and heterogeneous thickness of each layer. Interpretation indicated that the third and fourth layers were also considered as water bearing layers in this part. The water bearing zone consists of fissured and argillaceous limestone as indicated from the gathered well data.

The depth to aquifer increases at the southern part of the study area and decreases in the northern part. In the northern half of the study area the mean depth of the aquifer reaches about 20 m. while, in the southern part the thickness ranges from 50 to 80 m. and reached about 100 m in the southeastern part of the area. The thickness of the aquifer varies along the area and with mean value ranges from 20 to 30 meters. The contour values indicate that the aquifer in the southern part of the study area has great thickness. The map also, indicates that there are some localities at which the aquifer thickness decreases to less than 15 meters as in the central part of the study area.

Hydrogeologically, Eocene aquifer represents the main water resource of water supply for domestic, industrial and irrigation purposes in the study area. The Eocene aquifer is mainly composed from The Eocene sediments of different of limestone, marl and fissured L.S overlying shale, represents the main aquifer in the area east of the Nile River. The thickness of the water bearing layers varies from well to another and the same in another (50 to 80 m.). The thickness of the aquifer increases to the east and south reaching its maximum value at wadi Sharounna. However, the depth to water in the study area ranged between 58 and 72m and water level ranges between 8 to 25m. From the water contour maps in the study area showed that the water levels increases eastward to the limestone plateau.

There are many flow direction, from the southern portion to the north-east, from south to north (the Nile River) and from the east to west in the middle of the study area. The discharge from the Eocene aquifer is represented by pumping of groundwater of the aquifer through the drilled wells for irrigation purposes in the reclamation area. In the study area, Eocene aquifer is mainly recharging from the deepest aquifer, called the Nubian Sand Stone aquifer (NSSA), during structures (Faults, fissures and cracks). The upward seepage from the deep Nubian sandstone aquifer are expected to be a main source of recharge to the Eocene aquifer. The hydraulic properties of the aquifer, the transmissivity of the aquifer ranged between 2.47 and 1248 m2/day. The hydraulic conductivity ranged between 0.035 to 17.87 m/d.

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