Qatar Univ. Sci. J. (1993), 13(2): 341 - 347

APPLICATION OF THE RESISTIVITY METHOD TO STUDY GROUNDWATER POTENTIALITIES ON A PART OF THE ENTRANCE OF WADI EL-ASSIUTI, EASTERN DESERT, EGYPT

By

A. A. BAKHEIT, H. A. IBRAHIM, A. A. OMRAN, S. RIAD and M. A. SENOSY
Department of Geology, Faculty of Science, Assiut University, Assiut, Egypt.

استخدام الطريقة الجيوكهربائية في دراسة احتمالات تواجد المياه الجوفية في جزء من مدخل وادى الأسيوطي ، الصحراء الشرقية ، مصر

أبو ضيف عبد العال بخيت و حمزه أحمد إبراهيم
عوض عبد الخالق عمران و سمير رياض و محمود محمد سنوسي

تقـع منطقـة الدراسـة عند مـدخل وادي الأسـيوطي الواقع في الصـحـراء الشـرقـيـة بمصر . ويعتبر هذا الوادي في الوقت الحاضر من مناطق الاستصلاح الهامة . ولذلك فقد تم اختيار جزء صغير من مدخل هذا الوادي لاجراء دراسة جيوكهربائية .

ويحيط وادي الأسـيوطي من الجهـات الشمـاليـة والجنوبية والشـرقيـة هضبـة الحجر الجيري الايوسيني ، بينما يحده من الغرب رواسب نهر النيل والأرض الزراعية . ويغطي منطقة مدخل وادي الاسيوطي رواسب غير متماسكة ومفككة من رواسب الطين والرمال والتربة الرملية الطينية إلى جانب الحصى والحصباء وهي رواسب منقولة ترسبت بفعل المياه السطحية إلى جانب تأثير الرياح إلى حد ما .

وقد تم قياس ٢٩ جسة « كهربائية » رأسية موزعة بانتظام (كل ٣٠٠ متر) . وقد تم تفسير المنحنيات الكهربائية باستخدام برامج الكومبيوتر المعدة لهذا الغرض وذلك بهدف التعرف على عمق وسمك وقيمة المقاومة الحقيقية لكل طبقة جيوكهربائية عند كل محطة قياس .

وقـد اسـتـخـدمت نـتـائج التـفـسـيـر الكمي للجسـات الكـهـربائيـة مـع المعلومـات التي تم الحصـول عليـها من بعض الآبار المحفورة حول منطقة الدراسـة في التـعرف على امكانيـة وجود خزانات مياه جوفية بمنطقة الدراسة .

ولقد أوضحت نتائج الدراسـة الحاليـة إمكانيـة تواجد خزان جوفي يتـراوح عمـقة من ١٤ـ٤٧ متر بينما يتراوح سمكة بين ٢٠ ، ٧٠ متر . ويتراوح منسوب السطح العلوي للطبقة الحاملة للمياه بين ٣٥ ، ٦٩ متر فوق سطح البحر . ويعتقد أن تغذية هذا الخزان تتم عن طريق نهـر النيل . وتشير نتائج الدراسـة إلى احتمـال تواجد خزان جوفي أعمق يتراوح عمقة من ١١٠ - ١٣٠ متر ، بينما يتراوح سمكة من ٦٠ - ٨٠ متر .

ولقد أظهرت البيانات تحت السطحية عند موقع الجسة رقم ٥ تطابقاً مع تلك البيانات المستنبطة من نتائج التفسير الكمي لهذه الجسة .

Key Words: Resistivity method, groundwater potentialities, Wadi El-Assiuti, Eastern desert

ABSTRACT

Wadi El-Assiuti is located east of Assiut city and extends in almost northeast direction. The entrance of the wadi is suitable site for reclamation and city planning projects. Consequently, it is very important to study the groundwater potentialities of this part of Assiut governorate. Electrical resistivity measurements included 29 vertical electrical sounding (VES) applying Schlumberger layout were carried out. The obtained VES-curves were quantitatively interpreted to deduce the corresponding geological layers, its true resistivities and thicknesses using the available computer program. The results of quantitative interpretation indicated presence of two possible water-bearing layers. The first is expected at depth ranging between 13 and 47 m with thickness varies between 20 and 70 m. A second possible aquifer is expected at the eastern part of the area and is characterized by depth ranging between 110 and 130 m and thickness between 60 and 80 m. The results of drilling data obtained at VES station 5 emphasized the data obtained from the quantitative interpretation of the VES-curves in the studied area.

INTRODUCTION

Wadi El-Assiuti is one of the most important wadies in the Eastern Desert of Egypt. Its entrance lies to the east of Assiut city, east of the Nile flood plain (Fig. 1). The area investigated covers about 3 km^2 from the great area of the entrance of the wadi. The major problem of this vast area is the lack of sufficient and safe water supply necessary for land reclamation, construction of new communities and livestock needs. Consequently, the authors carried out an earth resistivity study only on this small part of the entrance of the wadi (as example) to investigate possible solutions for the groundwater exploration.

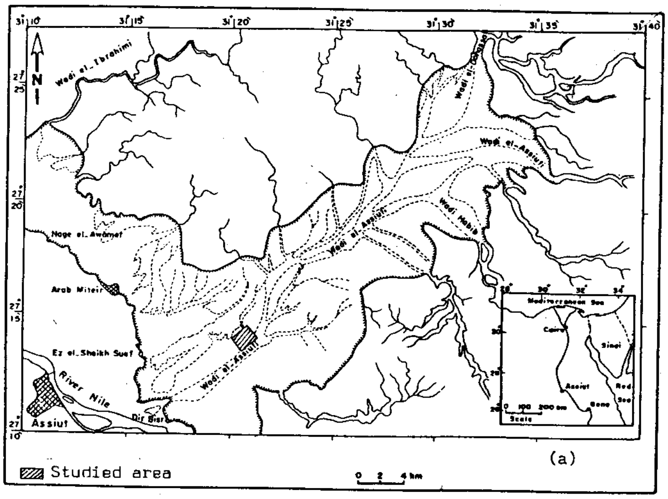

Fig. 1: Location map of the studied area (a) and the drainage system of Wadi El-Assiuti (b).

Different geological and geophysical studies were carried out by many authors on the area and its neighborhood such as El-Gamili (1964), Omara *et al.* (1970, 1974) Youssef *et al.* (1977), Bakheit (1983, 1989) and many others. It is important to mention here that Bakheit carried out a geoelectrical study at the entrance of the wadi on a regional scale. In the present study 29 VES-stations were measured only on small part of the entrance of the wadi to recognize its groundwater possibilities in some detail.

GENERAL GEOLOGY

The entrance of Wadi El-Assiuti is mainly covered by Plio-Pleistocene sediments concealing Lower Eocene limestone bed rock. It is bounded by the Eocene limestone scraps from the north, south and east, and by the Nile flood plain from the west. The wadi drains southwestward into the present River Nile. Its drainage system is identified in Fig. 1.

Said (1981) traced and mapped the Quaternary sediments at the entrance of Wadi El-Assiuti (Fig. 2) as follows:

1. Recent to subrecent alluvial cover (fanglomerates and wadi filling).

2. Neonile sediments (made up of silts and clays).

3. Prenile sediments (Qena Formation, made up mainly of sands).

4. Paleonile/Protonile sediments (composed of Armant Formation which made up of gravels and fine grained clastics together with Issawia Formation which made up of travertines with conglomerates and breccias.

5. Paleonile sediments (made up of red-brown clays, sands and silts).

The Lower Eocene limestone exposed on the escarpment faces bounding the entrance of the wadi can be arranged from base to top as: Thebes, Durnka, Manfault and Ibrahimi formations (Mansour and Philobbos, 1983).

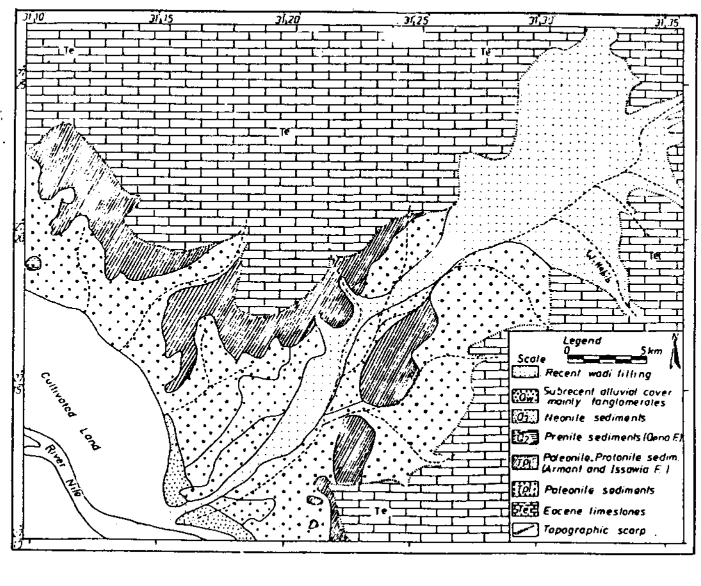

Fig. 2: Geological map of Wadi El-Assiuti area (after Said, 1981)

According to Bakheit (1989) the structural elements observed in the limestone plateau surrounding the entrance of the wadi include faults and folds. The faults have different trends; N 140°, N 50°-70° and N-S. Folds are represented by a very dense system of narrow and long folds having the dominant direction N 115°.

For the purpose of the geological study a topographic map of the surveyed area was set up (Fig. 3). It shows elevations ranging between 77.5 and 84 m above sea level.

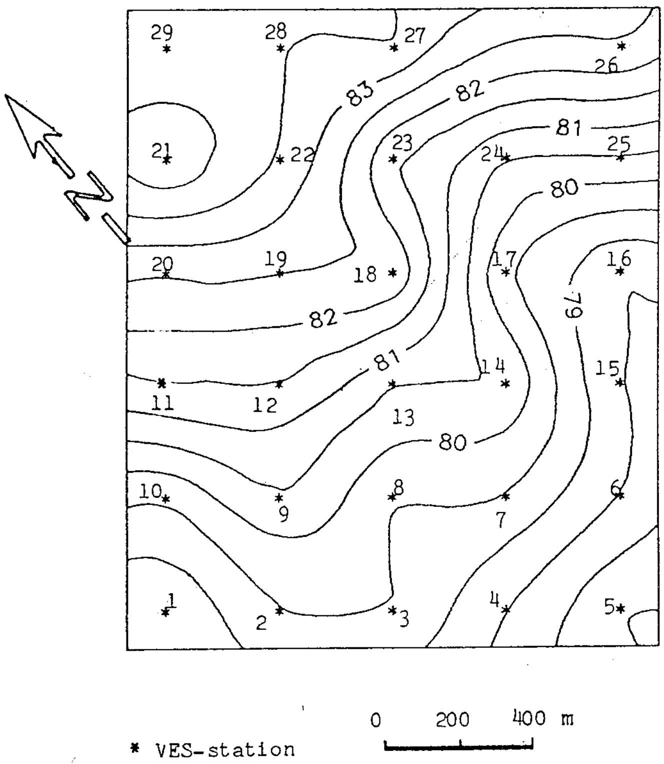

Fig. 3: Topographic map of the area.

GEOPHYSICAL INVESTIGATION

The electrical resistivity survey carried out in the studied area was achieved in January, 1991. It comprises 29 vertical electrical sounding (VES) stations distributed in regular grid of electrode spacing (AB/2) varied from 1.5 m to 700 m in NE-SW direction. The distance between every two stations equals to 300 m (Fig. 4).

Before going on the quantitative interpretation process for the measured field curves in this study, using computer program prepared by Zohdy and Bisdorf in 1989, the authors applied this program on four-layer theoretical curve (Fig. 5a) of known results (Table 1). As shown in this table it is clear that there is no essential difference between the known results of the theoretical curve and those results obtained from the application of the computer program. Consequently all the measured VES-curves were interpreted following this program in order to recognize its different buried geoelectrical layers, its resistivities and depths.

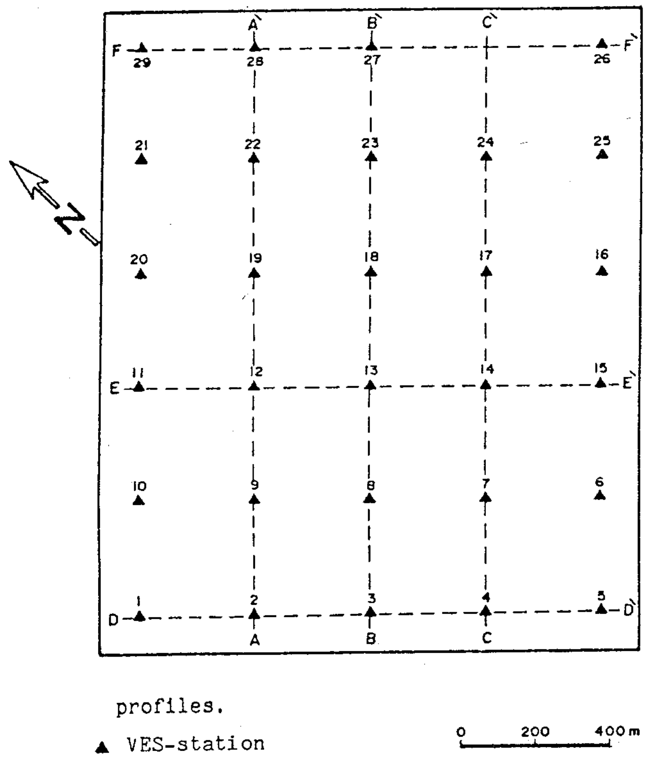

Fig. 4: Location map of the VES and the studied profiles.

Table 1
Comparison between the known results and those detected from the application of the computer program on four layer Schlumberger theoretical curve.

Layer No.	Known results		Interpreted results	
	Resistivity (ohm.m)	Thickness (m)	Resistivity (ohm.m)	Thickness (m)
1	30	13	31	12
2	75	45	69	41
3	12	137	15	115
4	>>100	-	222	-

RESULTS AND DISCUSSION

The obtained results of the the quantitative interpretation usually give rise to many sub-layers with different resistivity values. Therefore, these layers must be grouped together according to resistivity value consideration into a limited number. An example showing field curve (Fig. 6a) and its calculated and digitized one (Fig. 6b) which selected here is representing the VES-curve no. 13. In this sounding curve the detected sub-layers were grouped into 6 layers. The results of the quantitative interpretation recognized in this study is presented in Table 2.

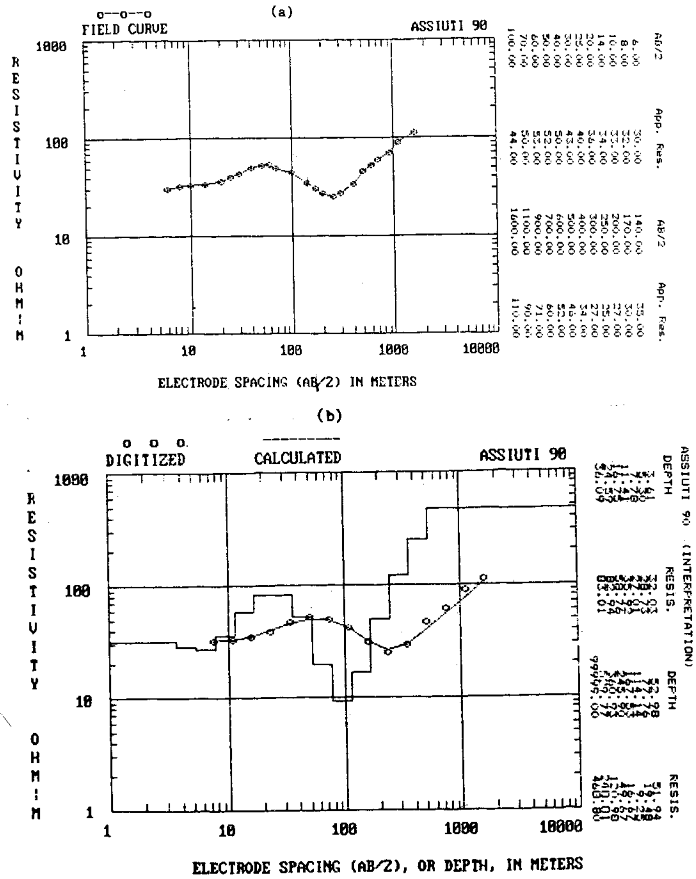

Fig. 5: Test example for the automatic interpretation process on theoretical curve (a) and its corresponding interpreted one (b).

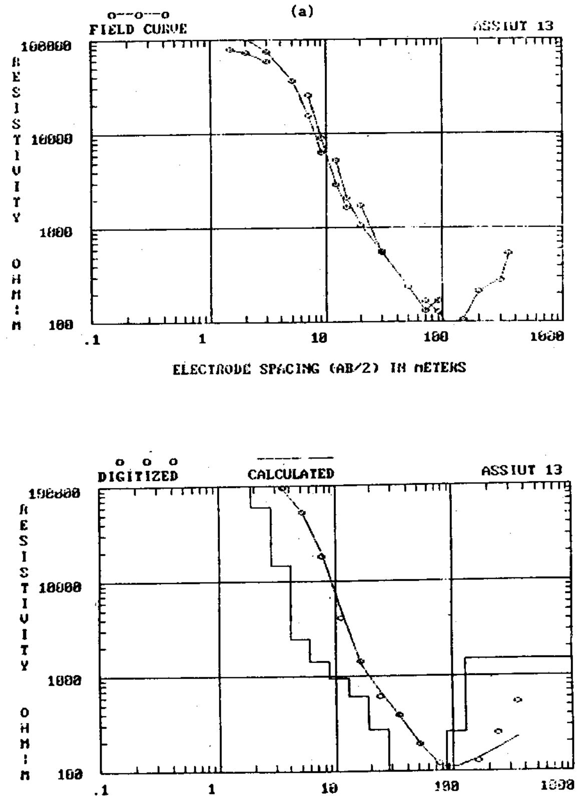

Fig. 6: Example showing measured field curve at the station 13(a) and its corresponding interpreted one (b).

Table 2
Results of quantitative interpretation in the studied area.

		Calculated true resistivity (ρ_t) of detected layers in ohm.m							Thickness (t) of layers (m)						Assumed aquifer (First)		
VES No.	Elevation (m)	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	ρ_6	ρ_7	t_1	t_2	t_3	t_4	t_5	t_6	Depth (m)	Thick (m)	ρ_t (ohm.m)
1	78	4500	2250	104	40	∞	–	–	1.5	4.5	27.0	66.0	–	–	33	66	40
2	79	110000	2750	1200	400	28	∞	–	1.5	10.5	6.5	8.5	70.0	–	27	70	28
3	79	100000	6660	2165	700	29	∞	–	2.0	12.5	9.5	10.0	60.0	–	34	60	29
4	78	12000	12000	2900	300	68	∞	–	1.5	5.0	4.0	22.5	57.0	–	33	57	68
5	77	72000	2200	500	100	60	620	∞	1.5	3.0	5.5	37.0	55.0	–	47	55	60
6	78	125000	12500	4329	260	23	∞	–	2.0	11.5	7.5	11.0	63.0	–	32	63	23
7	79	85000	56695	2520	23	∞	–	–	1.0	3.0	17.0	58.0	–	–	21	58	23
8	79	63000	3150	410	45	∞	–	–	2.5	5.0	17.5	64.0	–	–	25	64	45
9	80	123000	40959	1150	60	∞	–	–	1.0	2.0	31.0	38.0	–	–	34	38	60
10	79	100000	5000	700	45	20	∞	–	1.5	2.5	5	18.0	36.0	–	27	36	20
11	81	80000	2000	600	90	36	∞	–	2.0	4.0	3.5	16.5	50.0	–	26	50	36
12	81	70000	1750	180	80	∞	–	–	2.0	5.5	16.5	63.0	–	–	24	63	80
13	80	150000	37000	1600	450	45	∞	–	2.0	2.0	9.0	15.0	60.0	–	28	60	45
14	80	135000	5600	580	70	∞	–	–	2.0	5.5	15.5	44.0	–	–	23	44	70
15	78	80000	5328	750	80	∞	–	–	2.0	4.5	12.5	30.0	–	–	19	30	80
16	78	160000	4000	400	11	∞	–	–	1.0	3.0	17.0	53.0	–	–	21	53	11
17	79	200000	5000	153	26	∞	–	–	2.0	5.0	24.0	36.0	–	–	31	36	26
18	82	65000	13000	375	38	∞	–	–	2.0	4.0	25.0	46.0	–	–	31	46	38

Table 2 Contd.

		Calculated true resistivity (ρ_t) of detected layers in ohm.m							Thickness (t) of layers (m)						Assumed aquifer (First)		
VES No.	Elevation (m)	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	ρ_6	ρ_7	t_1	t_2	t_3	t_4	t_5	t_6	Depth (m)	Thick (m)	ρ_t (ohm.m)
19	82	90000	9000	253	15	∞	–	–	2.0	4.0	12.0	36.0	–	–	18	36	15
20	82	100000	10000	300	16	320	–	–	2.0	3.0	15.0	45.0	–	–	20	45	16
21	84	50000	5000	175	9	∞	–	–	2.0	4.0	19.0	21.0	–	–	25	21	9
22	83	85000	5300	2650	220	8	∞	–	2.0	2.0	6.0	24.0	23.0	–	34	23	8
23	81	33000	6600	200	10	∞	–	–	2.0	3.0	18.0	18.0	–	–	23	18	10
24	80	95000	19000	1300	33	∞	–	–	1.0	1.0	15.0	45.0	–	–	17	45	33
25	80	55000	5500	200	40	∞	–	–	1.0	1.0	28.0	52.0	–	–	30	52	40
26	82	42000	4800	1250	65	1000	19	∞	1.0	2.0	10.0	23.0	75.0	60	13	23	65
27	83	60000	6000	700	18	1120	16	∞	1.0	3.0	14.0	29.0	80.0	80	18	29	18
28	83	55000	11000	650	17	∞	–	–	2.0	3.0	16.0	40.0	–	–	21	40	17
29	83	85000	8500	238	12	∞	–	–	1.0	2.0	13.0	20.0	–	–	16	20	12

These results together with the subsurface data collected from some private wells were used to recognize the possibility of occurrence of water-bearing layer in the studied area. Possibly two water-bearing layers can be expected in this area.

The assumed shallow aquifer is expected at depths ranging between 13 and 47 m (Fig. 7). Its thickness varies between 20 and 70 m (Fig. 8) showing increase southwestward (i.e. toward the Nile flood plain). The calculated resistivity of this detected aquifer ranges from 8 ohm.m (VES-station 21 & 22) to 80 ohm.m (VES-stations 12 & 15) (Fig. 9). The determined elevations at all VES-stations and the recognized depths of assumed shallow aquifer were used to infer its probable water table shape. This water table varies between 35 m at VES station no. 5 (in the western part of the studied area) and 68 m at VES station 26 (in the southeastern part). The contour values generally increase to the northeast direction (Fig. 10).

The interpreted low resistivity values within the first assumed water-bearing bed at some VES stations, e.g. VES-es 16, 21 and 23 can be related to presence of brackish water at these localities.

Six subsurface sections have been constructed along the profiles illustrated in Fig. 4. These sections (Fig. 11) show different geoelectrical sub-layers of different shapes.

Inspection of these sections show the following:

1. The first geoelectrical layer (representing the surface layer) has a high resistivity reaching 200.000 ohm.m

2. The second layer has an intermediate resistivity ranging from 8 to 80 ohm.m. It probably represents the assumed first water-bearing layer in the area concerned.

3. The third layer is characterized by very high resistivities and may be represent the bed rock (possibly the limestone).

4. An assumed relatively deeper water-bearing layer can be expected in the area and it appears to the east (Fig. 11f). Its depth and thickness varies from 110 to 130 m and from 6 to 80 m respectively.

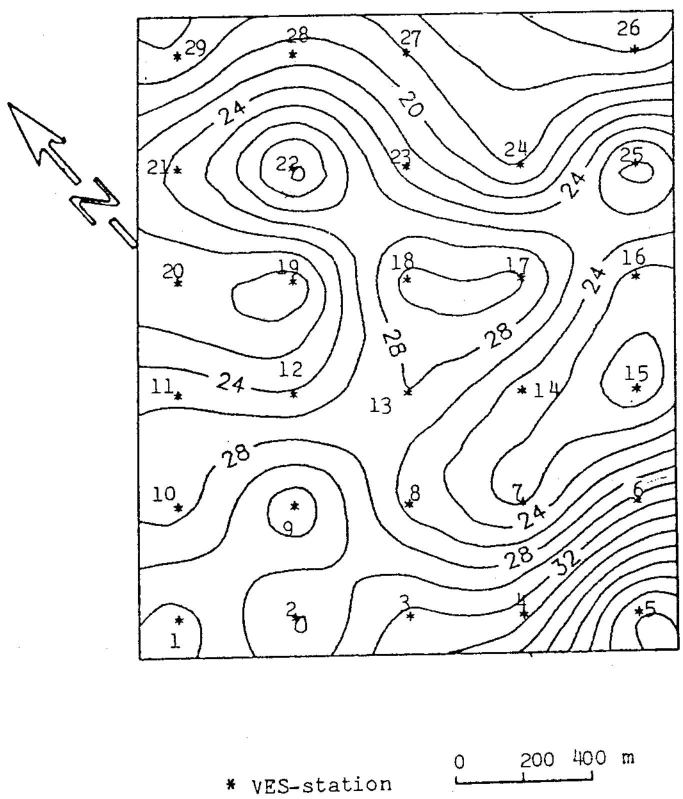

Fig. 7: Depth map to the top of the first assumed water-bearing bed.

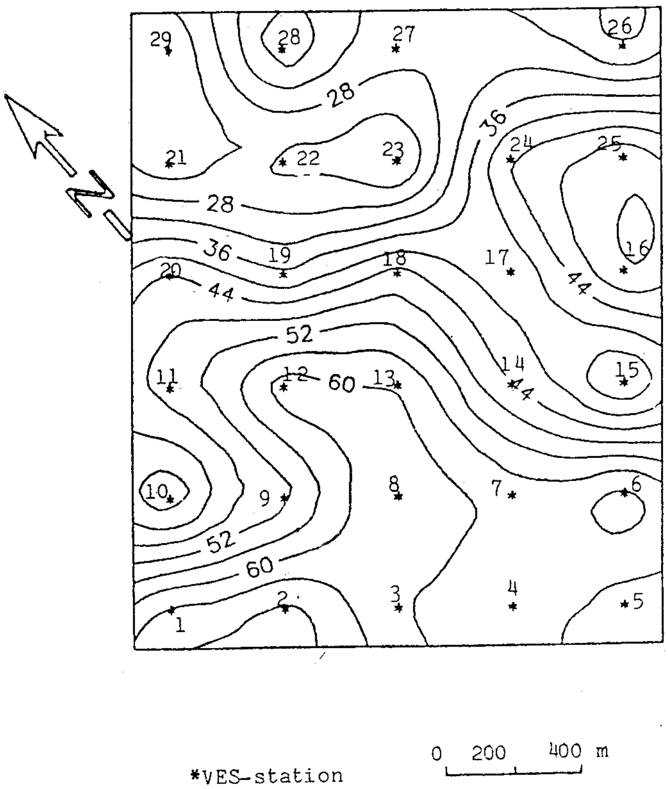

Fig. 8: Thickness map of the assumed first water-bearing bed.

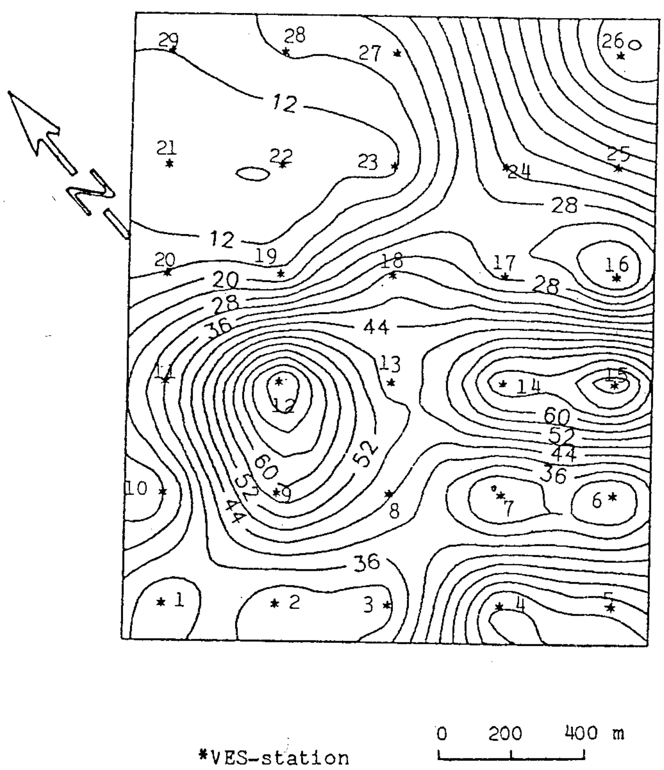

Fig.9: Interpreted true resistivity map of the assumed first water-bearing layer.

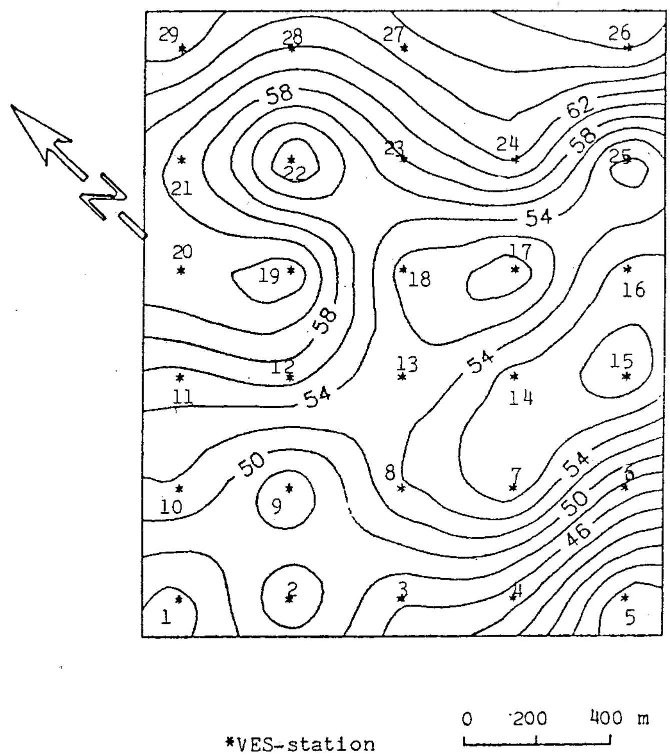

Fig.10: Interpreted water table map at the studied area.

The recharge of the assumed first water-bearing layer is probably related to the River Nile especially in areas at which the water table is lower than 48 m (the value of the water level of the River Nile at the area south of Assiut bridge) (Fig. 10).

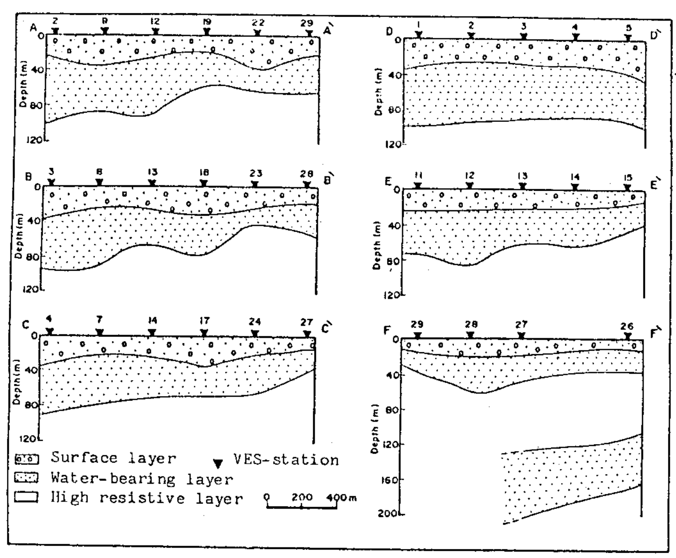

Fig.11: Interpreted subsurface cross-sections in the studied area.

Results of drilling data at the VES-station 5 (considered the best locality having lowest water table) emphasized the results of the quantitative interpretation of the VES-curve. A correlation between the lithologic information and the results of the interpreted VES-curve at the VES-station 5 is identified in Fig. 12.

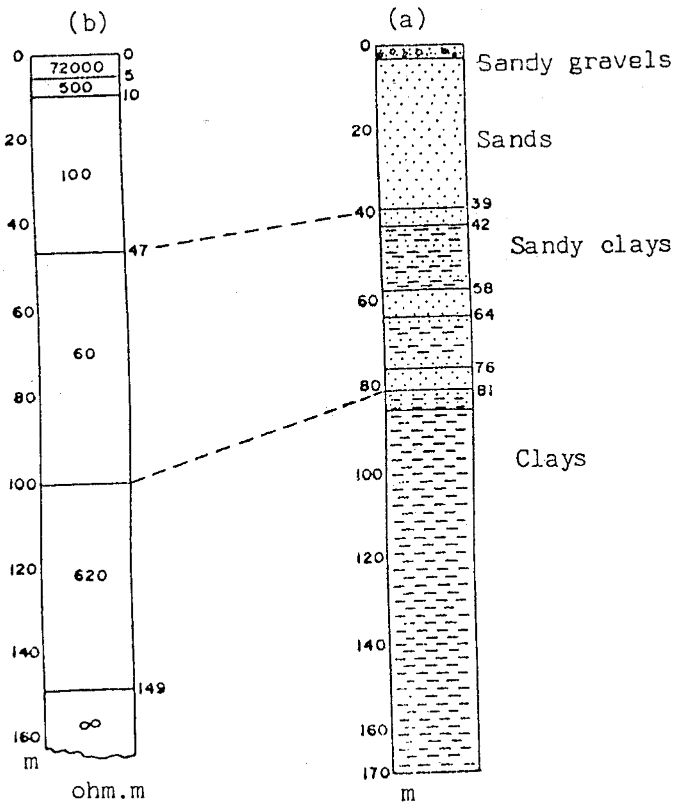

Fig.12: Correlation diagram between the drilling results (a) and the interpreted geoelectric layers at the VES-stations 5 (b).

CONCLUSIONS

From the foregoing results and discussion, the following conclusions can be formulated: 1) The VES-curves characterize multilayer sections of 5-7 geoelectrical layers, 2) The depth to the assumed first aquifer varies between 13 and 47 m, while its thickness ranges from 20 to 70 m, 3) Possible second aquifer is expected in the eastern part of the area and it has a depth ranging between 110 and 130 m and its thickness varies from 60 to 80 m, 4) The first aquifer feeding is probably from the River Nile, and 5) The subsurface information at the location of station 5 confirmed the geophysical conclusions where water was explored at a depth of 39 m.

REFERENCES

Bakheit, A. A., 1983. Geophysical and geological studies on the entrance of Wadi El-Assiuti, Eastern Desert, Egypt. M.Sc. Thesis, Geol. Dept., Assiut Univ., 137 p.

Bakheit, A. A., 1989. Geological and geophysical studies on the areas around Wadi El-Assiuti, Eastern Desert, Egypt. Ph.D. Thesis, Geol. Dept., Assiut Univ., 203. p.

El-Gamili, M. M., 1964. Geological and geophysical studies on Wadi El-Assiuti area, Eastern Desert, Egypt. M.Sc. Thesis, Geol. Dept., Assiut Univ., 185. p.

Mansour, H. H. and **I. R. Philobbos, 1983.** Lithostratigraphic classification of the surface Eocene carbonates of the Nile Valley, Egypt. Bull. Fac. Sci., Assiut Univ., 12 (20): 128-153.

Omara, S., M. R. El-Tahlawi and **H. M. Mansour, 1970.** The geology of the environs of Assiut. Bull. Soc. Geograph. Egypt, 43.

Omara, S., M. R. El-Tahlawi and **K. Shama, 1974.** Detailed geological mapping of the desert area between Manfault and Dairut, Upper Egypt. Bull. Soc. Geograph. Egypt. 47.

Said, R., 1981. The geological evolution of the River Nile. Springer Verlag, New York, p. 151.

Youssef, M. M., S. Riad and **H. H. Mansour, 1977.** Surface and subsurface structural study of the area around Assiut, Egypt. Bull. Fac. Sci., Assiut Univ., 6 (2): 293-306.

Zohdy, A. A. R. and **R. J. Bisdorf, 1989.** Program for automatic processing and interpretation of Schlumberger sounding curves in quick BASIC 4: U.S. Geol. Surv. Open file rep. 89.137 A and B, 64.