

Geological and Surface Geoelectrical Investigations in an Area Southwest of Qena, Western Desert, Egypt

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Abstract. The stratigraphic sequence in an area southwest of Qena, Egypt, has been mapped by earlier investigators and the recognized structural features seem to be simple. The distribution of the Quaternary sediments in the area is structurally controlled. Thirty (30) vertical electrical soundings (VES) were made to obtain information about the subsurface in this dry area of the country. These soundings were interpreted using a computer program. The results of the interpretation indicate the presence of two possible aquifers. The first possible aquifer is at a depth ranging between 2 and 23 m and its thickness varies from 9 to 65 m. The second possible aquifer is at a depth ranging between 80 and 276 m and of uncertain thickness. The distribution of the two assumed aquifers may be controlled by either a variation in thickness or a fault system. Layers at shallow depths (≤ 10 m) lying above the first assumed aquifer are considered as non-water-bearing layers.

Introduction

Geophysical methods play an increasingly important role in the search for suitable and productive groundwater reservoirs. The direct current resistivity method has been used routinely in exploration for groundwater.

The studied area lies on the western bank of the River Nile (Fig. 1) southwest of Qena city. It lies between longitudes $32^{\circ} 8' - 32^{\circ} 22'$ E and latitudes $25^{\circ} 50' - 26^{\circ} 21'$ N.

We used the resistivity method and made Schlumberger vertical electrical sounding measurements using the ABEM Terrameter SAS system (SAS 300 and SAS 2000 Booster). We made the resistivity survey only in a small selected area (Fig. 2) suitable for laying out the electrode array. We studied the surface geological features on a larger scale to recognize the common drainage system of the area using aerial photographs.

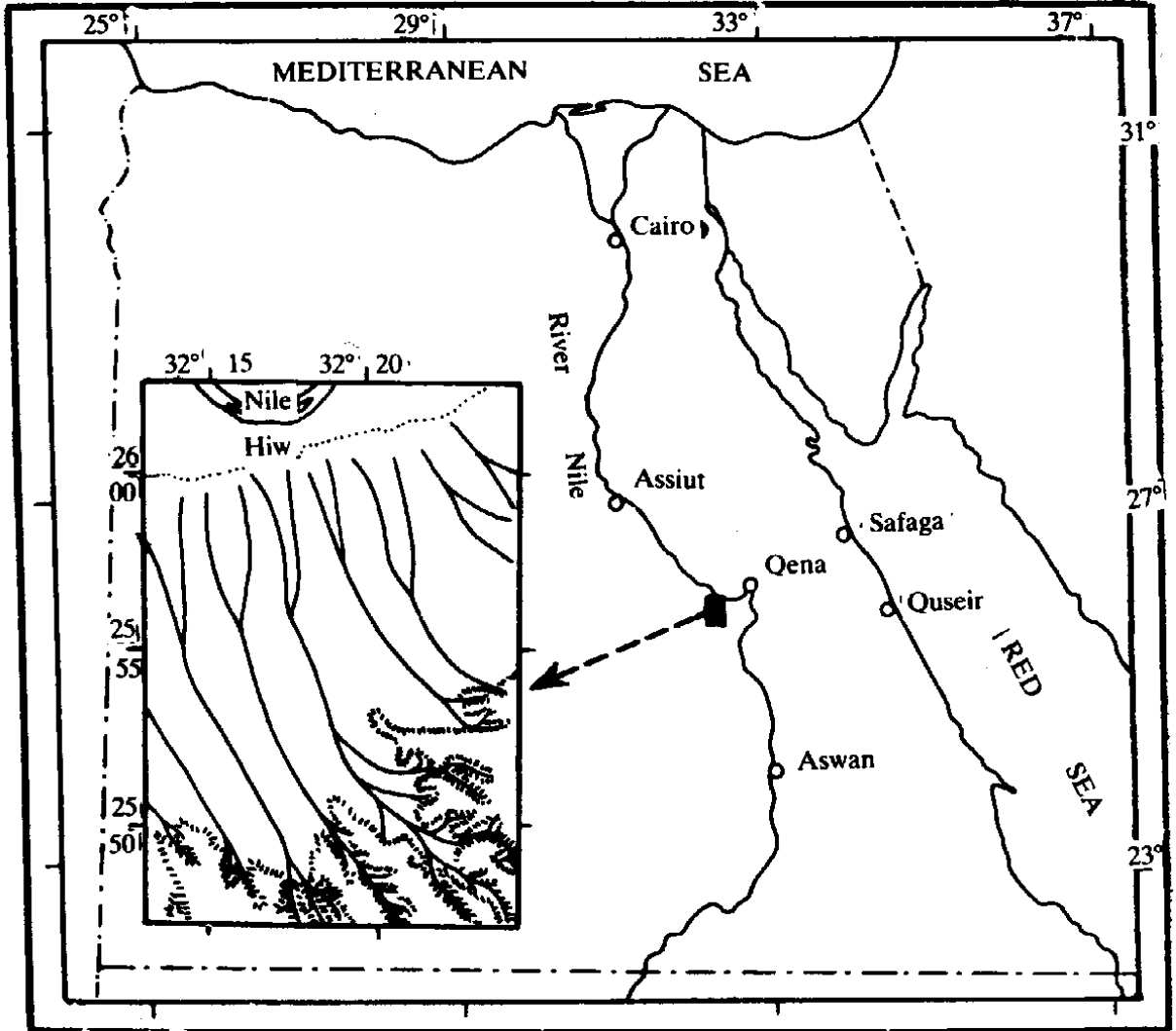


Fig. 1. Geological map of the study area showing the different rock types.

The study of the groundwater possibilities in this arid part of the southwestern desert adjoining the Nile Valley is of great importance because the water resources are rare and thus constitute a major problem obstacle to both living and industrial projects. The groundwater resources originate mainly from occasional rainfall or from the River Nile. Therefore, the objective of this study was to investigate the prospects for additional groundwater supplies for domestic and possible industrial use.

Surface Geology

The studied area (Fig. 1) covers approximately 510 km² south of the cultivated land of the Nile Valley, south of the Hiw village. The area is bounded on its northern flank by the Rannan canal and on its southern side by a dissected and irregular limestone escarpment which represents the geographical continuation of the western plateau of Lower Eocene limestone. The maximum elevation on the scarp reaches

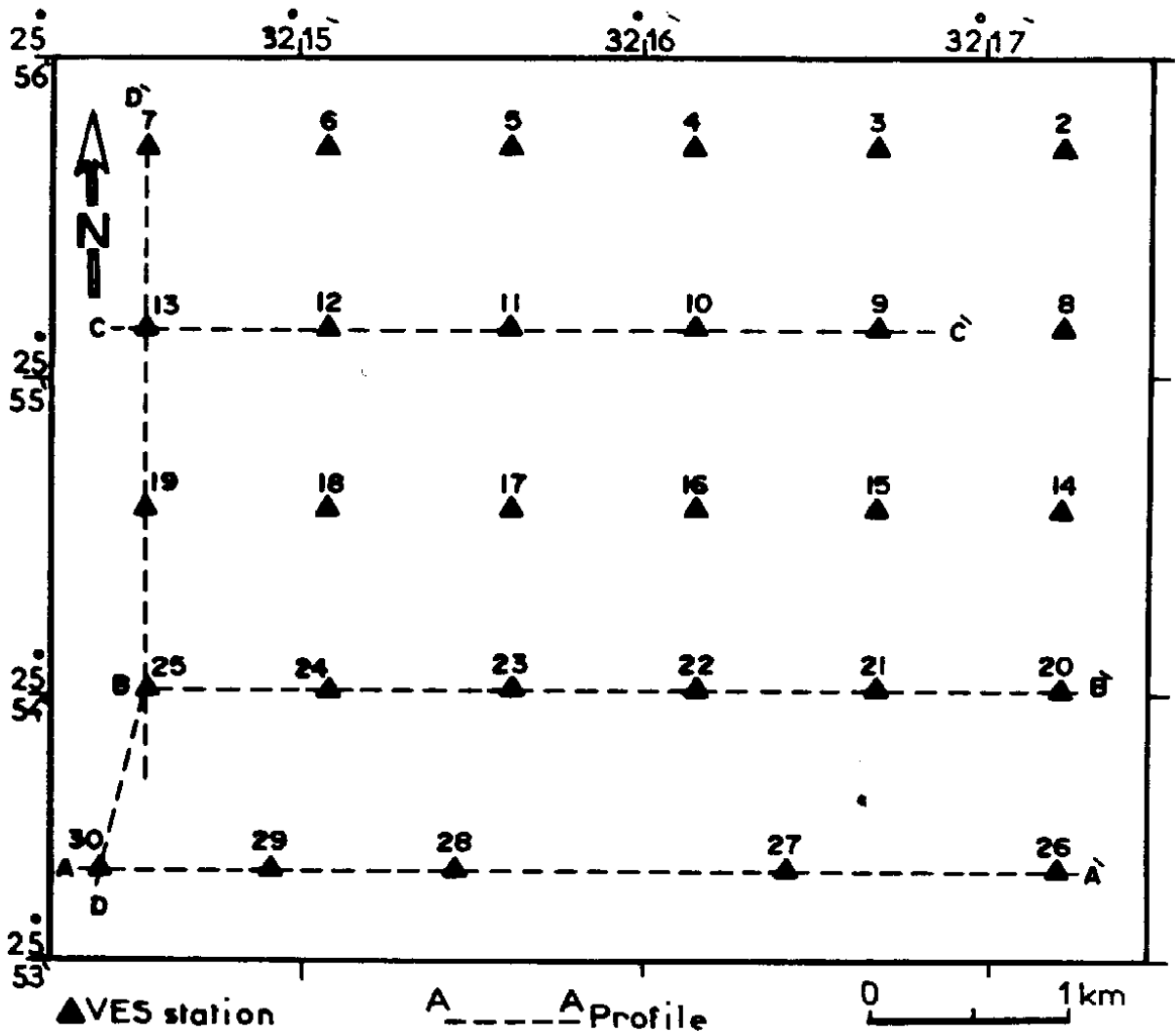


Fig. 2. Distribution of the VES-stations on the study area.

393 m above sea level, whereas the average elevation of the plain is about 150 m above sea level with a very small gradient towards the north.

The surface of the studied area is drained by a system of dry channels which catch their water every several years from rain and torrents collected from the higher limestone plateau located a few kilometers to the south. The drainage channels exhibit a diverse pattern, density, and order (Fig. 3). Yet, most of the channels show a general flow towards the northwest and north-northwest directions into the plain. The channels discharge in the flood plain of the Nile Valley which stretches in an east-west direction at the extreme north of the area.

The exposed Eocene rocks (about 80 m thick) in the mapped area (Fig. 3) are Said's Thebes Formation [1]. They are composed mainly of alternating medium to thin bedded limestone and chalky limestone. Flint bands and nodules are also abun-

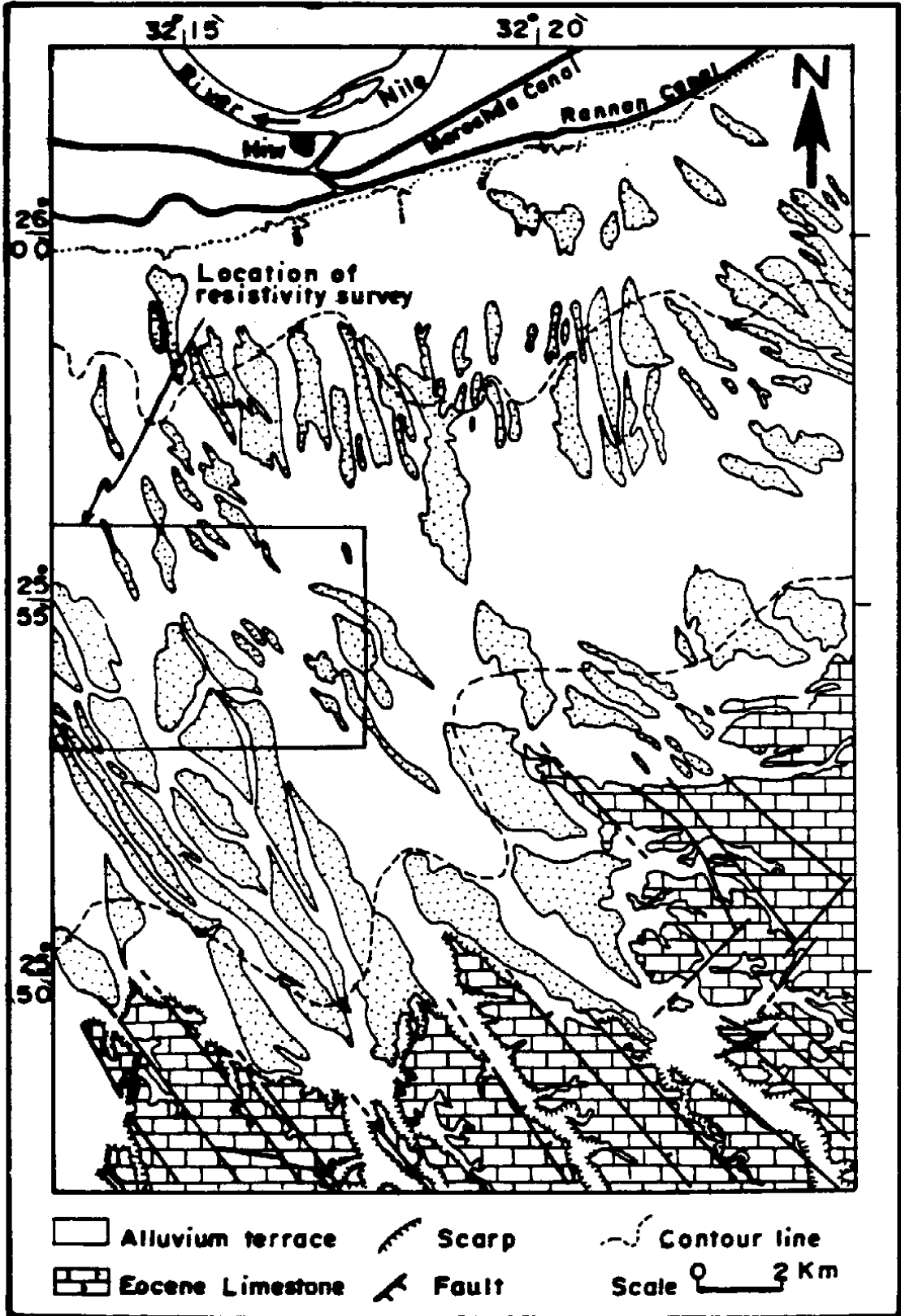


Fig. 3. Photogeological map of the area showing drainage system.

dant. Petrographically, these rocks can be differentiated into, Nummulitic biomicrite; Echinoidal bioclastic; Algal biomicrite and Pelecypodal biomicrite (coquina) microfacies reflecting environments ranging between tidal flat/lagoonal and outer shelf. These rocks were deposited in the Early Eocene time (Early Ypresian) [2;3].

Recent and subrecent covers are widespread over most of the low-lying plain in the mapped area [4]. They are mainly represented by unconsolidated sediments of the recent fan conglomerates and wadi fillings. These deposits include the alluvium sediments which are composed of gravels of different sizes embedded in a sandy, silty, and clayey matrix. All are derived from the adjacent limestone plateau. Sand drifts and sand sheets are plastered on the foot of the Lower Eocene scarp. The Nile flood plain sediments are composed of mud and silt with fine sand grains.

Structures

The structural map (Fig. 3) constructed from areal photographs shows that faults are the main structural features affecting the Eocene plateau. They are mostly high-angle normal faults with various extensions and relatively small throws. The NW-SE Faults (Erythrean) are very remarkable features that deform the Eocene rocks. This trend seems to have controlled the path of the Nile Valley to the north of Idfu [5]. Faults with the same trend are also known to dissect the Paleozoic or even Precambrian rocks in the Eastern Desert [6]. Most of the drainage lines (Fig. 3) debouching in the main plain of the area are controlled by this faulting trend.

Northeast-Southwest faults are less abundant. They dislocate and/or terminate the older "NW-SE" faults in different parts of the area. They represent the predominant structural direction controlling the path of the Nile Valley between Qena and Nag Hammadi [4]. Few tributaries that join the main wadies on the plateau are controlled partially by NE-SW fault lines.

The distribution and accumulation of Quaternary deposits (mainly derived and deposited by the action of surface water draining from the southern plateau and discharging towards the Nile Valley) are believed to be controlled by a NW - SE fault system dissecting the underlying Eocene bedrock.

The Direct-current Resistivity Method

The vertical electrical sounding (VES) method was used in this study. Its objective and importance as stated by many workers [7] is to recognize the variation of electrical resistivities with depth and to correlate these variations with geological information. In the 1970's and 1980's several methods were developed for computerized interpretation of vertical electrical sounding by different authors such as Ghosh [8], Zohdy and Bisdorf [9;10] and Zohdy [11]. The maximum Schlumberger spread (AB) was 1400 m for all VES stations.

Results and Discussion

Visual inspection of the measured VES curves identified six curve types, namely; QH, QQH, HKH, QHK, QQQH, and QQHK (Table 1). For a description of curve types see Bhattacharya and Patra [7]. The first and the third types were not very common. Most of the measured VES curves are continuous except those at stations 2,3,4,8 and 18. An example of a strongly discontinuous curve is shown in Fig. 4. According to Parasnis [12] a discontinuity can be caused by a vertical contact between two different rock units having different electrical resistivities. In the present study the abrupt variations at VES curves 2,3,4,8 and 18 may be caused by vertical step faults of NW-SE directions, at depth ranging between 10 and 200 m, or they may be caused by errors resulting from exceeding equipment accuracy, by current leakage, or some other man-made cause and not by geologic structures (Fig. 4).

The quantitative interpretation of the measured VES curves in the studied area was made using the software developed by Zohdy and Bisdorf [10]. An example showing a field curve and its interpretation is illustrated in Fig. 5. The selected sounding is VES No. 26 which is interpreted in 13 sub-layers and then grouped into 6 layers. The steeply rising branch on the curve may be caused by geological or non geologic causes.

Table 1 summarizes the results of the interpreted field data (25 VES curves) in the area southwest of Qena, and lists the resistivities and depths of the different geoelectrical layers.

Because of the scarcity of subsurface information in the study area, we assume that the low resistivity zone of ≤ 250 ohm. m possibly represents a water-bearing layer. Based on that assumption two water-bearing layers could be identified in the area.

The interpretation of the sounding curves indicated that the geoelectric section (Fig. 6) in the studied area is primarily composed of four major geoelectric layers:

- 1) The first layer has a high resistivity ranging from 1500 ohm.m. to greater than 7000 ohm. m and represents a dry zone composed of sand and gravel.
- 2) The second layer has a low resistivity (≤ 250 ohm. m). It probably corresponds to the first assumed water-bearing layer.
- 3) The third layer has a relatively high resistivity (about 2400 ohm. m). The material of this deeper layer is probably composed of buried fragments of limestone derived from the Eocene limestone plateau.
- 4) The fourth layer in some localities has a relatively low resistivity that ranges from about 13 ohm. m. to 200 ohm. m and represents the second assumed water-bearing layer.

Table 1. Results deduced from the quantitative interpretation of VES curves

VES No.	Curve type	No. of layers	Interpreted true resistivity (ρ) in ohm. m.						Thickness (t) in meters				
			ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	ρ_6	t_1	t_2	t_3	t_4	t_5
1	QQH	5	32,000	6400	1,260	65	∞	-	0.60	14.3	74.3	106.8	-
5	HKH	5	20,000	500	28,000	14,000	∞	-	0.95	4.8	14.0	7.0	-
6	QHK	5	125,000	3125	170	11,200	28	-	0.50	3.2	5.0	150.0	-
7	QHK	5	24,000	1200	73	3,200	8	-	0.80	1.2	7.6	72.0	-
9	QHK	5	1,300	130	91	4,200	10.5	-	2.00	20.0	45.0	126.0	-
10	QHK	5	70,000	7000	400	18,200	46.0	-	0.90	0.5	26.8	92.0	-
11	QHK	5	440,000	11,000	350	8,000	20.0	-	0.40	0.4	12.0	168.0	-
12	QHK	5	70,000	7,000	260	11,200	28.0	-	1.00	1.0	18.0	160.0	-
13	QHK	5	150,000	15,000	575	24,000	60.0	-	0.80	0.8	10.4	68.0	-
14	QH	4	7,250	2,900	80	∞	-	-	0.90	1.8	15.8	-	-
15	QQH	5	140,000	56,000	2000	50	∞	-	0.40	2.8	3.0	23.2	-
16	QQH	5	15,000	1,500	200	12.5	∞	-	0.70	0.7	3.9	8.0	-
17	QH	4	500	50	5	∞	-	-	0.70	10.5	1.3	-	-
19	QH	4	270,000	6,750	250	∞	-	-	1.30	1.30	10.5	-	-
20	QQHK	6	100,000	50,000	650	140	6800	17	0.80	0.40	4.8	21.0	63.0
21	QQHK	6	50,000	5,000	53	35	8000	200	0.60	1.20	3.1	6.0	12.0
22	QQQH	6	61,000	12,200	2600	780	25	∞	0.72	3.60	4.2	4.4	14.4
23	QHK	5	50,000	2,500	260	12,000	30	-	0.80	4.00	34.0	130.0	-
24	QQHK	6	10,000	5,250	560	57	5400	13.5	0.60	3.00	12.5	10.0	250.0
25	QQQH	6	550,000	110,000	9500	2,000	70	2800	0.60	0.60	6.8	6.4	71.3
26	QQQH	6	33,290	2,925	880	490	205	∞	1.00	5.00	12.0	38.0	64.0
27	QQQH	6	180,000	18,000	2400	1,200	160	∞	1.10	1.10	4.9	2.5	63.0
28	QQH	5	190,000	12,654	650	32.5	∞	-	0.90	3.40	19.0	30.0	-
29	QQHK	6	360,000	72,000	2500	1,120	50,000	125	0.80	0.80	7.8	30.0	60.0
30	QQHK	6	200,000	40,000	2800	150	8,000	20	0.80	1.20	12.5	45.0	132.0

Remarks

VES station (1) was measured outside the studied sd area near drilled well.
VES curves 2,3,4,8 and 18 could not be interpreted due to distortions.

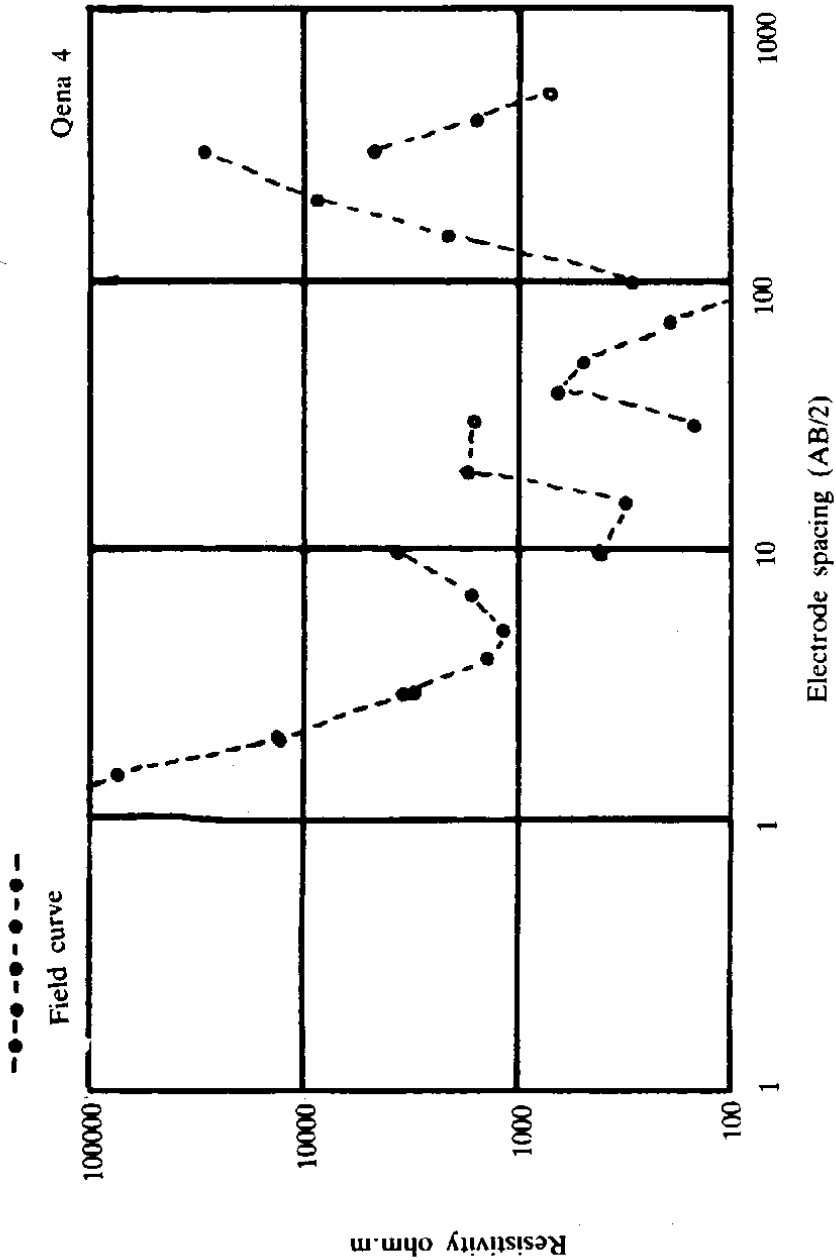
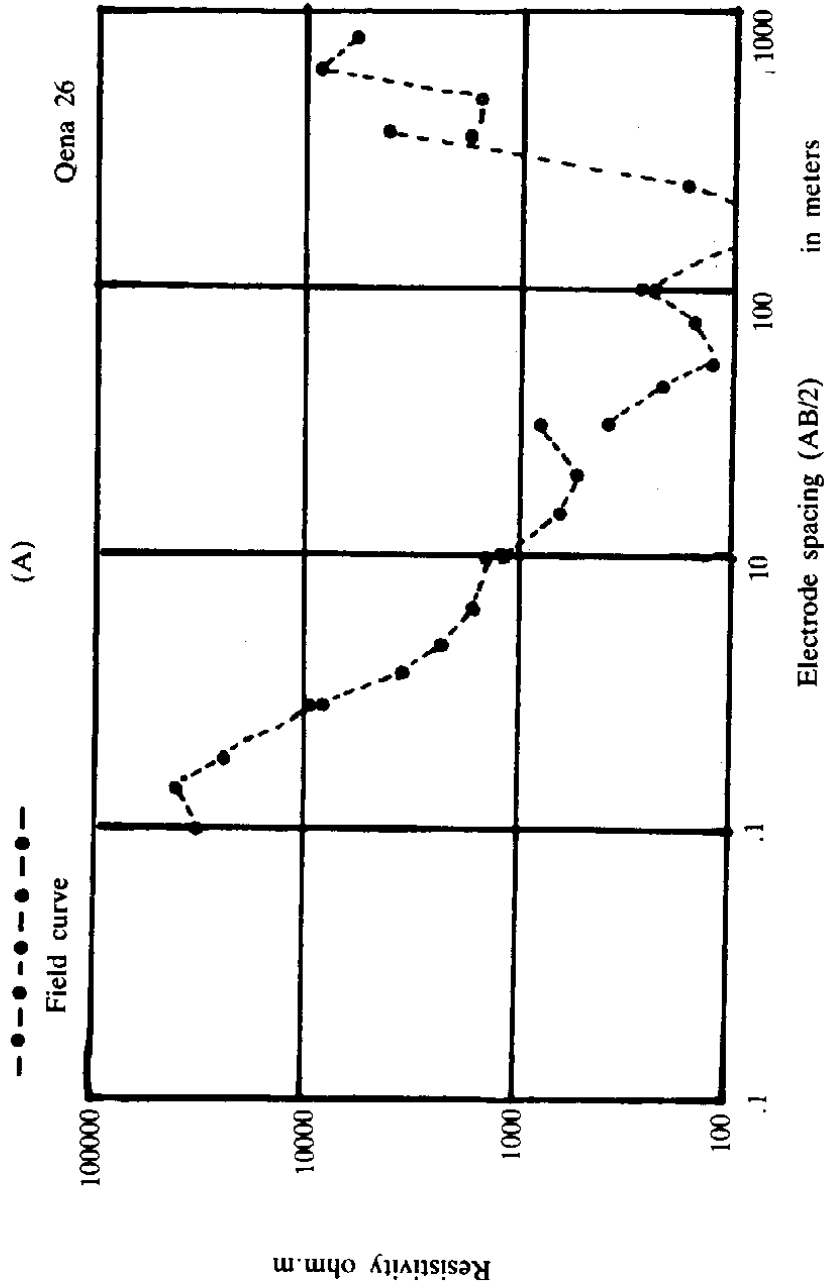


Fig. 4. Example showing discontinuities in a measured field curve in the studied area.

4 (FIELD DATA)

AB/2	App. Res.	AB/2	App. Res.
1.00	2189658.00	30.00	1685.00
1.50	72272.00	30.00	152.00
2.00	12692.00	40.00	647.00
3.00	3033.00	50.00	512.00
3.00	3357.00	70.00	203.00
4.00	1390.00	100.00	63.00
5.00	1177.00	100.00	295.00
7.00	1725.00	150.00	2337.00
10.00	3853.00	200.00	9154.00
10.00	412.00	300.00	29201.00
15.00	316.00	300.00	4595.00
20.00	1732.00	400.00	1617.00
		500.00	717.00



26 (FIELD DATA)

AB/2	App. Res.	AB/2	App. Res.
1.00	26852.00	30.00	447.00
1.50	35311.00	40.00	258.00
2.00	22018.00	50.00	153.00
3.00	8368.00	70.00	203.00
3.00	8711.00	100.00	333.00
4.00	3669.00	100.00	294.00
5.00	2456.00	150.00	69.00
7.00	1775.00	200.00	198.00
10.00	1458.00	300.00	3931.00
10.00	1178.00	300.00	1767.00
15.00	715.00	400.00	1617.00
20.00	618.00	500.00	8701.00
30.00	898.00	700.00	5072.00

Fig. 5A. Example showing the interpretation of Schlumberger sounding curve 26 using the curve matching.

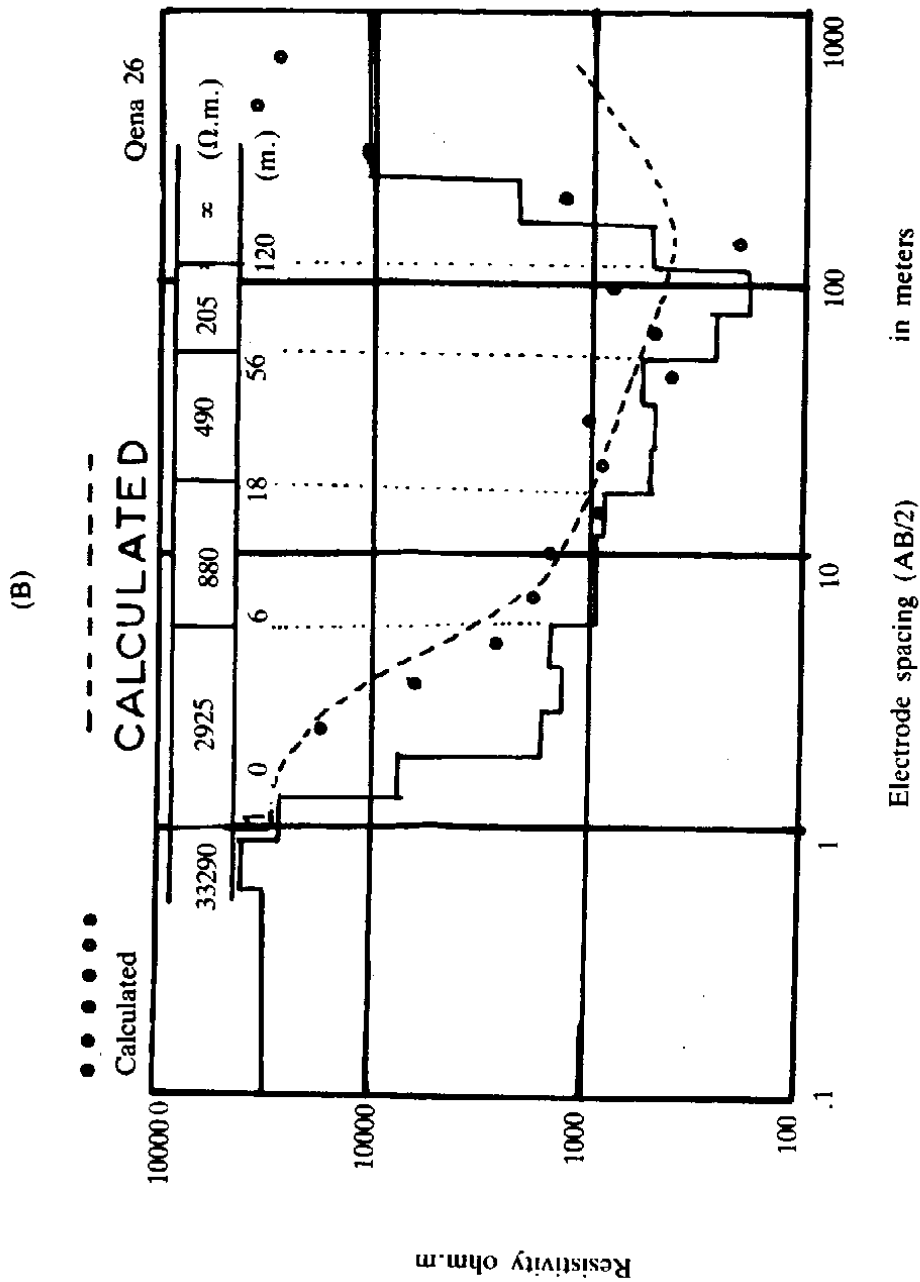


Fig. 5B. Example showing the interpretation of schlumberger sounding curve 26 using the automatic modelling.

26 (INTERPRETATION)

DEPTH	RESIS.	DEPTH	RESIS.
0.55	31778.98	17.55	815.66
0.81	41036.16	25.75	479.29
1.20	27002.23	37.80	470.89
1.75	7518.30	55.48	530.01
2.58	1523.00	81.44	242.19
3.78	1255.00	119.53	168.74
5.55	1408.94	175.45	477.67
8.14	892.89	257.53	2095.30
11.95	925.76	99999.00	10461.68

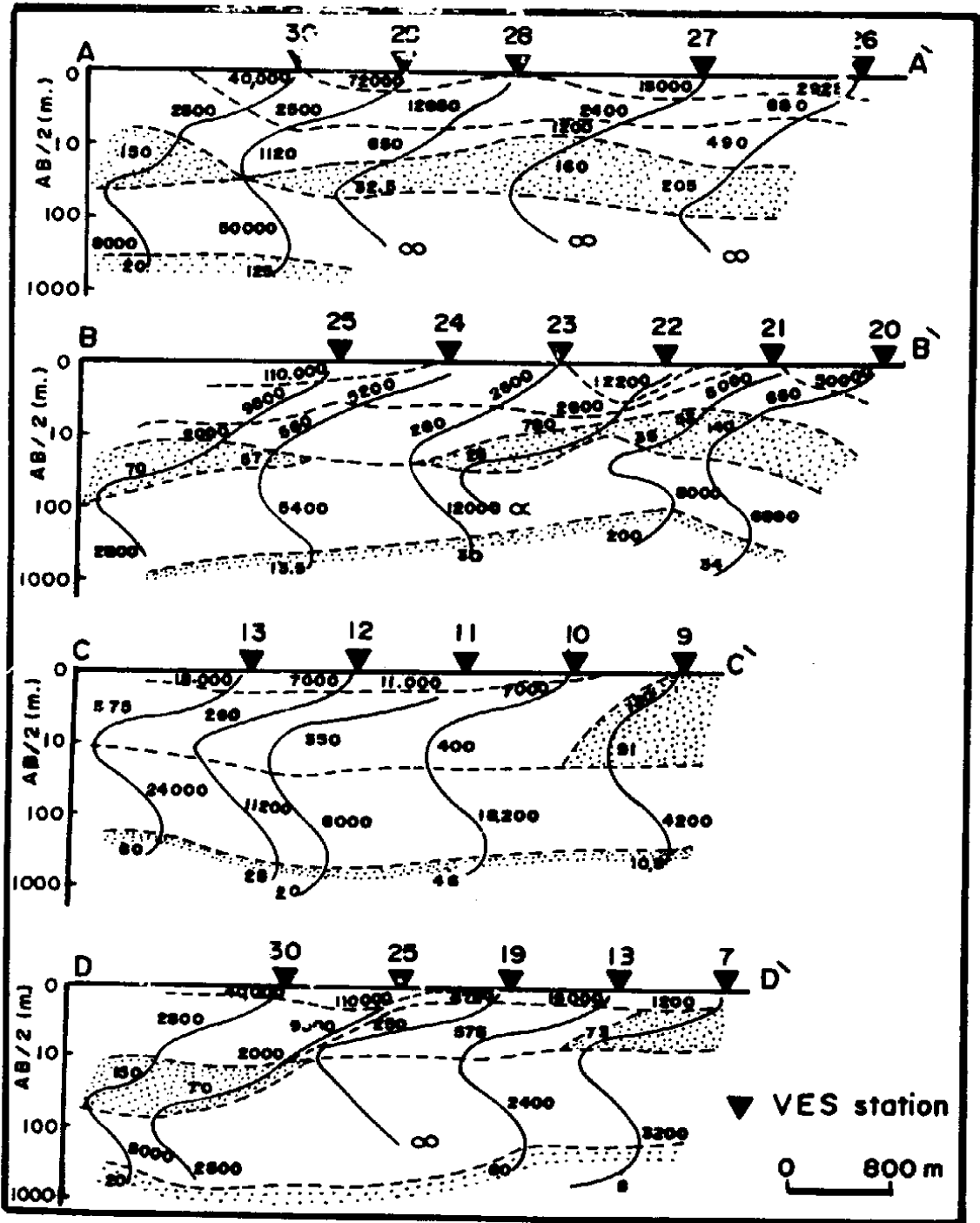


Fig. 6. Vertical geoelectric cross-section in the area southwest of Qena (curves represent forms of VES-curves and numbers designate interpreted resistivities).

The depth to the first assumed water-bearing layer varies between 2 m (VES station 7) and 23 m (VES station 28) (Fig. 7). Its thickness varies between 8 m (VES sta-

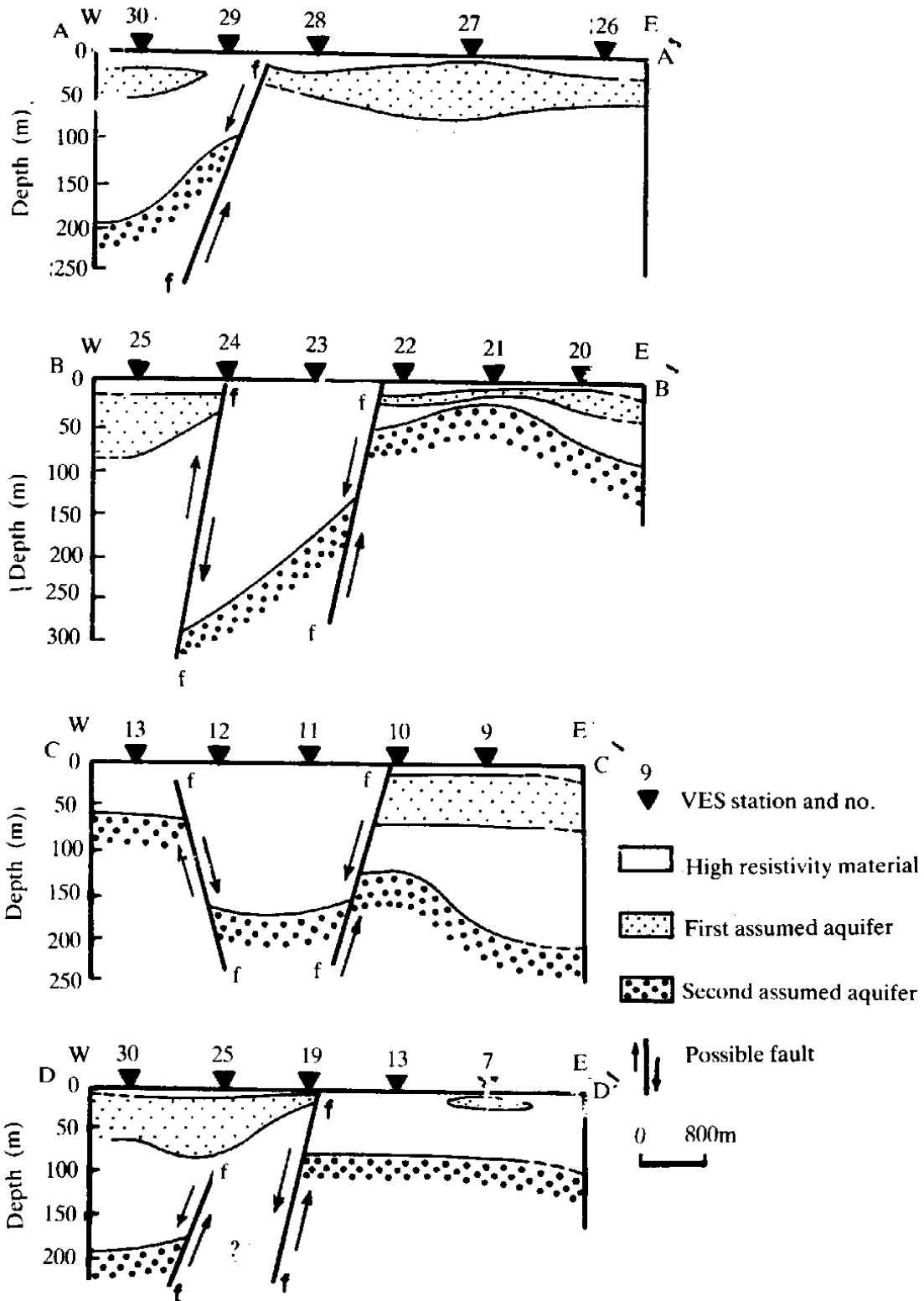


Fig. 7. Subsurface sections showing occurrence of the two assumed water-bearing layers in the studied area.

tion 7) and 65 m (VES station 9). The depth to the second assumed aquifer ranges from 80 m (VES station 13) to 276 m (VES station 24) and its thickness is uncertain.

It is obvious that the fault system in the studied area is responsible for the present distribution of the two assumed aquifers and also is responsible for the presence of the first aquifer beneath VES station 7 as an isolated body (Fig. 7).

Conclusions

In this paper, we have presented the results of interpretation of surface geological and VES data acquired in an area lying in a dry district of the country. The study revealed the presence of two possible water-bearing layers lying at different depths in the investigated area. The distribution of these two assumed water-bearing layers is possibly controlled by the fault system which dominates the area. In some localities the first aquifer occurs as an isolated body (VES station 7). The fault system is believed to have caused the discontinuities of some VES curves (VES curves 2, 3, 4, 8 and 18). The feeding of the first aquifer is possibly from the infiltration of the surface water coming from the Eocene plateau. The second aquifer is fed from both the infiltration of surface water and/or the River Nile across different fractures and faults.

References

- [1] Said, R. *The Geology of Egypt*. New York: Elsevier, 1962.
- [2] Kenawy, A.I. "Planktonic Foraminifera of the Lower Tertiary Succession in the Taramsa Section, Qena, Nile Valley, Egypt." *Fragm. Min. Pal.*, 3 (1972), 25-116.
- [3] Mansour, H.H., et al. "Geology of the Area Northeast of Sohag, Nile Valley, Egypt." *Fac. Sci., Assiut Univ. Bull.*, 16(1987), 111-137.
- [4] Said, R. *The Geological Evolution of the River Nile*. New York: Springer Verlag, 1981.
- [5] Abdel Razik, T.M. and Razvaliaev, A.V. "On the Tectonic Origin of the Nile Valley Between Idfu and Qena, Egypt." *Egypt. J. Geology*, 16 (1972), 235-244.
- [6] Schurmann, H.M.E. "The Pre-Cambrian of Egypt East of the River Nile." *Geologie on Mijnbouw*, 19 (1957), 165-171.
- [7] Bhattacharya, P.K. and Patra, H.P. *Direct Current Geoelectric Sounding, Principles and Interpretation*. New York: Elsevier, 1968.
- [8] Ghosh, D.P. "The Application of Linear Filter Theory to the Direct Interpretation of Geoelectrical Resistivity Sounding Measurements." *Geoph. Prosp.*, 19(1971), 192-217.
- [9] Zohdy, A.A.R. and Bisdorf, R.J. "Computer Programs for the Forward Calculation and Automatic Inversion of Wenner Sounding Curves." *Nat. Tech. Inform. Serv.*, 27(1975), 247-265.
- [10] Zohdy, A.A.R. and Bisdorf, R.J. "Programs for the Automatic Processing and Interpretation of Schlumberger Sounding Curves in Quick Basic 4.0." *U.S. Geol. Surv. Open File rep.*, (1989), 89-137 A and B, 64 plus disk.
- [11] Zohdy, A.A.R. "A New Method for the Automatic Interpretation of Schlumberger and Wenner Sounding Curves." *Geophysics*, 54 (1989), 245-253.
- [12] Parasnis, D.S. *Mining Geophysics*: New York: Elsevier, 1973.

دراسة جيولوجية وجيوكهربائية على المنطقة الواقعة جنوب غرب قنا، الصحراء الغربية، مصر

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(سُلمَ في ٢٣ ذي القعدة ١٤١٢هـ، وقُبِلَ للنشر في ١٦ جمادي الثانية ١٤١٤هـ)

ملخص البحث. تقع منطقة الدراسة جنوب غرب مدينة قنا، وتنحصر بين خطي طول ٣٢ ٨° و ٣٢ ٢٢° شرقاً، وخطي عرض ٢٥ ٥٠° و ٢٦ ٢١° شمالاً. وتمثل منطقة الدراسة هذه جزءاً من المناطق القاحلة الواقعة غرب وادي النيل.

ولقد اهتم الباحثون في منطقة الدراسة المذكورة بإجراء دراسة جيولوجية سطحية ودراسة جيوكهربائية وذلك لمعرفة احتمالات توجد مياه جوفية بها. ولقد تمثلت الدراسة الجيولوجية في إعداد خريطة جيولوجية للمنطقة للتعرف على مختلف الوحدات الصخرية المنتشرة بالمنطقة وأيضاً للتعرف على اتجاهات المجاري المائية القديمة وكذا التعرف على اتجاهات الفوالق بالمنطقة. أما الدراسة الجيوكهربائية فقد تمثلت في قياس عدد ثلاثين حَبَسَةً كهربائية رأسية (VES) وذلك في جزء من منطقة الدراسة. ومن خلال فحص الجسّات الكهربائية وجد أن بعض هذه المنحنيات (وهي تلك التي تحمل أرقام ٢، ٣، ٤، ٨، ١٨) غير مستمرة مما قد يعزى إلى وجود فوالق في أماكن قياس هذه الجسّات.

وقد تم تفسير كل الجسّات المقاسة باستخدام البرنامج المعد لهذا الغرض بواسطة الحاسب الآلي. وبناءً على نتائج التفسير أمكن التعرف على عدة نطاقات جيوكهربائية. النطاق الأول والثالث هي نطاقات جافة ذات مقاومة كهربائية عالية بينما النطاق الثاني في أغلب المنطقة يعتبر نطاقاً رطباً ذا مقاومة كهربائية منخفضة قد يكون حاملاً للمياه ولكن نظيره الرابع غير شائع في أغلب المنطقة ولكنه متواجد في مناطق محدودة. يتراوح عمق المكون الأول الحاوي للمياه من ٢ إلى ٢٣ متراً ويتراوح سمكه من ٨ إلى ٦٥ متراً. ويظهر هذا المكون على شكل أجسام عدسية معزولة في بعض المناطق، ويتم تغذيته من المياه السطحية القادمة من هضبة الحجر الجيري الأيوسيني، بينما يتم الصرف ناحية وادي النيل. أما المكون الثاني فهو يظهر على أعماق بعيدة في بعض المناطق حيث يتراوح عمقه من ٨٠ إلى ٢٧٦ متر. ويتم تغذيته من المياه السطحية وأيضاً مياه نهر النيل المتخللة لمجموعات الكسور والفواصل المنتشرة بالمنطقة.