Arab Gulf J. Scient. Res., **11**(1), pp. 17-36 (1993)

A Geoelectrical Study in Wadi Abu Shih Area, Eastern Desert, Egypt

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ABSTRACT. In order to study the ground water potentialities in Wadi Abu Shih, twenty six vertical electrical soundings (VES) are measured using the AREM Terrameter SAS System . The obtained VES curves are quantitatively interpreted using software prepared by Zohdy (1989). The obtained results show the presence of two aquifers separated by a shale bed. The shallower aquifer lies at a depth ranging from 4 to 12 m, and a thickness ranging from 5 to 35 m. The deeper one, which is considered as a confined aquifer, has a depth ranging between 20 and 70 m and thickness between 20 and 70 m. The depth and thickness of the shale bed separating the two aquifers vary between 5 and 25 m and 10 and 110 m respectively.

The study area lies at the entrance of Wadi Abu Shih southeast of Assiut, to the east of El-Itmania and Gaw El-Nawawra villages. It is limited by latitudes 26°50' – 26°57' N and longitudes 31°30' – 31°40' E (Fig. 1).

The entrance of Wadi Abu Shih is bounded by limestone scarps varying in elevations between 235 and 386 meters above sea level. While at the entrance of the Wadi the elevations vary between 60 and 120 meters above sea level decreasing westward downstream of Wadi Abu Shih. The floor of Wadi Abu Shih plain is covered by pebbles, gravels and boulders of limestone and chert.

There is no previous hydrogeological or geophysical studies in the study area. Therefore, the present study aims essentialy at throwing light on the groundwater potentialities at Wadi Abu Shih which is considered as one of the important reclamation regions. For this purpose, an earth resistivity survey including 26 vertical electrical soundings has been conducted.

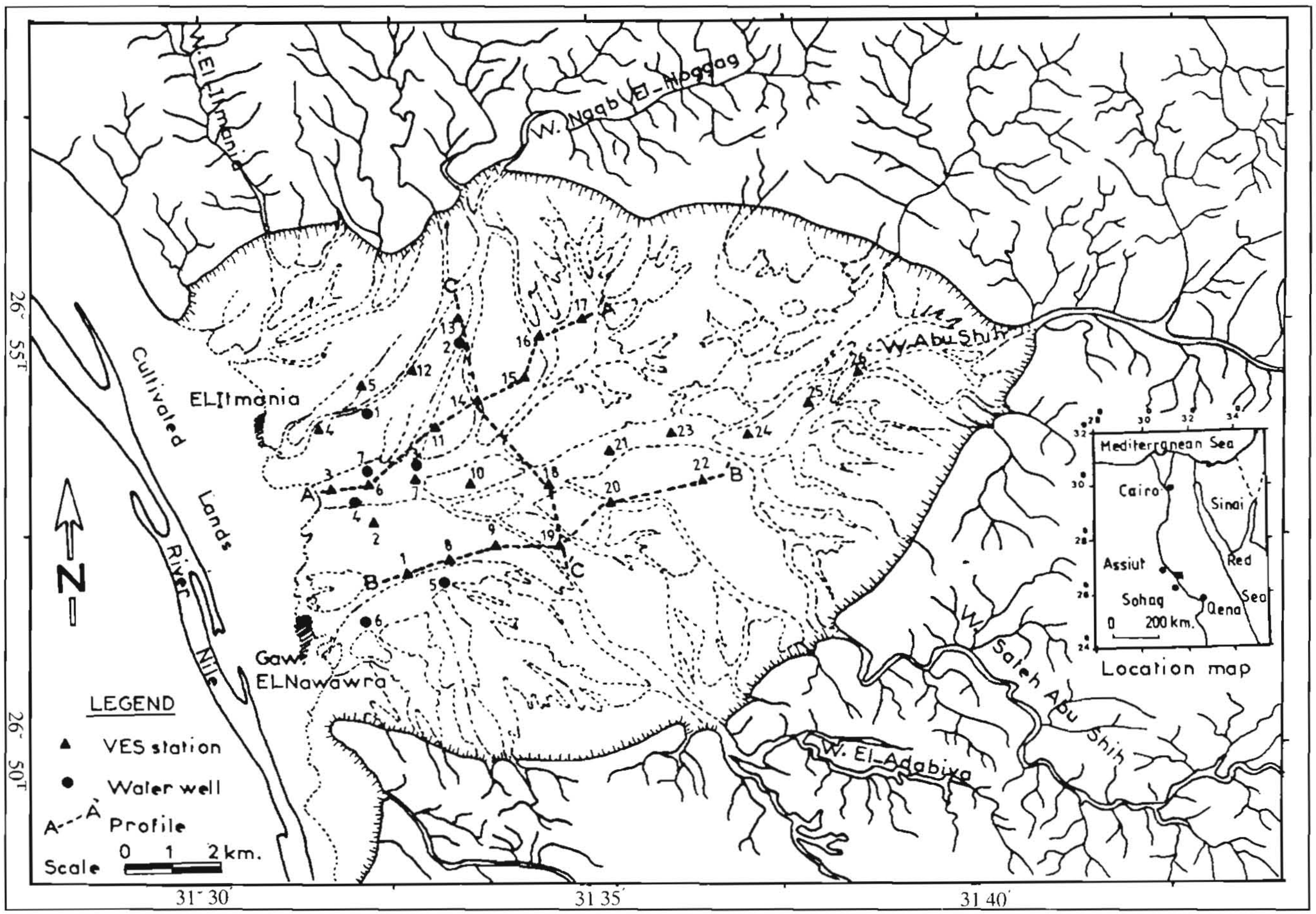


Fig. 1. Map showing the study area, drainage pattern, VES stations and profiles.

General Geology

Wadi Abu Shih plain is bounded by the Eocene limestone scarps in the north, south and east, and by the Nile flood plain in the west. It is covered by Nile terraces and wadi alluvium of Plio-Pleistocene and Recent ages (Said 1981).

Wadi Abu Shih drains westward to the River Nile. Its tributaries are Wadi El-Adabiya, Wadi Sateh Abu Shih, Wadi Naqb El-Hoggag and Wadi El-Itmania (Fig. 1).

The geologic map of Wadi Abu Shih prepared by Mansour *et al.* (1987) is given in Fig. 2. This map indicates that the Eocene limestone surrounding the wadi is devided into Thebes, Drunka and Manfalut formations. Wadi Abu Shih plain is occupied by wadi terraces and wadi alluvium. From the structural point of view, faults are the most dominant deformational feature in the study area. They have different trends, the most important of them is the N 35°–45° W. Folds have in general NW-SE trending fold axes with wadies following somtimes these trends.

Geophysical investigation

Geoelectrical resistivity methods are used as a tool to clarify the geology of near surface layers of the Quaternary deposits. It leads to the detection of some anomalous variations in resistivity values, number of geoelectrical layers and their thicknesses. More about the resistivity method interpretation may be found in Keller and Frischknecht (1966), Bhattacharya and Patra (1968), Zohdy *et al.* (1974) and Koefoed (1979).

The electrical resistivity survey carried out at Wadi Abu Shih, in November (1990), comprises twenty six Schlumberger vertical electrical soundings using the ABEM Terrameter SAS system. Electrode separation (AB/2) varied from 1.5 m to 350 m. The distribution of the VES stations (Fig. 1) and the direction of spreading were governed by the topographic accessibility of the study area.

The interpretation of the obtained VES curves is carried out using the software prepared by Zohdy (1989).

Results and Discussion

The obtained VES data are interpreted qualitatively and quantitatively.

Qualitative Interpretation

The inspection of VES curves in the study area revealed that all these curves characterize multilayer sections of 5,6 and 7 geoelectrical layers (Table 1). The VES curve of station 21 is not continuous, this discontinuity according to Paraznis (1973) can be interpreted as a vertical contact between two different rock types with different electrical properties.

Table 1. Resistivities (in ohm-meter) and thicknesses (in meters) of the geoelectrical layers interpreted from VES curves of Wadi Abu Shih

VES No.	No. of Layers	Resistivities (Ω.m.)							Thickness (m)						First aquifer		Shale		Second aquifer	
		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)	Depth. (m)	Thick. (m)	Depth. (m)	Thick. (m)
1	7	20517	3239	219	30	131	521	∞	1.5	1.5	11.4	31.5	21.6	31.7	3	12	15	32	46	22
2	7	92594	4250	198	40	58	34	∞	1.3	2.8	4.7	10.1	40.9	69.0	4	5	9	10	19	41
3	5	13199	41	205	774	∞	–	–	1.3	4.8	22.2	61.1	–	–	6	22	2	5	–	–
4	5	48405	1264	94	0.6	0	–	–	1.9	4.1	2.9	110	–	–	6	13	19	110	–	–
5	6	10620	200	3	248	1303	∞	–	3.5	1.6	11.1	18.7	75.5	–	4	2	5	11	16	19
6	7	29707	790	75	14	203	1340	∞	1.2	4.2	2.5	3.7	13.5	54.3	6	3	8	4	12	14
7	7	1735	267	757	185	345	224	∞	0.9	1.9	10.2	15.0	13.1	47.0	13	15	–	–	41	47
8	6	4935	115	29	255	611	∞	–	1.5	3.2	16.8	46.3	31.7	–	2	4	5	17	22	47
9	7	21668	1530	136	18	189	378	∞	1.9	6.9	4.1	6.0	21.8	88.0	9	4	13	6	19	22
10	5	36869	911	53	202	634	∞	–	0.9	1.0	2.2	37.3	47.9	–	4	37	2	2	–	–
11	6	38275	2087	263	6	76	∞	–	2.4	5.1	16.4	51.4	35.2	–	8	17	24	52	76	36
12	6	2200	207	4.8	264	1210	∞	–	1.3	1.5	10.3	28.4	47.9	–	2	2	3	10	13	29
13	6	14006	3431	116	0.7	46	∞	–	1.6	3.5	2.4	67.7	35.2	–	5	3	8	68	76	36
14	5	4373	239	0.9	117	∞	–	–	1.9	6.9	51.0	69.0	–	–	2	7	9	51	60	69
15	6	104434	12062	272	432	1226	∞	–	1.2	1.3	9.2	25.2	42.6	–	3	9	–	–	–	–
16	6	10997	8	202	1061	9467	∞	–	2.1	4.6	8.0	17.0	68.0	–	7	8	3	5	–	–
17	6	23067	1489	199	830	4627	∞	–	1.2	2.6	4.4	9.4	37.7	–	4	5	–	–	–	–
18	5	14580	162	7	109	∞	–	–	2.3	8.5	39.3	23.5	–	–	3	9	11	40	50	24
19	6	12278	2606	249	345	144	∞	–	2.4	5.1	16.3	11.1	75.5	–	8	17	–	–	35	76
20	7	59780	4287	300	9	89	321	∞	1.9	11.0	14.9	32.0	28.0	41.0	13	15	28	32	60	28
22	7	9858	810	213	7	157	464	∞	1.9	2.2	14.8	21.8	47.0	41.0	4	15	19	22	41	47
23	5	118174	4035	298	850	∞	–	–	1.5	8.5	21.5	67.9	–	–	10	22	–	–	–	–
24	5	135770	1412	238	842	∞	–	–	1.1	9.6	23.1	15.8	–	–	11	23	–	–	–	–
25	5	232471	99152	5578	1773	∞	–	–	1.1	1.2	5.0	42.4	–	–	–	–	–	–	–	–
26	5	254302	841	1692	433	∞	–	–	0.9	1.9	10.0	27.5	–	–	–	–	–	–	–	–

N.B. VES station 21 is not interpreted.

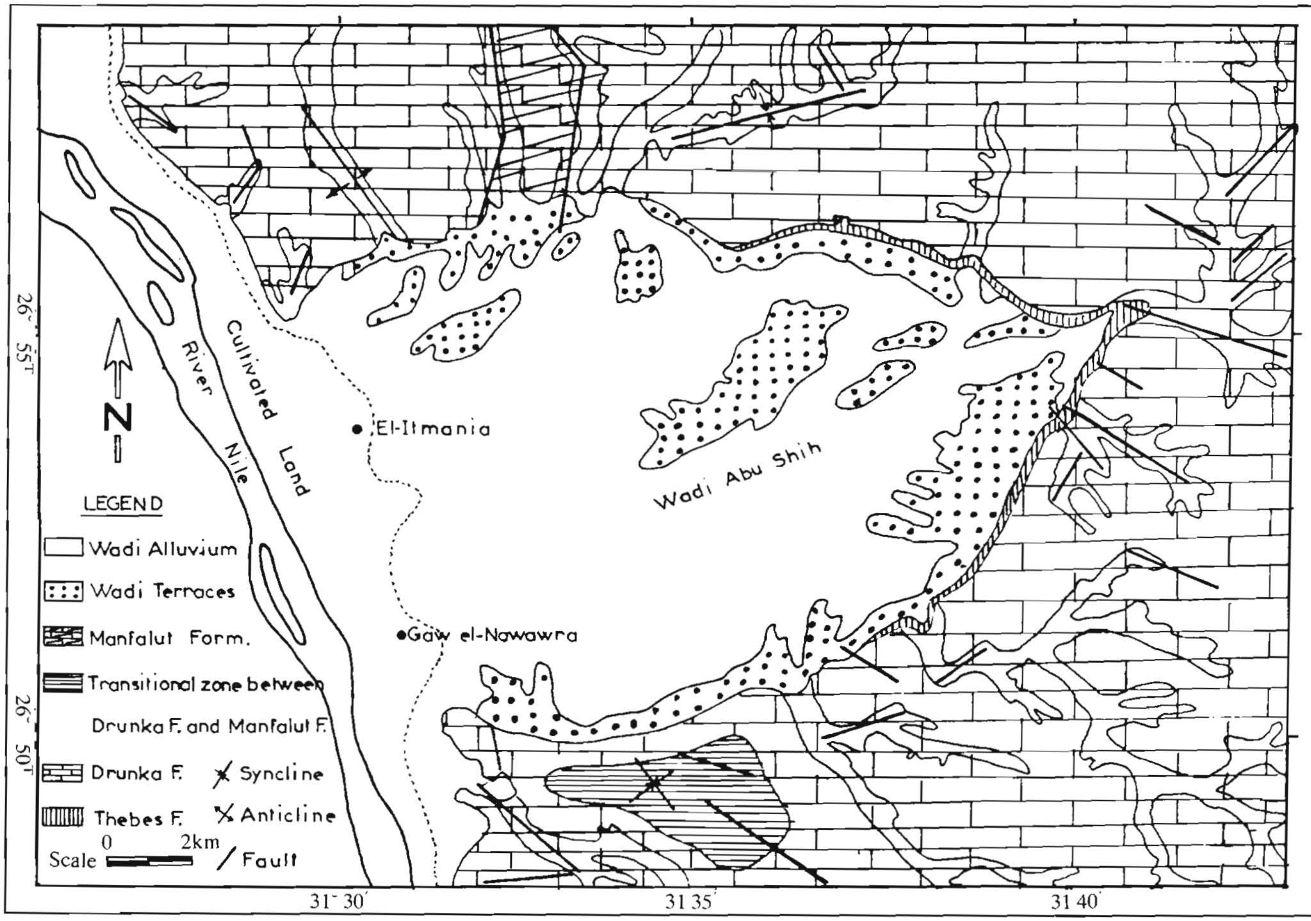


Fig. 2. Simplified geological map of Wadi Abu Shih area. (Compiled after Mansour *et al.* 1987).

Three apparent resistivity sections are prepared, AA' and BB' extending along a W-E direction, and CC' extending along a N-S direction.

The inspection of these sections (Fig. 3) shows:

- The apparent resistivity values are very high for the upper zone at the three section (reaching 50,000 ohmm), they decrease with depth and then increase again.
- There are high resistivity anomalies at VES stations 17,22 and 18 along sections AA', BB' and CC' respectively. This may be attributed to the presence of a buried resistive formation under these station.
- Abrupt lateral changes in resistivities between VES station: 16, 17 (Fig. 3A); 20, 22 (Fig. 3B); and 14, 18 (Fig. 3C) may be due to lithologic contacts or faults.

Quantitative Interpretation

The quantitative interpretation of the obtained VES curves has been done using the software "programs for the automatic processing and interpretation of Schlumberger sounding curves" prepared by Zohdy (1989). By this software, twenty five VES curve are analyzed in terms of layers of certain true resistivities and well defined depths for the upper and lower surfaces of the encountered beds. Two examples are selected for illustration in this study; these are the VES No. 7 and 8 (Fig. 4). VES No. 7 is interpreted in detail in fourteen layer and grouped in seven layers, while VES No. 8 is analyzed in detail in fourteen layer and grouped in six layers.

Table (1) gives the results of quantitative interpretation of VES data in Wadi Abu Shih area. A correlation between the results of quantitative interpretation of some VES curves measured beside drilled wells and the lithologic logs at these wells is given in (Fig. 5). The results of this correlation leads to delineate the true resistivities, thicknesses and depths to the top of the expected aquifers, and also the depth and thickness of the shale bed mostly separating the expected two aquifers.

Three depth contour maps to the top of the first aquifer, the shale bed and the second aquifer are prepared (Fig. 6). These depths range between 4 and 12 m, 5 and 25 m, and 20 and 70 m respectively. The depth map to the first aquifer (Fig. 6a) shows minimum depth (4 m) reported at VES stations 2, 5, 8, 14 and 22, and maximum depth (12 m) reported at VES stations 7 and 20. For the map of the shale bed (Fig. 6b), the minimum depth (5 m) is noted at VES stations 5,8 and 12 while the maximum depth (25 m) is noted at VES stations 11 and 20. For the depth map to the second aquifer (Fig. 6c), the minimum depth (20 m) is observed at VES stations 2, 5, 6, 9 and 13, while the maximum depth (70 m) is observed at VES stations 11 and 13.

Isopach maps to the first aquifer, the shale bed and the second aquifer are prepared (Fig. 7). Their thicknesses range between 5 and 35 m, 10 and 110 m and 20 and 70 m respectively. The thicknesses at these maps decrease towards both sides of Wadi Abu Shih near the foot of the escarpements. The thickness of the shale bed increases towards the western part to the east of El-Itmania village (it reaches 110 m), i.e. towards the downstream of Wadi Abu Shih and the Nile flood plain.

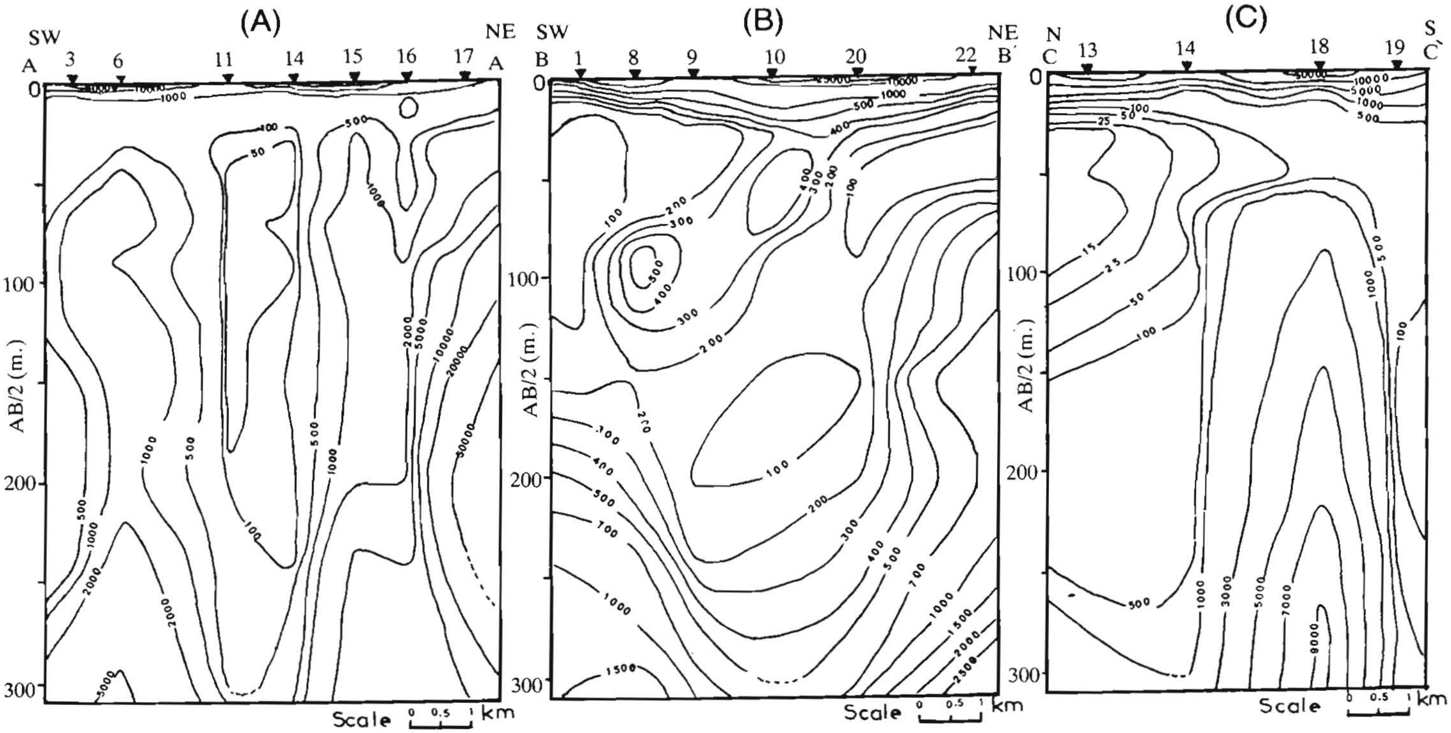
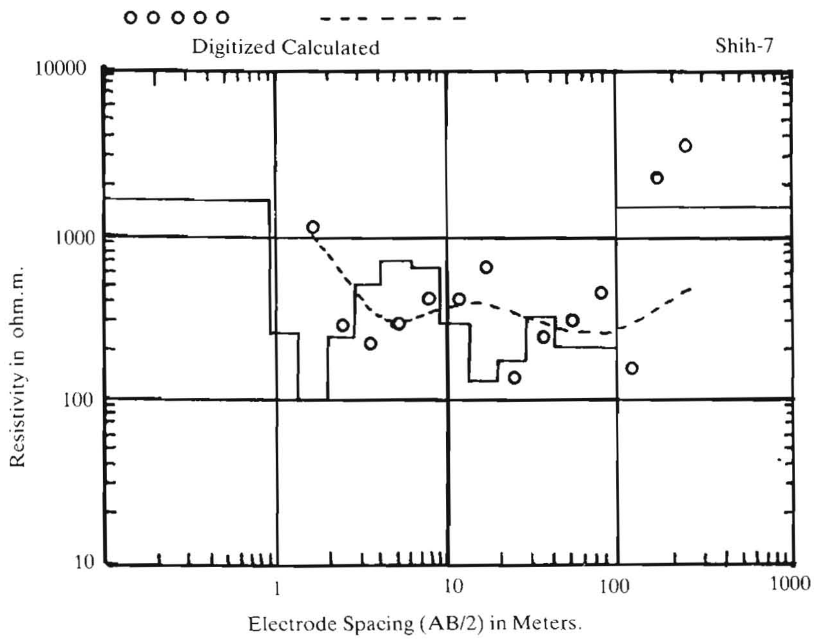


Fig. 3. Apparent resistivity sections along profiles AA', BB' and CC'.



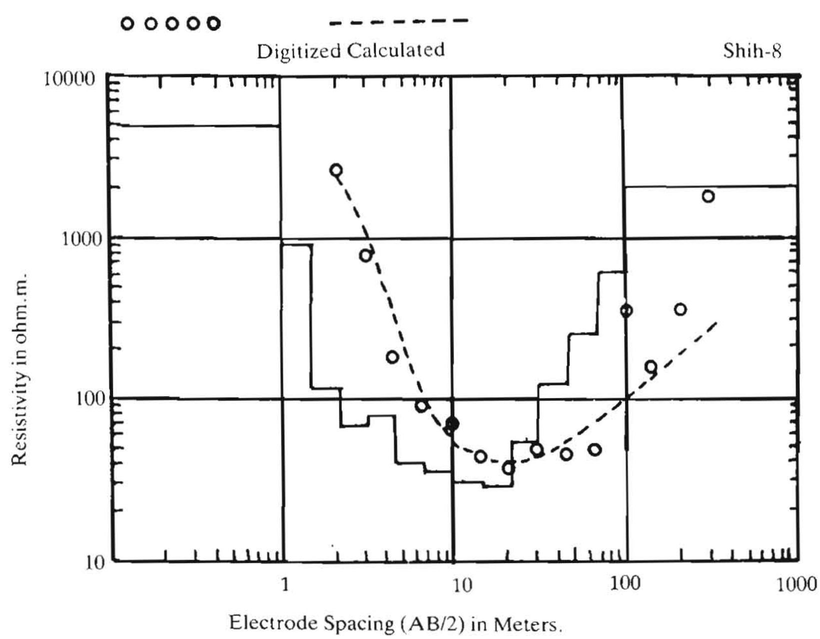


Fig. 4. Interpretation of VES stations Nos. 7 and 8.

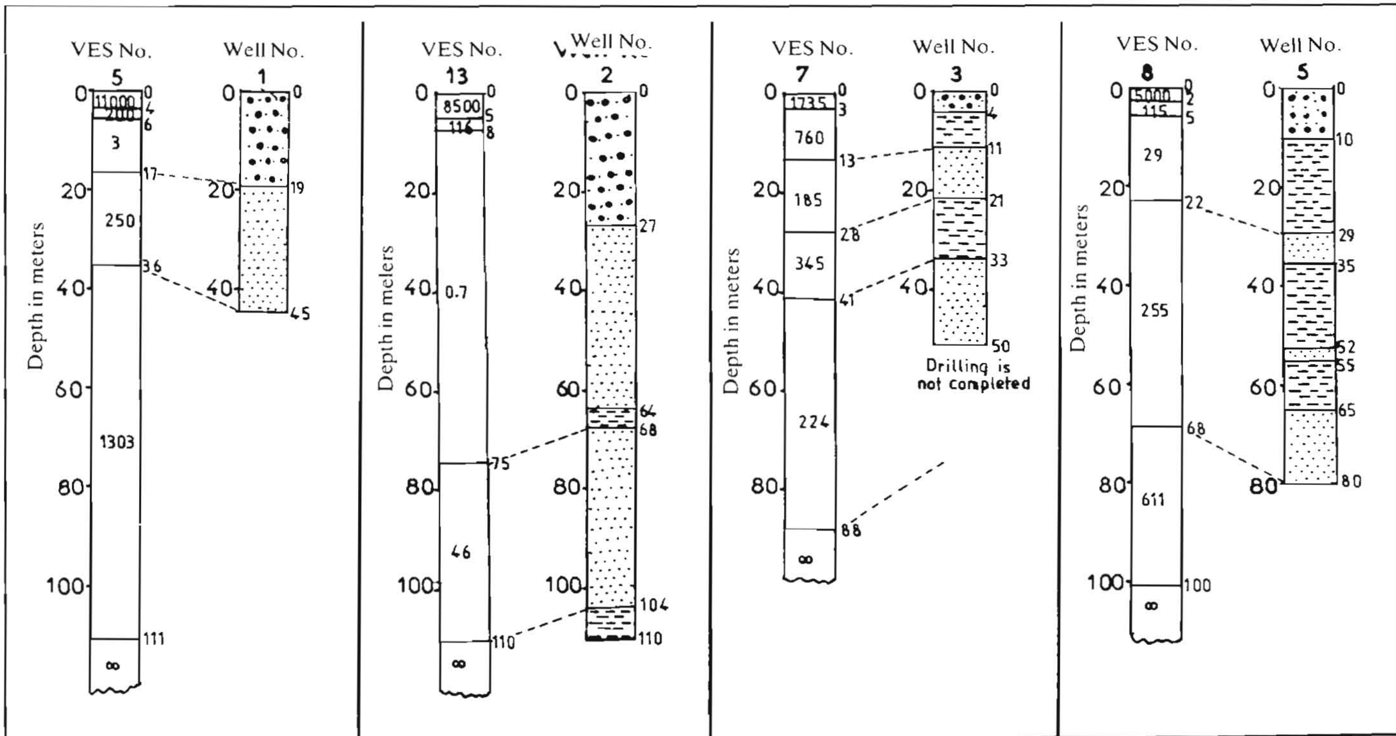


Fig. 5. Correlation between results of quantitative interpretation of VES curves and the lithologic logs of drilled wells.

Sandy gravels

Shales

Water-bearing sands

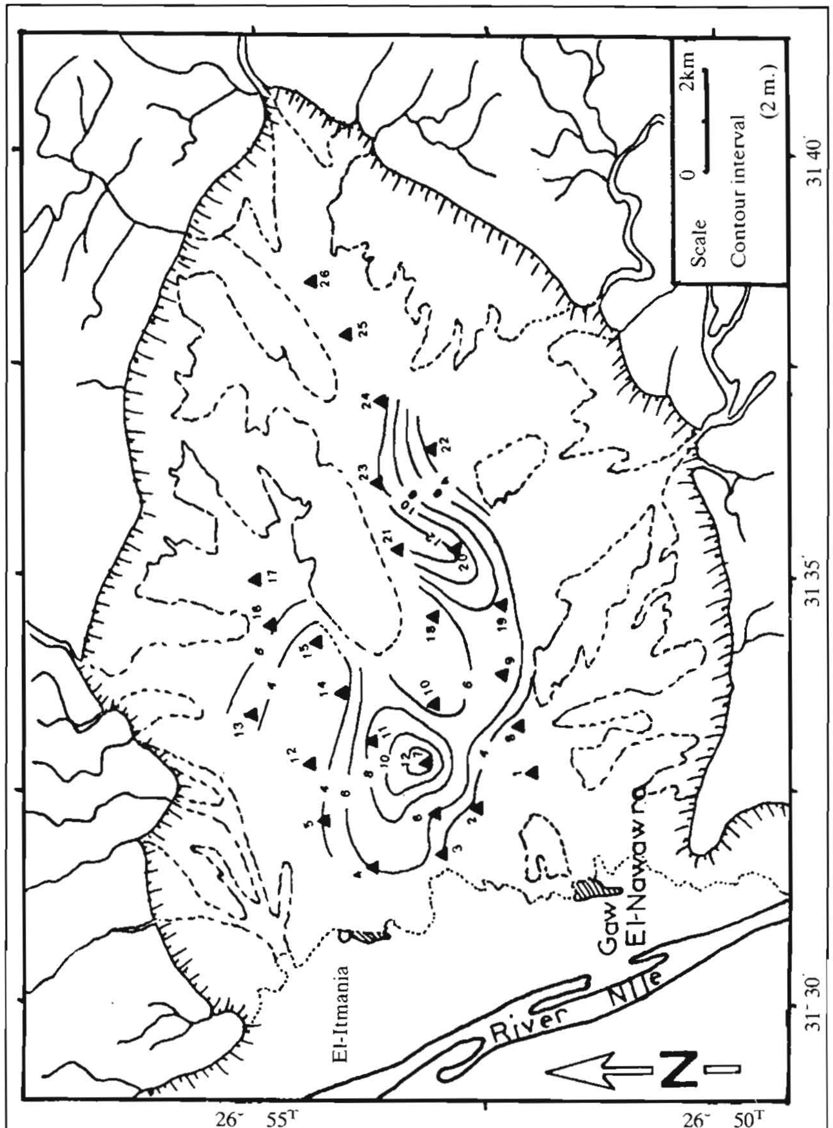


Fig. 6. Depth contour maps to the tops of the first aquifer, the shale bed and the second aquifer.

(**a**): Depth contour map to the first water-bearing formation.

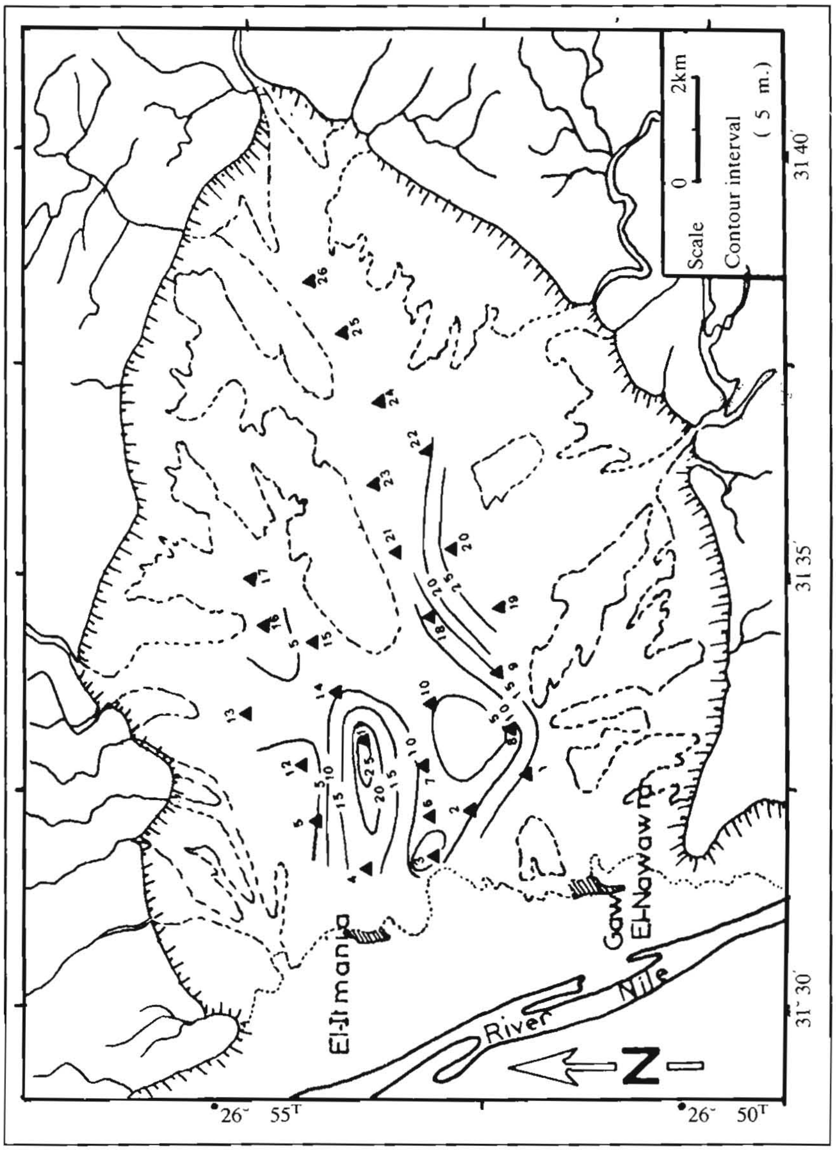


Fig. (6 - b): Depth contour map to the shale bed.

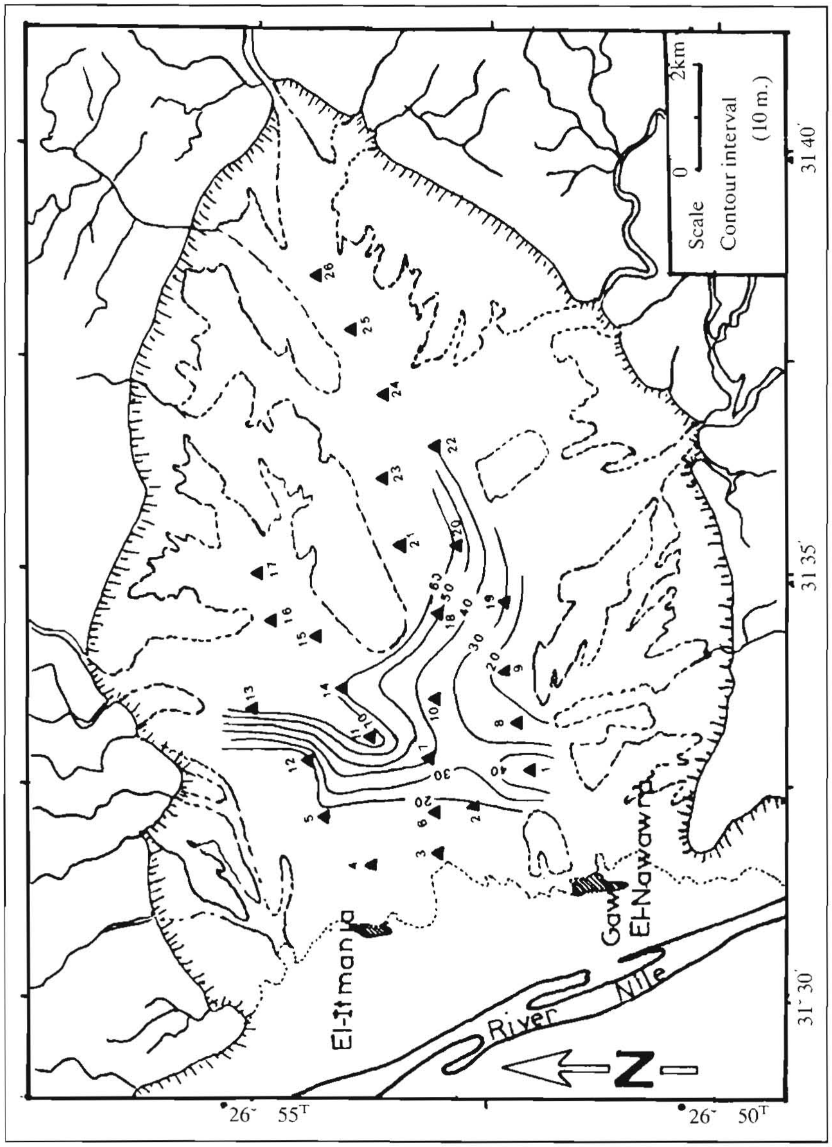


Fig. (6 - c): Depth contour map to the second water-bearing formation.

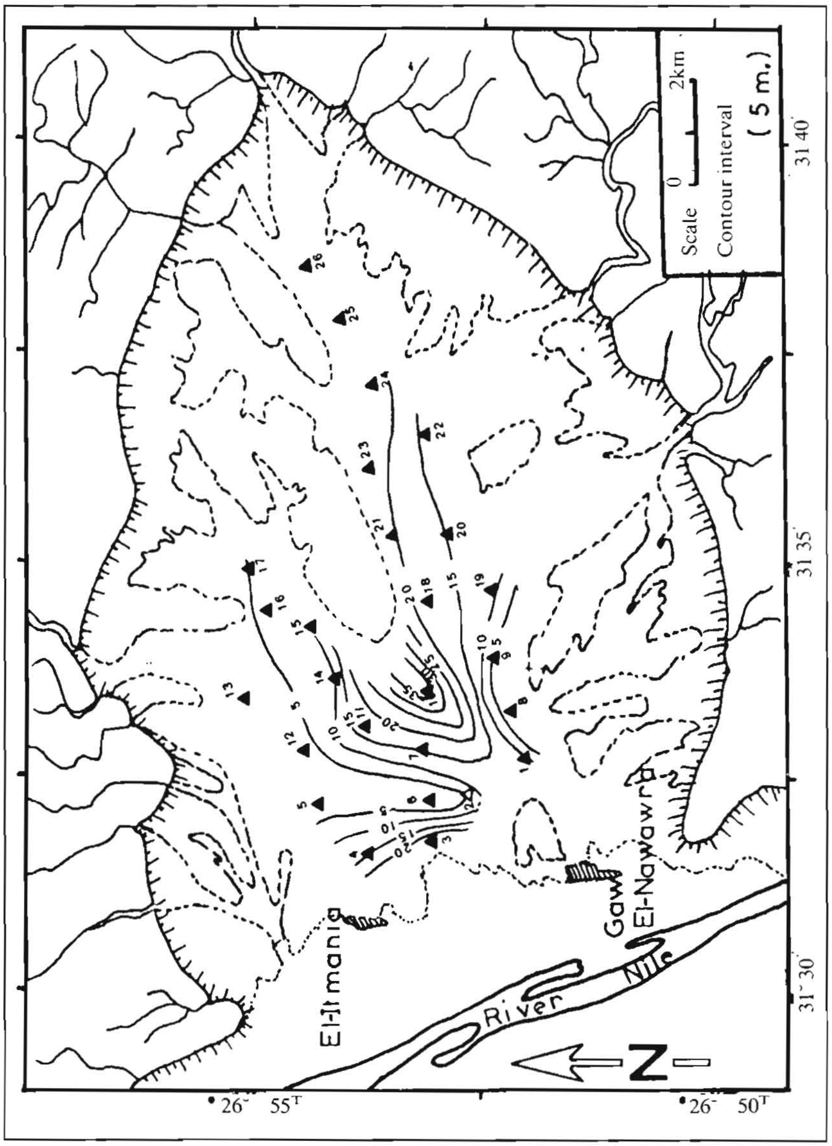


Fig. 7. Isopach maps of the first aquifer, the shale bed, and the second aquifer.

(a): Isopach map of the first water-bearing formation.

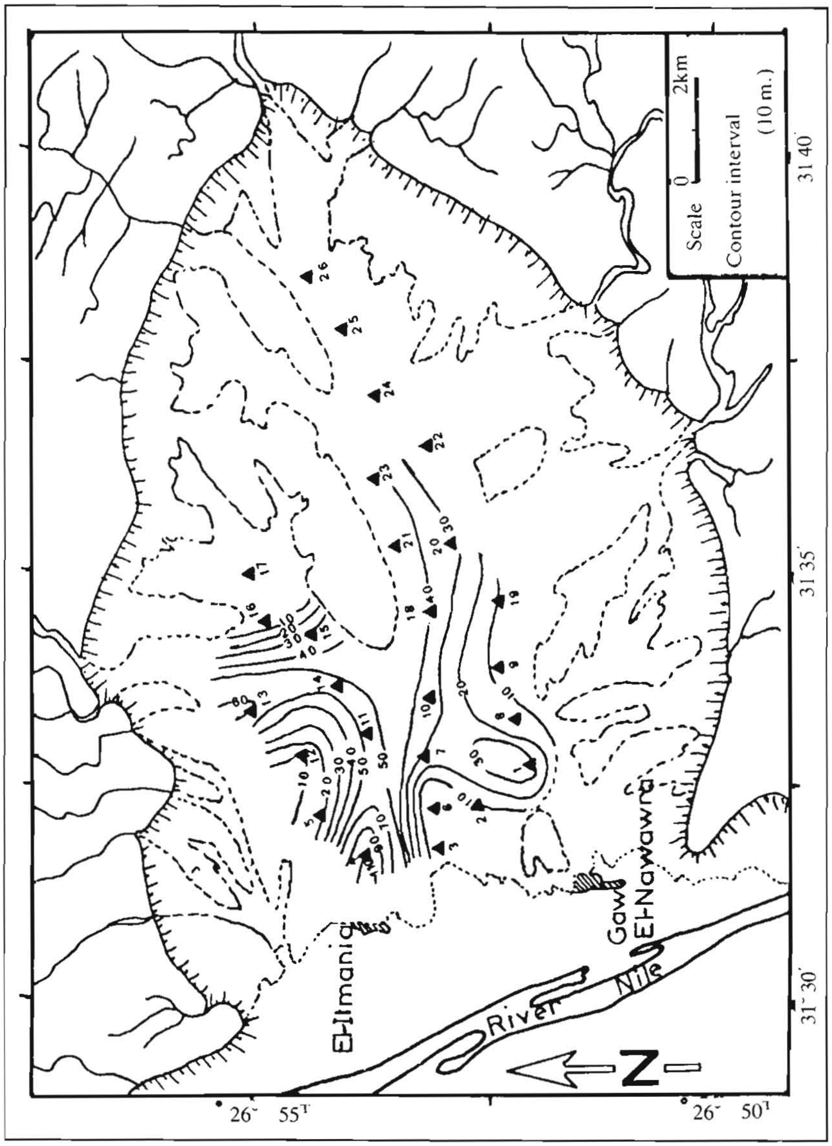


Fig. (7 - b): Isopach map of the hale bed.

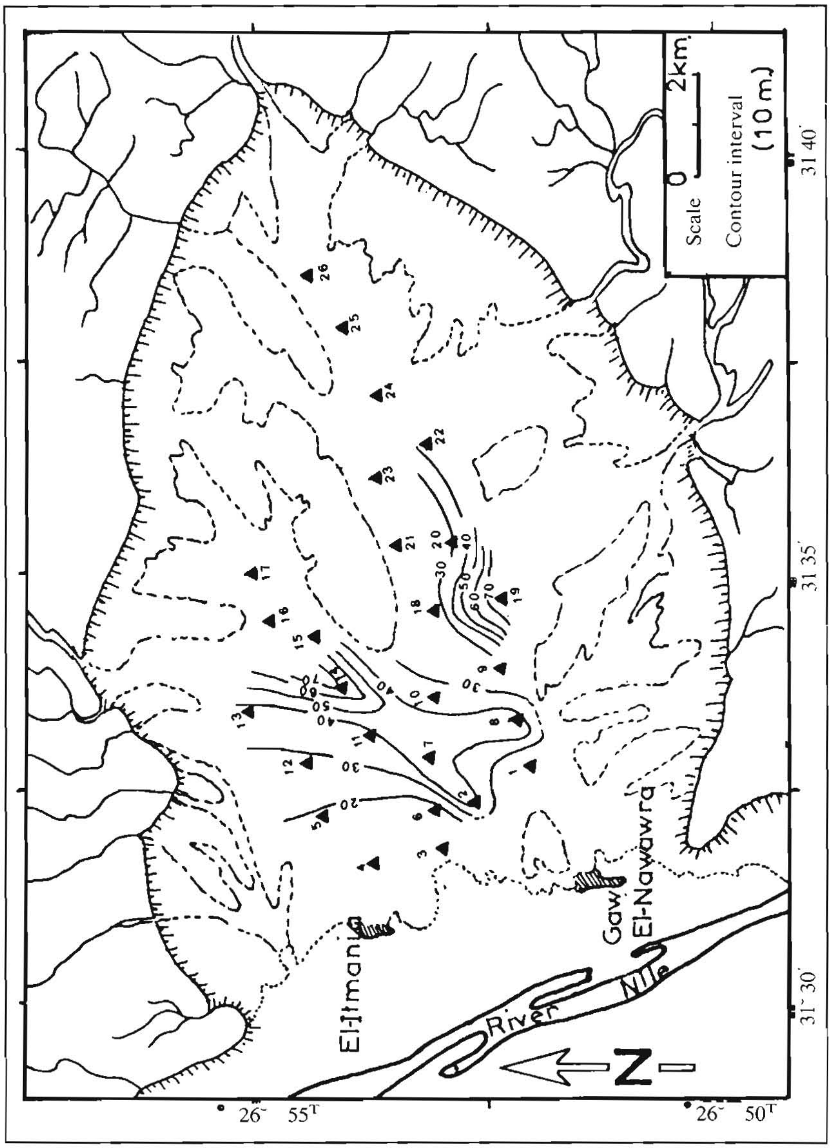


Fig. (7 - c): Isopach map of the second water-bearing formation.

Three subsurface sections along the same directions of the apparent resistivity sections (AA', BB' and CC') have been drawn (Fig. 8). They are constructed to show the different geoelectrical layers, as well as, the location of the water bearing formations and their geometrical shape. The investigation of these sections shows that:

- The first geoelectrical layer which has high resistivities (reaching 50000 ohmm) represents the surface layer. The second layer has moderate resistivities (ranging from 115 to 300 ohmm) and represents the first aquifer. The third layer is charactarized by remarkably lower resistivities of 30–0.7 ohmm. It is believed that it represents a shale bed. The fourth layer which has moderate values of resistivities (45 to 255 ohmm) represents the second aquifer. The last layer is characterized by high to very high resistivities, (reaching infinity) and is considered to be the bed rock.
- The two aquifers are mostly separated by a shale bed, the second aquifer is always thicker than the first one.
- The second aquifer is a confined one, this fact is emphasized by water level measurements on farmer's wells. So, the water level in the drilled wells, penetrating the two aquifers, is considered as a piezometric level and not as a water table.

Seven groundwater samples were collected from the drilled wells in the study area. The pH and electrical conductivity of these samples were measured. From the conductivity values, the corresponding salinities were calculated. The results of these measurements are shown in Table (2).

Table 2. The analytical parameters for the collected groundwater samples

Well No.	Total depth (m)	Water depth (m)	pH	Conductivity (µs/cm)	Salinity (p.p.m.)
1	44.5	19	8.7	3400	2088
2	110.0	27	5.6	5500	3360
3	50.0	10	5.2	–	–
4	12.0	10	5.6	2800	1721
5	78.0	18	8.9	2100	1272
6	12.0	10	5.6	–	–
7	22.0	7	9.3	1400	848

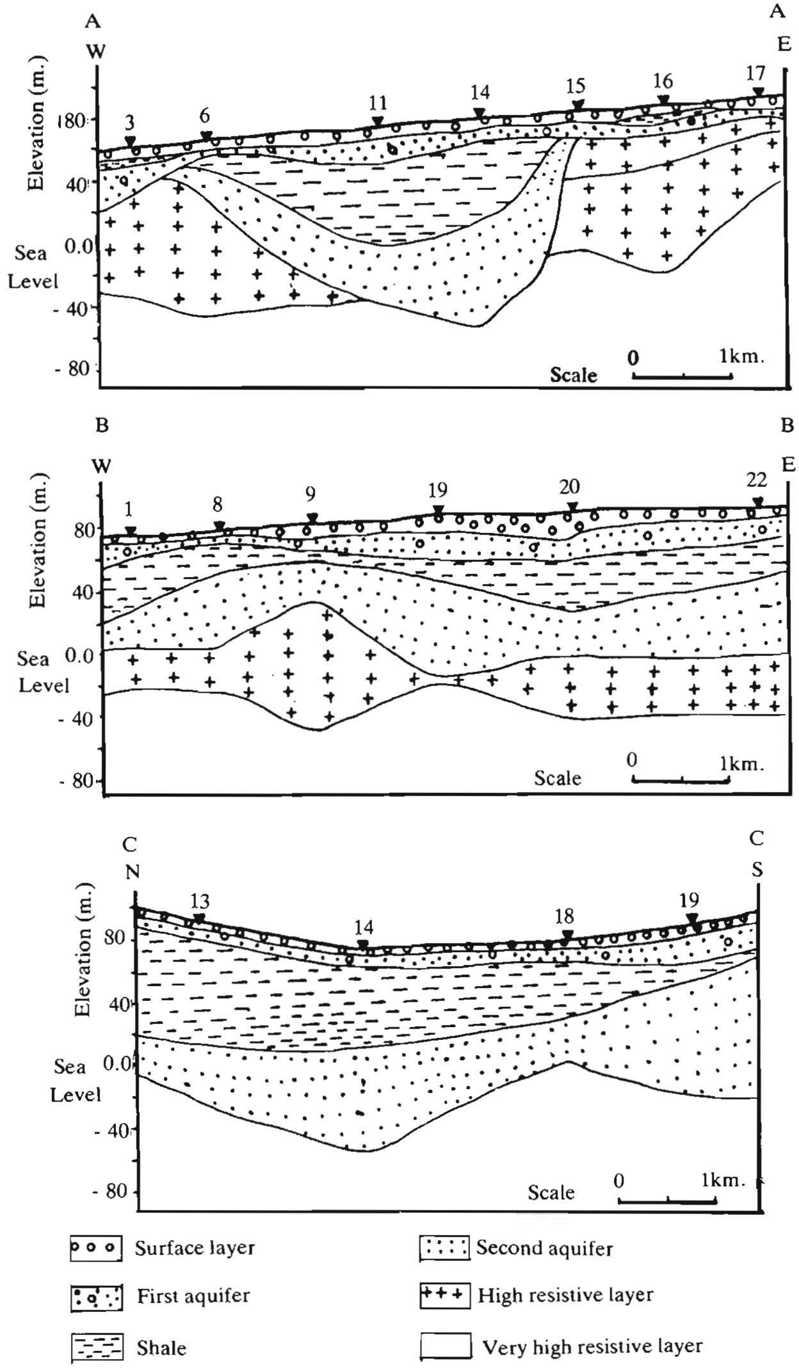


Fig. 8. Subsurface sections along profiles AA', BB' and CC'.

Conclusion

Groundwater potentialities in Wadi Abu Shih area are mainly deduced from geoelectrical survey. Twenty six Schlumberger VES are carried out using the ABEM Terrameter SAS System. Qualitative and quantitative interpretation of the VES curves led to the following results:

- All the VES curves characterize multilayer sections of 5,6 and 7 geoelectrical layers.
- The presence of two aquifers separated by a shale bed and varying in depth from 5 to 25 m and in thickness from 10 to 110 m.
- The depth to the top of the first aquifer ranges between 4 and 12 m, while its thickness range from 5 to 35 m.
- The second aquifer, which is mostly a confined one has a depth ranging from 20 to 70 m and a thickness ranging between 20 and 70 m.
- The water level in the drilled wells penetrating the two aquifers is considered as a piezometric level and not as a water table.

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(Received 02/10/1991;
in revised form 27/05/1992)

دراسات جيوكهربية
على منطقة وادي أبو شيح بالصحراء الشرقية بمصر

أبو ضيف عبد العال بخيت

قسم الجيولوجيا - كلية العلوم - جامعة أسيوط - اسيوط - مصر

تقع منطقة الدراسة على وجه التحديد جنوب شرق أسيوط شرق قريتَي العتمانية وقاو النواورة بصحراء مصر الشرقية.. ويُحاط وادي أبو شيح من الشمال والجنوب والشرق بهضاب الحجر الجيري الذي ينتمي إلى عصر الأيوسين، ومن الغرب بمستوى فيضان نهر النيل أمّا سطح الوادي نفسه فهو مغطّى بالرمل والحصى.. ويصرف وادي أبو شيح ناحية الغرب في اتجاه نهر النيل.

تهدف هذه الدراسة إلى إلقاء الضوء على احتمالات تواجد المياه الجوفيّة بوادي أبو شيح.. ولهذا الغرض فقد تمّ اجراء مسح كهربي للمنطقة باستخدام طريقة المقاومة النوعية الكهربية تضمن قياس ستة وعشرون جسة كهربية رأسية بإتباع تشكيل شلمبر جير لمواقع الأقطاب واستخدام جهاز قياس المقاومة النوعية الكهربية للأرض من طراز "ABEM Terrameter SAS System". وبفحص الجسات الكهربية المقاسة للمنطقة يتّضح أنها جسات كهربية تقابل قطاعات عديدة الطبقات.. وقد تمّ رسم ثلاثة قطاعات للمقاومة النوعية الكهربية الظاهرية في ثلاثة اتجاهات مختلفة لتوضيح الاختلافات في قيم المقاومة جانبياً ورأسياً على طول هذه القطاعات.

وقد تمّ تفسير الجسات الكهربية كمياً باستخدام برامج الكمبيوتر المخصّصة لذلك والتي تمّ الحصول منها على نتائج تمثّل عدد الطبقات الجيوكهربية عند كل جسة وقيم السُّمْك والمقاومة النوعيّة الكهربية الحقيقية لكل طبقة. بمقارنة نتائج التفسير الكمي للجسات المقاسة بالقرب من بعض الآبار المحفورة بالمنطقة بالتتابع الطبقي في هذه الآبار اتّضح وجود خزّانين أحدهما سطحي والثاني أكثر عمقاً وتفصل بينهما طبقة من الطفلة.. ويعتبر الخزّان

الجوفي الثاني خزّان محبوس "Confined aquifer" وقد تمّ تعميم نتائج الجسات المجاورة للآبار على باقي المنطقة بالقياس.. وقد أمكن الحصول على قيم للعمق والسمك لكل من الخزّان الجوفي الأول والثاني والطفلة كالآتي:

- يتراوح عمق الخزان الجوفي الأول بين ٤ - ١٢ متراً وسمكه بين ٥ - ٣٥ متراً.
- يتراوح عمق طبقة الطفلة التي تفصل الخزانين الجوفيين بين ٥ - ٢٥ متراً وسمكها بين ١٠ - ١١٠ متراً.
- أمّا الخزان الجوفي الثاني فيتراوح عمقه بين ٢٠ - ٧٠ متراً وسمكه بين ٢٠ - ٧٠ متراً وقد تمّ رسم مجموعة خرائط للسمك والعمق للخزّانين الجوفيّين الأول والثاني وكذلك طبقة الطفلة التي تفصل بينهما.. ويُلاحَظ أن قيم السمك تتناقص على الجانبين بالقرب من حوائط الوادي وتزداد في المواقع التي تمثّل تجمّع مياه قنوات الصرف.

وكذلك تمّ رسم ثلاثة قطاعات جيوكهربية تحت سطحية في ثلاثة اتجاهات مختارة بهدف توضيح الطبقات الجيوكهربية المختلفة، ومواقع الطبقات الحاملة للماء، والتغيّر الجانبي في هذه الطبقات من ناحية العمق والسمك على طول هذه القطاعات.