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Structural effect on the groundwater at the Arish City, north eastern part of Sinai Peninsula, Egypt

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Abstract

Arish area is considered as the most promising area for agricultural development in north Sinai. Groundwater is the most important resources necessary for such development. Ninety seven vertical electrical soundings (V.E.S.'s), using Schlumberger array were carried out in Arish area. The main goal of such survey was to elucidate hydrogeological information and to delineate subsurface structural elements. V.E.S. curves were interpreted using a 2-D horizontal layering resistivity model assumption. The interpretation results showed that the geoelectrical succession consists of three geoelectrical layers. The top layer is formed of gravely sand with relatively high electrical resistivity values, the second layer is composed of sand (aquifer) with relatively intermediate electrical resistivity values and the third layer is made up of clay (aquiclude) with relatively low electrical resistivity values. As for groundwater potentiality, the second layer is highly promising to be the water-bearing layer. The maximum depth to water ranges between 5.6 to 176 m. structurally the study area is divided into three zones: The northern two zones may be including saltwater intrusion seepage from the sea water. The southern zone might include the fresh water.

Keywords: Groundwater, V.E.S., aquifer, Arish.

1. Introduction

Arish area lies at the north eastern part of Sinai Peninsula, Egypt. It is located between Longitudes 33° 44' and 34° 00' E and Latitudes of 31° 00' and 31° 10' N Figure 1. Groundwater is important in environmental geophysics i.e. many of the environmental studies are directly or indirectly related to groundwater, such as exploration, effects of groundwater on the soil, effects on archaeological sites and groundwater pollution (Gaber *et al.,* 1999; Mesbah, 2003; and Mohamaden, 2005). Geophysics, particularly geoelectrical resistivity techniques, has been extensively used for a wide variety of geotechnical and groundwater exploration problems (e.g. Zohdy, 1975; Barker, 1980; Bernard and Valla, 1991; Nowroozi *et al.,* 1999; Mousa, 2003, Ibrahim, *et al.,* 2004; Youssef *et al,* 2004; Al-Abaseiry *et al,* 2005; Hosny *et al,* 2005; Alotaibi and AlAmri, 2007; Nigm, *et al,* 2008). This is due to the fact that, the electrical resistivity survey is one of the simplest and less costly geophysical surveys employed. Moreover, it can be used either in the form of vertical electrical soundings (VES's) or horizontal profiling to search for groundwater in both porous and fissured media (e.g. Barker, 1980; Van Overmeeren, 1989; Abd El-Rahman, and Khaled**,** 2005; and Abd Alla *et al.,* 2005).

2. Geophysical data acquisition

In the present study geoelectrical resistivity field survey was carried out by applying the vertical electrical sounding (VES) technique which measures the electrical resistivity variation with depth. It is worth mentioning here that the electric resistivity of a rock formation varies according to the rock nature of material (density, porosity, pore size and shape), water content and its quality and temperature. Hence, there are no sharp limits for electric resistivity of porous formations. The resistivity is more controlled by the water contents and its quality within the matrix of the formation than by the solid granular resistivity value itself. Therefore, the geological unit may be subdivided into different geoelectrical units according to the different percentage of humidity within it. (Parasnis, 1997).

In present work, Schlumberger array was applied with half current electrode spacing (AB/2) starting from 1m to 1000 m. This spacing is sufficient to reach adequate depths covering the Quaternary aquifer in the study area (Abd El Fattah, 1994). A total number of 97 vertical electrical soundings were measured along 13 profiles Figure 2. The sounding number 1 is located at the extreme south eastern part of the investigated area. These profiles run mainly from south to the north direction.

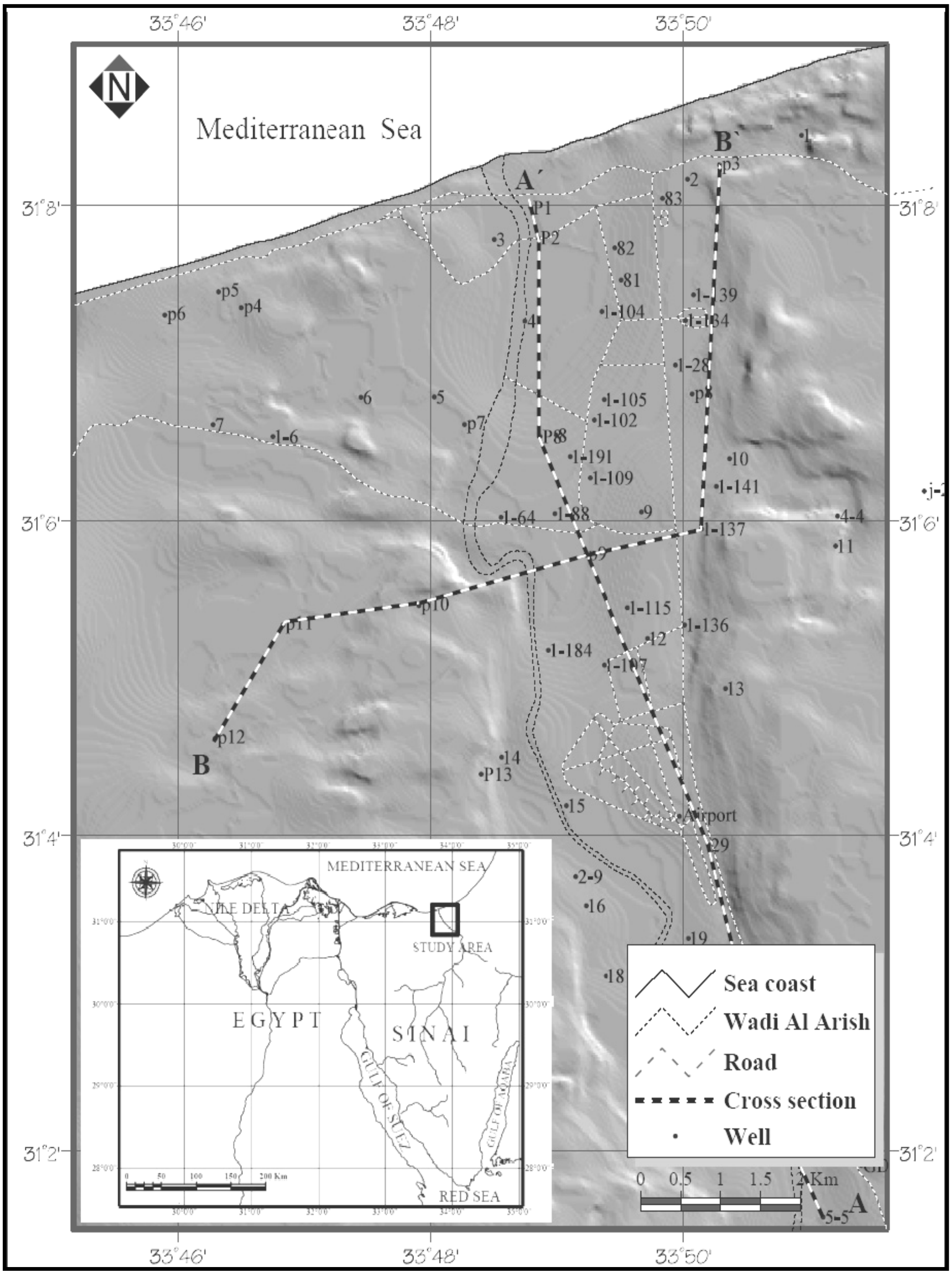

Figure 1: Area of Study (after El Alfy M. and Merkel, B.; 2006).

The geoelectrical resistivity measurements were performed applying two U.S.A. multimeter units of the type Fluke-27 allowing to filter the potential of the earth and measure the potential difference (ΔV) due to the fed current (I) and the current itself simultaneously. About 20% of the total measurements were recorded twice by changing the supply voltage. According to these repetitions the mean relative error for the field measurements was calculated and found to be ±1.45% or within the permissible limits.

The result of the geoelectrical survey was processed and quantitatively interpreted using available geological information and presented as geoelectrical sections along the various profiles. Many authors such as Koefoed (1965 a, b, and 1960), Gosh (1971), Zohdy (1975 and 1989), and Hemeker (1984) studied the quantitative interpretation of the geoelectric resistivity measurements. The interpretation of the apparent electrical resistivity data were achieved using two methods, the first is based on curve matching technique

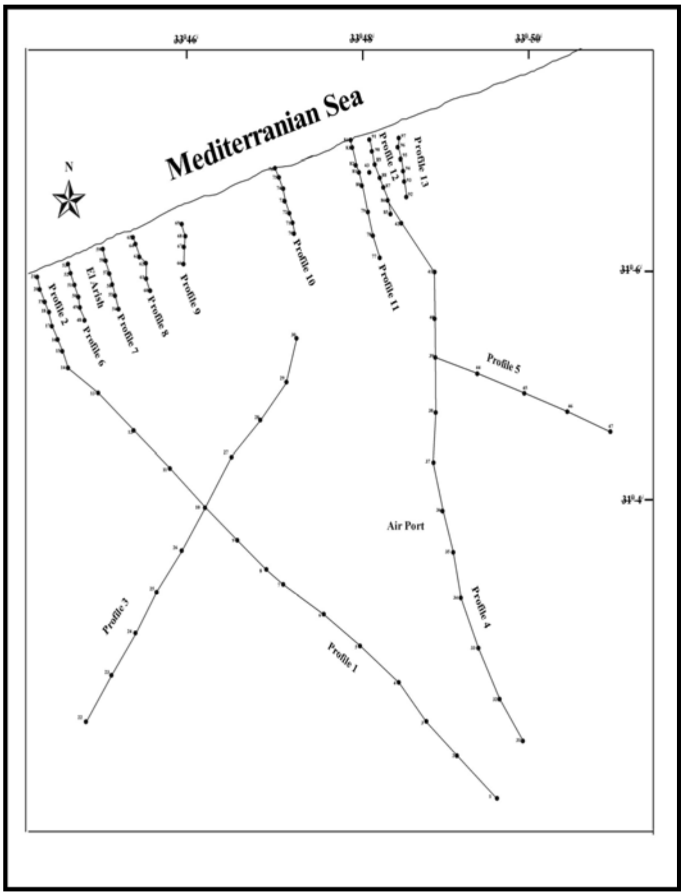

Figure 2: Location Map

using Generalized Cagniard Graph method constructed by Koefoed (1960 a), in which the results obtained treated with the inverse problem method using computer programs constructed by Hemeker (1984).

2.1. Geology of the Area Under investigation

According to the results of drilled boreholes and the geological section performed by Diab (1998), the geological succession from top to bottom is follows:
1-Hollocene Deposits: It has variable thicknesses and consists mainly of:
a) Gravel, loam, sand calcareous in places, and silt in Wadi El-Arish.
b) Drift sand and loose essentially composed of loose Qz grains in the coastal and inland areas.
2- Pleistocene Deposits (80 m thick) it consists of:
a) Alluvial Deposits of Wadi El-Arish (10-50 m thick) composed of sand, calcareous silt and gravel.
b) Old beach deposits occurring within the coastal zone between El-Arish and west Rafah with variable thicknesses underlying dune sands, and mainly composed of sands, sandstone and clayey sands.
c) The Complex calcareous sandstone (Kurkur) which dominates the whole zone between the western vicinity of El-Arish town in the west Rafah in the east and southward to about 10 Km from the coastal line.
The Kurkur deposits are distinguished into two series:

- Upper Continental Kurkur, having a thickness of 20 m in few wells in Wadi El-Arish, to the north of the airport and east of El-Arish town. It occurs as continuous bed or interbeded in the alluvial deposits of Wadi El -Arish.
- Lower Marine Kurkur, having a thickness of about 40 m where it was penetrated in few wells in Wadi El-Arish to the north of Lahfan. This series contain shell fragments. It is either overlain by the alluvial deposits in Wadi El-Arish or by old beach deposits in the coastal zone in the west of El-Arish town and underlined by the Pliocene facies.

2.2. Geoelectrical Sections

The geoelectrical study of this profile shows the superficial and shallower formations which are characterized by some heterogeneous electrical resistivity values, whereas, the deeper one seem to be homogenous to a great extent. The geoelectrical sections formed from the quantitative interpretation of different V.E.S.'s. Table (1) shows the obtained result from quantitative interpretation of different vertical electrical soundings:

Table 1: Geoelectrical Parameters for the Study Area.

V.E.S. No.	Layer 1		Layer 2		Layer 3		Layer 4		Layer 5
	ρ_1	d_1	ρ_2	d_2	ρ_3	d_3	ρ_4	d_4	ρ_5
1	7	0.64	830	5.3	50	56.2	13		
2	494	0.65	330	6.3	69	135	9		
3	94	0.81	9	2	157	64.5	14		
4	613	0.91	153	12.3	40	176	5		
5	11	1.1	196	88.5	30				
6	17	0.89	22	12.4	68	60.1	18		
7	548	0.91	331	2	656	15.4	81	53.6	13
8	454	0.85	263	9	470	18.4	28	119	0.1
9	245	0.35	469	40.5	2				
10	458	0.83	235	43.9	2				
11	441	0.7	351	12.7	176	50.3	0.8		
12	577	1.4	449	35.4	0.7				
13	344	1.9	294	4.2	684	18.6	70	58.2	0.3
14	91	0.86	286	29.2	0.6				
14	91	0.86	286	29.2	0.6				
15	90	0.2	384	15.3	0.7				
16	441	1.5	345	19.2	0.7				
17	330	1.7	1150	7.9	8	40.7	0.9		
18	562	1.2	625	6.1	135	21.8	0.5		
19	1290	1.6	694	5.6	1870	15.1	7	38.6	0.8
20	2870	0.47	404	2.1	970	13.5	7	22.2	2
21	496	6.4	0.9						
22	465	0.97	509	18.4	34	120	4		
23	454	2.1	291	18.5	10	95.8	0.7		
24	543	2.2	383	24.2	34	92.1	0.5		
25	411	1.4	308	8.6	134	53.4	2		
26	394	1.3	427	28.9	71	99	2		
10	458	0.83	235	43.9	2				
27	335	1.7	440	47.9	2				
28	164	1.1	404	4.4	118	61.8	4		
29	117	1	40	4.9	124	71.8	6		
30	71	0.99	654	3	134	19.7	19	131	0.6
31	87	1.6	197	3.1	1480	8.3	66		
32	628	1	393	11.9	78	122	22		
33	139	1.5	377	13.6	88	146	22		
34	555	0.86	418	5.6	484	62	38		
35	506	1.2	481	31.6	159	114	5		
36	324	1.2	607	20.1	236	85.2	5		
37	506	0.7	320	54.9	0.8				
38	442	0.73	379	27.8	154	88.3	0.6		
39	327	0.5	12	3.6	8	138	1		
40	406	1.7	339	38.2	29	99.8	1		
41	390	1.2	316	45.6	0.8				
42	438	0.85	196	4	326	34.7	40	68.7	0.6
86	744	0.63	155	4.2	351	24	20	69	0.5
43	459	1.9	83	5.4	722	11.6	1		
39	327	0.5	12	3.6	8	138	1		
44	275	0.86	343	5.7	26	47.3	2		
45	3	0.95	28	25.9	3				
46	2	0.35	51	22.1	2				
47	237	0.98	236	28.7	3				

Table 1: Continued

V.E.S.	Layer 1		Layer 2		Layer 3		Layer 4		Layer 5
No	ρ_1	d_1	ρ_2	d_2	ρ_3	d_3	ρ_4	d_4	ρ_5
48	450	1.2	370	19.1	5	52.9	0.4		
49	370	0.69	530	15.8	29	41.5	0.4		
50	527	1.1	429	10.9	13	23.9	0.4		
51	488	3.4	188	15.8	4	32.1	0.8		
52	1080	4.7	21	27.5	1				
53	339	1.5	8	5.6	2				
54	212	1.4	364	31.6	8	49.1	0.9		
55	606	3	850	8.5	289	29.7	8	63.2	0.5
56	232	4	573	17.8	28	27.2	1		
57	726	2.6	1210	9.3	2	74.4	0.5		
58	770	1.9	291	12.3	22	30.4	0.5		
59	468	1	266	7	2				
60	389	0.87	477	4.5	259	29.5	3	110	0.4
61	485	2.9	292	26.2	13	73.4	0.7		
62	332	1.8	536	14.6	27	51.2	0.8		
63	428	1.3	758	7.4	125	32.9	1		
64	496	3.9	212	17.3	41	22.7	1		
65	622	1.8	81	4.5	10	14.8	1		
66	415	0.58	277	18.2	12	62.2	1		
67	461	0.76	283	3.4	440	22.9	30	53.4	0.5
68	645	1.3	477	5.9	74	35.5	0.7		
69	31	1.2	200	14.4	5	79.1	0.4		
70	36	0.9	89	4	13	61.3	2		
71	71	1	173	3.1	5	54.6	0.3		
72	147	3.5	5	71.4	0.8				
73	207	4.1	5	55.9	2				
74	32	1.9	3	42.4	1				
75	201	1.2	2	31.7	0.7				
76	2	2.2	1						
77	2	0.89	36	48.8	0.7				
78	990	0.4	10	3	85	9.8	17	53.2	1
79	603	1.1	59	15.8	2				
80	284	0.43	13	2.4	384	3.2	72	13.2	1
81	345	1	327	10.4	11	38	1		
82	9.2	3.9	49	24.2	1				
83	634	0.7	357	14.4	3	44.1	0.5		
84	344	0.99	389	10.9	12	27.9	0.7		
85	271	1.2	398	23.9	50	55.4	0.4		
86	744	4.2	351	24	20	69	0.5		
87	310	0.85	155	33.2	1	148.7	0.4		
88	312	1.4	393	29.4	10	46.6	0.7		
89	17	1.3	467	3.2	4	53.2	0.4		
90	373	1.5	128	2.9	610	16.5	20	68	1
91	514	2.4	181	14.1	23	59	0.9		
92	534	0.87	324	26.3	12	81.8	1		
93	456	1.1	396	23.6	30	66.7	0.6		
94	199	1.8	166	11.8	6	67.7	1		
95	51	5.7	17	23.1	0.7				
96	503	1.1	202	13.4	0.5				
97	850	1.1	631	19	37	41.7	0.9		

Note: ρ = True electrical resistivity value d = depth (m)

Profile 1

This profile is lies on the south western part of the area under investigation. It runs from the southeast to the northwest direction. It is composed of 14 V.E.S.'s (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 and 14). This profile included three geoelectrical layers as follows Figure 3 & Table1.

a. Gravel

The first layer is characterized by relatively very high electrical resistivity values (91–870 ohm-m) formed of dry gravel. Sometimes, its resistivity became ranged from 7 to 11 ohm–m according to the percentage of sand and clay
(sabkha). This layer reached their thicknesses from 12.3 to 64.5 m. This layer covered the ground surface along this profile with exception around V.E.S. 6.

b. Sand

This layer which underlies the gravel surface layer is represented at the area southeast of V.E.S. 8 (with exception at V.E.S. 6). This layer is characterized by relatively moderate electrical resistivity values (17-81 ohm–m) indicating probably fresh water layer. The depth of this layer ranges from 58.2 to 176 m. This layer disappears at the northwest of V.E.S. 8 as a result of deep sited fault around V.E.S. 8 with downthrown side towards the southeastern direction. Also, its thicknesses increase towards the central part of this profile as a result of another fault around V.E.S. 5 with down thrown side towards the northwestern direction. Sometimes, as under V.E.S.'s 5, 6 and 7, this layer extends to the maximum depth of penetration.

c. Clay

This layer with resistivity range from 0.1 to 9 ohm–m is completely disappeared at the central part of the profile as a result of the effect of the graben structure. It appears at both sides of this structure.

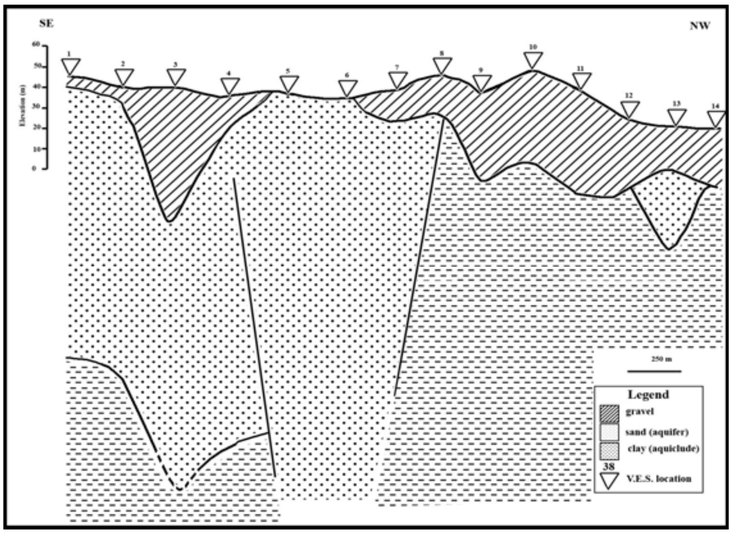

Figure 3: Geoelectrical Section of Profile 1.

Profile 2

This profile is occupied at the extremely western part of El Arish area. It is composed of 8 vertical electrical soundings (14, 15, 16, 17, 18, 19, 20 and 21). Figure 4 shows the geoelectric section along this profile.

a. Gravel

The superficial layer is formed of gravel with relatively very high electrical resistivity values (135-1870 ohm–m). Sometimes, it formed of gravel with sand with relatively moderate electrical resistivity values (90-91 ohm-m) as shown at V.E.S.'s 14 and 15 formed of sabkha. The thicknesses of this layer range from 6.4 to 29.2 m.

b. Sand

The second geoelectrical layer could not be detected along this profile.

c. Clay

At the maximum depth of penetration you can regard the aquiclude layer is formed of clay with relatively very low electrical resistivity values (0.5-7 ohm–m).

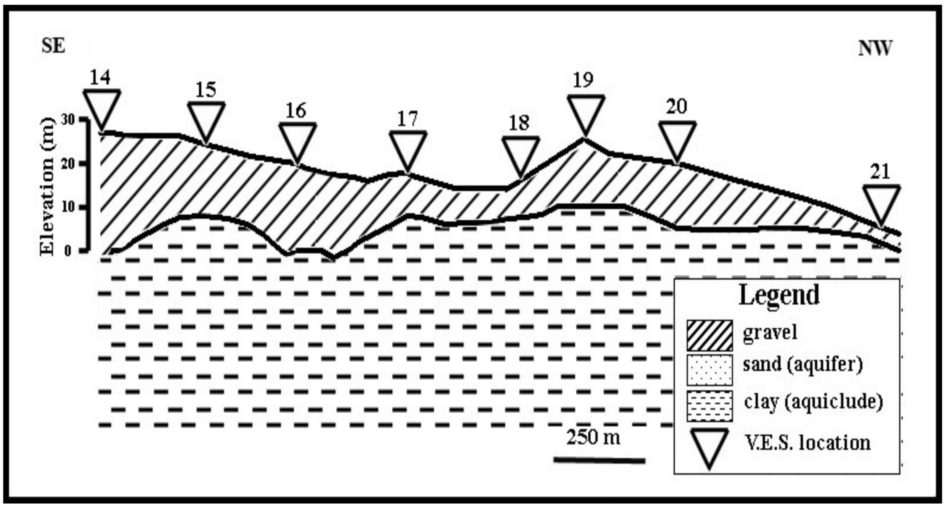

Figure 4: Geoelectrical Section of Profile 2.

Profile 3

This profile lies at the central part of El Arish area. It runs from northeast to the southwest. It is composed of 10 V.E.S.'s (22, 23, 24, 25, 26, 10, 27, 28, 29 and 30). The geoelectrical interpretation is given in table 1 and represented at figure 5 which gives the following geoelectrical layers:

a. Gravel

The superficial layer is formed of gravel covered the ground surface of this profile with relatively very high electrical resistivity values (117 - 654 ohm–m). Its thicknesses range from 1 to 47.9 m.

b. Sand

The second geoelectrical layer (sand) which dominated along this profile except the area between V.E.S.'s 10 and 27. This layer is characterized by relatively moderate electrical resistivity values (10 – 134 ohm–m) and maximum depth ranges between 53.4 and 131 m. the wide range of the resistivities values due to the percentage of salt water content.

The area between V.E.S.'s 10 and 27 is bounded by probably two faults with down thrown side towards the northeast and southwest directions.

c. Clay

At the maximum depth of penetration we can detected the third geoelectrical layer. It formed of clay or shale (aquiclude). It characterized by relatively low electrical resistivity value (0.6 – 6 ohm–m).

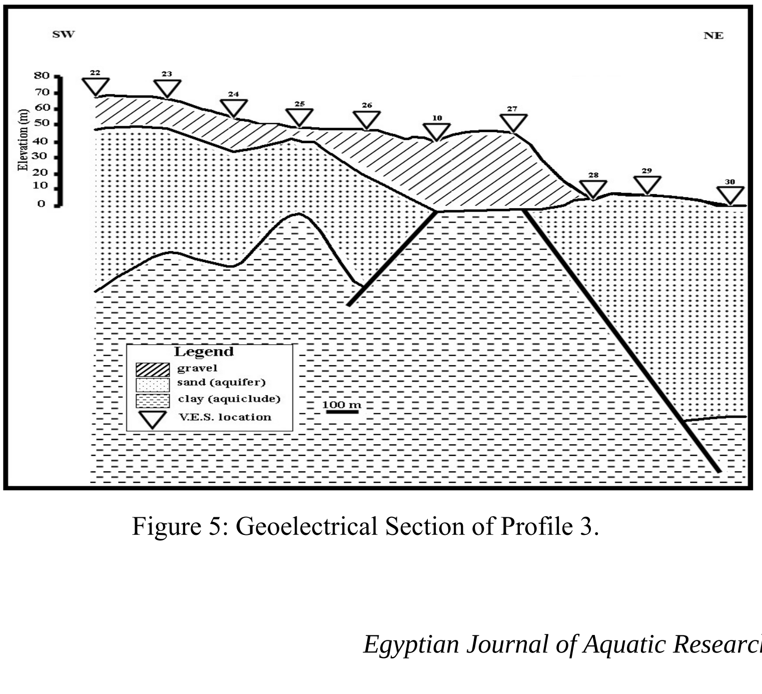

Figure 5: Geoelectrical Section of Profile 3.

Profile 4

This profile is run from the southern to the northern direction. It is composed of 14 V.E.S.'s (31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 86 and 43). Figure 6 Shows the obtained result, where, the geoelectrical layers can detected:

a- Gravel

The superficial layer formed of gravel sometimes intercalations with sand (sabkha). It is characterized by relatively very high electrical resistivity values (139–1480 ohm–m), sometimes, reached to 84 or 87 ohm–m according to the percentage of sand (sabkha). Its thicknesses range from 0.5 to 85.2 m.

b- Sand

The second geoelectrical layer is formed of sand with relatively moderate electrical resistivity values (8–159 ohm–m). Such resistivity variations may be attributed to the saltwater intrusion coming from the northern part. At the south of V.E.S. 35, this layer reaches to the maximum depth of penetration. While, around of V.E.S.'s 36, 37, 41 and 43, it has been not recorded as a result of two faults around V.E.S.'s 39 and 35 with down thrown side towards N and S direction respectively. It is approximately decrease their thicknesses towards the north direction. The depth of this layer ranges from 68.7 to 138 m.

c. Clay

Layer three can be detected at the maximum depth of penetration. It can be detected directly to first layer around of V.E.S.'s 36, 37, 41 and 43 due to the two faults. This layer is characterized by relatively low electrical resistivity values (0.5-5 ohm-m). It considered as aquiclude.

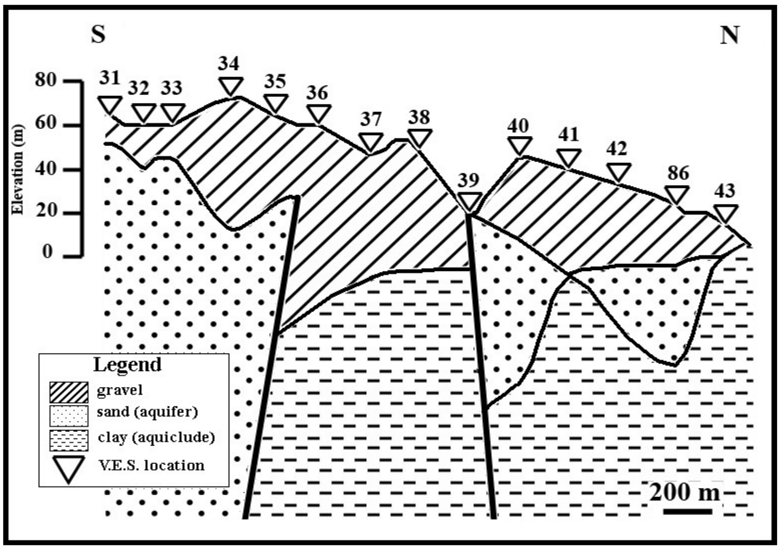

Figure 6: Geoelectrical Section of Profile 4.

Profile 5

This profile runs from NW to SE direction. It is composed of 5 V.E.S.'s (39, 44, 45, 46 and 47). It lies at the central part of the study area. The geoelectrical interpretation deduced that this profile formed of three geoelectrical layers as follows (Figure 7& Table 1):

a- Gravel

The superficial layer consists of two members according to lithological content. The first member covered the extremely NW and SE parts of this profile formed of gravel with relatively high electrical resistivity values (236–343 ohm–m) with thin thicknesses (0.5–28.7 m). The second member formed of clay or shale (Sabkha) at the central part of this profile. It is characterized by relatively low electrical resistivity values (2–3 ohm–m) with thin thicknesses (0.35-0.99 m).

b- Sand

The second geoelectrical layer is formed of sand with relatively moderate electrical resistivity values (8–51 ohm–m). These values increase towards the southeastern part according to seepage of saline seawater. It maximum depth range from 22.1 to 138 m. We can not be detected it under V.E.S. 47.

c- Clay

The third geoelectrical layer is formed of clay or shale (aquiclude). It is characterized by relatively low electrical resistivity values (1–3 ohm–m). It can be detected along this profile under the second layer with exception at V.E.S. 47, it deposited directly under the first layer.

This profile affected by two deep sited faults NW of V.E.S. 47 and SE of V.S.E. 39 with down thrown side towards NW direction.

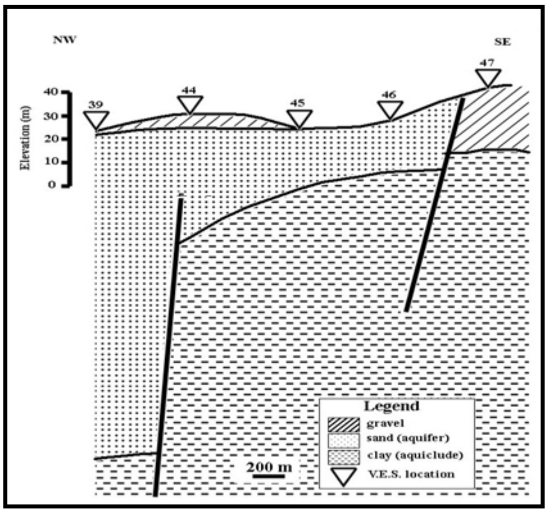

Figure 7: Geoelectrical Section of Profile 5.

Profile 6

This profile is one of the offshore profiles. It is composed of 6 V.E.S.'s (48, 49, 50, 51, 52 and 53). The geoelectrical interpretation deduced that (Figure 8 & Table 1):

a. Gravel

The superficial geoelectrical layer is characterized by relatively high electrical resistivity values (188–1080 ohm–m). These values increase towards the southern direction reflect the percentage of seepage of sea water. Thicknesses of this layer range from 1.5 to 19.1 m. Also, the thicknesses increase towards the southern direction.

b. Sand

The second geoelectrical layer is formed of sand (aquifer). It can be detected beneath the first layer. It characterized by relatively moderate electrical resistivity values (4–29 ohm–m) and maximum depth ranges from 5.6 to 52.9 m. The thicknesses of this layer increase towards the southern direction. The varieties of electrical resistivity values according the percentage of seawater intrusion.

c. Clay

At the maximum depth of penetration, a third layer could be detected. It is formed of clay or shale (aquiclude) and relatively low electrical resistivity values (0.4–2 ohm–m).

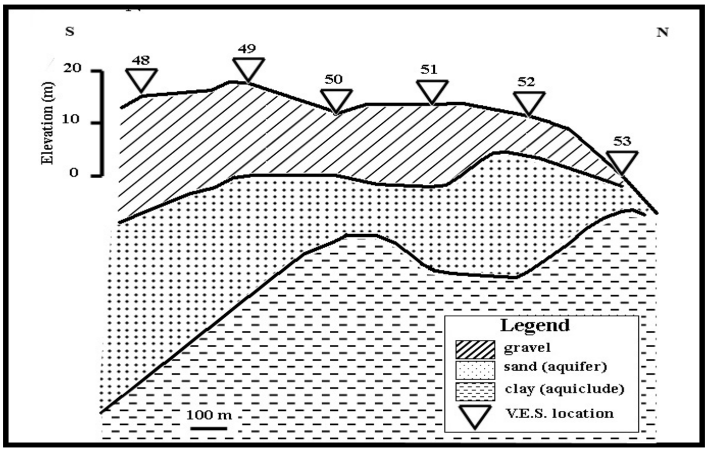

Figure 8: Geoelectrical Section of Profile 6

Profile 7

This profile is composed of 6 V.E.S.'s (54, 55, 56, 57, 58 and 59). It runs from southern to northern direction. The geoelectrical interpretation deduced that (Figure 9& Table 1):

a- Gravel

The superficial geoelectrical layer is formed of gravel sometimes with sand saturated with saline water. It is resistivity ranges from 212 to 1210 ohm–m. The thicknesses increase towards the southern direction (9.3 - 31.6m).

b- Sand

The second geoelectrical layer formed of sand saturated with seawater. It is characterized by relatively moderate electrical resistivity values (8-28 ohm–m). It can be detected at the southern direction of V.E.S. 56 with variable depth (27.2–63.2 m). Also, it can be recorded beneath V.E.S. 58 as a lens with 22 electrical resistivity value and depth 30.4m. The area around V.E.S. 56 may be affected by a fault with down thrown side towards the southern direction. This layer can not be detected around V.E.S. 59.

c. Clay

This layer formed of clay and shale (aquiclude). It located at the maximum depth of penetration along this profile. It is characterized by relatively low electrical resistivity values (0.5-2ohm.m).

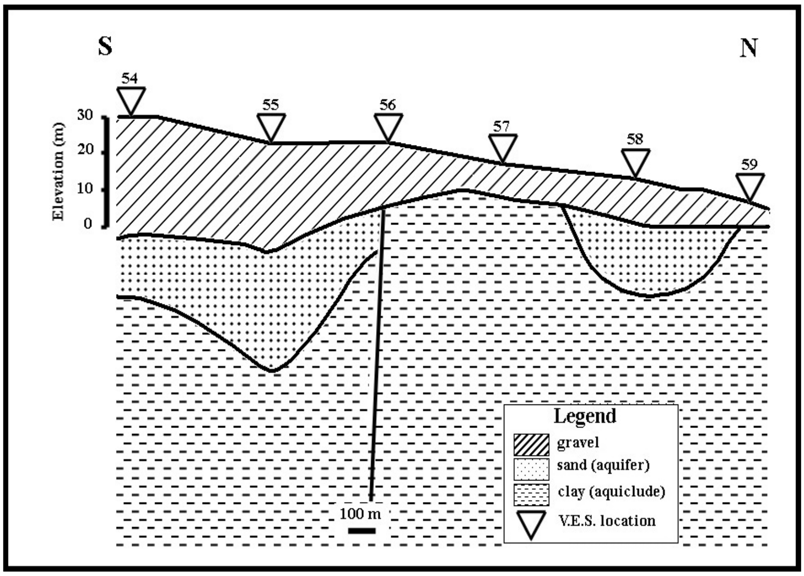

Figure 9: Geoelectrical Section of Profile 7.

Profile 8

It is composed of 6 V.E.S. (60, 61, 62, 63, 64 and 65). The geoelectrical interpretation shows that (Figure 10& Table 1):

a. Gravel

The superficial geoelectrical layer is formed of gravel. It characterized by relatively high electrical resistivity values (212–758ohm–m) and variable depth (1.8–29.5 m). It covered the ground surface of this profile.

b. Sand

The second geoelectrical layer is formed of sand (aquifer) which saturated with seawater is located at the northern of V.E.S. 60. The area north of V.E.S. 60 may be affected by deep sited fault with down thrown side towards the northern direction.

This layer is characterized by relatively moderate electrical resistivity values (10–125 ohm–m) and

variable maximum depth (14.8 to 73.4 m). These variables of depth result from another deep sited fault around of V.E.S. 63 with down thrown side towards the southern direction.

c. Clay

At the maximum depth of penetration, indicates the aquiclude layer (from clay or shale). It is characterized by relatively low electrical resistivity values (0.4-3 ohm-m).

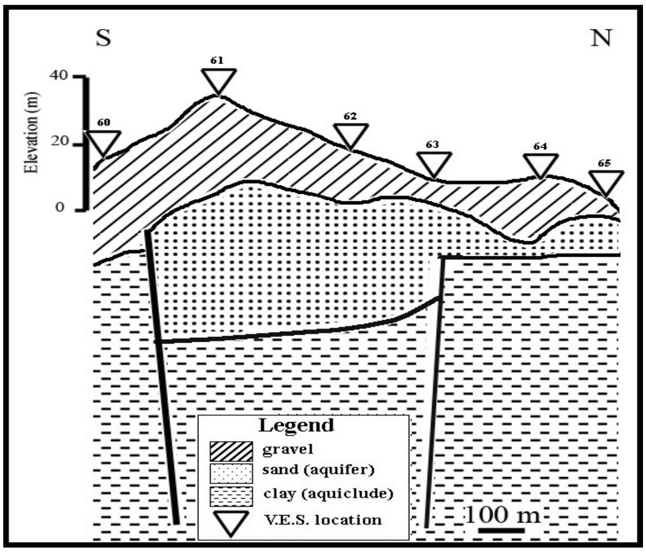

Figure 10: Geoelectrical Section of Profile 8.

Profile 9

This profile is composed of 4 V.E.S.'s (66, 67, 68 and 69). The interpretation of this profile shows that (Figure 11& Table 1):

a- Gravel

The superficial geoelectrical layer is formed of gravel. It resistivity ranges from 200 to 645 ohm–m. Sometimes, it reached to 31 according to the percentage of clay and sand (sabkha).The thicknesses range from 5.9 to 22.9 m.

b. Sand

The second geoelectrical layer is formed of sand. It characterized by relatively moderate electrical resistivity values (5–74 ohm–m) and maximum depth ranges from 35.5 to 79.1 m. The varieties of electrical resistivity values reflect the percentage of seawater intrusion.

c. Clay

At the maximum depth of penetration, inspects the third layer. It formed of clay or shale (aquiclude) and relatively low electrical resistivity values (0.1 – 1 ohm–m). Also, this profile may be affected by a probably deep seated fault around of V.E.S. 68 with down thrown side towards the northern direction

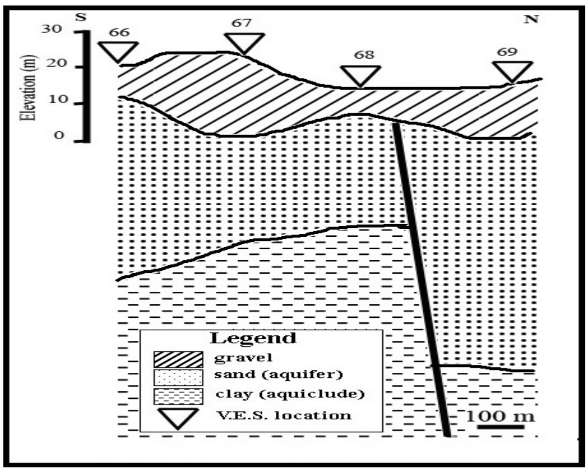

Figure 11: Geoelectrical Section of Profile 9.

Profile 10

This profile is considered as one of the offshore line with elevation nearly to the sea level. It is composed of 7 V.E.S.'s (70, 71, 72, 73, 74, 75 and 76). The geoelectrical interpretation of this profile deduced that (Figure 12 & Table 1):

a. Gravel

The first superficial layer is formed of gravel and sand saturated with seawater. It is characterized by relatively moderate electrical resistivity values (32–201 ohm–m) and variable thicknesses (1.2–4.1 m). This layer covered the ground surface of this profile with exception at V.E.S. 76 as a result of a fault the southern direction of V.E.S.76. The lowest values of this layer reflect the percentage of the clay and sand (sabkha).

b. Sand

The second geoelectrical layer is formed of sand (aquifer) oversaturated from seawater. It characterized by relatively low electrical resistivity values (2–20 ohm-m) and variable depth (31.7–71.4 m). This layer is missing around of V.E.S. 76 due to a deep seated fault with down thrown side towards the southern direction.

c. Clay

The third geoelectrical layer is formed of clay or shale (aquiclude) with very low electrical resistivity values (0.3 – 2 ohm-m). North of V.E.S. 71, it is inspects that another fault with down thrown side towards the northern direction.

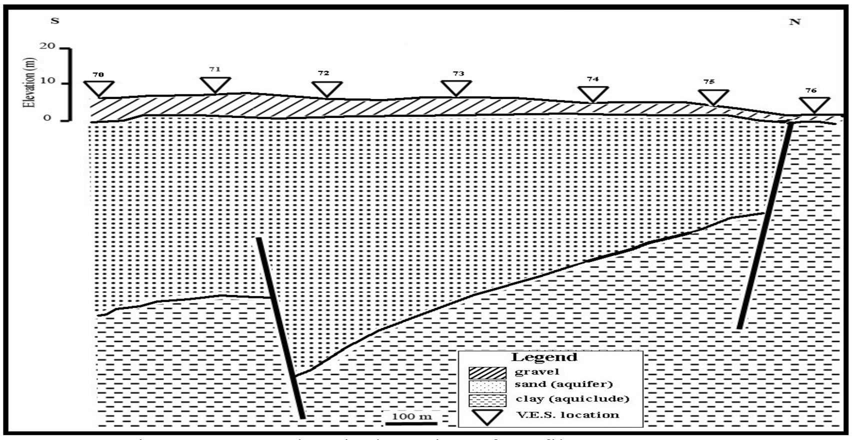

Figure 12: Geoelectrical Section of Profile 10

Profile 11

This profile runs from the south to the north direction. It is composed of 8 V.E.S.'s (77, 78, 79, 80, 81, 82, 83 and 84). The geoelectrical interpretation deduced that this profile formed of three geoelectrical layers as follows (Figure 13 & Table 1):

a- Gravel

The first layer covered the ground surface formed of gravel with exception at the area south of V.E.S. 77. It is characterized by relatively high electrical resistivity values (284–990 ohm-m) and thin thicknesses (0.4–14.4 m). While these values of resistivity decrease (2-13 ohm-m) as around V.E.S. 77.

b- Sand

The second geoelectrical layer is formed of sand (aquifer) may be carried salt water. Its resistivity is relatively moderate electrical resistivity values (3–85 ohm-m) and variable depth (13.2 – 53.2 m). This layer could be detected along this profile with exception around V.E.S. 79 due to a fault with down thrown side towards the southern direction.

c- Clay

The third geoelectrical layer is formed of clay or shale (aquiclude) with relatively low electrical resistivity values (0.4–2 ohm-m) and extended to the maximum depth of penetration.

This profile is affected by two probably deep seated faults around of V.E.S. 83 and south of V.E.S. 79 with down thrown side towards the north and the south directions respectively.

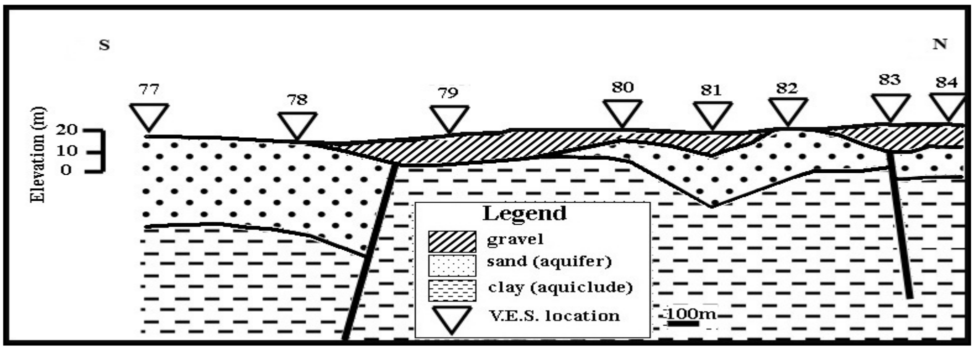

Figure 13: Geoelectrical Section of Profile 11

Profile 12

This profile is composed of 7 V.E.S.'s (85, 86, 87, 88, 89, 90 and 91). It runs from south to north direction. The geoelectrical section shows that (Figure 14 & Table 1):

a- Gravel

The superficial layer is formed of gravel that characterized by relatively high electrical resistivity values (128–774 ohm-m) and thin thicknesses (3.2–33.2 m). Sometimes these values reached to 17 according to the percentage of clay and sand (sabkha).

b- Sand

It formed of sand (aquifer). The second geoelectrical layer is formed of sand that laying under the superficial layer. It characterized by relatively moderate electrical resistivity values (4–155 ohm-m) and variable maximum depth (33.2–69 m).

c- Clay

the clay layer is located at the maximum depth of penetration, this third geoelectrical layer, clay or shale (aquiclude) is characterized by low electrical resistivity values (0.4-1 ohm-m).

Structurally, this profile may be affected by a fault around V.E.S. 87 with down thrown side towards the southern direction.

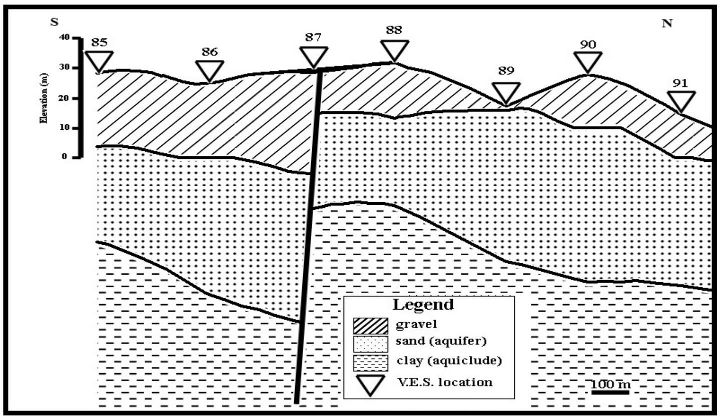

Figure 14: Geoelectrical Section of Profile 12

Profile 13

This profile runs from the south to the north direction. It is composed of V.E.S.'s (92, 93, 94, 95, 96 and 97) at the extremely east of the area under study. The geoelectrical interpretation deduced that this profile formed of three geoelectrical layers as follows (Figure 15 and Table 1):

a- Gravel

The first one covered the ground surface is formed of gravel with exception at the area south of V.E.S. 95.

It is characterized by relatively high electrical resistivity values (166–850 ohm-m) and thin thicknesses (11.3 – 26.3 m).

b- Sand

The second geoelectrical layer is formed of sand (aquifer) may be carried salt water. Its resistivity is relatively moderate electrical resistivity values (12–51 ohm-m) and variable depth (23.1 – 81.8 m). This layer is continuously covering all over this profile with exception around of V.E.S. 96 due to a fault with down thrown side towards the southern direction.

c- Clay

The third geoelectrical layer is formed of clay or shale (aquiclude) with relatively low electrical resistivity values (0.6–1 ohm-m).

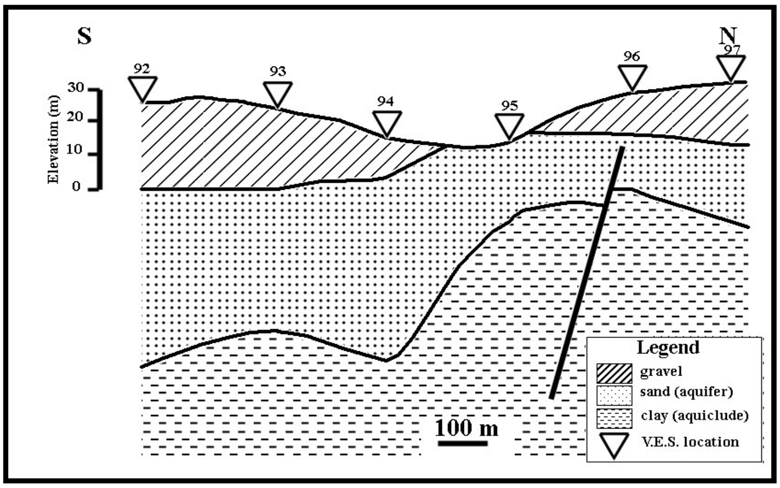

Figure 15: Geoelectrical Section of Profile 13

3. Result and conclusions

In general, the area under investigation can be classified into three geoelectrical layer as follows:

The superficial geoelectrical layer is characterized by relatively high electrical resistivity values (91-1870 ohm-m). It is formed of gravel sometimes intercalated with sand and clay (sabkha). Sabkha is characterized by relatively low electric resistivity values (2-91 ohm-m). The thicknesses of this layer ranges from 0.35 to 85.2 m. It is covers the ground surface. This layer is absent at some localities.

The second geoelectrical layer is formed of sand (aquifer). Usually, this layer is covered by the gravel layer with rarely covered the ground surface. It is characterized by relatively moderate electrical resistivity values (2-159 ohm-m). The moderate electrical resistivities values result from this layer contain fresh water. While the low electrical resistivity values due to the salt water intrusion seepage from the sea. This layer is characterized by variable depth (5.6-176 ohm-m). This layer extended to the maximum depth of penetration. Rarely this layer can not record.

The third geoelectrical layer is formed of clay (aquiclude). It is characterized by relatively low electrical resistivity values (0.1-9 ohm-m), and extends to the maximum depth of penetration.

Structurally, the area under investigation is affected by sets of faults that divided it into three zones. These zones may be bounded the groundwater. The first and second include saltwater intrusion seepage from the sea water. The third zone might include the fresh water (Figure 16).

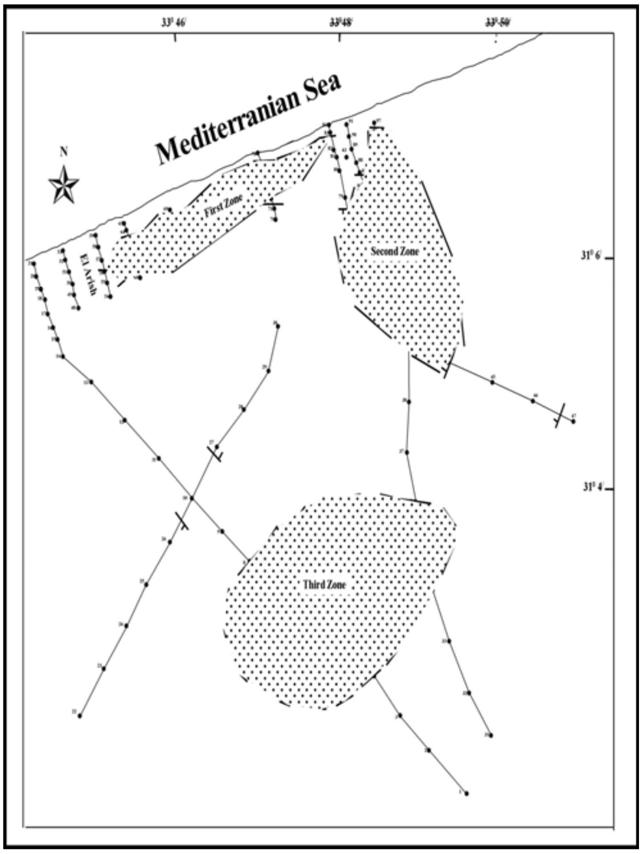

Figure 16: Structures affecting the study area

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التراكيب الجيولوجية المؤثرة علي المياه الجوفية في محافظة العريش شبه جزيرة سيناء – مصر

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منطقة العريش تعتبر أكثر المجالات الواعدة للتنمية والزراعة المروية في شمال سيناء. المياه الجوفية هي أهم الموارد اللازمة لهذه التنمية. سبعة وتسعون جسة كهربائية (السبر العمودي) ، وذلك باستخدام مجموعة شلمبرجير جرت في منطقة العريش. الهدف الرئيسي من هذه الدراسة لتوضيح المعلومات المتعلقة بالمياه والسطحي لتحديد العناصر الهيكلية.

تفسير النتائج الكهربية أظهرت إن المنطقة يتألف من ثلاث طبقات. الطبقة العليا تتكون من الحصى بالغ الارتفاع النسبي لقيم المقاومة الكهربائية ، والثانية تتكون طبقة من الرمل (طبقة المياه الجوفية) وهي متوسطة لقيم المقاومة الكهربائية ، والثالثة تتكون طبقة من الطين (حاجز للمياه) منخفضة نسبيا لقيم المقاومة الكهربائية.الطبقة الثانية طبقة واعدة للغاية للمياه الجوفية. ويبلغ الحد الأقصى لعمق المياه يتراوح ما بين 5.6 إلى 176 متر.

التراكيب الجيولوجية التي تؤثر على المنطقة في إطار تحليل النتائج الكهربية توضح أن هذه المنطقة مقسمة إلى ثلاث مناطق : اثنان في اتجاه الشمال حاوية للمياه المالحة. المنطقة الثالثة قد تكون حاجزا للمياه العذبة.