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ELECTRIC RESISTIVITY INVESTIGATION AT NUWEIBA HARBOUR GULF OF AQABA, SOUTH SINAI, EGYPT

MAHMOUD ISMAIL ISMAIL MOHAMADEN

National Institute of Oceanography and Fisheries, Alexandria, Egypt.

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ABSTRACT

The results obtained from the interpretation of the V.E.S.'s gave information regarding the geological situation in the Nuweiba Harbour, Gulf of Aqaba south Sinai, Egypt. A total of 20 vertical electrical soundings (V.E.S.'s) were conducted along 6 profiles. The geoelectrical field emphasis some knowledge about structural geology and lithology of the subsurface formations of the study area. In this work, the Schlumberger array with maximum current electrode half spacing (AB/2) of 75 m was applied. This spacing is sufficient to reach adequate depths for this study. The established geoelectric sections reveal the presence of the following geoelectric units: (a) A superficial unit characterized by electric resistivity value ranging from 2.47 to 106 ohm-m., and with a thickness ranges from 0.7 to 9.7 m. (b) A second unit with electric resistivity values (0.82 - 24 ohm-m.) and of depths from 0.35 to 5.8 m. (c) A third unit characterized by electric resistivity values ranging from 0.7 and 6.5 ohm-m. This third unit has a maximum thickness of 22m. which disappears at some localities. (d) A basal unit characterized by lower electric resistivity values that ranging from 0.2 to 0.6 ohm-m.

Location for cathodic protection necessary for construction of civil engineering harbour project is determined by the lowest values of resistivity values.

INTRODUCTION

The geoelectric survey is one of the cheapest tools applied in the solving civil engineering problem (Reynold, 1997). The geoelectrical field clarifies some knowledge about lithology and structural geology of the study area. Electrical resistivity techniques are used extensively in the engineering surveys to locate subsurface cavities, faults and fissures, permafrost, mineshafts, etc. The aim of the current geoelectric study at Nuweiba Harbour is to fulfill the following goals:

1-Identification of the subsurface formations, with respect to it's lithological and structural features.

2-Localization of conductive zones favorable for cathodic protected stations used for caviling engineering projects.

A total number of 20 vertical electrical soundings (V.E.S.'s) were conducted along 6 geoelectric profiles, in order to evaluate the geological setting of the Nuweiba Harbour, Gulf of Aqaba, south Sinai, Egypt (Fig. 1). Schlumberger electrode arrangement has been used in this study. It covers an area for about 5 Km^2.

Many authors as Koefoed (1965), Meinardus (1970), Ghosh (1971), and Zohdy (1975 and 1989) discussed the quantitative interpretation of the earth resistivity measurements. The interpretation of the apparent resistivity data was achieved using two methods. The first is based on curve matching technique using Generalized Caginard Graph method constructed by Koefoed (1960), in which the results obtained are subjected to a direct method using an algorithm constructed by Hemeker (1984) which based on Gosh (1971).

The results of the interpretation are represented in the form of the apparent electric resistivity values that can be used for preparing the isoapparent electric resistivity map and the geoelectric cross sections. These sections reflect both lateral and vertical variations in resistivity.

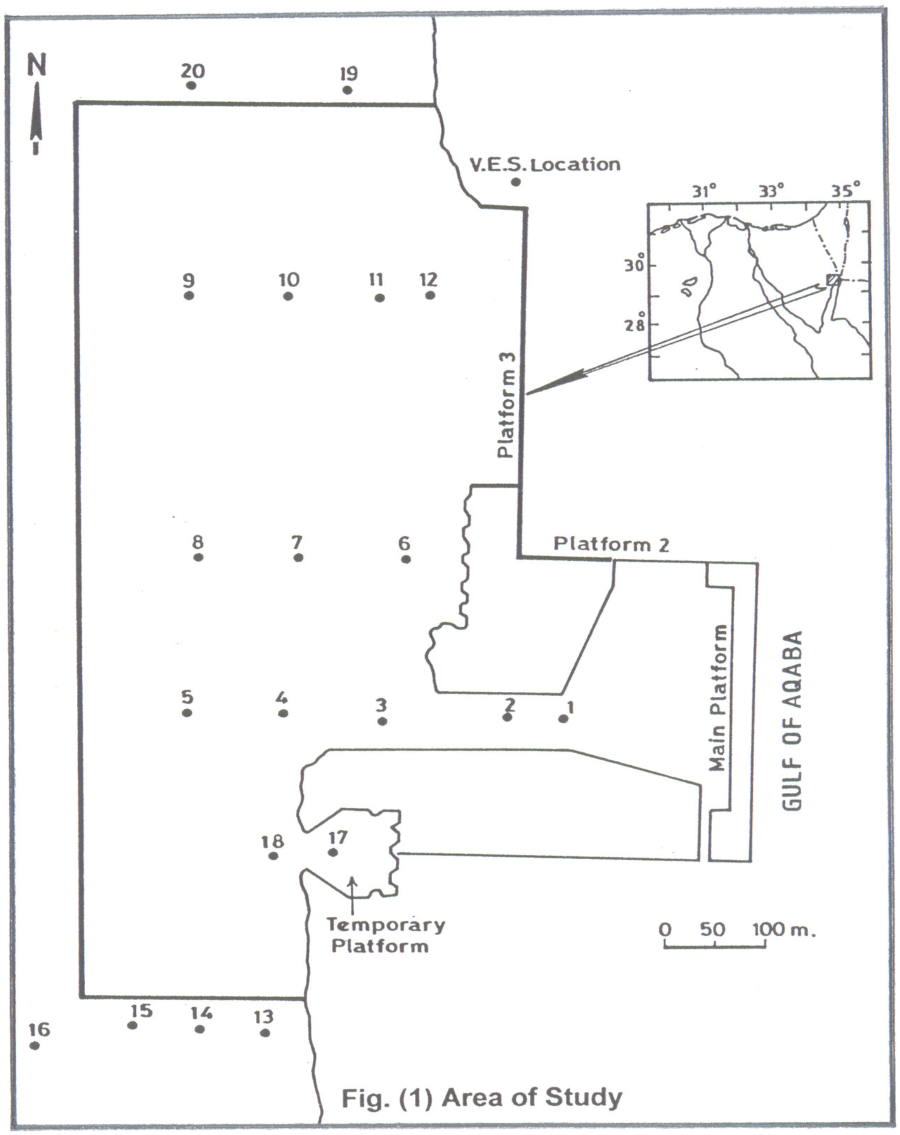

Fig. (1) Area of Study

METHODOLOGY

The geoelectric resistivity measurements performed within the present study are executed applying U.S.A. made digital electric voltameters of the type Fluke - 27 allowing filtering the self potential of the earth. Accordingly, it is possible to measure simultaneously, the potential difference (ΔV) due to fed current (I).

Schlumberger array used in the field survey is found to be more suitable for this study (Reynold, 1997). The advantage of the array is to minimize the lateral variation changes in geology as well as the near surface effect and increase the depth of the current penetration. The AB spacing begins with a distance equal to 3 meters and extends up to 150 meters. The ratio between the MN distance and AB distance ranges between 1/3 to about 1/10 (Parasnis, 1997).

The layers parameters (True Resistivity & Thickness) obtained from the quantitative interpretation are shown in Table (1). These parameters are therefore, integrated with the available geological information (Flathe; 1976) to construct the geological picture of the study area.

Table (1) Geoelectrical parameters for Different V.E.S.'s

V.E.S.	Layer 1		Layer 2		Layer 3		Layer 4
	ρ_1	d_1	P_2	d_2	ρ_3	d_3	ρ_4
1	23.3	0.79	5.6	1.8	0.98	9.5	0.36
2	17.1	0.75	7.86	2	0.86	9.5	0.72
3	67.6	2.6	13.6	5.8	0.74	23.7	0.26
4	7.13	0.87	1.31	9.6	0.48		
5	9	1.6	6.5	1.7	0.98	17.4	0.37
6	10.2	2.4	0.55				
7	12	2	10.9	2.1	0.97	5.2	0.6
8	10.4	1.4	0.49	4.2	1.13	6.4	1.73
9	2.69	1.5	0.59	27.1	17.8		
10	49.3	1	1.98	3.8	0.9	12.5	0.47
11	17.9	0.7	0.82	2.4	0.9	16.3	0.43
12	2.33	1.6	1.04	3	0.96	14.1	0.52
13	3.22	0.52	24.4	1.2	0.59	2.7	1.12
14	0.6	0.49	4.94	1.6	0.68	15.8	0.58
15	6.32	2.1	2.94	2.4	1.23	7.5	1.01
16	10.3	0.35	2.67	2.8	3.01	9.8	0.76
17	106	0.51	24.5	9.7	0.68		
18	32.2	1.3	1.98	5.8	0.91		
19	0.77	1.5	0.67	31.7	0.36		
20	2.47	2.2	1.56	10	0.55		

ρ= True resistivity (Ω. m.) **d = Depth (meter)**

RESULTS AND DISCUSSION

The field results obtained within the present study are presented in the form of qualitative interpretation (isoapparent electric resistivity maps) and quantitative interpretation (geoelectric sections).

Isoapparent Electric Resistivity Maps

Three isoapparent electric resistivity maps are constructed at AB/2= 3, 15, and 50 m. The choice of such spacing depends on the variability between them. These maps reflect the lateral variations of the electric resistivity at a depth of about 1, 5, and17meters, respectively. (Roy and Elliot; 1981)

Isoapparent Electric Resistivity Map for AB/2 = 3 m. (Figs. 2)

This map reflects the lateral variation over a horizontal plane at a depth of about 1 meters. It shows some sort of transported filling material around of V.E.S.'s 3, 17, and 8, with relatively high apparent electric resistivity values.

Isoapparent Electric Resistivity Map for AB/2 = 15 m. (Figs. 3)

This map reflects the lateral variation over a horizontal plane at a depth of about 5 meters. It shows the effect of transported filling materials still existed, but it tends to be vanished. The electric resistivity values decrease from west to the east towards the Gulf and increase towards the land which indicates that the invasion of the sea water in land decrease towards west. Also, gradation from coarse sediments to finer sediments near the Gulf.

Isoapparent Electric Resistivity Map at AB/2 =50 m. (Fig. 4)

This map reflects the lateral variation over a horizontal plane at a depth of about 17 meters. It shows that a nucleus of relatively high electric resistivity values exists at the location of V.E.S.'s 3 and 17 at the present temporary platform of Nuweiba Harbour which is believed to be due to the transported filling materials.

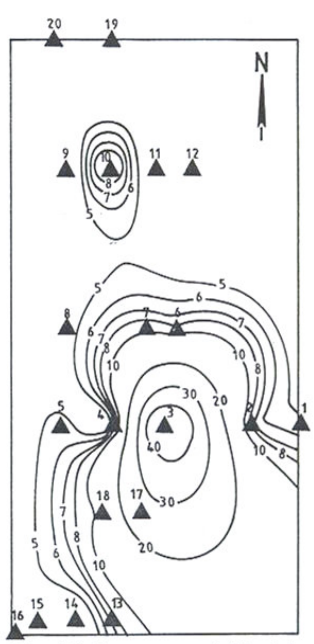

Fig. (2) Isoapparent Electric Resistivity Map For AB/2 = 3 m.

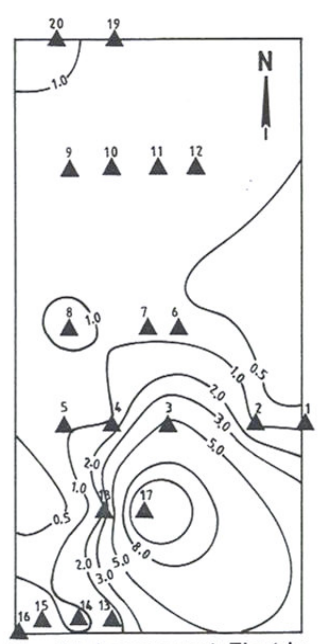

Fig. (3) Isoapparent Electric Resistivity Map For AB/2= 15 m.

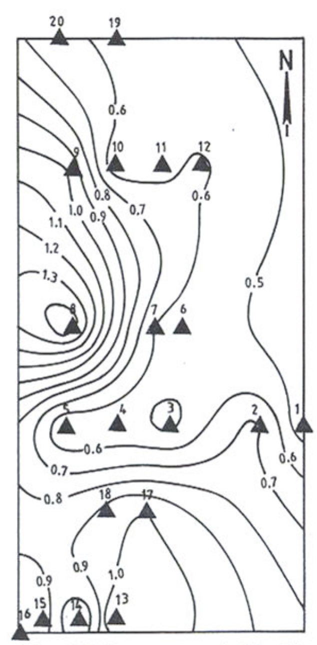

Fig. (4) Isoapparent Electric Resistivity Map For AB/2= 50 m.

Geological Investigation

The quantitative interpretation of the different points reveals the following results:

Profile A-A\\:

Profile A-A\\ runs from east to the west perpendicular to the Gulf of Aqaba. It is crossing five vertical electrical sounding (V.E.S.'s) namely 1, 2, 3, 4, and 5 (Fig. 1). The geoelectric section has been constructed according to the quantitative interpretation of V.E.S.'s which leads to the following observations as indicated in Figure 5 and Table 1:

A superficial unit is detected between V.E.S.'s 2 and 4 which consists of dry transported land filling. It is characterized by its thin thickness (0.75-2.6 m.) and relatively high electric resistivity values (17.1 - 67.6 ohm-m). This situation may be attributed to the topographic condition prevailed during sedimentation.

The second unit has variable depths where it reached the ground surface west of V.E.S. 4 or covered by the superficial unit east of V.E.S. 4.The depositional conditions prevailed is similar to the first unit. It is characterized by relative moderate electrical resistivity values (5.6-13.6 ohm-m) and of depth ranges from 0.87 to 5.8 m. Partial sedimentation of the land filling material with salt water may be responsible for such a situation.

. The third unit is characterized by relatively low electric resistivity values (0.735 - 6.5 ohm-m) and of depths ranging from 1.7 to 23.7 m. It may consisted of sand contaminated with clay and rock fragment and coral fragment.

At the maximum depth of penetration a layer has detected from sandy clay contaminated with coral and marine shell fragment. It is characterized by very low electric resistivity values (0.261-0.369 ohm - m).

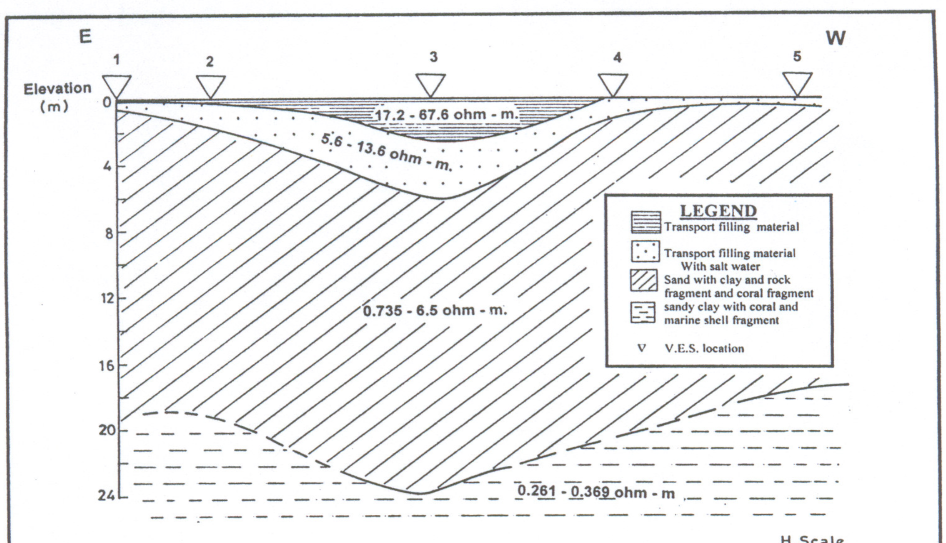

Fig. (5) Geoelectrical Section of Profile A_ A\\

Profile B-B\:

Profile B-B\ is located to the north of profile A-A\. It extends to the platform. The geoelectric section is constructed according to the quantitative interpretation results of V.E.S.'s number 6, 7, and 8, which are correlated with V.E.S.'s 3, 4, and 5, respectively (Fig.1). The results of this section is indicated to the following observations (Fig.6 &Table1):

While the fist unit is missed, the second and third units previously mentioned, are still observed along this section. The superficial unit consists of (partial saturated with seawater), land filling material attains its maximum thickness around of V.E.S. 6 (2.4 m.). This unit is thinning towards the western direction (1.4 m.) with moderate electric resistivity values (10.2-12 ohm-m).

At the maximum depth of penetration a sand layer is contaminated with clay and rock fragment and coral fragment with relatively low electric resistivity values (0.493-1.73 ohm-m). The increase in the electric resistivity values can be interpreted due to the increase of the percentage of coral reef fragments at such depth, which may be attributed to an old beach existing under the recent sedimentation. This unit is supposed to be fully saturated with seawater.

Profile C-C\:

Profile C-C\ is located to the north of profile B-B\; it is perpendicular to the platform 3 (Fig 1). This profile is crossing by four vertical electrical soundings namely V.E.S's 12, 11, 10, and 9. The quantitative interpretation of this V.E.S.'s leads to construction of geoelectrical section as shown in figure 7 and Table 1. It leads the following observations:

The land filling material is shown at the ground surface around of V.E.S.'s 10 and 11. It's thickness is ranging from 0.7 to 1m with resistivity ranges from 17.9 to 49.3 ohm-m. While that filling material charged with salt water is considered as the second geoelectric resistivity unit. It various maximum calculated depths (1.5 – 3.8 m.) and various electrical resistivity values (0.82 – 2.69 ohm-m.). This unit covers the ground surface around V.E.S.'s 12 and 9. The third geoelectric unit can be detected at maximum depth various from 12.5 to 16.3 m or to the maximum depth of penetration at the east of V.E.S. 9. This unit is formed of sand contaminated with clay and rock fragment and coral fragment with variable electrical resistivity values from 0.589 to 0.96 ohm-m.

At the maximum depth of penetration to the east of V.E.S. 9 the fourth geoelectric unit can be detected that forms of sandy clay contaminated with coral and marine shell. It is characterized by very low electric resistivity values (0.429 to 0.522 ohm-m.).

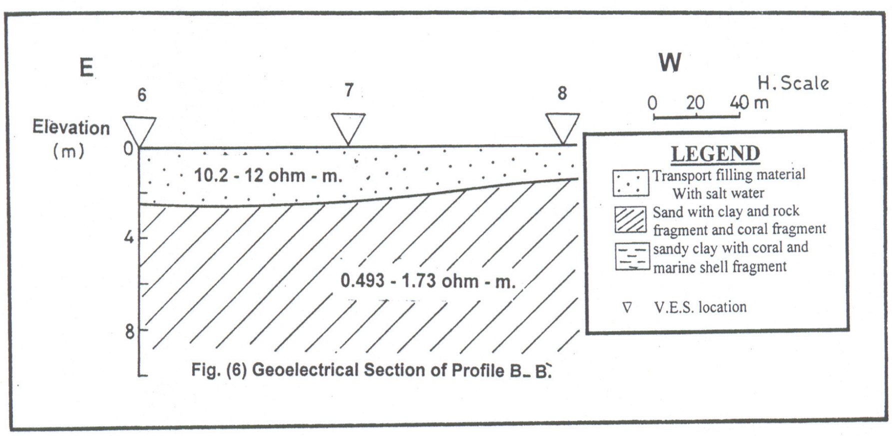

Fig. (6) Geoelectrical Section of Profile B_B\

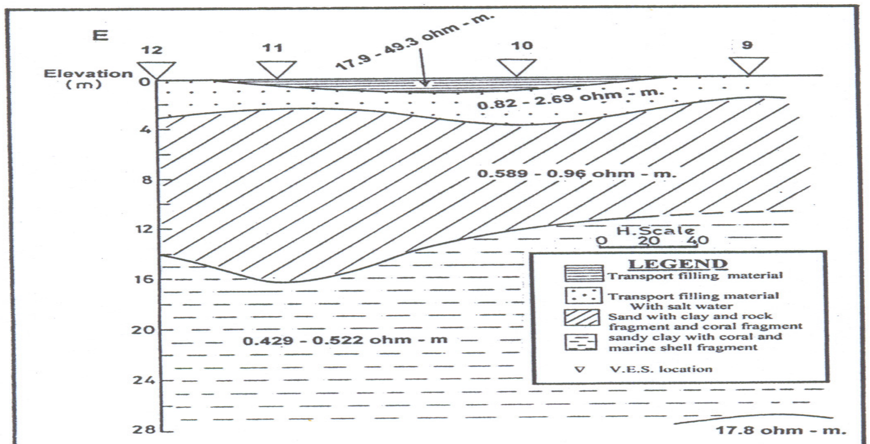

Fig. (7) Geoelectrical Section of Profile C_ C\

Profile D-D\:

Profile D-D\ is running at the south fence of Nuweiba Marine Harbour. It is crossing V.E.S.'s 13, 14, 15, and 16 (Fig. 1). The geoelectric section can be explained as shown (Fig. 8 & Table 1):

The superficial electrical unit characterized by high electric resistivity values (4.94 - 24 ohm-m.) and formed from land filling material. The thickness of this unit varies from 0.35 to 1.6 m. The second electrical unit is characterized by moderate electrical resistivity values (1.12 – 3.01 ohm – m.) and is formed from land filling material filled charged with salt water.

The third electric unit is located at the maximum depth of penetration with various electrical resistivity values (0.58 - 1.01 ohm-m.). It forms of sandy clay contaminated with coral and marine shell fragment.

Profile E-E\:

This geoelectric section is running along the temporary platform (Fig. 1). Where a nucleus of relatively electric resistivity values exits (Fig. 9 & Table 1) and probably explained by the presence of big thickness from land filling material at this locality. The quantitative interpretation of V.E.S.17 indicates that, this unit attains a thickness of about 9.7 meters, whereas, at the site of V.E.S. 18 it attains a thickness of about 1.3 meters. The ohmic values characterizing this unit show big difference ranges from about 24.5 ohm. m to about 106 ohm-m. The intermediate unit appears underneath the superficial one where it is characterized by electric resistivity values ranging from 1.98 to 0.679 ohm-m. The basal unit is not reached along this section.

Profile F-F\:

This section is located along the northern fence of Nuweiba Harbour (Fig. 1). It is constructed due to the quantitative interpretation results of V.E.S.'s 19 and 20. The study of this geoelectric section (Fig. 10) shows that: The superficial transported filling unit is absent at the site of V.E.S. 19, whereas it attains a thickness of about 2.2 m at the site of V.E.S. 20 and it is characterized by an ohmic value equivalent to about 2.47 ohm-m. It seems that, a crest of an andulation exists at the site of V.E.S. 19. The land filling material with salt water (second unit) is located at the ground surface around of V.E.S. 19 and is charged with located beneath the fist unit around of V.E.S. 20.

The third electric unit is located at the maximum depth of penetration with various electric resistivity values (0.546 – 0.667 ohm-m.). It forms of sandy clay contaminated with coral and marine shell fragment.

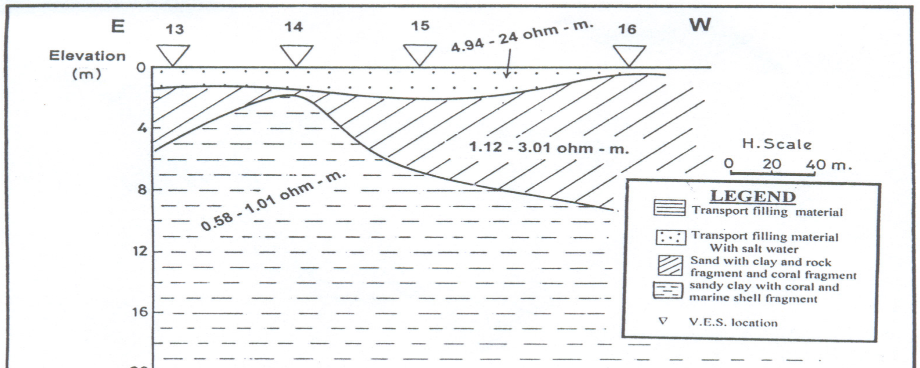

Fig. (8) Geoelectrical Section of Profile D_D`

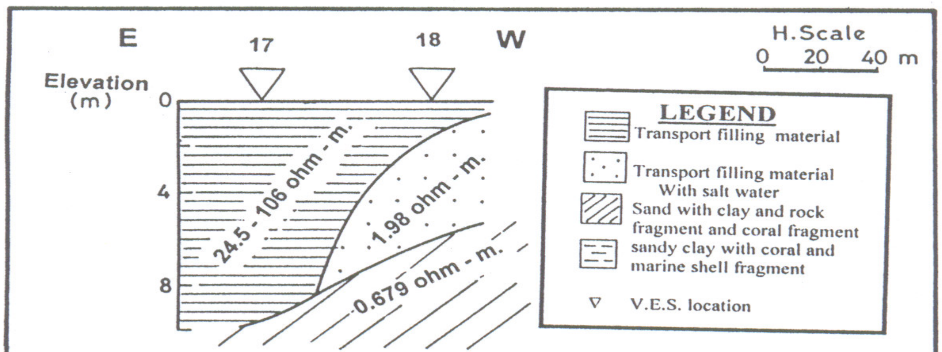

Fig. (9) Geoelectrical Section of Profile E_E`

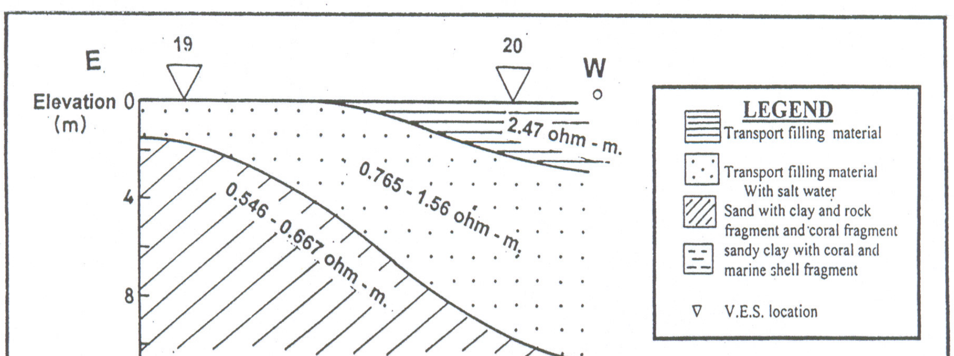

Fig. (10) Geoelectrical Section of Profile F_F`

CONCLUSION

According to the previous discussion of the results of the geoelectric survey executed at Nuweiba Marine Harbour, it is possible to reach the following conclusions:

1-The isoapparent electric resistivity maps constructed yield that sedimentation took place in a normal condition. The nucleus of high electric resistivity at the location of V. E. S.' s 3, 17, and 8 (Fig. 2,3,and 4), may indicate the land filling material attains a big thickness at this locality. Also electric resistivity values appearing at depth at the sites of VES 8 and 9 may be due to an old beach existing before more recent sedimentation took place.

2-The geoelectric sections constructed reveal the presence of four geoelectric units. (a) Variable electric resistivity values of ranges from 2.47 to 106 ohm-m. and the thickness ranges from about 0.7 to about 9.7 m. characterize the superficial unit. The electric resistivity values, whereas, It is considered to consist of land filling material. (b) A land filling material with salt water saturation is detected with various electric resistivity (0.82 – 24 ohm-m.) and various depth from 5.8 to 0.35 m. (c) The third unit consists of sands contaminated with clay material and probably contains some rock and coral and marine shell fragments. It is characterized by electric resistivity values ranging from 0.7 and 3 ohm-m. and attains a thickness up to 22 meters. (d) A basal unit, which is considered to consist of sandy clay containing some coral and marine shell, fragments. It is characterized by lower electric resistivity values raging from 0.2 to 0.6 ohm-m.

3-As an exception for the previous dominating geoelectric units, a relatively high ohmic appears at depth and is considered to be due to an old beach existing before recent sedimentation took place.

4- It is assumed that, both intermediate and basal units are filly saturated with seawater, whereas, superficial one consisting the filling material is partially saturated, due to the invasion of seawater in land.

5- It seems that, some sort of andulation may affect sedimentation at the area of study. As a result of sea water movement along the shore during the sedimentation.

6-The area favorable for cathodic protection stations is that characterized by low ohmic values i. e. the northeastern zones of the area of the study.

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