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EARTH RESISTIVITY AND SELF-POTENTIAL STUDY ON THE AREA EAST OF SOHAG CITY AND THEIR GROUNDWATER IMPLICATIONS

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دراسة المقاومة الأرضية والجهد الذاتي واستخدامها في الكشف عن مخزون الماء الجوفي في المنطقة الواقعة شرق مدينة سوهاج - مصر

حمـزه أحمـد إبـراهيـم و أبو ضيف عبد العال بخيت
و صبحي محمد فهيم

تم قياس ١٩ جسه كهربائية رأسية في المنطقة الواقعة شرق مدينة سوهاج وذلك بهدف الحصول على المزيد من المعلومات المفيدة في البحث عن مصادر المياه في هذه المنطقة . ولقد تم تفسير ١٨ من هذه الجسات باستخدام البرنامج الذي تم إعداده بواسطة زهدي (١٩٨٩ب) . ولقد أشارت نتائج الدراسة الحالية إلى وجود خزان جوفي قليل العمق بالجزء الجنوبي من منطقة الدراسة ، بينما يختفي هذا الخزان ناحية الشرق . وتجدر الاشارة في هذه الدراسة أنه بالرغم من وجود طبقات في أماكن معينة من منطقة الدراسة تتميز بصغر مقاومتها الكهربائية مما يشير إلي أنها طبقات حاملة للمياه إلا أنها فسرت على أنها طبقات من الطفلة التي تكثر بها الأملاح بمنطقة شرق مدينة سوهاج . ولقد عكست قياسات الجهد الذاتي والمقاومة النوعية (التي تمت عند كل ٢٥ ، ١٠٠ متر في اتجاهين فقط) مدى التغير في سحنة الترسيب بمنطقة الدراسة .

Key Words: Earth resistivity, self-potential, groundwater.

ABSTRACT

Nineteen field vertical electrical soundings have been made in the area east of Sohag to provide hydrogeologic information for groundwater exploration. These sounding are interpreted using programs for the automatic processing and interpretation of Schlumberger sounding curves prepared by Zohdy (1989B). Results of the interpretation indicate the presence of shallow water-bearing layer especially in the southern part of the study area. This aquifer is missing towards the east. In certain parts, the low-resistivity material cannot be explained as a water-bearing bed but it is possibly related to a dominated shale bed. The SP and horizontal resistivity profiling measurements taken in certain directions show lateral variation of sedimentary facies.

INTRODUCTION

The application of geophysical methods to study groundwater problems is gaining support in the hydrogeological community. Of these methods, earth resistivity (ER) method has a wide application to problems of groundwater exploration. The self-potential (SP) method comes second in groundwater exploration, but it is useful when aligned with the ER method.

The region investigated lies east of Sohag city (Fig. 1). Its major problem is its lack of a sufficient and safe water supply necessary for the present land reclamation plans for domestic and livestock uses when new communities set up in the future. Therefore, the authors of this work carried out an ER and SP study in the area concerned to find some solutions for groundwater exploration.

Few geological studies have been carried out by Abdel Kireem (1972) and Abdel Rahman (1990), to investigate the drainage system, stratigraphy and structural setting of the area. On the other hand, a few hydrogeological work had been carried out by El-Gamili (1975) and Abdel Moneim (1987).

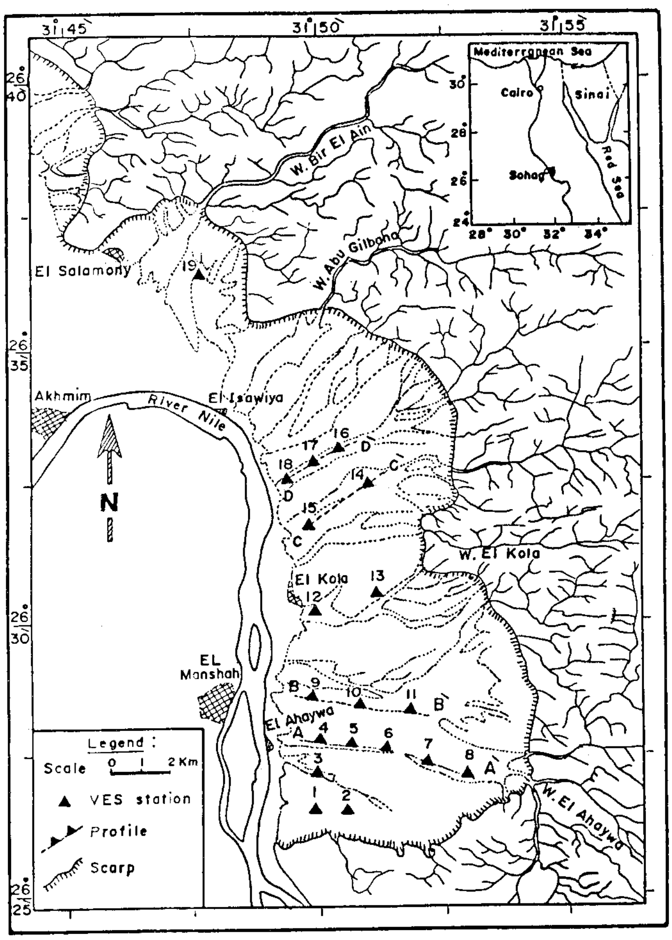

Fig. 1: Location map of the study area.

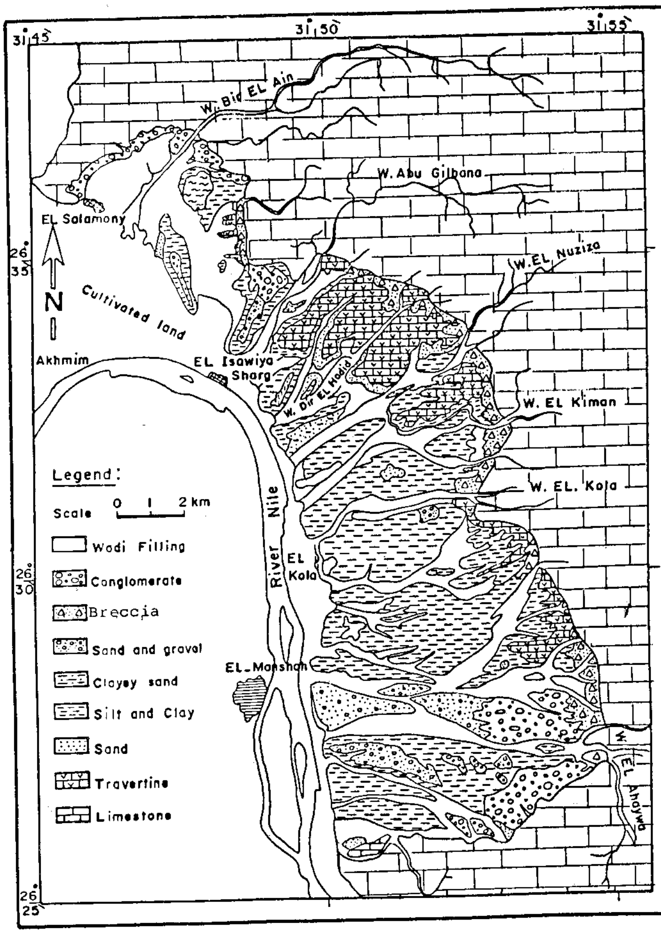

Fig. 2: Geological map of the area east of Sohag (compiled after Abdel Rahman, 1990).

Table 1
Results of quantitative interpretation of VES curves at the area east of Sohag city

VES No.	No. of geoelectric layers	True resistivity (ρ_t) of layers in ohm.m. ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	ρ_6	Thickness (t) of layers in m. T_1	T_2	T_3	T_4	T_5
1	6	9399	2392	88	3	30	∞	1.1	4.0	11.0	35.0	60.0
2	6	28597	9624	547	78	780	∞	1.1	2.5	7.1	40.0	60.0
4	5	9976	691	152	400	∞	–	1.1	6.3	27.0	40.0	–
5	5	19433	506	171	301	∞	–	1.0	3.5	26.0	36.0	–
6	6	21649	592	180	474	1270	∞	3.5	7.5	12.8	27.5	59.0
7	5	3	67	490	2052	∞	–	1.1	2.2	7.3	62.0	–
8	6	47160	2092	510	1750	23880	∞	1.0	3.6	10.0	16.0	68.0
9	4	5038	303	140	∞	–	–	2.3	8.5	63.0	–	–
10	6	22881	910	158	710	4568	∞	1.6	3.5	11.0	18.7	75.5
11	6	23926	380	2997	846	1128	∞	1.5	1.7	18.3	24.7	53.2
12	5	559	50	0.5	62	∞	–	1.1	1.3	49.0	49.0	–
13	5	18913	3270	178	394	∞	–	1.0	1.1	44.0	53.2	–
14	5	4178	1847	130	2	∞	–	1.6	2.0	43.0	94.0	–
15	5	23102	2333	149	1.5	∞	–	2.2	2.5	5.5	137.0	–
16	5	14371	472	147	0.4	∞	–	2.2	4.6	3.2	137.0	–
17	5	3292	588	192	2.4	∞	–	1.1	1.3	5.1	103.0	–
18	5	606	400	143	3.7	∞	–	1.0	2.1	3.6	93.0	–
19	5	60	220	166	3.3	∞	–	2.1	2.3	5.1	55.6	–

GENERAL GEOLOGY

The area under study (Fig. 2) is bounded to the west by the River Nile and to the east by the Eocene limestone plateau of the eastern desert. It is characterized by low relief of elevation ranging between 80-90 m. A major scrap defines the boundary between the lower Eocene limestone plateau and the post-Eocene sedimentary rocks extending in NW-SE direction and more or less parallel to the River Nile (Fig. 2). The lower Eocene plateau bounding the study area to the east is dissected by numerous wadies (W. Bir El-Ain, W. Abu Gilbana, W. El-Kola, and W. El-Ahaywa). Most of these wadies as shown in Fig. 2 cross the plateau perpendicular to the direction of the Nile Valley.

Said (1981) classified the exposed post-Eocene sediments in the area east of Sohag which is a sector of the south-eastern part of Egypt into; Paleonile clay (Paleonile), Armant and Issawiya formations (Paleonile and Protonile), and sands of Qena Formation (Prenile).

HYDROGEOLOGICAL REVIEW

The surface water hydrogeology of the study area as part of Sohag district is principally represented by the regime of water in the Nile, the irrigation canals and agriculture drains.

Generally, the Cenozoic clastic aquifers have a very wide geographic distribution in the Nile Valley basin and also in the adjacent desert wadies. They are composed mainly of gravels, sands, sandstone, and clay which is related to a Pliocene sediment overlying the fissured carbonate rocks (Said, 1981).

EARTH RESISTIVITY (ER) AND SELF-POTENTIAL (SP) METHODS

A - Earth Resistivity (ER) Method

Two earth resistivity (ER) survey methods are used in the fieldwork. These are vertical electrical sounding and horizontal resistivity profiling. The objective of electrical sounding as mentioned by different authors (e.g. Zohdy, 1974), is to deduce the variation of electrical resistivity with depth below a given point at the earth's surface, and to correlate it with the geological knowledge in order to infer the subsurface structure in detail. Several methods have been developed by different authors (e.g. Koefoed, 1979; Zohdy, 1989B) for computerized interpretation of vertical electrical sounding curves over horizontally stratified media. The horizontal resistivity profiling technique is normally aim at the detection of lateral variations of electrical resistivity in a certain subsurface layer. The technique involves measurements at a grid of observation points using an electrode array deployed at a fixed spacing.

B - Self-Potential (SP) Method

Two SP method, as its name implies, is based on measuring the natural potential differences which generally exist between any two points on the ground. Different theories have been developed by many authors (e.g. Sato and Mooney, 1960) to explain the origin of different types of self-potential. The quantitative interpretation of the SP data measured on the surface is more complicated. Therefore, they are only interpreted qualitatively in this study.

FIELD PROCEDURE

The field work in the area studied has been conducted using the Italian E 85/A mod controls. The vertical electrical sounding involves measuring of 19 stations (Fig. 1) following the array of Schlumberger and using (AB=600 m) which is just sufficient to recognize the shallow aquifer in the area. Unfortunately, the authors in this study could not use AB greater than 600 m, to recognize the possible occurrence of deeper aquifers, because the VES locations and their directions are both governed by topographic accessibility dominated in the area by terraces distributed anywhere. The SP and horizontal resistivity profiling have not been carried out in all study profiles due to the topographic unsuitability mentioned above. They have been measured in steps of equal separation (a=25, 100 m) along the line of measurements. They were made only along the profiles AA' (a=25, 100 m) and CC' (a=100 m), of Fig. 1.

RESULTS AND DISCUSSION

The measured field apparent resistivities in the study area are represented in terms of apparent resistivity sections along the profiles AA', BB' and CC' (Fig. 3). The investigation of these sections reveals the following:

1. The dry surface zone (sand and gravel) in all sections exhibits very high resistivity values (reaching 28,000 ohm.m).

2. The middle zone has moderate values in sections AA' and BB' (100-500 ohm.m), and very low values in sections CC' and DD' (5-10 ohm.m).

3. The third zone is characterized by very high resistivity values in sections AA' and BB' (1000-12,000 ohm.m) and very low values in sections CC' and DD' (10-25 ohm.m).

4. The middle zone in sections AA' and BB' represents the water bearing bed in the study area, while in sections CC, and DD, this middle zone together with the third one possibly represent the thick shale bed dominated in the area east of Sohag.

The vertical electrical sounding data in the study area are interpreted using the software (Schlumberger sounding data processing and interpretation) prepared by Zohdy, (1989B). Eighteen vertical electrical sounding stations measured in the study area are analyzed in terms of layers of certain true resistivities and well defined depths for the upper and lower surface of the encountered beds. Results of the interpretation of the measured sounding data are given in Table 1.

Two examples, each one showing the digitized curve and interpretation of the sounding (Fig. 4), are selected for illustration. These are soundings 13, and 19. Electrical sounding No. 13 (Fig. 4a) is interpreted in 15 layers grouped into 5 layers, while No. 19 is analyzed in 14 layers and grouped into 5 layers.

Four subsurface cross-sections are initially constructed (Fig. 5) using the interpreted data presented in Table 1. Along two sections (AA' and CC') SP and horizontal resistivity profiling are made. The inspection of these section shows the following:

1. Dry surface zone with very high resistivity material (>20,000 ohm.m) which is composed mainly of sand and gravel.

2. Wet major zone (140-180 ohm.m) recognized in the area includes the cross-sections AA' and BB'. This zone in the

sections CC' and DD' may divide into two wet sub-zones; the upper (130-192 ohm.m) and the lower one (0.4-3.7 ohm.m). It is of interest to mention here that the top of the major wet zone in the cross-sections AA' and BB' and also the top of the upper sub-zone in the cross-sections CC' and DD' may represent the top of the water table. The lower sub-zone in the sections CC' and DD' possibly corresponds to the thick shale bed distributed allover the area.

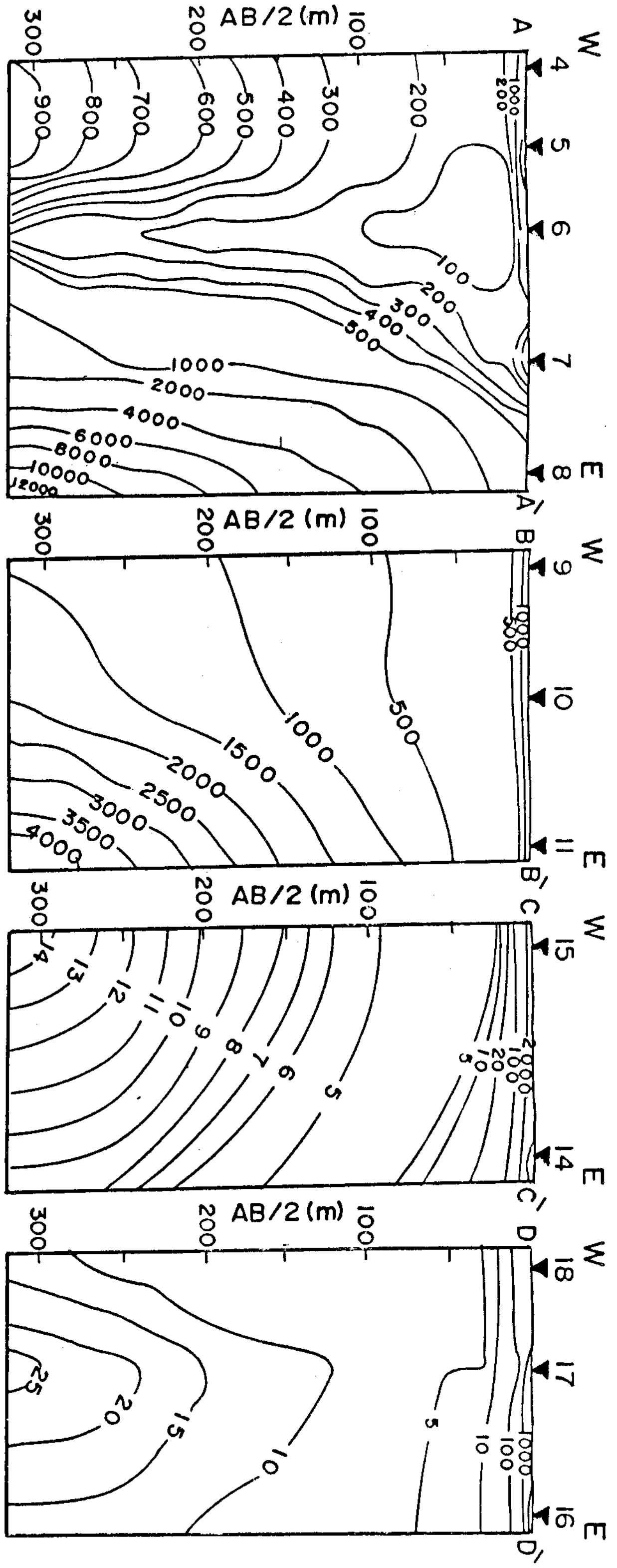

Fig. 3: Apparent resistivity section along the study profiles.

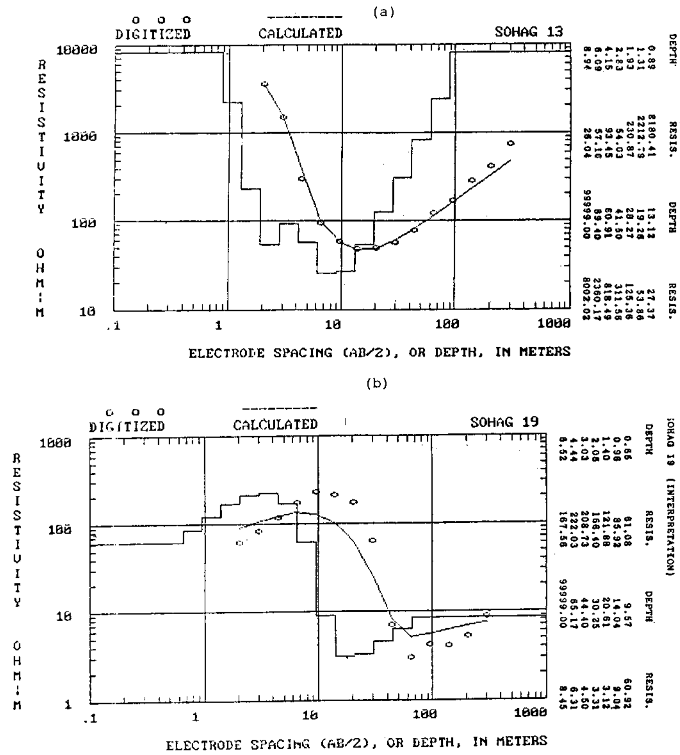

Fig. 4: Interpretation of VES stations No. 13 and 19.

3. Generally, the third zone in the whole area is dominated by very high-resistivity material which may represent the substratum.

4. The qualitative interpretation of the SP values measured along the profiles AA' and CC' shows variation from part to another (-200 to +200 mv). Generally, there is some correlation between the SP profiles (a=25 and 100 m) measured along the profile AA' (Fig. 5). Such correlation possibly reflects some regularity in the distribution of the sedimentary facies by depth.

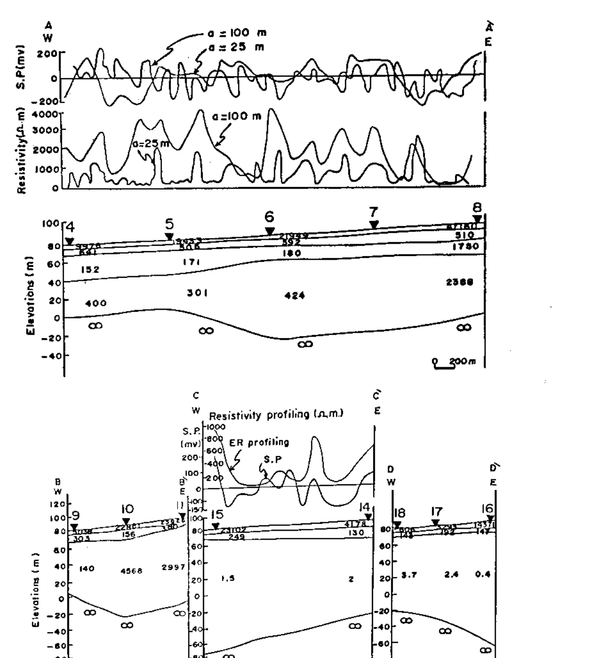

Fig. 5: Subsurface sections along the study profiles with SP and horizontal resistivity profiling along AA' and CC'.

5. The SP and horizontal resistivity profiling measurements made along the profiles AA' and CC' my reflect strong lateral variation of sedimentary facies in the area investigated.

SUMMARY AND CONCLUSIONS

As price of water, being a primary necessity of life, is very low compared to those for oil and ore, the cost of geophysical surveys for groundwater should be kept low accordingly. This economic factor limits the application of geophysical methods. Unfortunately the investigated area lacks detailed geophysical data.

In the present study we applied the electrical resistivity method (the most commonly applied geophysical tool for groundwater explorations) in the area east of Sohag city. 19 vertical electrical sounding stations have been measured at different locations of the area. These sounding data are analyzed using the software prepared by Zohdy (1989). The results of interpreting the sounding curves provide information on the occurrence of a major shallow aquifer occupying the southern sector of the area. Low-resistivity material in certain parts may not be interpreted as water-bearing material but is possibly due to a thick shale bed well represented in the whole area east of Sohag. In general, the authors recommend doing integrated geophysical surveys to obtain more information on the Pliocene clay and the depth to bedrock.

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