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# GEOELECTRICAL STUDY ON THE AREA WEST OF ASWAN TOWN, EGYPT

By

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# دراسات جيوكهربائية على منطقة غرب مدينة أســــوان - مصــــر

حمزة أحمد أبراهيم وعوض عبد الخالق عمران وسيد عبده أحمد سليم

تم إجراء مسح جيوكهربائي على منطقة غرب مدينة أسوان لمعرفة الوضع الهيدروجيولوجي السائد فيها ، والقاء الضوء على بعض الظروف الجيولوجية تحت السطحية . ولقد اسفرت نتائج التفسير الكمي والكيفي للجسات الكهربائية عن أحتمال وجود طبقة حاملة للمياه ذات سمك وعمق غير منتظمين . ويشير التغير في قيم المقاومة الكهربائية إلى التغير في الخواص الصخرية وأيضاً إلى التغير في نوعية المياه الجوفية بمنطقة الدراسة من مكان إلى آخر . وتتم تغذية هذا الخزان الجوفي بصفة أساسية من مياه نهر النيل عن طريق الكسور المؤثرة في صخور المنطقة . وباستخدام نتائج تفسير الجسات الكهربائية فقد أجريت محاولة للتعريف على طبوغرافية القاعدة المعقدة ( Basement Complex Relief ) بمنطقة الدراسة .

*Key Words:* VES, $\rho_a$, Ground water.

## ABSTRACT

A geoelectrical resistivity survey on the area west of Aswan has been conducted in order to investigate its prevailing hydrogeological and subsurface geological conditions. The study demonstrates the occurrence of a probably water-bearing bed of irregular thickness and variable depth. The change in resistivity values within the aquifer may reflect the variation in water quality and rock texture. The aquifer is mainly recharged across the dominant joint system and through fractures from the Nile and occasionally to some extent in earlier periods from rainfall. An attempt to recognize the basement relief was made by using the resistivity results only.

## INTRODUCTION

Surface electric resistivity method is still the most suitable and widely used for groundwater exploration as major advances are made in processing and handling of data.

Such a method has been followed in the investigated area which lies at Lat. 24° 03′ 40″ - 24° 07′ N and Long. 32° 49′ 50″ - 32° 53′ 16″ E (Fig. 1) of Aswan town. Due to the scarcity of subsurface geological information in this area the present study aims to get some information about the underground water potential and subsurface conditions from the interpretation of the vertical electrical sounding.

Different surface geological studies of the area were carried out by many authors (e.g. Attia, 1954; El-Ramly, 1973; El-Shazly *et al*, 1975; Khader, 1978; Klitzsch and Harms, 1979; Issawi, 1981; Said, 1981; Issawi and Jux, 1982).

The topography of the study area is generally irregular (Fig. 1). A number of small, shallow and dry wadies (e.g. W. Saluga, W. Barbar and others) run towards the Nile and are mainly controlled by the ENE-WSW and E-W Fractures and by rock texture (El-Shazly *et al*, 1975). Also several hills (e.g. G. Saluga, and G. Sidi Osman) are present.

Geologically, the Nubia formation of Cambrian to Cretaceous age (Issawi, 1981) which covers all the examined area and overlies the basement rocks, is mainly composed of sand and sandstone with clay and shale intercalations of irregular thickness.

The sturcture of the area, which represents part of west Aswan area, is dominated by ENE-WSW trending open folds of regional and local scale, while the fractures and faults have several trends and partly extend across long distances, some are short and grouped together in parallel arrangement accompanying the major fractures (El-Shazly *et al*, 1975).

The meterological conditions of the surveyed area are arid, i.e. the climate is characterized by no rainfall, low relative humidity and a relatively high rate of evaporation.

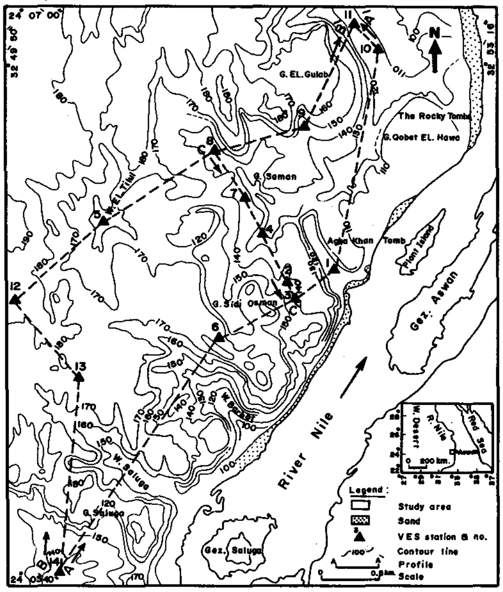


**Fig. 1: Location map of the VES stations, drilled water wells and the different selected profiles in the study area.**

## MATERIALS AND METHODS

The field work including the geoelectric resistivity survey, and well data collection has been conducted in two trips during January and October, 1988. The resistivity measurements were carried out in 14 VES stations using the Schlumberger configuration. The ratio ΔV/I were measured with the field ABEM Terrameter SAS system. The apparent resistivities ($\rho_a$) were calculated using the formula:

$\rho_a = K. \Delta V/I$ Ω.m, where ΔV is potential difference, I is current intensity and K is geometrical factor which depends on the mutual arrangement of the current and potential electrodes.

Maximum spacing used between the current electrodes was 600 m, which was sufficient to recognize the water-bearing layers in the area. The log resistance-log distance curves observed were interpreted with the aid of the theoretical master curves (Orellana and Mooney, 1966; Rijkswaterstaat of Netherlands, 1975) when we applied the auxiliary point method making use of the auxiliary point charts (Zohdy, 1965, Orellana and Mooney, 1966). Then the obtained results have been adjusted following Koefoed's method (1968) utilizing the VME/2900 electronic computer centre based in Assiut University.

The distribution of VES stations (Fig. 1) and their selected orientations (Table 1) were both governed mainly by the topographic suitability for placing the electrode spreads. Unfortunately certain sites (e.g. small and/or narrow wadies, and areas covered with very high resistive loose sands or large boulders) are unfavourable for sounding.

Water samples from the four available wells drilled by the farmers and located, unfortunately, somewhat, away from the most northeastern portion of the electrically surveyed area (Fig. 1) were collected and analysed using field devices (PH-meter, depth sounder, and temperature-conductivity-salinity measuring device). On the other hand, surface rock samples had been previously collected at several localities representing the different varieties of the Nubia sandstone considered to be the water-bearing rocks of the survey area and their lithology, effective porosity, permeability and true resistivity ($\rho_t$) had been evaluated in the Desert Research Institute Laboratories, Cairo (El-Ramly, 1973).

## RESULTS AND DISCUSSION

The measured apparent resistivity values ($\rho_a$) in Ω.m were plotted versus half the spacing between current electrodes (AB/2) in meters on logarithmic papers. Different types of VES curves in the area were obtained (e.g. QH, KH, QQH, KQH) as shown in (Table 1).

The distinct variety in the VES curves probably reflects the expected variation in numbery and characteristics of the geoelectric layers both vertically and laterally (e.g. absence or presence of some surface layers, thickness, water saturation and/or lithologic characteristics). (Table 1) presents the results of the quantitative interpretation of the VES curves.

Apparent resistivity profiles (Fig. 2) and sections (Fig. 3) along three selected directions AA, BB, and CC were constructed. Their careful investigation shows the following:

1. A general increase of the apparent resistivity from north to south (except for the northernmost station 11) and from east to west which may be due to the general variation of lithological facies, thickness and/or water saturation of the dominant Nubia sandstone overlying the basement rocks (both laterally and vertically) in these directions.
2. The apparent resistivity values recorded in the VES stations located in relatively low lands, e.g. VES no. 1, 4, 7, 8, and 10 are relatively low. These low lands can be considered inter-montane valleys which are suitable sites for groundwater prospection.
3. The abrupt lateral changes in apparent resistivity values recorded clearly between VES no. 12, 13, 10, 11; and moderately between VES no. 1, 3; and 5, 8 may be due to the presence of vertical lithologic contacts as e.g. faults.
4. The high surface resistivity of the dry zone is considered the main reason for abrupt vertical changes in the apparent resistivity values observed near to and generally parallel to the surface topography in each profile.

Based on the comparison between the inferred resistivity values obtained in this work and those obtained by laboratory measurements of fully saturated samples of Nubia sandstone with the water stored in the Nubia aquifer (El-Ramly, 1973), beside the collected bore hole information (Table 2), the authors conclude that the true resistivity ($\rho_t$) of the water-bearing bed is possibly less than 200 Ω.m in the examined area. The geoelectric layers overlying the expected aquifer in each VES station are grouped together and correlated as a high resistive zone. Accordingly, three maps were constructed showing the depth, thickness, and true resistivity of the water-bearing bed (Figs. 4, 5, and 6).

**Table 1**
Results of quantitative interpretation of the vertical electrical soundings.

| VES No. | Elevation (m) | Orientation | Curve type | Probable water-bearing bed | | | Interpreted Basement rocks | |
|---|---|---|---|---|---|---|---|---|
| | | | | Depth (m) | Thickness (m) | True ρ (Ω.m) | Depth to basement (m) | True ρ (Ω.m) |
| 1 | 105 | N 45°W | QH | 10 | 20 | 135 | 30 | ∞ |
| 2 | 144 | EW | QQH | 26 | 38 | 73 | 64 | 2900 |
| 3 | 142 | NS | KQQH | 25 | 35 | 45 | 60 | 1900 |
| 4 | 130 | N 15°W | KQHK | 20 | 25 | 163 | 45 | 1100 |
| 5 | 191 | N 5°W | QHKH | 39 | 16 | 108 | 655 | ∞ |
| 6 | 175 | S 70°E | KQH | 46 | 26 | 70 | 72 | ∞ |
| 7 | 133 | N 10E | QQH | 22 | 41 | 184 | 63 | ∞ |
| 8 | 135 | S 70°E | QHKH | 20 | 18 | 155 | 38 | ∞ |
| 9 | 147 | N 25°W | QQHKH | 25 | 10 | 54 | 35 | ∞ |
| 10 | 110 | N 10°W | QQH | 15 | 16 | 22 | 31 | ∞ |
| 11 | 115 | N 20W | KQQH | 15 | 15 | 65 | 30 | ∞ |
| 12 | 182 | N 20°W | KH | 38 | 32 | 175 | 70 | ∞ |
| 13 | 172 | N 20°E | KQQ | 44 | 35 | 165 | 79 | ∞ |
| 14 | 135 | N 5°W | KQHK | 40 | 5 | 160 | 45 | 10400 |

N.B.: The infinity values of true ρ (Ω.m) indicate too high resistivities to be determined.

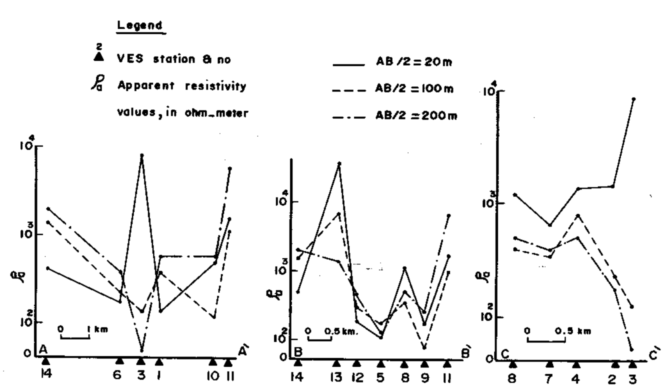


Fig. 2: Apparent resistivity profiles AA', BB' and CC' with different AB/2 values.

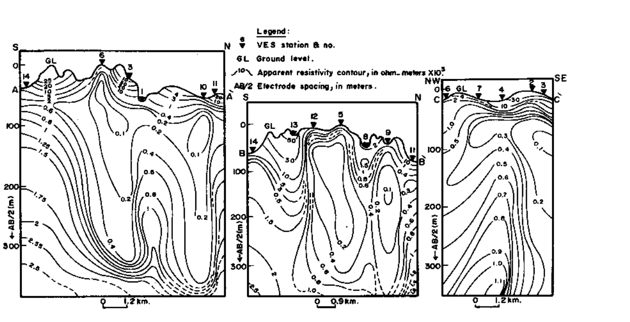


Fig. 3: Apparent resistivity sections AA', BB' and CC'.

(Fig. 4) shows the variation in depth to the top of the probable water-bearing bed. The depth reaches its minimum value (10m) at VES no. 1 near the western bank of the River Nile, whereas

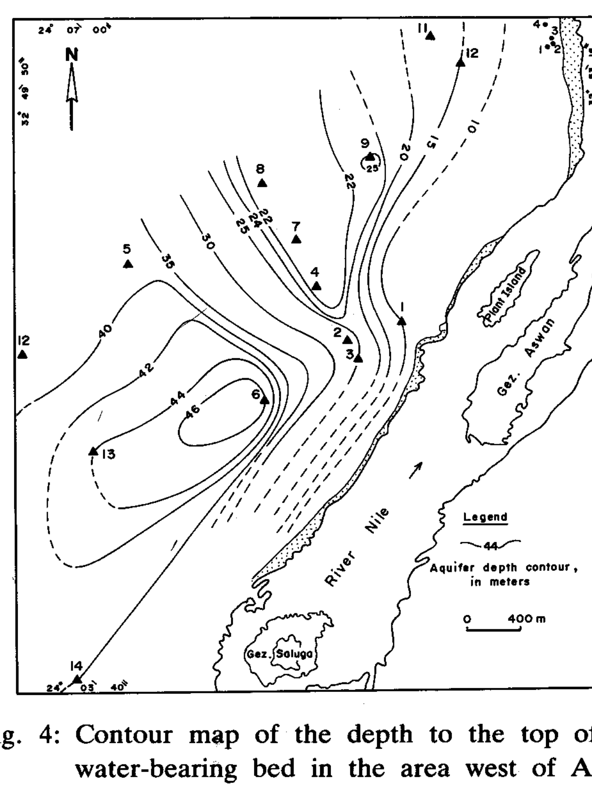


Fig. 4: Contour map of the depth to the top of the water-bearing bed in the area west of Aswan town.

the maximum depth (46m) is found for VES no. 6 south of G. Sidi Osman. Generally, the depth decreases eastwards, i.e., towards the present River Nile, and increases westward where a thick succession of sediments occurs. It is important to mention that the water level measured by the authors in the four available wells lying in the most northeastern portion of the study area is about 14-20 m (Table 2). This confirms on the interpretation of depth as obtained from VES no. 10 and 11 (Table 1) located close to the wells.

**Table 2**
Measured data of different drilled wells near the most northeastern part of the study area.

| Well No. | pH | Depth (m) | Temperature (C°) | Electric Conductivity (us/cm) | Salinity (ppm) |
|---|---|---|---|---|---|
| 1 | 7.8 | 14 | 26 | 850 | 440 |
| 2 | 8.1 | 16 | 24 | 1050 | 533 |
| 3 | 7.6 | 20 | 24 | 1000 | 512 |
| 4 | 8.8 | 17 | 24 | 1600 | 825 |

The thickness of the probable water-bearing bed as shown in (Fig. 5) varies from 5 to 41 m. The minimum value (5m) is found at VES no. 14 at the southern part of the investigated area (near the western bank of the River Nile), whereas the maximum thickness (41m) is found at VES no. 7 South G. Sidi Osman. In general the thickness decreases eastwards (towards the River Nile) and southwards (Fig. 5).

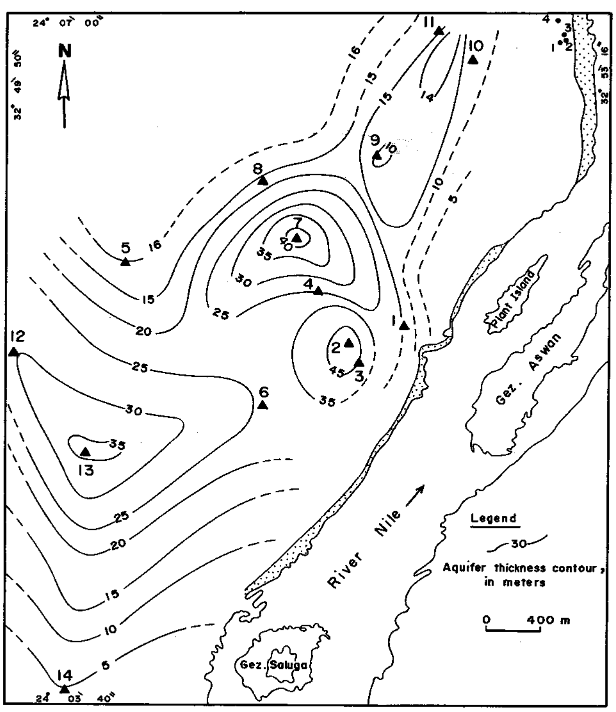


Fig. 5: Isopach map of the water-bearing bed in the area west of Aswan town.

The inferred resistivity distribution within the probable water-bearing bed is illustrated in (Fig. 6). The minimum value of 22 Ω.m is found at VES no. 10 in the most northeastern portion of the study area, at a locality where slightly brackish water is found in the wells drilled by the farmers (Table 2). The maximum value of 18 Ω.m is found at VES no. 7 in the central part of the study area at a location of higher relief. There is a general northward decrease of the resistivity values which may be due to the type of the water present and/or changes in lithologic facies of the aquifer.

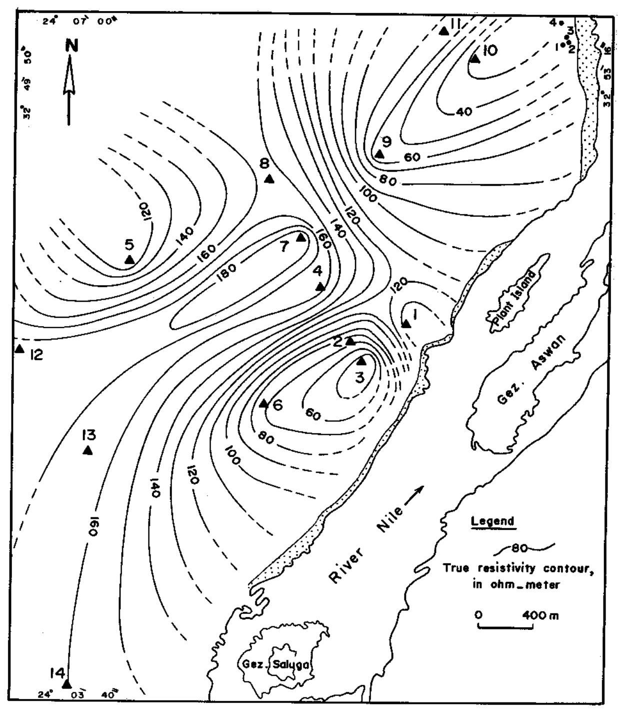


Fig. 6: True resistivity map of water-bearing bed in the study area.

The inspection of the true resistivity results given in (Table 1) shows that the deepest geoelectric layer detected in each VES station has usually a high resistivity. We believe that such high resistivity values may be related to the basement rocks which directly underlie the probable water-bearing bed. Therefore, a map showing the depths to the basement rocks in the area was constructed as shown in (Fig. 7). The comparison between this map and the topographic features show some resemblance.

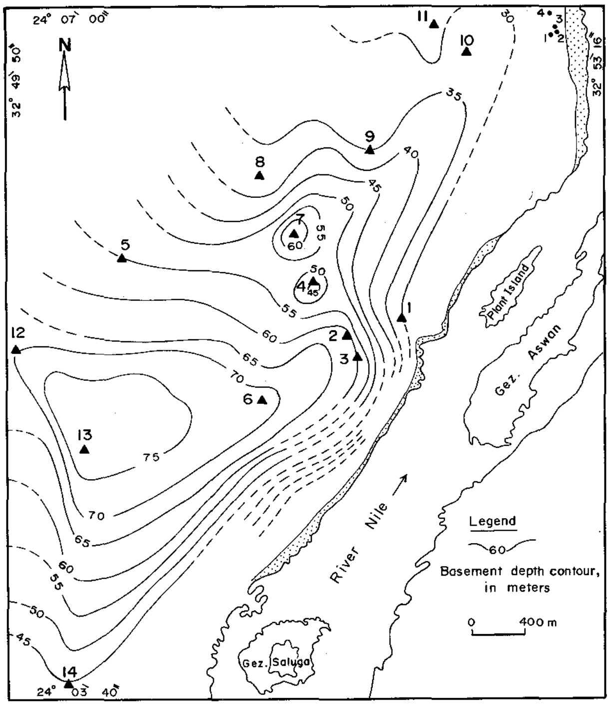


Fig. 7: Contour map of the depth to the basement rocks in the study area.

For more illustration of the subsurface conditions (e.g. geometry of the probable water-bearing bed and the inferred depth to the basement), three sections along the directions selected above (AA', BB', and CC') were constructed as illustrated in (Fig. 8). The study of these sections shows: a) an irregular distribution in the thickness of the probable aquifer which may be related to the basement relief, and b) the occurrence of faults through which the probable aquifer may be recharged.

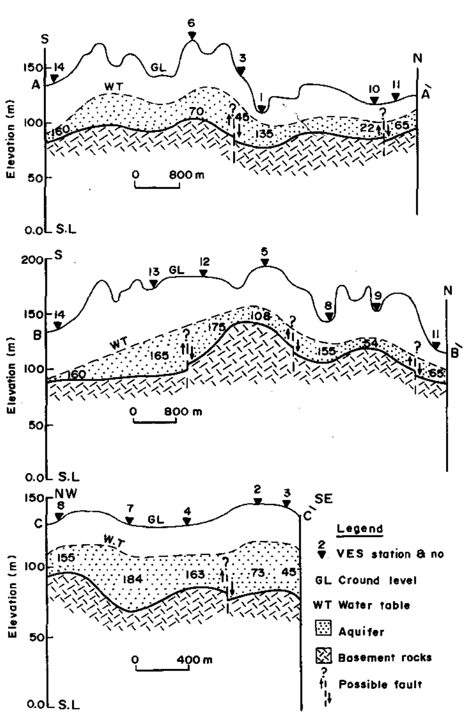


Fig. 8: Subsurface sections AA', BB' and CC'. Numbers in layers designate interpreted true resistivities.

## CONCLUSIONS

The work done in this paper has led to the following main conclusions:

1. Presence of a water-bearing bed which is mainly Nubia sand-stone with a thickness range of 5-41 m, which can be reached through 10-46 m depth.
2. The inferred variation of the true resistivity values within the water-bearing bed is possibly due to the variation in water quality as well as rock texture.
3. The probable recharge source of the expected water-bearing bed in the area is mainly across joint system and through fractures from the Nile in directions from south to north and/or from east to west. The recharge from the rainfall, in early periods, could occasionally assisted in feeding the expected aquifer.
4. The highly resistive geoelectric bed underlying the water-bearing bed may be considered at the basement rocks with a topography in good correlation to the surface topography of the area.

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