Groundwater Assessment of the Area between Belbies and Tenth of Ramadan Cities (Egypt), Using Geophysical Tools.

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Motivation

Electrical and Electromagnetic methods play an important role in groundwater exploration. The quantity of the available surface water in the study area can not cope the needed requirements. So it was necessary to look for an additional water resource to fulfill the water quantities needed for agricultural and industrial activities. For this reason, the main objective of this research is studying the subsurface geology in order to investigate the shallow (Quaternary) and deep (Miocene) groundwater aquifer using **DC resistivity, transient electromagnetic (TEM) and magnetotelluric (MT) methods.** The second objective is to make 1D and 2D inversions of these types of data and joint inversion.

Survey area

The study area is located on the southeastern fring of the Nile Delta region (Fig.1). It is bounded by Belbies City and Ismailia Canal from the North and Tenth of Ramadan City from the south. Topographically, it decreases from south (99.5m amsl) towards the north (25.5m amsl) with a general slope towards the North.

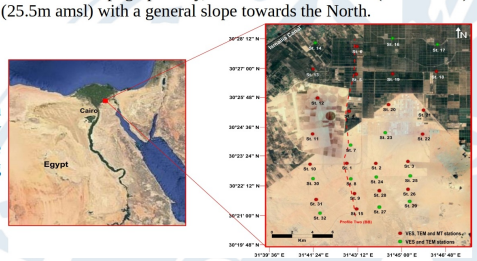

Fig. 1: Location map of the study area showing the sites of measuring points.

Geologically, the investigated area has sedimentary succession ranges in the age from Cretaceous to Quaternary (Fig.2a) which represents the main groundwater-bearing zone in this area (Pleistocene sediments, 200m thick)[1]. Quaternary deposits are composed of aeolian sands, fluviatile deposits, gravel and clay[2]. Geomorphologically, the area is considered as a part of the Tenth of Ramadan- El Salhiya gravelly and sand plains.

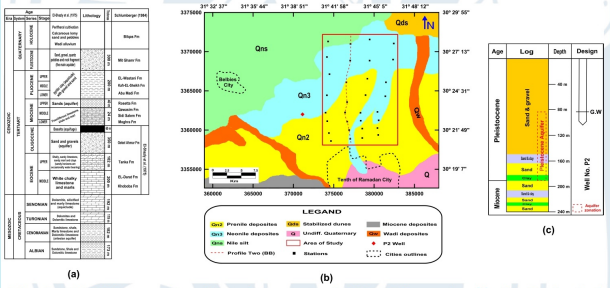

Fig. 2: (a) Litho-stratigraphic column east of Nile Delta region [1], (b) Geological map of the study area and its surroundings [2] and (c) Lithologic-column of P2-well west of the study area.

Data acquision

DC resistivity data in the form of vertical electrical sounding (VES) were measured at 32 stations along four main profiles (Fig.1) with Syscal/R2 acquisition system (Fig.3). We applied Schlumberger electrode configuration where the current electrode separation (AB) begins with 2m and extends to reach maximum distance 1000m in order to access the depth range of shallow groundwater aquifer.

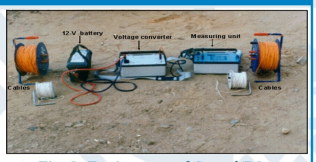

Fig. 3: Equipments of Syscal/R2 instrument in the field survey.

TEM data were acquired by SIROTEM MK3 instrument, at the same DC stations, using single loop configuration (50*50m). 20 MT soundings were conducted by using the controlled source Stratagem EH4 imaging system.

References

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[3]: Bobachhev A. A.., Modin I. N., and Shevnin V. A. (2001). IPI2Win Program for vertical electrical sounding curves 1D interpreting along a single profile, Dep. of geophysics, Geological Faculty, Moscow University, Russia.
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1D inversion of DC data

1D inversion of DC data was carried out with IPI2WIN software used for interpreting DC data in terms of 1D layered earth model. The starting models were adjusted to obtain a best fit between the observed data and the model response[3]. 1D inversion results of profile two in the study area are shown in Fig. 4. RMS values of each station are shown in Fig. 6.

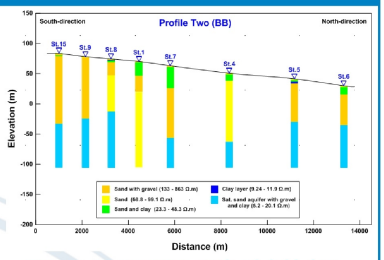

Fig. 4: 1D inversion result of field data with IPI2WIN software.

2D inversion of DC data

2D inversion of DC data is performed using the inversion algorithm of the geological survey of Japans (1990)[4]. A starting model of 30 Ω.m and two kinds of meshes (calculation mesh and model mesh) were used in this program. The topography was taken into the consideration. The inverse problem is solved using damped non-linear least squares algorithm of Madrquardt's method. A laplacian smooth filter operator is incorporated in the parameter inversion to reduce the roughness of the spatial variation of resistivity.

2D inversion results of profile two (Fig.5) (RMS=8.85%) are contoured by Kriging method, where the best subsurface model is obtained after 8 iterations. It shows a highly conductive zone with resistivities below 25 Ω.m, at depths starting from 100m which could be considered as the upper boundary of shallow Quaternary aquifer as indicated from the borehole information (Fig.2c).

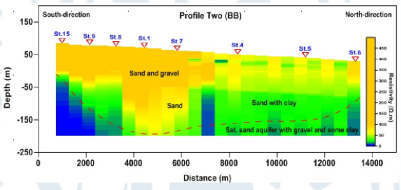

Fig. 5: 2D inversion result of field data, RMS=8.85%.

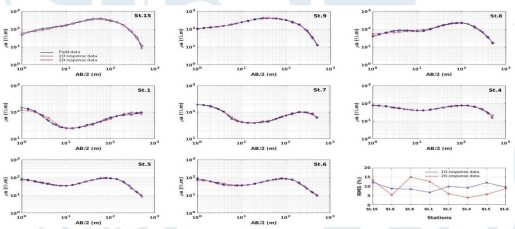

Fig. 6: Comparison between measured, 1D and 2D model responses of VES data along profile two.

ρ^* - z^* Representation of MT-data

In this figure, the apparent resistivity and phase of both off-diagonal impedance tensor (Z_{xy} and Z_{yx}) are shown. Depending on the values of resistivity (ρ_a), phase Φ) and frequency (f), ρ^* - z^* transformation gives the first indication about the deep conductivity structure.

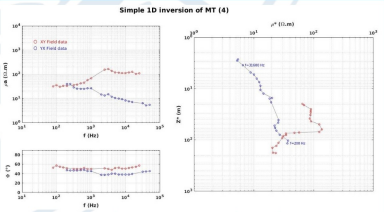

Fig. 7: Simple 1D inversion of MT data at St. 4

Conclusions

- The DC field data is fitted best with synthetic data from 1D and 2D responses.
- The 2D inversion provides an independent validation of the subsurface resistivity distribution in the area. The obtained 2D model is in good agreement with the 1D inversion results.
- The obtained results revealed a highly conductive zone with resistivities below 25 Ω.m and at depths starting from 100m, which gives indication about the upper boundary of the shallow (Quaternary) groundwater aquifer in the study area.