

Ain Shams University
Faculty of Science
Department of Geophysics



***Aquifer Characterization of West El-Minia Area, Egypt,
through the Forward and Inverse Modeling of the DC
Resistivity and Transient Electromagnetic Data***

A Thesis
Submitted in Partial Fulfillment for the Requirements of
M.Sc. Degree in Geophysics

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B.Sc. in Geophysics
Faculty of Science – Ain Shams University, 2015

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Cairo, 2020

Approval Sheet

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Note

The present thesis is submitted to the Faculty of Science, Ain Shams University in partial fulfillment for the requirements of the Master degree of Science in Geophysics.

Beside the research work materialized in this thesis, the candidate has attended ten post-graduate courses for one year in the following topics:

- 1) Geophysical field measurements,
- 2) Numerical analysis and computer programming,
- 3) Potential theory,
- 4) Electric method,
- 5) Magnetic method,
- 6) Gravity method,
- 7) Shape of the earth,
- 8) Plate tectonics,
- 9) Electromagnetic and telluric current method,
- 10) Radiometric method.

He successfully passed the final examinations in these courses.

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ABSTRACT

The main topic of this thesis is to determine of the aquifer characteristics using the DC resistivity and transient electromagnetic methods through forward and inverse modeling in West El-Minia area, chapter I: describe the background knowledge of the of the study area, in this chapter, general overview of the geology of the area, as well as, the previous studies made in the study area. Chapter II: represents a study of the aquifers using DC resistivity. Chapter III: represents a study of the aquifers using transient electromagnetic method. Chapter IV: reveals the results of integration of the DC resistivity method with the TEM method. Chapter V: this chapter presents summary, as well as, conclusion and results.

Exploration for determination of the electrical, geological and hydrogeological characteristics of the considered aquifer can be done, by applying the forward modeling, to get the initial multi-layers model, and inverse modeling, to get the final earth model, for interpreting the DC-resistivity (VES) and TEM data. So, 22 VESs, using Schlumberger array configuration ($AB/2 \approx 500\sim 700\text{m}$) and 12 TEMs, using the in-loop array configuration (square with $\ell \approx 200\text{m}$) were carried out at West El-Minia selected area. VESs were interpreted, using Zohdy technique (1989) and Rinvert software (1999) for studying the shallow resistive and conductive depths, and delineating the faults. TEMs were interpreted, using Steminv and Tcinv softwares for investigating the shallow and deep conductive layers. This study was applied for studying the shallow and deep Oligocene clastic aquifers and the Carbonate aquifer.

The inverse (layered) model of the VESs and TEMs was calibrated with the drilling data and translated the subsurface electrical, geological, and hydro-geological results into four layers; dry Oligocene clastics (of $173\text{-}467\Omega\text{m}$), dry limestone (of $273\text{-}374\Omega\text{m}$), saturated Oligocene clastics (Oligocene aquifer) (of $2\text{-}107\Omega\text{m}$), due to the increase in clay content and salinity values (~ 900 - $\sim 6800\text{ppm}$),

then saturated fractured limestone to shally limestone (Eocene carbonate aquifer) (of 5-188 Ω m), due to the increase in shale content, salinity values and also in fracture density with high in salinity. The estimated depths to groundwater were varied from 62m to 131m. This model assisted in managing the promised locations choosed for drilling productive wells. So, two hydro-geoelectrical profiles were built for simulating the resistivity values of the resistive and conductive layers vertically and horizontally with depth, and showing the resolution of the shallow section and deep section as well as their thickness variation, in which the resistivity values indicated that, the shale content at the limestone layers increases toward the northwestern parts. The thickness of the Oligocene clastics increase toward the southern and southwestern directions and they disappear toward the northern direction. Also, it is found that, the area is subjected to several faults affecting the geological and hydro-geological conditions of the area.

Moreover, it was found that, from studying the ramp-off time effect on the TEM data, which is due to the interference of the resulted primary and secondary magnetic fields in the early time of receiving the TEM response, as well as the effect of the high resistivity shallow thickness, (~50-100m) was not recorded, as matched with the recorded thickness from VESs analysis, in which the maximum depth of penetration was 672m.

For confirming the previous outputs, Tech-log software were used for analysing the available well logging data at the two aquifers. Accordingly, the saturated zones were determined and the volume of shale was calculated, ranging from 0% to 100% at the two aquifers. Added, the porosity values were calculated, in Oligocene aquifer ranges between 9% and 35%, while in the carbonate varies ranges from 4% to 15.5%. These values are controlled by the geological and hydrogeological conditions of the aquifers and showed good matching with the outputs deduced from the inverse model of the resistivity soundings. So, the use of the forward and inverse models of the VESs and TEMs interpretation and the integration between both is considered as, powerful tool for solving several problems during these soundings interpretation and for increasing the accuracy in estimating the hydro-geoelectrical and geological characteristics of the studied

aquifers. Also, it should be used for low ramp transmitter ($\sim 2.5 \mu\text{s}$), because it is more preferable in identifying the shallow depths, especially at the parts of high resistive shallow depths and reducing the ramp-off time effect.

Keywords: DC-Resistivity Method, TEM Method, Forward Model, Inverse Model, Fault Determination, Ramp-off Time Effect, Aquifer Characterization.

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