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THE USE OF GEOPHYSICS APLLICATIONS IN GROUNDWATER EVALUATION

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ABSTRACT

This study aims to shorten the distance between civil engineers and some other fields not far from any civil engineer`s work and these fields is very important to the civil engineers specially the public work engineers. This study is focusing in using the available geophysical field data in Wadi El Rayan area to be able to evaluate the groundwater in this study area from an environmental aspect, the geophysical data found for this area will lets us integrate and interpret these data to study the groundwater and the aquifer beneath the earth surface.

KEYWORDS: Groundwater, environment, water, geophysics, environmental geophysics, geology, applied geophysics, hydrogeology, seismic waves, well logging, petrophysics, aquifers.

INTRODUCTION

Life means water and water means life, nowadays many studies refer to a global problem will be happened in the future concerning the water due to the global increase of the world's population in the next decades more than the previous decades.

It was recognized that Egypt's water demand for irrigation, industry, and domestic consumption already exceeds the supply of the Nile, then looking for alternatives is very important.

Searching for clean water using all traditional techniques will be the most important thing the next generations will talk about, then using the groundwater as one of the main resources in the future is inevitable.

Groundwater will be one of the most important resources of securing the future of the next generations and because the water is one of the most important resources of the national security of any country then exploring and evaluating the groundwater with the modern techniques must take place more than before.

Evaluating the groundwater using one method can help but evaluating the groundwater using integrated methods could help more, in this study the groundwater will be evaluated using more than one method.

Putting in consideration the environmental aspect in evaluating the groundwater of any area is also very important because water is a very important factor in any ecological system and if the next generation will use the groundwater as a main resource of water in some places then we have to make sure that the groundwater that will be used is clean as much as we can and also helping them by making more studies and researches they may use as a reference in different locations to minimize their efforts and their time.

The selected area of this study was Wadi El Rayan depression due to the poor of detailed information of the available data concerning the groundwater in this area and also the importance of Wadi El Rayan as a protected area.

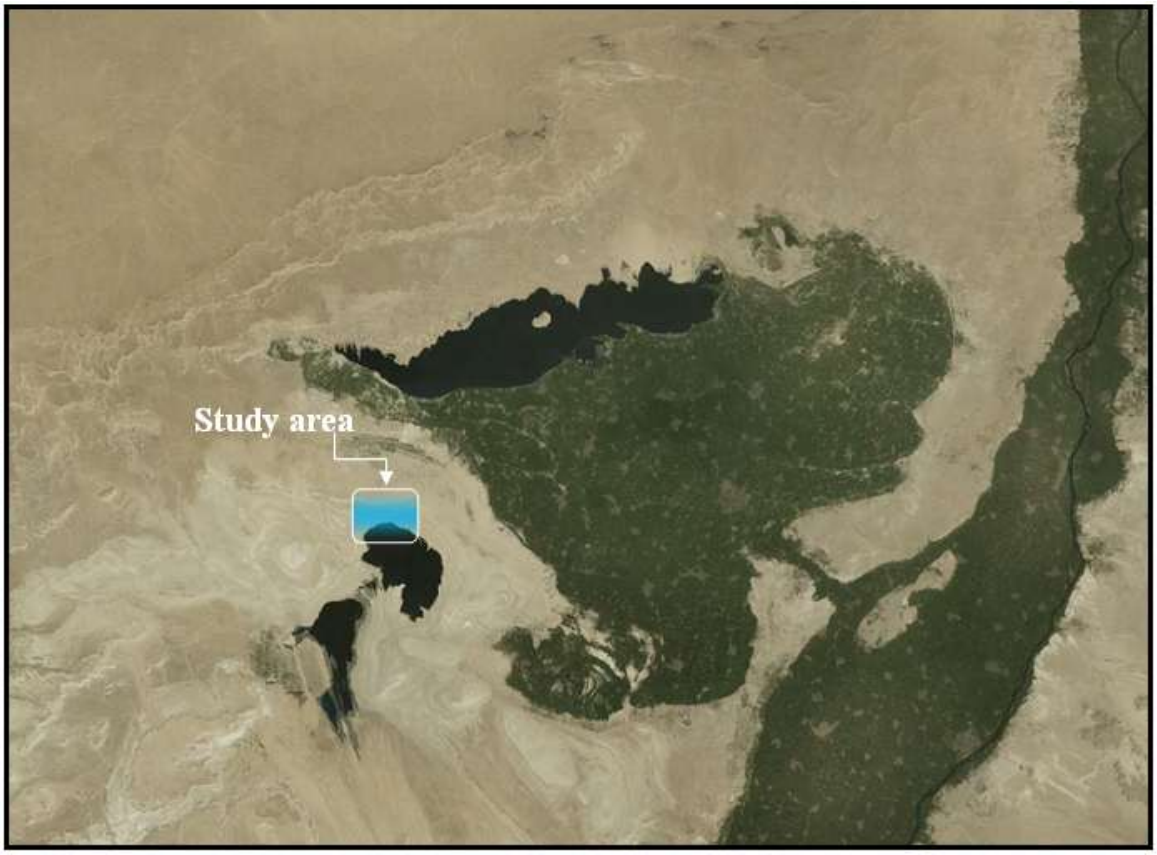

Figure 1: Study area location.

MATERIALS AND METHODS

The available materials for Wadi El Rayan area were found at Qarun Company and without these materials this research could not be accomplished. The available field data for this virgin area was limited and after searching in many places that supposed to find data in it.

The seimic data and the well logging information were the used field data that found,the seismic survey area is located within the West of Beni Suef concession,the 3D program of land seismic acquisition in Egypt was planned by APACHE Company on 2004. The Area of Operations is at 1.5 hours drive from Cairo town.

The requested seismic data for this study was taken from Qarun Company after an official approval from the **Egyptian General Petroleum Corporation (EGPC)**.

The available well logs tookalso from Qarun Company after an official approval from the **Egyptian General Petroleum Corporation (EGPC),** many logs were found at Qarun Company, and only two logs were selected due to the existence of the needed information that was recorded for the shallow part.

The only available logs in the study area were found in Qarun company and it was hard to find these logs because the target zone of the oil and gas companies usually targeting the deep section not the shallow section and what help this research to be accomplished is that the recorded logs in the study area were recorded by taking inconsideration the information of the shallow part.

The hard ware that used is a laptop Lenovo yoga 3 pro with the following specs:

- CPU: Intel Core M 5Y70 / 1.1 GHz
- Max Turbo Speed: 2.6 GHz
- Number of Cores: Dual-Core
- Cache: 4 MB
- Memory Speed: 1600 MHz
- Intel HD Graphics 5300
- Resolution: 3200 x 1800 (QHD+)
- OS Provided: Type Windows 8.1 64-bit Edition

The software that used to read all the field data were as the following:

- **Petrel@Schlumberger** is a software platform used in the exploration and production sector of the petroleum industry. It allows the user to interpret seismic data, perform well correlation, build reservoir models, visualize reservoir simulation results, calculate volumes, produce maps and design development strategies to maximize reservoir exploitation. Risk and uncertainty can be assessed throughout the life of the reservoir. Petrel is developed and built by Schlumberger.
- **Techlog@Schlumberger**is a software platform enables you to perform both basic and advanced interpretation on all wellbore data types, including log, core, images, photos, and thin sections. You can design your own petrophysical workflow to generate meaningful quick-look interpretations based on local expertise and the application of industry standard methods for lithology, porosity, saturation, and permeability.

Methods used to complete this study were:

- The reflected seismic data method.
- Well logging method.
- Method used in calculating the total porosity using the sonic log.
- Method used in calculating the water saturation.

Seismic exploration based on the propagation of waves inside the earth. The propagation velocity and amplitude (signal strength) of these waves depend on the dynamic elastic constants of the rocks and on their density.

Seismic waves travelling through a homogeneous layer with constant seismic velocity form circular wave fronts, the propagation of which can be described by straight rays. The seismic signals are usually recorded along linear geophone spreads where sensors (geophones) are placed at regular distances.

Well logging or borehole logging used to know a detailed record of the geologic formations using instruments lowered into the hole, some types of logs can be recorded during any phase of exploration process.

Wire-line logging is a powerful tool for delineation, correlation and evaluation of the strata traversed by bore holes to acquire information about reservoir characteristics. Wireline logging evaluation is a vital part in the petroleum industry and is accepted as the most reliable and accessible geophysical-geological method for determining the petrophysical rock characteristics.

Calculating the porosity of logs depends on the existed logs. The suitable technique to calculate the porosity was the third way according to **Selly (1998)** by measuring the acoustic velocity using the sonic log according to the equation of (Wyllie et al., 1956, 1958):

$$\phi = \frac{\Delta t_{\log} - \Delta t_{ma}}{\Delta t_f - \Delta t_{ma}}$$

Δt]og -interval transit time recorded on the log
Δt ma -velocity of the rock at ϕ (porosity) = 0
Δtf-velocity of the pore fluid.

The saturation of a formation represents the amount of a given fluid present in the pore space. Water saturation is the percentage of pore volume in rock, which is occupied by formation water. It represents an important log interpretation concept, because it helps in evaluating the groundwater for a selected region.

Calculating the water saturation using the calculated porosity of logs depends on the existed logs. the suitable method to calculate the water saturation was Archie`s equation method:

$$Sw = \left(\frac{a}{\phi^m} \frac{R_w}{R_t} \right)^{1/n}$$

Sw - Formation water saturation

Rw - Formation water resistivity (ohmm)

Rt - True formation resistivity (ohmm)

Φ - Formation effective porosity (fraction)

a - Formation resistivity factor

m - cementation factor

n – saturation exponent

RESULTS

Integrating different geophysical methods gave us better image for the evaluation than using one geophysical method.

Overlaying the field and calculated logs of WR 2X on the two seismic lines (inline 10071 & crossline 2102) that are corresponding to the well location can show us that the zones that are expected to be filled by groundwater in the Eocene limestone plateau. The Apollonia formation contains fissures, fractures and joints which all construct the groundwater system in the study area.

The following figure showing the zones that are expected to be filled with groundwater on the two stacked seismic lines:

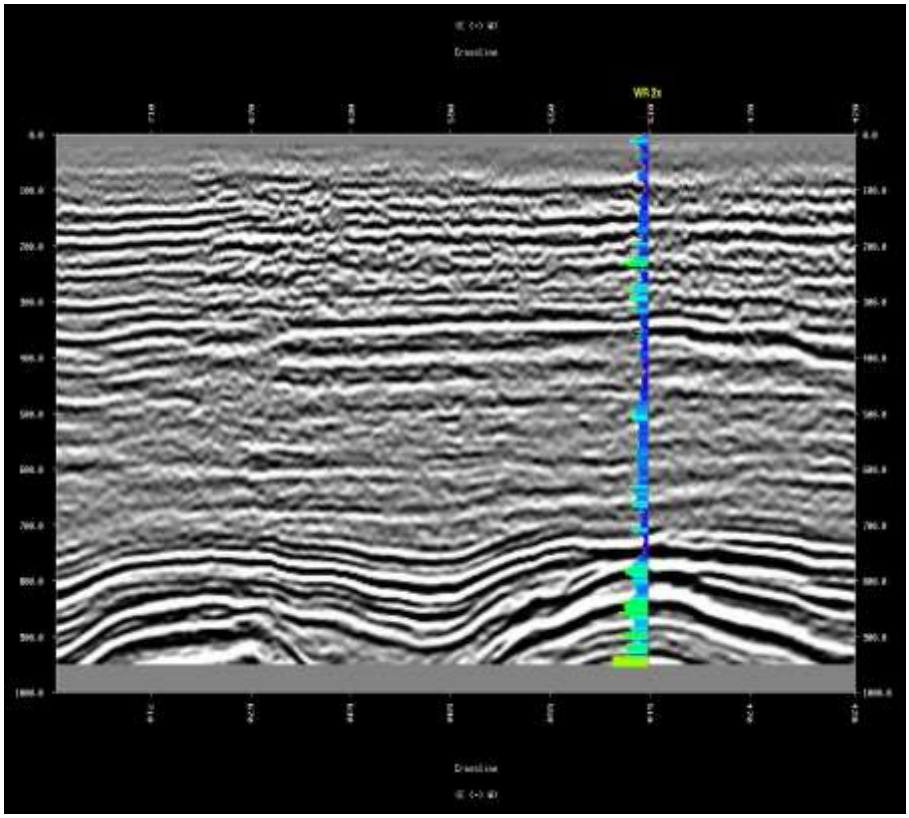

Figure 2: The water saturation log for wr 2x well shows the expected groundwater on inline 10071.

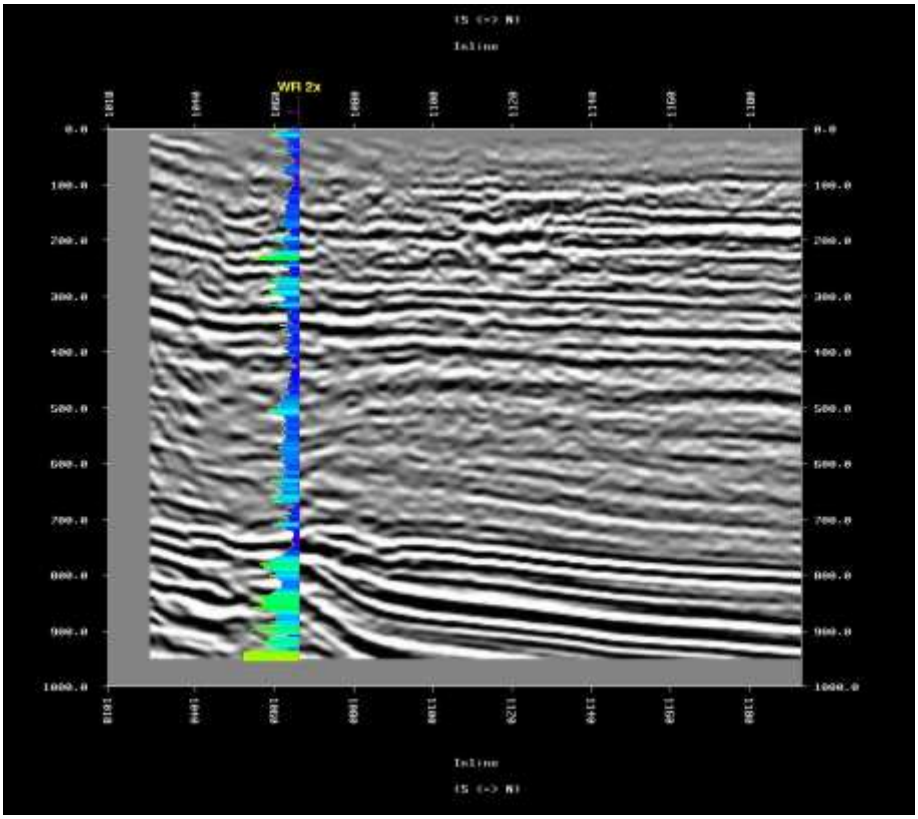

Figure 3: The water saturation log for WR 2X well shows the expected groundwater on Crossline 2102.

The logs of WR 2X indicates that the Apollonia formation of the study area is an aquifer and this eventuality was noticed from calculating the total porosity using Wyllie`s equation by using the sonic log of the well logging data and with calculating the water saturation using Archie`s equation, knowing that Archie`s equation linked the porosity and the resistivity logs with the amount of the water present.

The groundwater salinity approximately 7000 ppm computed by knowing the Rw of WR 2X of the study area. The calculated total porosity range is 10% - 35% and the water saturation percentage range is 40% - 95%.

The Eocene carbonate aquifer (Apollonia Formation) in the Bani Suef oil field area near Wadi El Rayan considered as the main source for irrigation and drinking. this groundwater system that consists of two productive aquifers; the Quaternary sand and clay water bearing formation and the Eocene Carbonate aquifer.

The Apollonia Formation is suitable for storing groundwater in it and also suitable for water injection process using the available dry wells for this area, injecting this formation can help in getting ride from the drainage of the Qarun lake due to the rise of the water level of the Fayoum area and that must be done after making primary treatment for the agriculture waste water that came from the Fayoum depression and sure this can help the environment and the ecological system in the Fayoum area. These results can be used in further researches and can help in integrating more geophysical data in the future.

CONCLUSION

It is important for any civil engineer to take the advantage to work on studies that can add to him/her more dimensions to his experience specially the environmental studies because it is a multidisciplinary science.

The objectives of the study fulfilled their aims and gave a good knowledge for some important methods related to the environmental engineer`s duty.

The study was targeting using geophysical field data in evaluating the groundwater and the aquifer of Wadi El Rayan study area from an environmental perspective and doing some petro-physical works using some important methods and theories that helped the study to accomplish this assessment.

After collecting the all available geophysical field data for Wadi El Rayan study area during the life time of the study, a verification step started directly to check the validity of these data before doing any further step, the verification step required to convert the well log information from depth to time using the check shot that acquired in the field to be able to load the well logs on the stacked seismic lines in time domain to check that the formation top of the Khoman formation was matched with the seismic data and this step was done correctly and the results of the verification step was very good.

The next step was calculating the total porosity and the water saturation of WR 2X well using the given information while drilling the well to know the probability of the existed ground water in Apollonia formation`s aquifer and also to know the groundwater salinity when the well logging done by the end of year 1996.

By loading, the two new calculated logs (the total porosity and the water saturation) on the two stacked seismic lines attached to WR 2X well it was concluded that the Apollonia Formation in Wadi El Rayan area is suitable for storing groundwater in it and also suitable for water injection process using the available dry wells in the area.

The environment and the ecological system in the Fayoum and Wadi El Rayan area. These results can be used in further researches and can help in integrating more geophysical data in the future studies.

It is highly recommended to drill more wells in this area targeting the shallow part to be able to create 3D models for this virgin area showing the water salinity and the boundaries of the aquifer and also to be able to evaluate this area from the environmental point of view.

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