Egyptian Journal of Aquatic Research (2016) 42, 261–268

HOSTED BY

ELSEVIER

National Institute of Oceanography and Fisheries

Egyptian Journal of Aquatic Research

http://ees.elsevier.com/ejar
www.sciencedirect.com

FULL LENGTH ARTICLE

Application of electrical resistivity method for groundwater exploration at the Moghra area, Western Desert, Egypt

M.I.I. Mohamaden [a,*], A.Z. Hamouda [a], Salah Mansour [b]

[a] *National Institute of Oceanography and Fisheries, Alexandria, Egypt*
[b] *Geological Survey of Egypt and Mining Authority, Egypt*

Received 3 January 2016; revised 3 March 2016; accepted 23 June 2016
Available online 18 August 2016

KEYWORDS

Moghra area;
Groundwater;
VES;
Aquifer

Abstract Moghra territory is one of the most encouraging regions for watered farming and development in the northern part of Western Desert. To achieve that development groundwater is considered the most favorable tool. Geophysical survey in terms of geoelectrical resistivity sounding has been conducted using the Schlumberger array – eleven vertical electrical soundings (VES's) were measured on the study area. The aim of this study was to investigate the hydrogeological condition at the area under investigation.

Three geoelectric sections are prepared; each of them is composed of four units. The first layer has resistivity ranging from 58 to 2029 ohm.m and thicknesses from 0.46 to 10.7 m characterizing a gravely sand facies of Quaternary age (Pleistocene to Holocene). The second geoelectrical layer has resistivity values ranging between 188 and 518 ohm.m which are comparatively high, with various depths varying between 14.7 and 25.8 m from Lower Miocene age. It is formed of sand and gravel. The third geoelectrical layer is considered the aquifer for the area under investigation with moderate electrical resistivity values (17–111 ohm.m), and could be recognized sometimes as the most extreme depth of penetration. At the maximum depth of penetration of this area, the lower layer (fourth layer) was recognized with the highest electrical resistivity values (1227–8935 ohm.m) of basaltic sheet (Precambrian age).

Structurally, the study area is influenced by three faults two of them are geological/geoelectrical faults forming a graben structure at the central part; the third fault is a geoelectrical fault and is located to the west of the graben structure forming a horest structure.

Introduction

Groundwater is a vital water source, especially in areas that lack waterways, rivers and rain, and provides an indication of groundwater on the potentiality of establishing communities

* Corresponding author.
E-mail address: Mahmoud_Moha12@Yahoo.com (M.I.I. Mohamaden).
Peer review under responsibility of National Institute of Oceanography and Fisheries.

http://dx.doi.org/10.1016/j.ejar.2016.06.002
1687-4285 © 2016 National Institute of Oceanography and Fisheries. Hosting by Elsevier B.V.

to the extent permitted by their validity in terms of quality and quantity.

The study area (Trough Moghra) lies at the north of the Western Desert of Egypt at the northeastern tip of the Qattara Depression between longitude 28° 55\ and 29° 10\ E, and Latitude 30° 10\ and 30° 16\ N, as shown in Fig. 1. The climate of the study area lies in the dry belt of Egypt, a warm winter and hot summer with a broad change in climate over the day and the scarcity of rainfall. The average temperature ranges from 23 °C in winter and 39 °C in summer. The estimated maximum wind speed of about 3 Knots and less wind speed in November, and up to 0.65 Knots. The rate of natural evaporation between 5.1 mm/day in December and 14 mm/day during the month of June at an average annual rate of 9.6 mm/day. The annual precipitation is between 25 and 50 mm (Aref et al., 2002).

Geophysics and specifically, geoelectrical resistivity method is, generally, considered to be the most promising and most suitable method for ground water prospecting. This is based on the concept of determination of the subsurface, which can yield useful information on the structure, composition and content of buried formation. This study aims to determine the depth of the aquifer, stratigraphy and water quality of the aquifer.

Geological context

The geological study is to know the stratigraphy of the layers and geological structures within the study area, geological and hydrology and dug wells near the area.

Lithostratigraphic section of the study area is characterized by sand and dunes, especially the southern part, the thickness ranges from 2 to 3 m from the Quaternary deposits. A Lower Miocene sediment is represented by white sand, sandstone, intercalated with shale and contains fossils of backbone, fossilized wood and a thickness ranging between 20 and 50 m. This sediment overlays Lower Oligocene deposit which is composed of sand, gravel and sandstone with overlaps of the shale and its thickness ranges between 180 and 200 m, (Khan et al., 2014). The upper Eocene deposit is located at the bottom of Lower Oligocene deposits. It is formed from sandstone, limestone and shale overlaying the surface of unconformity followed by the created pond Qarun pond deposits from sandstone and limestone and shale with an overall thickness of 600 m. The *East Middle Eocene sediments* belong to the Mokattam formation which is a sequence of limestone and sandy limestone with a thickness of about 500 m.

The Upper Cretaceous formed from the Nubian Sandstone which is a residue consecutive sandstone rocks and sandstone clay with overlaps to the surfaces of unconformity and the thickness of a total 700 m, with a depth of about 1500 m from the surface of the earth.

Precambrian rocks are represented as the basement rocks that are igneous and metamorphic which are at a depth of about 2150 m (Said, 1981; Khan et al., 2014).

According to El Toukhy et al. (1999) the northern part of the Egyptian Western Desert is characterized by different tectono-stratigraphic episodes. The major structure orientated mainly NE, E–W and WNW (Hamouda, 2009), while according to Riad et al., 2003 the study area was affected by two sets of faults trending northwest – southeast and east – west, which are located at northern edges of Qattara Depression. These are related to successive phases of rotation and collision between the African Plate and Eurasia controlled structures and basin development (Hamouda, 2010). The rift basin at this area is characterized by early stage by estuarine deposits, which were sand-rich in many places due to the active syndepositional tectonics. Shallow marine shale and carbonates subsequently draped the sandy estuarine fills providing perfect seals as well as source rocks (Hamouda, 2010).

Geophysical data acquisition

The recent study is managing geoelectrical resistivity field survey that was completed by applying VES method which measures the variation of the electrical resistivity with depth. The changes in the electric resistivity values of geoelectrical section result from the material of the rock (density, shape, and porosity), water content, water quality and its content and temperature. So, the electric resistivity of porous formations has no limits. The difference in humidity percentage affects the geological unit; therefore it is separated into different geoelectrical units (Parasnis, 1997).

The Schlumberger array of electrode separation was used in this study by applying half spacing of current electrode (AB/2) starting from 1.5 m to 500 min successive steps. The aim of using this technique is to cover and reach the depth of the Quaternary aquifer in the study area (Abd El Fattah, 1994). Eleven VESs covering the whole area along 3 profiles were measured. These profiles are oriented from west to east direction (Fig. 1).

Using the previous geological information, the qualitative and quantitative interpretation of the geoelectrical survey data along the various profiles was done. There are many authors such as Santos et al. (2006), El-Galladi et al. (2007), Sultan et al. (2004), Sultan (2009), Mohamaden (2005), Mohamaden and Abu Shagar (2009), Abbas and Sultan (2008), Mohamaden (2009) and Mohamaden et al. (2009) studied the quantitative interpretation of the geoelectrical resistivity measurements for different areas. The interpretation of the apparent electrical resistivity data was obtained quantitatively through two steps, the first step was done using the Generalized Cagniard Graph method constructed by Koefoed (1965a–c), depending on the curve matching technique, while the second step deals with the treatment of the output results using computer software (the inverse problem method) (IPI2 W) and Ix1D (Interpex Ltd. (2008) based on Gosh (1973). Then results are represented as geoelectrical sections (see Fig. 2).

Geoelectrical sections

Qualitative and quantitative interpretations are carried out on the measured data and results. The qualitative interpretation is represented by constructing pseudo-section for apparent electric resistivity (Figs. 3, 5 and 7) while the quantitative interpretation is represented by geoelectrical sections (Figs. 4, 6 and 8). Inspection of these sections indicates the following:

Profile 1

Profile 1 lies at the southern part of the survey area. 3 VES (1, 2 and 3) were measured along this profile with total length for