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Full Length Article

Combined application of electrical resistivity and GIS for groundwater exploration and subsurface mapping at northeast Qattara Depression, Western Desert, Egypt

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ABSTRACT

The study area is located at northeast of Qattara Depression, Western Desert, Egypt. Geoelectrical resistivity method has been used by measuring twelve vertical electrical soundings using Schlumberger configuration with AB/2 spacing ranging from 1.5 m to 500 m in order to investigate the shallow groundwater aquifer and to delineate the subsurface structures in this area. The results revealed that the subsurface section consists of three geoelectrical units. The first unit is composed of surface Quaternary wadi deposits with resistivity values ranging from 248 to 1378 Ohm.m. and thickness ranging from 5.9 to 34.6 m. The second geoelectrical unit is composed of sandstone of Moghra Formation (Lower Miocene) with depth ranges from 5.9 to 34.6 m and its resistivity values range from 23 to 188 Ohm.m. This unit represents the main aquifer in the study area. The third geoelectrical unit is composed of claystone of Qattrani Formation with depth ranging from 106 to 174.4 m and resistivity values range from 0.5 to 9 Ohm.m. It extends to the maximum depth of penetration at the central part of the study area.

Structurally, the study area is affected by two probable faults trending mainly in NW-SE direction with upthrown side towards the central part of the study area forming a horst structure.

1. Introduction

The northeastern part of Qattara Depression is one of the highly promising areas for future development. In such area, groundwater is the main source of water and needs further exploration studies. The main aims of the present study are to explore the shallow sandstone aquifer and evaluating the structural elements affecting the study area which lies between latitudes 30.289549°N and 30.330554°N and longitudes 28.975918°E and 29.028553°E representing an area of about 20.5056 km^2 (Fig. 1).

The study area is located in the dry belt of Egypt. It is characterized by warm and hot climate in winter and summer, respectively. The average temperature is ranging between 39 °C in summer and 23 °C in winter [1]. The rate of natural evaporation between 5.1 mm/day in December to 14 mm/day during June at an average annual rate of 9.6 mm/day [1]. This area is suffering from a scarcity of rainfall; the annual precipitation ranges between 25 and 50 mm [2].

The electrical resistivity method is an effective geophysical tool which is widely used for groundwater exploration. It provides information about the subsurface structures and lithology [3]. The vertical electrical sounding (VES) method is used to provide reliable information about the shallow subsurface layers.

Many authors used the geoelectrical tool for investigating groundwater such as [3–10]. The main aims of the present study are to explore the sandstone aquifer and evaluating the structural elements affecting the study area.

2. Geologic setting

The study area is characterized by relatively low elevation (Fig. 2). The main surface geology was described in the geological map of Qattara Depression with scale 1:500,000 (Fig. 3). According to different studies on this area [11,12], the study area is covered by wadi and alluvial deposits of Quaternary age.

The northern border of the Qattara Depression is marked by a steep escarpment (250 m a.s.l.) of white limestone of the Middle Miocene Marmarica Formation. The Qattara Depression is cut into nearly horizontal beds of Miocene to Eocene age. The subsurface

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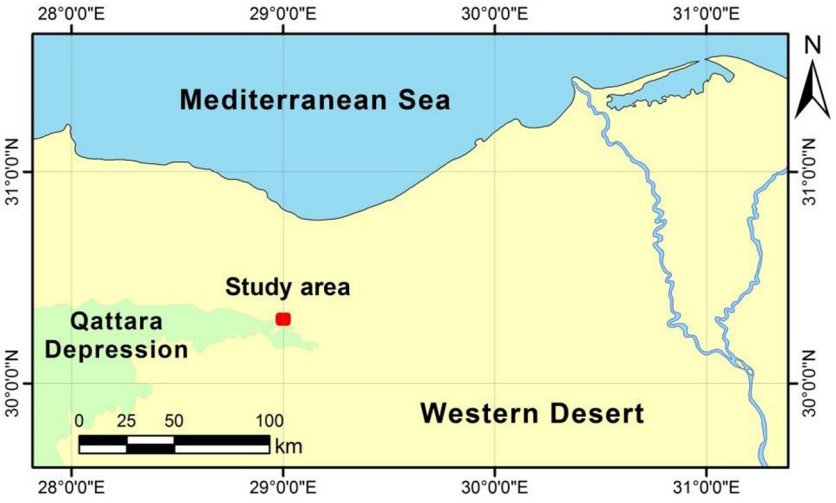

Fig. 1. Location map showing the study area.

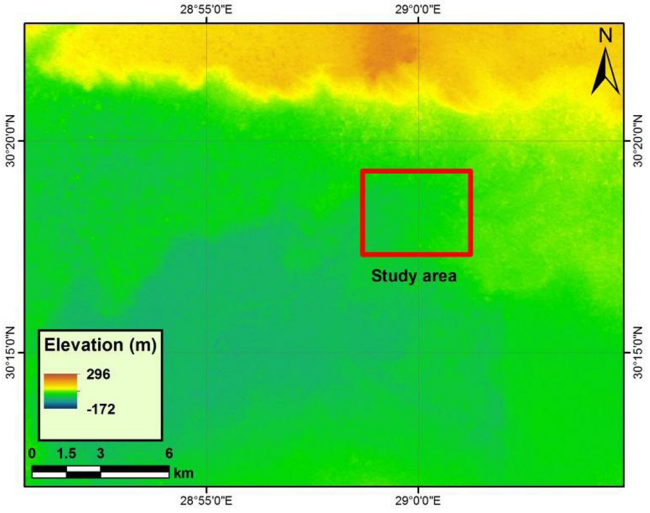

Fig. 2. Digital elevation model of Qattara Depression.

stratigraphy of the study area (Fig. 4) was described as follows [11,14]:

Quaternary Deposits: It consists of sand and dunes, especially at the southern part. **Lower Miocene Sediments:** It is represented by Moghra Formation which consists of white sand, sandstone, intercalated with shale and contains fossils of backbone, fossilized wood. It is considered as the shallow groundwater aquifer in this area. **Lower Oligocene Deposits:** It is represented by Qattrani Formation which is composed of sand, gravel and sandstone with overlaps of the shale. **Upper Eocene Deposits:** It is represented by Qasr El-Sagha and Birket Qarun Formations. It consists of sandstone, limestone and shale overlaying the surface of unconformity followed by sandstone and limestone and shale. **The East Middle Eocene sediments:** It is represented by Moqattam Formation which is a sequence of limestone and sandy limestone.

Upper Cretaceous: It is composed of the Nubian Sandstone which is mainly of sandstone. **Precambrian rocks:** It is represented by the igneous and metamorphic rocks.

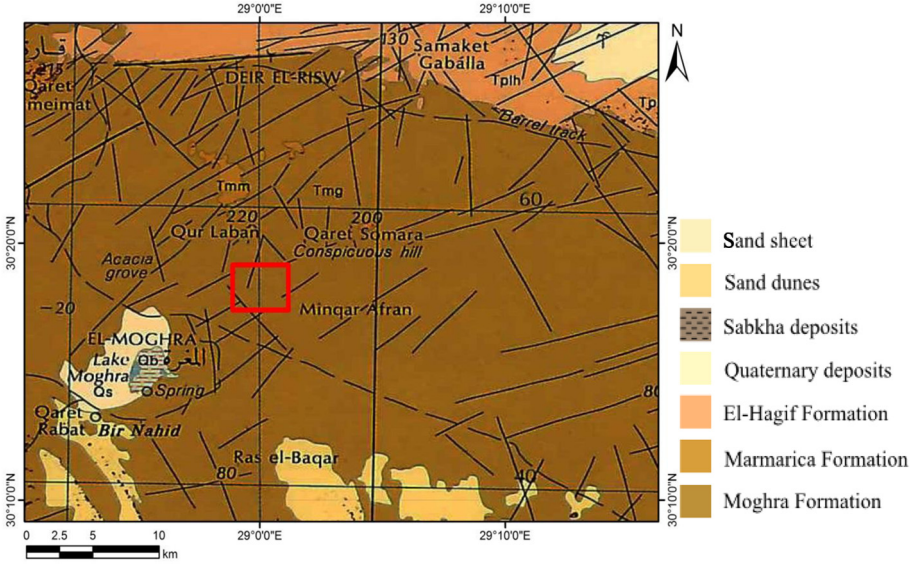

Fig. 3. Geological map of the study area (modified after Conoco, 1987) [13].