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Full length Article

Implementation of magnetic, gravity and resistivity data in identifying groundwater occurrences in El Qaa Plain area, Southern Sinai, Egypt

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ABSTRACT

El Qaa plain is one of the areas that have been proved to be promising as to its soil and groundwater resources in the southwestern part of Sinai. This study was carried out to study the lateral and vertical variations in the subsurface lithologic properties in El Qaa plain area and delineating the subsurface structure that affecting El Qaa plain depression. Gravity, magnetic data, fifty-one (51) vertical electrical sounding (Ves's) and Digital Elevation Model (DEM) map were used. Two-dimensional density modeling, analytical signal, tilt derivatives, Euler deconvolution techniques and interpretation of the resistivity data were applied on potential data. This study concluded that, El Qaa plain is a NE-SW depression confined by two normal faults and subdivided into five sedimentary units. Rock fragments and boulders derived to the plain from the surrounding highlands are the main components of the first surface unit that characterized by high resistivity values. This layer is overly another unit composed of gravelly sand with thickness ranging between 10 and 140 m. The third unit is composed mainly of sand with intercalations of clay with thickness ranging from 2 to 152 m. A Reefal limestone unit is a fourth unit interpreted from this study. The fifth unit is composed of clay. The water bearing formations in El Qaa Plain area are located principally in the second and the third layers. Finally, the depth to the basement surface ranges from 400 m to more than 1.5 km below sea level. Also, there are many minor structural trends interpreted from this study and affecting the El Qaa plain are striking in N–S, E–W and NE-SW directions.

1. Introduction

In the last decades, the strategic situation of Sinai attracted the government to set a national plan for its sustainable development. Since water is an important factor of this development, this study was carried out with the aim of defining the groundwater potentialities along El-Qaa plain area, lying in southwestern part of Sinai, parallel to the Gulf of Suez. So, it is planned to be an attractive new urban area in the forthcoming decades. It is mainly covered by sedimentary deposits belonging to Quaternary surrounded by igneous and metamorphic Pre-Cambrian rocks, and is separated from the Gulf of Suez by Gabal Qabaliat. Since, it is proposed that such flat areas witnesses developmental programs of land reclamation, agricultural and industrial plans. El Qaa plain basin has a thick aquifer that is contain paleowater and is getting indirect recent drain from eastern high highland areas. The El Qaa Plain composed mainly from alluvial sediments, sandstone and limestone. Most of the alluvial sediments originated from the erosion of southern Sinai hills act as the most promising area for oil and groundwater resources (Monier et al., 2003). The El Qaa plain extends for more than 120 km parallel to the margin of the Gulf of Suez, and is underlain by a half-graben structure trending in the NE-SW direction. It is located in the southwestern part of Sinai between latitudes 27° 55′ and 28° 55′ N and longitudes 33° 12′ and 34° 5′ E and extends along the southern section of the eastern coast of the Gulf of Suez (Fig. 1).

Many geophysical studies have been carried out in the past to understanding the groundwater potentiality of El Qaa plain area. Among these geophysical studies are (Webster and Riston, 1992; RIGWA 1982, 1986; El Refai, 1984; Shendy, 1984; Dames and Moore, 1985; Rizkalla, 1985; Abdel Rahman et al., 1987; Tealeb and Riad, 1987; Meshref and El-Kattan, 1989; Ibrahim and Ghoneimi, 1992; WRRI and JICA, 1999; Yousef, 2003; Rabeh et al., 2009; Massoud et al., 2010; Azab and El-Khadragy, 2013). These studies concluded that, the El Qaa plain is considered as a quaternary aquifer composed of gravel, sand, silt and clay. The eastern part of El Qaa plain is associated by Pre-Cambrian rock, while western side is characterized by carbonates and evaporites of Pre-Quaternary (Darwish and El Azaby, 1993; Khalil, 1998;

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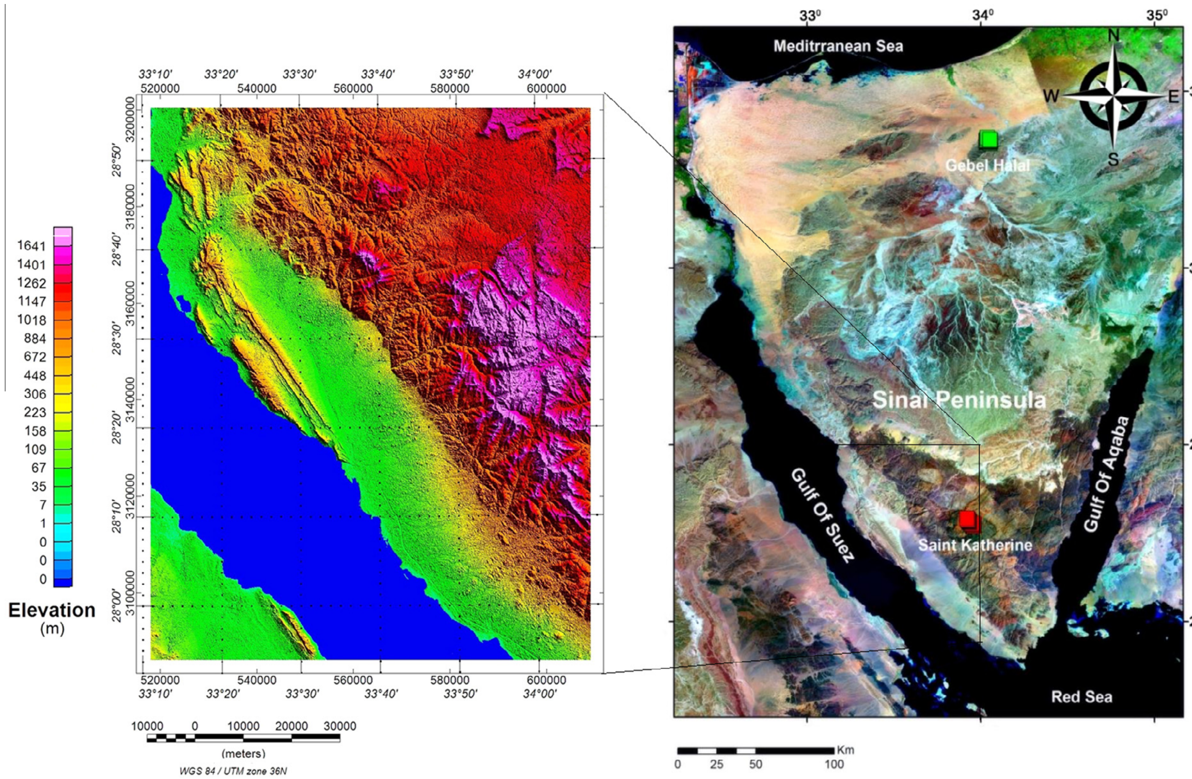

Fig. 1. (a) Location map of (Landsat ETM + Image) of Sinai Peninsula, showing the location of El Qaa plain Area in southwestern Sinai, and (b) location map of the study area superimposed on Digital Elevation Model map.

McClay et al., 1998; EGSMA, 2004; Sultan et al., 2013). The water resources in El Qaa plain area are very limited and need new discoveries in order to manage with the future demands. In most parts of the study area, the issue of delineating faults and fracture systems are not yet well understood, Many researchers have underlined the influence of faulting and fracture systems on the aquifer structure and groundwater movement. Groundwater movement through the fractures and faults is one of the least well understood areas of investigation in hydrogeology. The need to determine the location of fractures, faults or fault zones within soil or rock and to map their lateral and vertical extent is a common requirement for hydrogeologic projects.

The main objectives of the present work are to delineate the subsurface structural trends affecting the study area and its relation with the sedimentary cover, assess and evaluate the El Qaa Plain aquifer by identifying the different subsurface rock units that constitutes essentially the quaternary aquifer. This would be achieved through the following; (1) Recognizing the geology of the study area in view of the previous geological work; (2) Carrying out a detailed geo-electrical resistivity survey covering the study area to determine the aquifer geometry and characteristics; (3) Using the high resolution ground gravity and magnetic data and the available information of some drilled wells to determine the depth to the basement surface; (4) Recommending the sites of relatively high developmental potential as to groundwater resources.

2. Geologic and tectonic setting

In order to understand the structural style of Sinai, it is important to understand its tectonic setting and variation of such setting in space and time. The Sinai Peninsula is controlled by the Suez and Aqaba rifts which are the result of lithospheric plates divergence. They Gulf of Suez was created by extensional movements, whereas the Gulf of Aqaba was mainly formed by strike-slip movement with few extensional components (Ben Avraham et al., 1979; Garfunkel et al., 1981). The Gulf of Suez is composed of asymmetric half-grabens (Moustafa, 1976; Abdine, 1981) whereas, the Aqaba Gulf is considered as succession of pull-apart basin trending in the NNE-SSW direction. African, Arabian, Eurasian and Anatolian plates and their interaction in space and time is overprinted on the Sinai Peninsula. The rifting of the Red Sea and associated systems were initiated in the Oligocene by thermally driven uplift and domal arching of the Arabo-African Shield crust (Bannert, 1972). As a result of the rifting, the Arabian plate separated and moved northeast to collide with the Eurasian plate along the Taurus – Zagros mountain belt. The Arabian plate is also bounded on the northwest by the Aqaba-Dead Sea Rift system, which is the active boundary with the African plate (Fig. 2). This led to the northern Sinai is characterized by Cretaceous-Eocene folding and thrusting structural types (Syrian Arc System) during the rifting phase in the Gulf of Suez in the Oligocene-Miocene time whereas, the southern Sinai is dominated by strike-slip deformation in the Gulf of Aqaba from the Miocene to recent (Abdel Kader, 1990).

The geology of El Qaa plain area ranges in age from Pre-Cambrian basement rocks to Quaternary deposits (Fig. 3). The Pre-Cambrian basement complex in the southern Sinai formed from plate movements and adjustments between crust and mantle processes (Be'eri-Shlevin et al., 2009; Blasband et al., 2000; Cochran and Karner, 2007; Mahmoud et al., 2005; Meert, 2003). Pre-Cambrian igneous and metamorphic basement rocks belonging to the Arabian – Nubian Shield reaches an altitude of 2641 m (Gebel St. Katherine) in the south and are covered by a sedimentary succession in the north and becomes more recent toward the Mediterranean Sea. The western side of El Qaa plain is a graben