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Structural evolution and Cenozoic tectonostratigraphy of the Cairo-Suez district, north Eastern Desert of Egypt: Field-structural data from Gebel Qattamiya-Gebel Um Reheiat area

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ABSTRACT

Detailed field mapping reveals that continental rifting is strongly deforming the Gebel Qattamiya-Gebel Um Reheiat area and the entire Cairo-Suez district, in north Eastern Desert of Egypt. Rift-related structures are predominantly represented by E to WNW, NNW and NW oriented faults. The E to WNW oriented faults are small and build up the Gebel Qattamiya en echelon fault belt, whereas the faults trending NNW and NW establish a pervasive horst and graben structural style involving some rhomb-shape horsts as Gebel Qattamiya (GQRH), Gebel Um Reheiat (GURRH) and south Gebel Um Reheiat (SGURRH). Rock units of the Eocene succession and Oligocene sediments are well exposed and highly controlled by rift-related structures. Rifting was developed through two rift-phases; initial and major ones. The initial phase (a newly recognized phase in this contribution) has been occurred in Late Eocene (Priabonian), while the main phase was prevailing during Late Oligocene-Early Miocene time and is characterized by hydrothermal veins and basaltic eruptions. Continental transtension in the Cairo-Suez district, including the study area, was probably synchronous with a major tectonic stage (Pyrenean-Atlasic movement) of continental collision between African–Arabian and Eurasian plates in Late Eocene–Oligocene time.

Field investigation suggests that the transfer of displacement (slip) from the Gulf of Suez proto-rift into the E–W oriented faults "relays" is an important mechanism, which helps to explain the current structural framework and tectonic evolution of the Cairo-Suez district. Reactivation of such faults with right-lateral divergent wrenching with NE–SW oriented extension deformed the Cairo-Suez district with several E–W oriented en echelon fault belts (e.g. Gebel Qattamiya fault belt in the study area). Thus the Cairo-Suez district represents an accommodation or transfer zone in northeastern Egypt, intercepting the "far-field stresses" from the Arabian–Nubian Shield, the Red Sea-Gulf of Suez rift and the Maghrebian Shield.

1. Introduction

The passive continental margin of northern Egypt is related to Jurassic-Early Cretaceous rifting of the African–Arabian plate and the formation of E to ENE oriented faults (Moustafa and Khalil, 1988, 1989; May, 1991). The E–W to ENE-WSW oriented faults in northern Egypt, as a conspicuous part of the east Mediterranean passive continental margin, have experienced several phases of right-lateral wrenching during their tectonic history. Right-lateral wrenching in north Eastern Desert of Egypt, in particular, including the Cairo-Suez district (Fig. 1) was divergent (transtensional) and attributed to the transfer of a substantial amount of throw of the NW oriented faults from the Gulf of Suez rift into the north Eastern Desert (Moustafa et al., 1985; Moustafa and Abdallah, 1992).

On a regional scale, the importance of the Cairo-Suez district (including the study area) is attributed to its position as a segment of the Tethyan passive continental margin in the East Mediterranean region, which has been originated during the Jurassic-Early Cretaceous rifting of North Africa and Arabia (Argyriadis et al., 1980; May, 1991). Meanwhile, it acquires some local importance as it is lying in the northeastern Egypt between the Red Sea-Gulf of Suez rift and the Nile Delta-Eastern Mediterranean regions of active tectonics/seismotectonics (Mahmoud, 2003; Dahy, 2010).

Although the Cairo-Suez district was the subject of numerous

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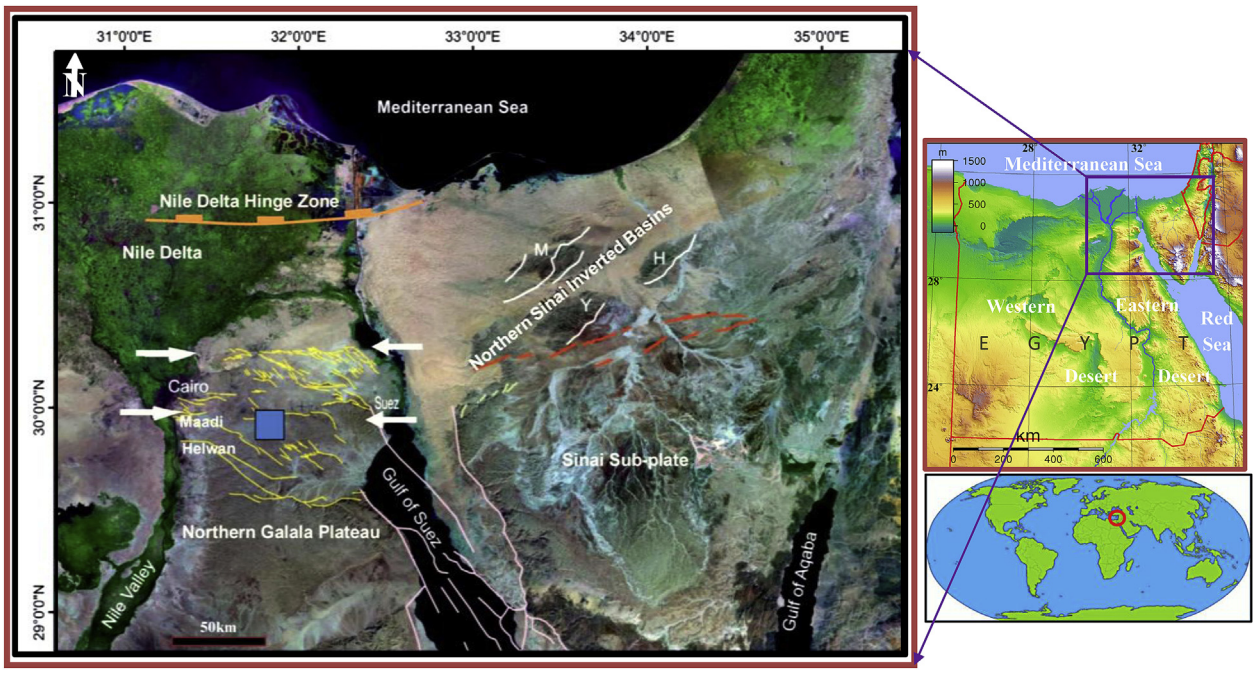

Fig. 1. Landsat ETM + mosaic showing the major structures deforming the northeastern part of Egypt: i) fault segments of the Sinai hinge belt (red lines) and the en echelon folds of Mitla Pass (green lines) after Moustafa et al. (2014), ii) normal faults (yellow lines) of the Cairo-Suez district (bounded by white arrows) after Said (1962) and Moustafa and Abdallah (1992), iii) major rift-bounded faults (pink lines) at the northern part of the Gulf of Suez rift after Patton et al. (1994) and Moustafa (2002), and iv) the Nile Delta hinge zone (orange line) after Hussein and Abdallah (2001). Realize the study area (a blue square) and the white lines show faults bounding the northern Sinai inverted basins (M. Gebel Maghara, Y. Gebel Yelleq, and H. Gebel Halal), after Moustafa (2010). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

studies concerning its regional geology and geotectonic (e.g. Said, 1962; Abdel Rahman and El Etr, 1979; Moustafa et al., 1985; Moustafa and Abdel Tawab, 1985; Moustafa and Abdallah, 1991; Abdallah, 1988, 1993; Khalil and Moustafa, 1994; Abdallah and Bakry, 1994; Hussein and Abdallah, 2001; Omran, 2006; Khalaf and Gaber, 2008; Dahy, 2010; Seleem and Aboulela, 2011; Hegazy et al., 2013; Sallam et al., 2015), detailed stratigraphy and structure have been accomplished for only few areas within its realm (e.g. Moustafa, 1975; Moustafa et al., 1983; Strougo, 1985; El Dawoody and Abdel Megaid, 1983; El Safori et al., 1997; El Bohoty and Mekkawi, 2005).

Gebel Qattamiya-Gebel Um Reheiat area is situated in the central part of the Cairo-Suez district, immediately to the south of the Cairo-Suez road (Figs. 1 and 2). It is delineated by latitudes 29° 51 30 and 29° 59 00 N and longitudes 31° 43 30 and 31° 53 00 E in the north Eastern Desert of Egypt, approximately in the midway between Cairo (to the west) and the Gulf of Suez (to the east), and covering an area of about 169 km^2.

Detailed field mapping of the Gebel Qattamiya-Gebel Um Reheiat area (blue square in Fig. 1) was achieved using Landsat TM and ETM + images (scale, 1:100,000) and aerial photo-mosaics (scale, 1:50,000) interpretation, beside the data acquired from the measured and studied lithostratigraphic sections. The different rift-related structures are recognized, analyzed and interpreted. In order to clarify the tectonostratigraphy and structural evolution of the Cairo-Suez district, the first detailed discussion of the geology and structure of the Gebel Qattamiya-Gebel Um Reheiat area, at the central part of the Cairo-Suez district of northeastern Egypt, is presented. This study presents a field based descriptions of the rift-related structures of the area, complemented by a lithostratigraphic investigation. It is to be demonstrated that rifting initiation in the Cairo-Suez district and most probably in the Gulf of Suez rift was started as early as Late Eocene (Priabonian) and was coeval with a phase of a continental collision between African–Arabian and Eurasian plates. Such initial phase was followed by a strong one in Late Oligocene-Early Miocene time, developing the previously formed rift-related structures. This contribution would return the attention to the timing of rifting in two of the most important regions in the northeastern part of the Eastern Desert of Egypt.

2. Regional geology and lithostratigraphy

The Cairo-Suez district can be subdivided into two large parts. The southern part consists of six slightly tilted faulted blocks build up mainly the Middle Eocene outcrops. These are Gebel Ataqa, Gebel Akheider-Gebel El Ramliya, Gebel Abu Treifiya-Gebel El Nugura, Gebel Qattamiya, Gebel Tura-Gebel Abu Shama and Gebel Mokattam (Fig. 2). However, the northern part is located to the north of the Cairo-Suez road and is dominated by gentle folds, deforming the Upper Eocene, Oligocene and Miocene strata (Khalil and Moustafa, 1994).

The district demonstrates successive reactivation of the E–W oriented deep-seated faults in Late Cretaceous, Miocene and post-Miocene times, and is also considered as the northwestern continuation of geologic structures of the Gulf of Suez rift (Hussein and Abdallah, 2001) and Sinai hinge belt (Moustafa et al., 2014) (Fig. 1).

The central part of the Cairo-Suez district consists of nearly parallel high mountainous ridges, which are trending E–W to NW–SE and bounding lowlands in between. The Middle Eocene rock units are essentially building up the high mountains and scarps, while the Upper Eocene and Oligocene sediments are filling up the structural and topographic lows. The Eocene succession of Gebel Qattamiya-Gebel Um Reheiat area comprises three main lithostratigraphic units, arranged from base to top: Observatory, Qurn and Maadi formations (Fig. 3). The Observatory and Qurn formations represent the Middle Eocene (Bartonian), whereas the Maadi Formation belongs to the Late Eocene (Priabonian). The