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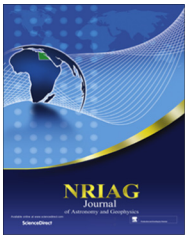

Earthquakes focal mechanism and stress field pattern in the northeastern part of Egypt

Emad K. Mohamed [a,*], **A. Hassoup** [a], **Abou Elenean K.M.** [a], **Adel A.A. Othman** [b], **Diaa-Eldin M.K. Hamed** [b]

[a] *National Research Institute of Astronomy and Geophysics (NRIAG), 11421 Helwan, Cairo, Egypt*
[b] *Faculty of Science, Al-Azhar University, Cairo, Egypt*

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Abstract Egypt is characterized by moderate size seismicity where earthquakes are distributed within several active regions. In the present study, we investigated the source mechanism of earthquakes using the digital waveform data recorded by the Egyptian National Seismic Network (ENSN) during the period from 2004 to 2008. The focal mechanisms are constructed with high reliability based on the polarity of the first motion of P-wave.

These solutions are used to examine the mode of tectonic deformation and the present-day stress field pattern affecting on different tectonic provinces in the northern part of Egypt. The results demonstrate mainly a normal faulting mechanism with minor strike slip component generally trending parallel to the northern Red Sea, the Suez rift, Aqaba rift with their connection with the great rift system of the Red Sea and the Gulf of Suez and Cairo-Alexandria trend.

The inversion technique scheme is used also in the present study for determining the regional stress field parameters for earthquake focal mechanism solutions based on the grid search method of Gephart and Forsyth (1984). The Results of the stress tensor using focal mechanisms of recent earthquakes show a prevailed tension stress field in N52°E, N41°E and N52°E for the northern Red Sea, Gulf of Suez and Gulf of Aqaba zone respectively.

1. Introduction

The northern part of Egypt is affected by tectonic movements along a number of plate tectonic boundaries. Thus, significant seismic activity is generated due to the relative motions between these three plates (African, Arabian and Eurasia plates). In this study, we focus on the area extending from 27°N to 31°N latitudes and 32°E to 36°E longitudes, which includes as few distinct regions (the Northern Red Sea, Gulf

* Corresponding author.
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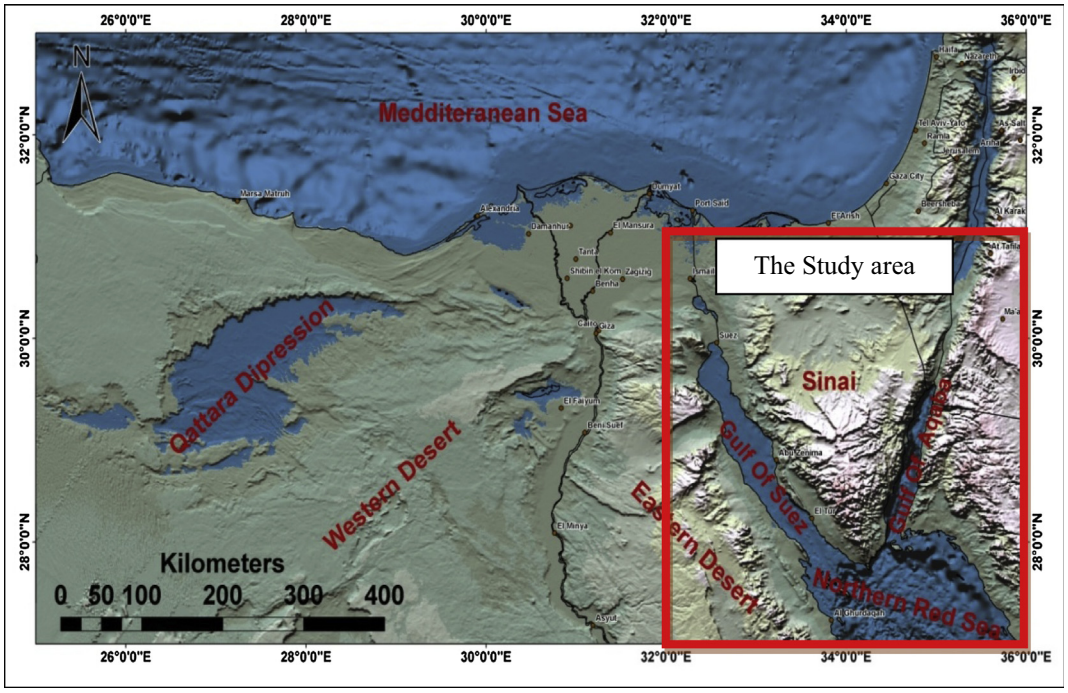

Figure 1 Location map of the study area.

of Suez, Gulf of Aqaba and Sinai Peninsula), as it is shown in Fig. 1.

The northern part of Egypt plays an important role in both historical and recent seismicity. Historically, few events have been reported very close to the Suez–Cairo district. The closer ones are that of 2200 BC (intensity = VII; macro seismic magnitude M_F = 5.4) and the destructive earthquake which occurred at the apex of the Suez Gulf in October, 1754 with intensity ranges ~VII–IX and M_F of 6.6 (Ambraseys et al., 1994). The large earthquakes are known to occur at larger distances along the northern Red Sea and the Gulf of Suez (e.g., the Shadwan earthquake in 1969 (M_W = 6.9); the Gulf of Aqaba earthquake in 1995 (M_W = 7.3) as well as in the Mediterranean offshore (i.e., the Alexandria earthquake in 1955 (M_S = 6.8); and the Cyprus earthquake in 1996 (M_W = 6.8). Instrumental seismicity from November 1997 to December 2009 shows few small-moderate size events with magnitudes up to M_L = 5 in this active area that are well recorded by the Egyptian National Seismic Network (ENSN) Bulletin (1997–2009).

There are several methods used for determining focal mechanism solutions (FMSs) such as polarity of P-wave first motion, amplitude ratio of S waves (e.g. Khattri, 1973), the analysis of P/S amplitude ratios (e.g. Kisslinger et al., 1981) and moment tensor inversion (e.g., Stein and Wysession, 2003). All these methods used the radiation pattern of seismic rays that expresses the orientation of the active fault and the slip direction.

In the present study we determined the focal mechanism solutions based on the polarity of P-wave first motion where constructed for a set of earthquakes that occurred during the period 2004–2008 in order to evaluate the stress field pattern affecting on the area of study using the digital waveform data recorded by the Egyptian National Seismic Network (ENSN) Fig. 2.

Knowledge of the stress field in a region is an important tool to understand local and regional effects induced by large-scale plate tectonics and the subsequent deformation field. According to the objects used to retrieve the stress field, different time periods are sampled. On one hand, slickensides measured on a sedimentary or crystalline outcrop describe the whole tectonic history experienced by the region. On the other hand, seismological data give an instantaneous picture of the present-day stress field. For example, Lund and Slunga (1999) presented stress tensor inversion based on detailed micro-earthquakes data in southwest Iceland. Together with accurate relative location, it was possible to assign a common fault plane to a cluster of events. In this paper, the direction and the shape of the stress tensor in the Northern Red Sea, Gulf of Suez and Gulf of Aqaba were determined from the seismological data, providing us with the present-day average state of stress prevailing in the region.

2. Geological and tectonic setting

The Study area is a part of the northern African continent. Egypt forms the northeast corner of Africa and is bounded by three active tectonic margins: the African–Eurasian plate margin; the Red Sea plate margin; and the Levant-Dead Sea transform fault. Three main tectonic deformations affecting northern Egypt are Jurassic-Early Cretaceous rifting, Late Cretaceous-Early Tertiary wrenching, and Miocene and post-Miocene extension. The tectonics of northern Egypt has been developed depending on detailed subsurface studies of the authors (Abdel Aal et al., 1994; Mosconi et al., 1996). Generally the major part of tectonic deformation within Egypt is remote and took place along those margins mentioned before (the African–Eurasian plate margin; the Red Sea plate margin; and the Levant-Dead Sea transform fault) as revealed by an