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Rift-related active fault-system and a direction of maximum horizontal stress in the Cairo-Suez district, northeastern Egypt: A new approach from EMR-Technique and Cerescope data

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ABSTRACT

An active fault system has been detected along the Cairo-Suez district in northeastern Egypt, applying the EMR-Technique using Cerescope. The E-W (old Mediterranean) and NW-SE (Red Sea-Gulf of Suez) fault-trends are estimated to have ongoing activity. Horizontal EMR-measurements indicate a NW to NNW orientation as a maximum horizontal stress direction (σ_1), whereas an E-W orientation to has a secondary tendency. A simplified stress map for the Cairo-Suez district is constructed from the horizontal stress data measured at about 20 locations within the district. The mapped stresses will contribute to the stress data of the Cairo-Suez region on the world stress map (WSM). The present study results indicate rejuvenation of the inherited Mesozoic E-W oriented and Oligocene-Miocene rift-related NW-SE oriented faults. The transfer of rift-related deformation from Red Sea-Gulf of Suez region, which is currently undergoing an extensional stress regime in NE to NNE direction, would explain a seismotectonic activity of the Cairo-Suez district. These results are consistent with a present day NNW oriented compressional stresses attributed to a convergence between the African and Eurasian plates.

1. Introduction

Natural electromagnetic radiation (EMR) has gained much attention in the fields of material and geosciences. Since EMR precedes rock failure, it is used in geosciences to determine directions of crustal stress, and to detect faults. The source mechanisms of natural EMR are diverse and the laboratory studies indicate micro-cracking as one of these mechanisms (Frid et al., 2003; Bahat et al., 2005; Rabinovitch et al., 2007). Crack-related EMR-emissions have directional properties and their maximum intensities are parallel to the direction of growth of micro-crack. Since micro-crack orientation is controlled by the surrounding stress field, a measurement of the directional properties of the associated EMR in the field offers a chance to determine the maximum horizontal stress direction σ_H.

The electromagnetic radiation (EMR) technique is a tool that enables investigation of geological structures and related stress patterns in a fast and easy way. The technique is based on the property that the brittle materials emit electromagnetic energy when subject to mechanical stresses. Little effort has been used to analyze the micro-mechanical background and to test applicability of this phenomenon in the field of structural geology. Hence, most investigations have focused on the processes generate the EMR in laboratory experiments (Misra and Gosh, 1980; Slifkin, 1993). Today, among other possible processes, micro-crack-related charge transfer is assumed to be the main source of the EMR (O'Keefe and Thiel, 1995; Gershenzon et al., 1986; Koktavy et al., 2004). The surface vibrational-wave model SVW of Frid et al. (2003) and Rabinovitch et al. (2007) explains the generation of EMR independent of the material and the directional properties of the emitted electromagnetic waves, which are the main characteristics of a source mechanism. Furthermore, the SVW model meets the investigations of Frid et al. (1999), Rabinovitch et al. (2000, 2002) and Takeuchi and Nagahama (2006) that are able to link the properties of the measured EMR waves with the crack dimensions and the material properties. For basic facts on EMR and its application in structural geology and neotectonics, it is recommended to read the valuable works of Bahat et al. (2005), Lichtenberger (2006a) and Greiling and Obermeyer (2010).

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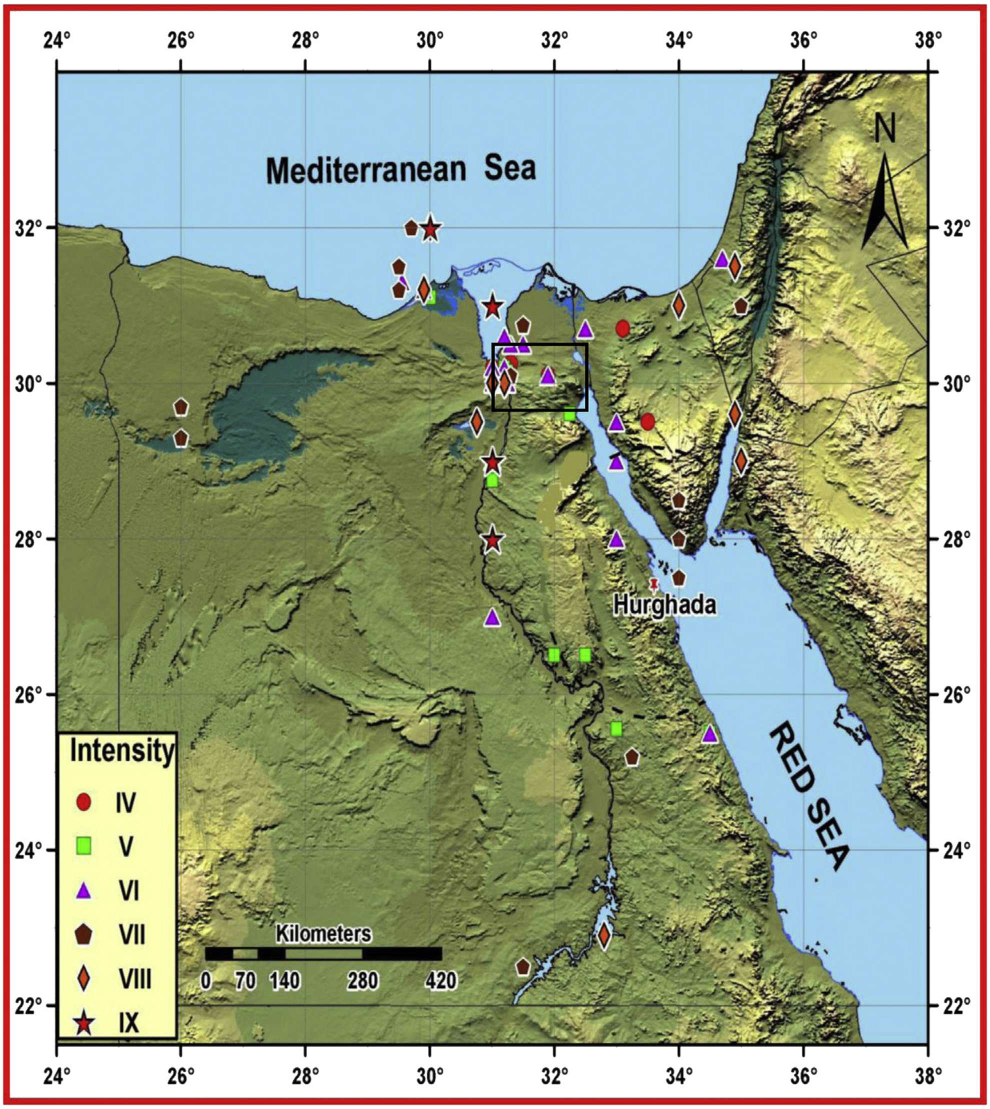

Fig. 1. Location map of the study area (a black rectangle) and review of historical earthquakes registered from 2200 BCE to 1900 AD, collected from Poirer and Taher (1980), Maamoun et al. (1984) and Ambraseys et al. (1994).

The previous publications based on the EMR-Technique and Cerescope are: Reuther et al. (2002), Lichtenberger (2005, 2006 a,b), Mallik et al. (2008), Reuther and Moser (2007) and Hagag and Obermeyer (2016).

The current study aims at detection of a currently active fault system and identification of a maximum horizontal stress direction (σ_H) along the Cairo-Suez district in northeastern Egypt (Fig. 1). It has been conducted using a Cerescope device and applying the EMR-Technique. A stress map for the Cairo-Suez district was achieved to fill a gap in maximum horizontal stress data, through this important region, on the world stress map (WSM). Reactivation of the E-W oriented deep-seated (basement) faults along the Cairo-Suez district, due to the transfer of deformation (slip-movements) from the Red Sea-Gulf of Suez active rift system (Moustafa and Abdallah, 1991; Moustafa et al., 1998), and its direct impact on a seismogenic activity and a seismic risk (earthquake activity) inside the district will be addressed in some detail. The present study considered a first attempt to apply the EMR-technique using a Cerescope device in a near surface detection, investigation and mapping of active faults in this region from northern Egypt. We hope for the present work to help much in deciphering the active neotectonics in Cairo-Suez district and in a passive continental margin of northern Egypt.

2. Methodology

2.1. The Cerescope

EMR-measurements are performed with the Cerescope (Fig. 2), a portable device developed by the Ceres GmbH Staffort/Baden in cooperation with the Department of Applied Geology (Karlsruhe Institute of Technology) and the company 'Slawische Brücke' in Dnjeprpetrowsk under supervision of Prof. Dr. W. Dachroth and Dr. H. Obermeyer. The Cerescope is manufactured today in the (GE&O) 'Company of Exploration and Radiolocation' Karlsruhe by Dr. H. Obermeyer. The Cerescope is composed of a beam antenna and a receiver with a frequency ranging from 5 kHz to 50 kHz. The antenna of 30 cm length is adjusted to this frequency range and is most sensitive to a frequency of 12.8 kHz. It is most sensitive to the h-component of an electromagnetic field (Fig. 3) so that the