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Regional structural mapping using a combined geological and geophysical approach – A preliminary study at Cairo-Suez district, Egypt

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ABSTRACT

Contrary to the usual application of individual geological and/or geophysical surveys, this paper represented a sequential use of surface structural mapping and DCR method to afford a sensible structural model in a cost effective way. Understanding the geological setting of a non-mapped area at the central part of Cairo-Suez District (CSD), Egypt, is an immediate engineering concern due to its complex deformation history. Field work is carried out to measure stratigraphic sections and establish structural characteristics of the rock units. Surface geophysical DCR sounding and electrical resistivity tomography (ERT) surveys are performed. To overcome the non-uniqueness problem of DCR interpretation, the available borehole data, detailed surface geological measurements and a sequential use of linear and non-linear inversion algorithms are applied. The practical benefits of detailed surface structural mapping are demonstrating in considering all geological parameters to a conceptual subsurface model, which would have not been identified or misinterpreted otherwise. In an integrative approach, such detailed surface data allow us to confirm the uncertain inferred regional subsurface structures based on DCR data inversion. For detailed subsurface structural characterization, the results of ERTs using coarse triangular mesh and iteratively reweighted algorithm show a good agreement with prior known surface and underground structural features. Additionally, ERTs significantly resolve the complex geological features, which constitute uncertain structures in the surface structural model. The main impact of presented integrative approach is to (i) constraint the DCR data interpretation and (ii) inform a preliminary study plan of regional structural investigation, which can be used as a platform for engineering decision –making and/or further detailed geophysical and geotechnical investigations.

1. Introduction

Nowadays, urbanization and development are becoming so rapid. On the other hand, the intensive urban growth can magnify the geo-environmental hazards. Accordingly, characterization of subsurface structures is prerequisite for development, foundation and civil engineering. In the northeastern part of Egypt, the Cairo-Suez District (CSD) represents a part of the unstable shelf units, which comprise the greater part of northern Egypt (Fig. 1a). This mobile shelf reflects a disturbance in tectonics and, consequently, structural highs and lows can be well-observed (e.g. Gebel Ataqa; Abu Treifiya; Gebel El-Qattamiya; Gebel Nasuri; Gebel Abu Shama; Gebel Mokattam). Structurally, CSD represents a part of two main fault belts (Fig. 1a) which are called Mokattam (MK)-Nasuri (N) and Maadi (MD)-Qattamyia (Q) (Moustafa and Abd-Allah, 1991). Recently, the CSD represents one of the most important locations in Egypt for major infrastructure projects and urbanization expansion. The predominant factor in terms of engineering hazard is generally related to moderate size earthquakes occurrence at short distances (Fig. 1a). Accordingly, understanding the impact of fault rupture hazards on the communities and constructions is (i) an immediate engineering concern (IEC) and (ii) essential for informing future science and policy directions. Fig. 1a indicates a general agreement that CSD represents a zone of low to moderate seismicity (e.g. Hussein et al., 2013), which is compiled from the National Earthquake Information Center (NEIC, 2016), the International Seismological Center (ISC, 2016), and published data (e.g. Abou Elenean et al., 2010; Grünthal and Wahlström, 2012). Moreover, the CSD is

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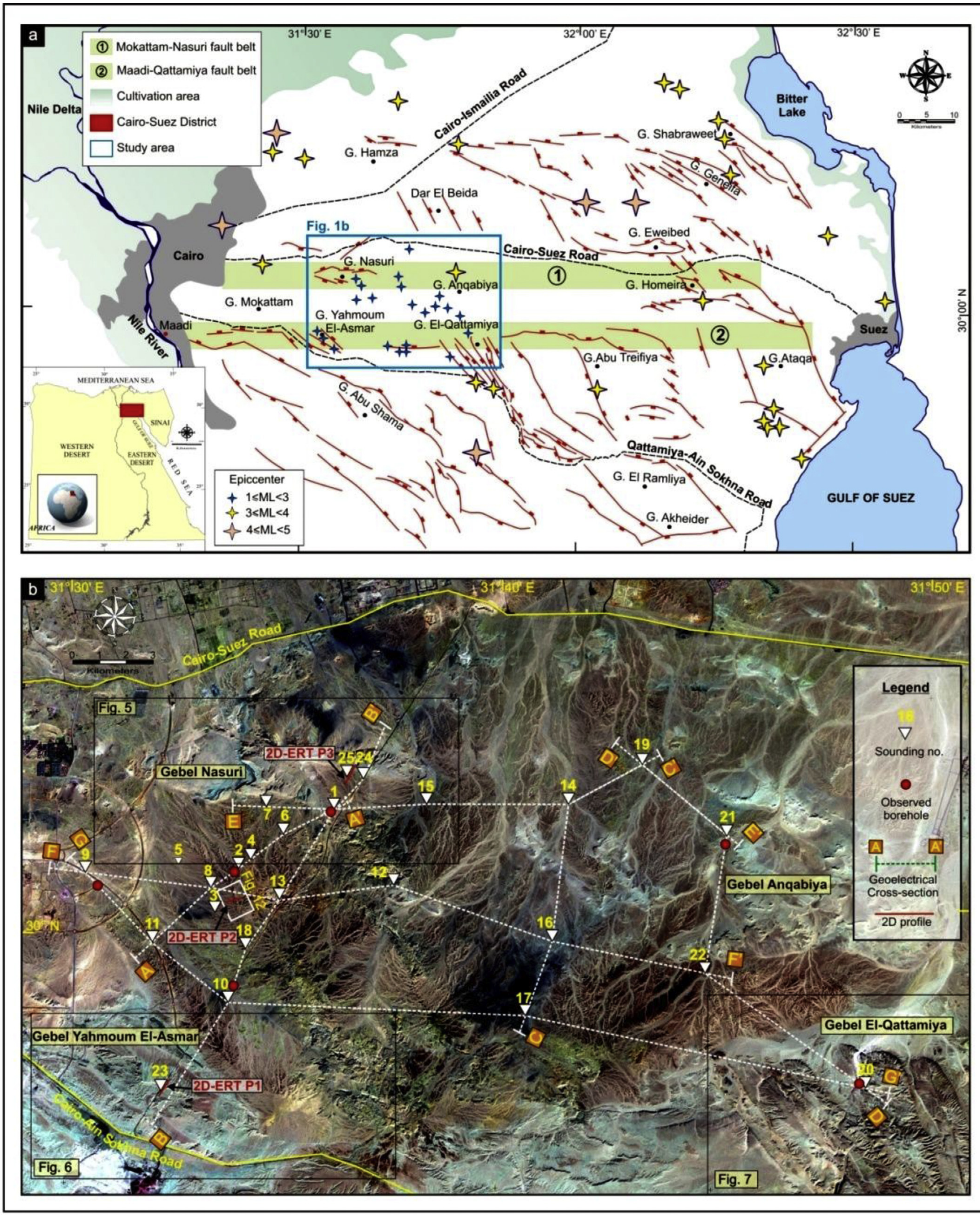

Fig. 1. (a) Simplified tectonic map of Cairo-Suez District (CSD), the compiled major structures (compiled from Moustafa et al., 1985; Moustafa and Abd-Allah, 1991; e.g. Maqbool et al., 2014; present study), and earthquake epicenters (stars). (b) Color composite Landsat ETM^{+} image of bands 7, 4, 2 as RGB shows the locations of the structural highs of the study area, DC resistivity soundings and ERTs, observed boreholes and constructed geoelectrical cross-sections in relation to the structural highs. The different rock units of the study area are displayed as follows: Middle Eocene rocks: brown; Upper Eocene rocks: blush green; Oligocene sand and gravels: olive to brown; Oligo-Miocene Basalt: black; Marine Miocene: light green; Non-marine Miocene: light brown; and Pliocene to Recent: brownish orange. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)