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The northern Egyptian continental margin

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ABSTRACT

Africa displays a variety of continental margin structures, tectonics and sedimentary records. The northern Egyptian continental margin represents the NE portion of the North African passive continental margin. Economically, this region is of great importance as a very rich and productive hydrocarbon zone in Egypt. Moreover, it is characterized by remarkable tectonic setting accompanied by active tectonic processes from the old Tethys to recent Mediterranean. In this article, seismicity of the northern Egyptian continental margin has been re-evaluated for more than 100-years and the source parameters of three recent earthquakes (October 2012, January 2013 and July 2013) have been estimated. Moment tensor inversions of 19th October 2012 and 17th January 2013 earthquakes reveal normal faulting mechanism with strike–slip component having seismic moment of 3.5E16 N m and 4.3E15 N m respectively.

The operation of the Egyptian National Seismic Network (ENSN) since the end of 1997 has significantly enhanced the old picture of earthquake activity across northern Egyptian continental margin whereas; the record-ability (annual rate) has changed from 2-events/year to 54-event/year before and after ENSN respectively. The spatial distribution of earthquakes foci indicated that the activity tends to cluster at three zones: Mediterranean Ridge (MR), Nile Cone (NC) and Eratosthenes Seamount (ERS). However, two seismic gaps are reported along Levant Basin (LEV) and Herodotus Basin (HER).

1. Introduction

The eastern Mediterranean Sea is characterized by high earthquake activity (Fig. 1) and a complex tectonic setting which is not fully understood yet. Several geodynamic models have been developed to explain the processes in this region (Makris, 1976; Le Pichon et al., 1982; McKenzie, 1970, 1972; Badawy, 1996; Badawy and Horváth, 1999a,b). Still the subduction process south of Crete, crustal structure below the Mediterranean Ridge (MR) and deep structure of the North African passive margin remain poorly understood. The geophysical data especially for the African margin are limited to potential fields and some industrial reflection seismic lines. From reflection seismic experiments (Chaumillon et al., 1996) at the southern edge of the Mediterranean Ridge (MR) a back-thrusting tectonic structure in the sediments was identified in the southward direction. This confirms the MR as an accretionary complex (Le Pichon et al., 1982; Ryan et al., 1982; Mascle et al., 1995) but it is not yet clear if and how far this back-thrusting reaches onto the African continental margin. Furthermore, the question arises how far the extant compression affects a tectonization of the African continental margin.

To investigate these questions and better understanding the geodynamic processes of the North Egyptian continental margin, the earthquake activities for more than 100-years has been re-evaluated. Source mechanism solutions for eight earthquakes have been investigated to shed some lights on the present-day stress regime affecting the north Egyptian continental margin. Source parameters and moment tensor of the recent felt and recorded earthquakes (October 2012, January 2013 and July 2013) have been estimated.

The northern Egyptian continental margin has suffered from historical and instrumental earthquakes (Maamoun et al., 1984; Ambraseys et al., 1994). Two historical earthquakes were widely notable in 320 and 956 A.D. (Badawy, 1999). These events were damaged numerous houses in Alexandria with maximum intensity VI on MSK scale (Ambraseys et al., 1994). Before the operation of the Egyptian National Seismological Network (ENSN) in 1997, the margin appears to be characterized by sparse activity and the only known and significant earthquake to have occurred offshore of Alexandria was 12 September, 1955 with surface magnitude of 6.7 (Fig. 2). The total reported earthquakes along the northern Egyptian margin (31–34N, 25–35E) throughout 98-years were only 225 (3-events with magnitude more than 5; 37-events from 3 to 5

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and 185-events less than 3) events with an annual rate of 2-events/year.

By the installation of ENSN the old picture of the northern Egyptian margin has totally enhanced, whereas, the annual activity rate has been jumped to 54-event/year with total recorded 864 (7-events with magnitude more than 5; 154-events from 3 to 5 and 703-events less than 3) events within 16-years period. Almost of earthquake activities tend to clustered at three zones (Fig. 2) the Mediterranean Ridge (MR), Nile Cone (NC) and the Eratosthenes Seamount (ERS). Along Levant Basin (LEV) and Herodotus Basin (HER) two seismic gaps are notable observed. Korrat et al. (2005) reported that although this region appears to be characterized by a sparse activity, there is a marked concentration of seismic activity in the Nile Cone (NC) before and after ENSN's installation.

Source mechanism solutions have proven to be of great value in defining the nature of earthquake faulting and its causative stresses. Instrumental recordings provide an ever expanding source of data for understanding earthquakes and source characterizations. The insufficient coverage of seismic stations and low seismicity until ENSN limit the number of source mechanism solutions that can be obtained for the northern Egyptian continental margin. Only eight earthquakes have sufficient data for source mechanism solutions (Fig. 2). For these events we gathered all available records and information from ISC and ENSN bulletins.

The source mechanism solutions in the northern Egyptian continental margin (Fig. 2) reflect the variety of mechanisms from site to site between normal and reverse with strike–slip component mechanisms. All solutions demonstrate that the present-day compressional stress related to the movement between African and Eurasian plates and represented by normal faulting mechanism (63%) along NNW trend and reverse faulting mechanism (37%) along ENE–WSW trend (Fig. 2). The northern Egyptian continental margin represents the transition zone between the continental–Oceanic crusts where the stress field changes from dominated tension on the Egyptian land to compression along the Hellenic Arc zone. The present-day stress regime affecting the northern Egyptian continental margin, where maximum compressional stress is oriented N to N30°W, comprise normal faulting trending nearly in the same direction and re-activated reverse faults in the perpendicular direction (Sofratom Group, 1984).

2. Geological and tectonics setting

The regional geology of the Egyptian continental margin was subject of numerous investigations since it forms a significant structural unit in tectonic framework of north Africa and eastern Mediterranean. The Egyptian continental margin considered as a remnant the Mesozoic Neo–Tethys Ocean and opened several rifting stages in the Triassic (Garfunkel, 1998, 2004; Robertson, 1998). It is characterized by nine identified geomorphological land types: beach and coastal flat, coastal dunes, agricultural deltaic land, sabkhas, fish farms, Manzala lagoon, saltpans, marshes and urban centers (EL-Banna and Frihy, 2009). The Egyptian continental margin is located to the south of the folded arc (Fig. 3) forming the Mediterranean Ridge (MR), where the sea floor is occupied by

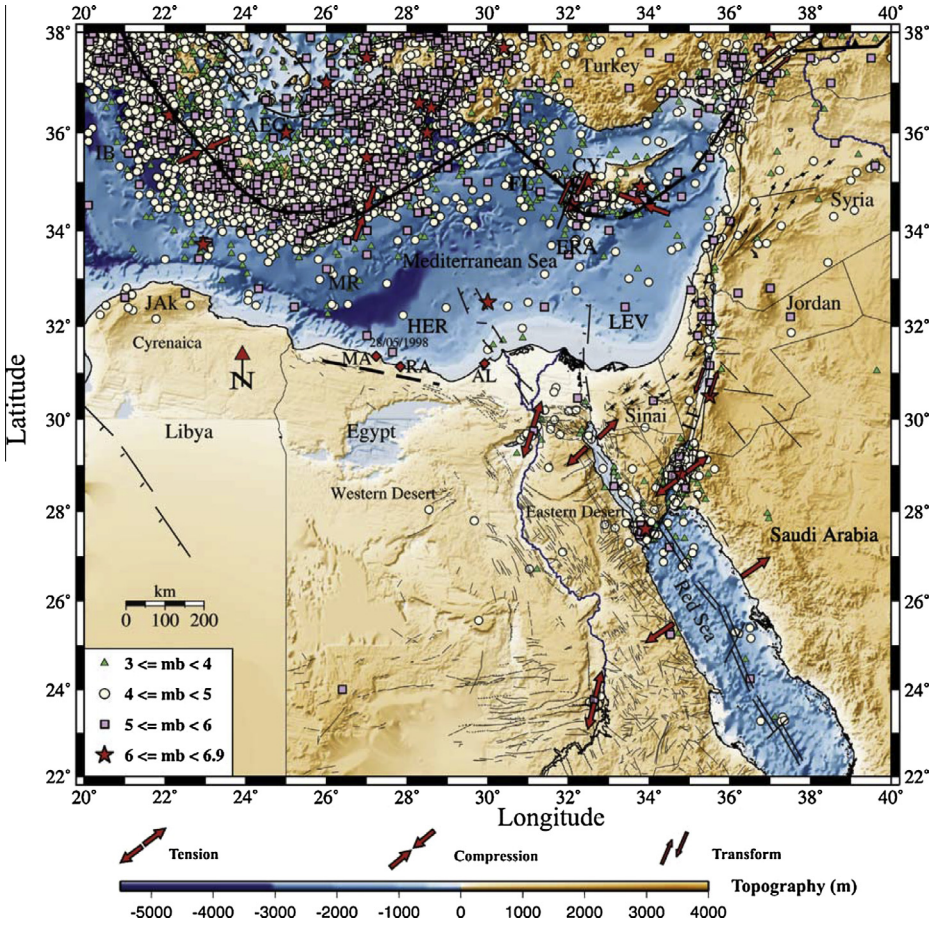

Fig. 1. Seismicity of the Eastern Mediterranean Region. Acronyms: AEG = Aegean Sea; Al = Alexandria City; CY = Cyprus; ERA = Eratosthenes Seamount; FL = Florence; IB = Ionian Basin; MR = Mediterranean Ridge; LEV = Levantine Basin; LF = Levant Fault; RA = Ras El Hikma Village; MA = Marsa Matruh City; JAK = Jebel Al Akhdar (from Abo Elenin and Hussein, 2007).