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Gulfs of Suez and Aqaba: New insights from recent satellite-marine potential field data

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ABSTRACT

Previous models and interpretations of crustal geometry and the nature of the crust under the Gulfs of Suez and Aqaba have generally been based on a local or small scale and have been limited due to a lack of data. The few studies that present larger scale crustal and uppermost mantle structure were dependent on one type of data with no consideration of other geological and/or geophysical features. Satellite-marine potential field data provide for the first time a full coverage dataset of the Gulfs of Suez and Aqaba as well as the Sinai area at the same scale which allows for a better understanding of crustal domains and geometry and the interplay between tectonic events. To that end, our forward models of magnetic and gravity data constrained by seismic data and available geological information in this area suggest that the crustal domains in the Gulf of Aqaba are more complicated than those in the Gulf of Suez. Our result supports continental rifting under most of the Gulf of Suez and a combination of transitional and continental crusts under the Gulf of Aqaba. Yet, there is no evidence of oceanic segment development in these gulfs. Regardless of oceanic or transitional crust, the models support a link between the Arabia and Sinai plates at the central Gulf of Aqaba. The data also support that Red Sea tectonism has no connection to or influence on both gulfs. The result suggests a continuation of lithological elements from land into the eastern part of the Gulf of Suez. Our synthesis and interpretations may play an important role in the reassessment of the tectonic history and extension of this important rift system.

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1. Introduction

The Gulf of Suez (GOS) and the Gulf of Aqaba (GOA) represent the northern arms of the Red Sea and are separated by the triangular promontory of Sinai (Fig. 1). The evolution of the Gulfs of Suez and Aqaba is important in understanding geotectonic processes in the Red Sea and adjacent areas (e.g., Rihm et al., 1991). The area represents an ideal location to study the consequences of the Dead Sea rift (DSR) or transform (DST) faulting because it is a modern and active structure (e.g., Ehrhardt et al., 2005; Noda, 2013). Three evolutionary stages have been recognized in this region including (1) the development of the northern Red Sea and GOS trough, (2) rift subsidence, and (3) the onset of the tectonic plate boundary known as the Gulf of Aqaba-Dead Sea Rift which reflects a major change in regional plate kinematics (e.g., Girdler and Southern, 1987; Le Pichon and Gaulier, 1988; Bosworth et al., 2005). The GOS links the Red Sea to the Mediterranean Sea whereas the GOA connects the extensional Red Sea to the collisional Taurise region (e.g., Barjous and Mikbel, 1990; Beydoun, 1999). Stratigraphic units in this region are mainly divided into three major units: pre-rift (Precambrian to Eocene), syn-rift (Oligocene? to Miocene) and post-rift (Pliocene to Recent) (e.g., Bosworth et al., 2005; Abd-Allah et al., 2014). A uniquely exposed stratigraphic section from basement to Upper Miocene has been reported in the Midyan area between the GOA and the Red Sea footwall uplifts (e.g., Tubbs et al., 2014).

The development of the two gulfs at the northern end of the Red Sea has occurred in different stages (e.g., Abdeen and Abdelmaksoud, 2014). The location was a zone of structural weakness during the Pan-African orogeny but major events that led to the current shape of the gulfs were taking place during the last 24 Ma (Fig. 2) (e.g., Khalil and McClay, 2001). These events involve oblique collision between the Arabia and Eurasia plates during closure of the Neo-Tethys and major strike-slip movement that led to a transform plate boundary system which forms the northwest boundary of the Arabian Plate (e.g., Beydoun, 1999; Bosworth et al.,

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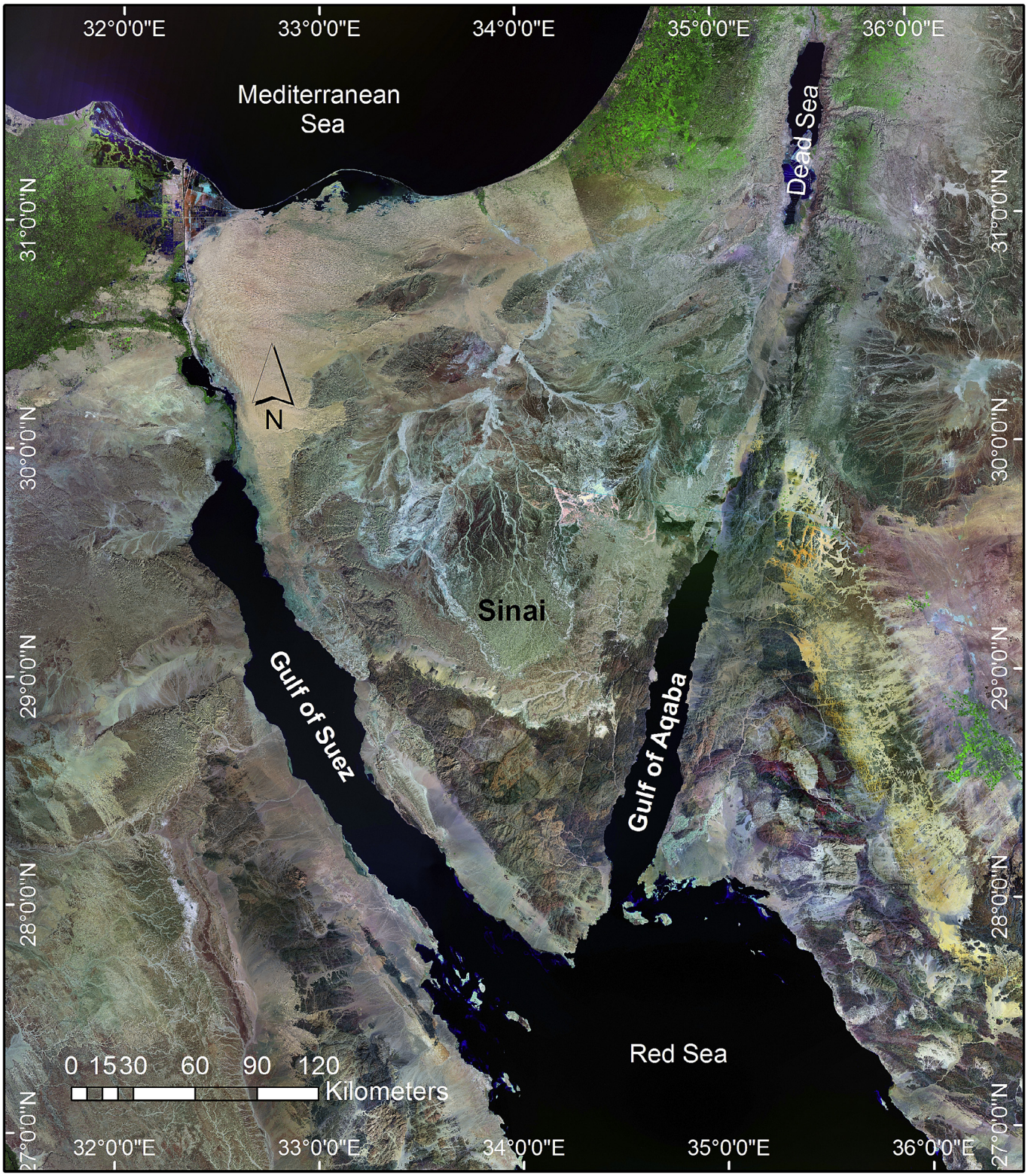

Fig. 1. Landsat imagery of the study area showing the current location of the rift system structure and configuration.

2005). Extension in the GOA and southern GOS has remained active during the Quaternary to the present supported by seismic activity (e.g., Daggett et al., 1986; Jackson et al., 1988). Another important feature of this region is the bounding sub-plate or micro-plate "Sinai" which is locked between the Arabian and African plates and the Anatolian-Aegean micro-plate (e.g., Mascle et al., 2000; Pietrantonio et al., 2016). However, the boundaries and kinematics of the Sinai sub-plate are still in doubt (e.g., Badawy, and Horváth, 1999; Mascle et al., 2000).

It is generally agreed that the location of the GOS was part of the

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