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Morphotectonics of Kid drainage basin, Southeastern Sinai: A landscape evolution coeval to Gulf of Aqaba – Dead Sea rifting

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ABSTRACT

The Pleistocene fluvio-tectonic conditions have shaped the landscapes of Sinai Peninsula through development of small sedimentary traps following preexisting lineaments. In the Gulf of Aqaba region, orientation of these lineaments with respect to the Pleistocene stress field develops strike-slip simple and dip-slip pure extensional shear models that induced rifting of the Gulf of Aqaba – Dead Sea fault system. The Beida and Nabq grabens are two major rift-related depressions at the southwestern coast of the Gulf of Aqaba region. Both grabens are landscapes that received alluvial sediments of the Kid drainage basin (KDB), which is one of the largest drainage systems in the western region of the Gulf of Aqaba fault-scarp. The Beida graben is formed at a horse tail structure next to Abiad and Kid faults, while the Nabq graben is a pull-apart structure formed as onshore continuation of the Dakar deep. The geometry and origin of these landscapes are the intrinsic themes of this study to investigate the morphotectonic evolution of the KDB terrain within the tectonic framework of the Gulf of Aqaba – Dead Sea rift.

The hanging terraces and canyons being at higher elevations on the Gulf of Aqaba fault-scarp; and the accumulation of younger alluvial fans, talus cones and bajada on its footslope indicate that the KDB landscape is basically shaped; and evolutionary modified by hinterland uplifting of the Gulf of Aqaba region. Hence, two morphotectonic evolution periods of the KDB terrain coincide with the early NE- and late NNE-trending extensional Pleistocene axes. The early period started with deposition of the older alluvial fan sediments that emerged at the outlet of KDB, and partially buried the Gulf of Aqaba fault-scarp. Subsequent hinterland uplifting revived the Gulf of Aqaba fault-scarp with development of hanging alluvial and bed-rock terraces; and the older alluvial fan sediments are uplifted on the footwall of southward-dipping normal faults whose hanging-wall received sediments of younger alluvial fans. Nature of the sediments constituting the Quaternary paleolakes and rift-related depressions, and their structural settings in Sinai, indicate that the Sinai terrain is basically shaped by crustal uplifting of the southern Sinai massif with severe rifting at the Gulf of Aqaba region.

1. Introduction

The morphotectonic evolution of landforms developed in regions of active deformations shows interplays between tectonic and fluvial processes (Simoni et al., 2003; Koral et al., 2009; Elsheikh et al., 2011). In an extensional terrain, endogenic processes induce crustal uplifting that influences geometries of drainage systems and depressions, which are destinations of surface runoffs of fluvial systems (Jaboyedoff et al., 2003; Maroukian et al., 2008; Oswald and Stüwe, 2011). The Syrian Arc fold belt and fault systems in central Sinai-formed in late Cretaceous- and the rifts of Gulf of Suez and Gulf of Aqaba, due to crustal extension since Oligocene (Meshref, 1990), have shaped the Sinai Peninsula (Fig. 1a). These structural features controlled the patterns of the drainage systems discharging the Sinai territory (El Refaei, 1992; Taha et al., 2004; El Gammal, 2005; Arnous and Green, 2011; Masoud and Koike, 2011) and created some isolated depressions, which accumulate alluvial sediments of Pleistocene runoffs (Fig. 1b; Deuser et al., 1976; Givertizman et al., 1992). These depressions occur in the form of paleolakes in the Wadi Fieran and Wadi El-Arish main channels; and rift-related depressions at the El-Qaa and Nabq plains (Issar and Eckstein, 1969; Garfunkel et al., 1974; Kusky and El-Baz, 2000; Rögner et al., 2000), "*Wadi*"

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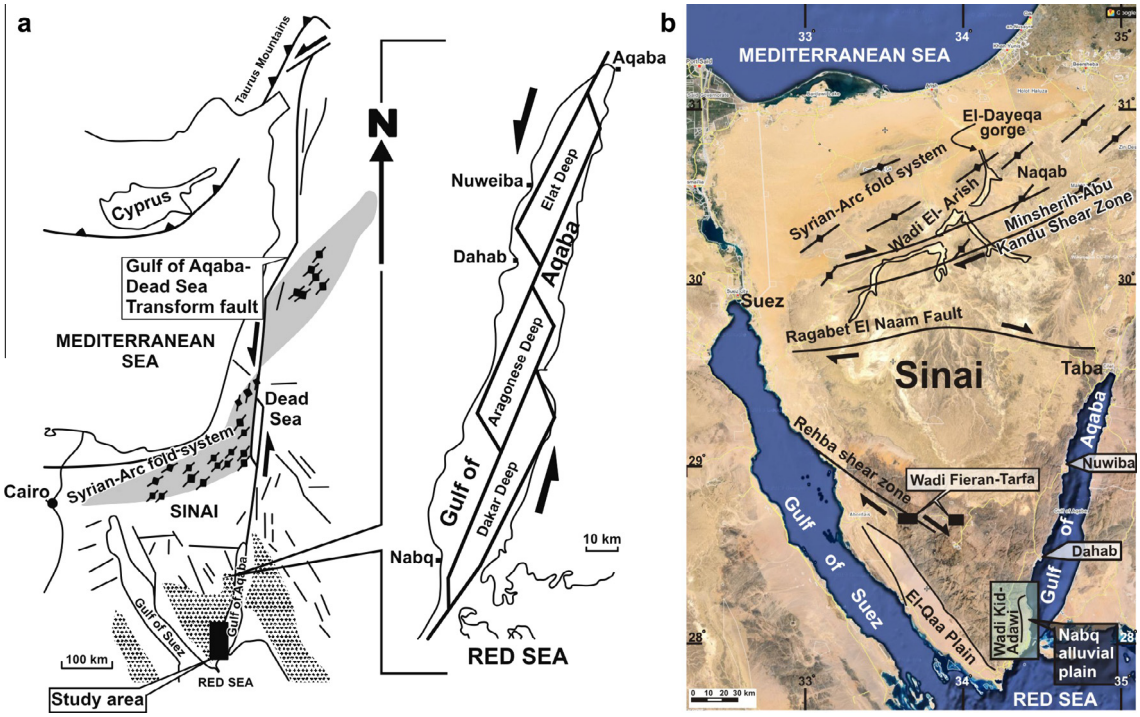

Fig. 1. (a) The Kid drainage basin occupies the southern end of Gulf of Aqaba – Dead Sea transform fault. The Gulf of Aqaba is portrayed by three main strike-slip pull-apart deeps (modified after Quennell, 1958 and Freund, 1970). (b) Landsat image of Sinai Peninsula describing the main structural elements and occurrences of the Quaternary inland paleolakes and rift-related onshore depressions; the structural patterns are from Shalaby et al. (2012) and references therein.

is an Arabic term that means a valley. Origin and geomorphic evolution of these drainage systems and depressions are recently debatable (e.g. Taha et al., 2004; Gaber et al., 2009; Embaby et al., 2010).

The Nabq alluvial plain occurs at the southern part of the western coast of the Gulf of Aqaba rift (Fig. 1b). This plain is formed of alluvial fans that emerged at the outlets of the Kid drainage basin (KDB) and many other smaller basins discharging the southeastern region of the southern Sinai basement terrain. The KDB landscapes involving fault-scarps, canyons, hanging valleys, stream and wave-cut terraces and raised beaches on margins of the Gulf of Aqaba imply that fluvial and tectonic processes are active. This study presents interpretations of the geometry and origin of these landscapes as well as their morphotectonic evolution, influenced by tectonic uplifting of the southern Sinai massif and subsequent evolution of the Gulf of Aqaba – Dead Sea rift (e.g. Hussein and Abd-Allah, 2001; Zain Eldeen et al., 2002; Rabeh, 2003; Mart et al., 2005; Oswald and Stüwe, 2011).

2. Methodology

This study is essentially a qualitative field-base data acquisition and analyses. Two field trips were conducted to KDB one week each in average. Field procedures include verifications and description of geomorphic features and structural lineaments. These lineaments are extracted from landsat ETM + 7 data image of KDB that was processed by Taha et al. (2013). The structural lineament map of KDB (Fig. 2a) is constructed by using both the geological map of southern Sinai (EGSMA, 1993) and the shaded relief image derived by Taha et al. (2013) from Digital Elevation Modeling of the KDB terrain. The collected structural data involve orientations of fault planes and striations, as well as type of displacements. Fault-slip data (Fig. 3a) are analyzed, following the procedure of Angelier (1984), to compute the palaeostress. The mesoscopic structural analysis approach is produced by *WIN_TENSOR_version 4.0.4* software utilizing the lower hemisphere-Schmidt's net stereoscopic projection. The computed palaeostress data confirm the conclusions of Bosworth and Taviani (1996) and Bosworth and Mc Clay (2001) who outlined palaeostresses of the Pleistocene rifting of the Gulf of Aqaba transform fault.

Geomorphic field description of fluvial and structural landforms, such as stream terraces, alluvial fans, talus cones, foothill slopes and fault-scarps, characterizing the KDB terrain are recorded. Simple morphometric description of KDB drainage systems involving widths and orientation of drainage channels and their patterns were collected aiming to give primary morphotectonic information. The channel widths are qualitatively described based on the acuteness of uphill pointed V-patterns of topographic contours of sheets constructed by the Military Survey of Egypt. This is accomplished taking into consideration that "the V-patterns become sharper at narrow and deep channels than those at broad and shallow courses", which described landforms from topographic contour maps.

3. Geological framework

The general geological setting of the Sinai Peninsula was described by several workers (e.g. Said, 1990). The Precambrian igneous and metamorphic basement rocks belonging to the Arabian–Nubian Shield exposed in southern Sinai are overlain by a Phanerozoic sedimentary cover in central and northern Sinai. These Phanerozoic deposits are composed mainly of: (1) Paleozoic sandstones with few intercalations of carbonates and shales, (2) Mesozoic limestones, marls, and shales; and (3) Cenozoic (except Oligocene and Miocene) limestones–shale intercalations and Quaternary mainly alluviums. The Oligocene red-sandstones and Miocene marls, shales and evaporites are limited to the Gulf of Suez region. These Miocene rocks are classified in Suez rift as syn-rift sediments, which are completely unrecorded in the Gulf of Aqaba region (Bartov et al., 1980; Garfunkel et al., 1974). The Plio-Pleistocene carbonates are predominantly composed of coral reefs and raised beach sediments in the Gulf of Aqaba region. They form few exposures of isolated low hills and terraces on foot-slopes of