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Remnants of Miocene fluvial sediments in the Negev Desert, Israel, and the Jordanian Plateau: Evidence for an extensive subsiding basin in the northwestern margins of the Arabian plate

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ABSTRACT

Relics of a thick, widely spread, fluvial sequence of Early Miocene age are scattered throughout southern Israel, eastern Sinai, the Dead Sea Rift Valley and the western margins of the Jordanian Plateau. These relics are mainly preserved in structural lows, karstic systems, and abandoned stream valleys. The paleogeography of this fluvial system was reconstructed based on the relations between the sequence remnants and the main structural and morphological features of the southeastern Levant region.

Three sedimentary associations were identified in the Miocene sequence: a lower part dominated by locally derived clastic sediments; a thicker middle part, composed mostly of far-field allochthonous clastic sediments; and an upper part composed of local as well as allochthonous sediments. The two lower parts are regionally distributed whereas the upper part is syn-tectonic and confined to the Dead Sea basin and the Karkom graben in the central Negev. The composition of the far-field allochthonous sediments points to a provenance of Precambrian crystalline rocks of the Arabo-Nubian massif that were exposed along the uplifted shoulders of the Red Sea Rift as the upper drainage basin of the fluvial system. The diverse mammal remains found in this fluvial sequence suggest a complex of savanna, forests and fluvial habitats similar to those of present East Africa, with monsoon-type rains, which were the dominant water source of the rivers.

The thickness of the Miocene sequence in the central Negev is at least 1700 m, similar to that of the subsurface sequence encountered in the Dead Sea basin. This similarity suggests that both were parts of an extensive subsiding sedimentary basin that developed between the Neo-Tethys and the uplifted margins of the Red Sea.

The relations between the reconstructed pre-depositional landscape of southern Israel during the Early Miocene and the overlying fluvial sequence indicate that the entire area was buried under several hundred meters of fluvial sediments, reflecting a subsidence of the northern margins of the African continent (Arabian plate) before its breakup and the splitting of the Sinai–Israel subplate by the Dead Sea Transform.

During the early Middle Miocene the subsidence was inversed as the mountainous backbone of Israel was uplifted. The uplift triggered a large scale denudation that removed the thick Early Miocene fluvial sequence from the Negev and transported the eroded sediments northwestward toward the eastern Mediterranean basin. Additional uplift during the late-Middle Miocene was associated with entrenchment of the Be'er Sheva Valley between the Judea Mountains in the north and the Negev Highlands in the south. This valley was flooded by the sea during the Late Miocene.

We suggest that the formation of the Early Miocene subsiding basin at the northern edge of the Arabian sub-plate predated the breakup of the Arabian plate by the DST. The inversion of the subsiding regime, which led to the establishment of the Negev Highlands seems to be intimately related to the detachment of the Sinai–Israel sub-plate from the Arabian plate during the Middle Miocene.

1. Introduction

During the Miocene the Levant region underwent major tectonic and paleogeographic changes. The breakup of the African plate along the Red Sea and the Gulf of Suez rifts, which started

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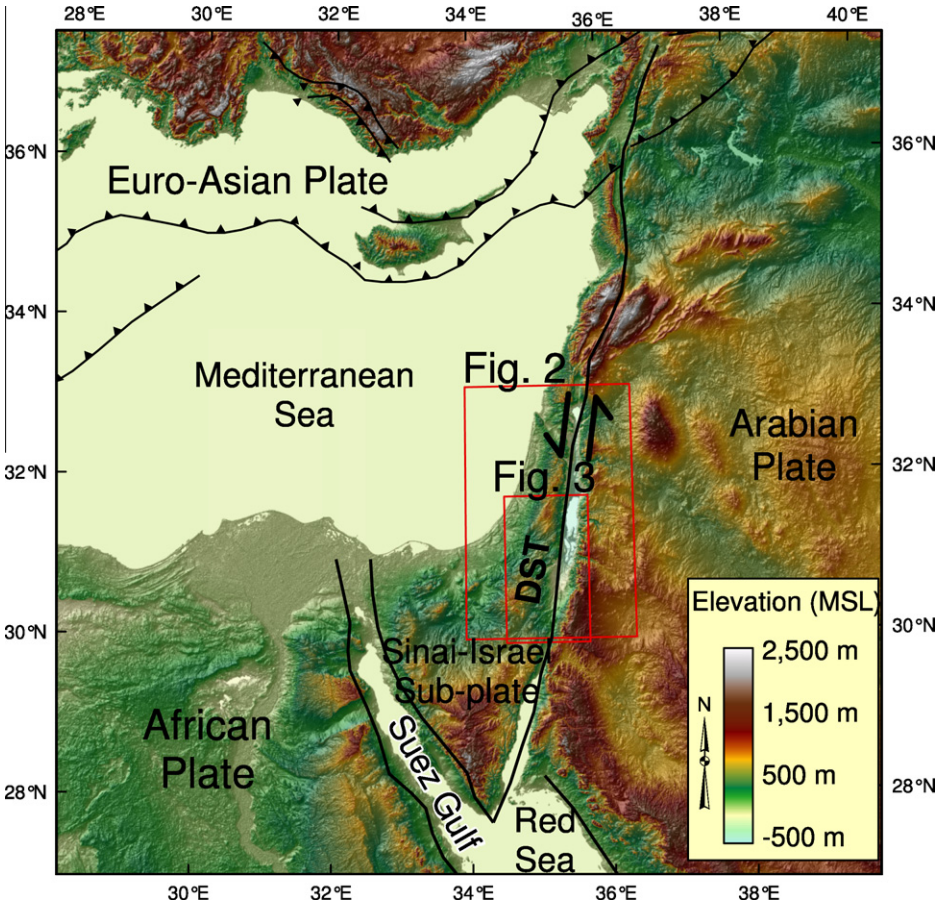

Fig. 1. The present plate configuration in the eastern Mediterranean region. The Sinai–Israel sub-plate is separated from the African plate along the Suez Rift, and from the Arabian plate along the Dead Sea Transform (DST). The elevated Arabian plateau as well as the elevated rift shoulders of the Suez and Red Sea rift are demonstrated using SRTM, 90 m pixel resolution, digital terrain model (ESRI, 2010).

in the Oligocene and was intensified in the Early Miocene, separated the Arabian plate from the African continent (Bohannon et al., 1989; Omar et al., 1989; Omar and Steckler, 1995) (Fig. 1). The northward movement of this plate toward the Euro-Asian plate, associated with the closure of the Neo-Tethys Ocean, established a land bridge between Africa and Asia and enabled migrations of continental fauna between these two ecological provinces (Berggren and Van Couvering, 1974; Adams et al., 1983; Tchernov et al., 1987; Tchernov, 1992). Later, during the Middle Miocene, 18–14 m.y. ago, the northward migrating Arabian plate was ruptured by the Dead Sea Transform (DST) (Quennell, 1958; Garfunkel, 1981; Joffe and Garfunkel, 1987; Bosworth et al., 2005 and references therein). Gvirtzman and Steinberg (2012) suggested that initial breakup of the lithosphere at around 25 Ma occurred along the Levant continental margin and when that incipient plate boundary failed, the strike-slip motion shifted inland to the DST. Moreover, the migration of deformation inland was not immediate, and during the transitional period, the Sinai–Israel block was an independent sub-plate with deformations all around it. The DST accommodated most of the northward movement of the Arabian plate and as a result, the Sinai–Israel sub-plate, although loosely connected (separation velocity between Sinai and Africa is on the order of 1 m/kyr; Bosworth and Taviani, 1996) became again part of the African plate (Fig. 1). Since that time, the Arabian plate moved some 100 km northward in relation to the Sinai–Israel sub-plate (Quennell, 1956, 1958; Freund et al., 1970; Bartov, 1974; Garfunkel, 1981). During the Miocene this movement was of a pure strike-slip nature, while a shift in the location of the Eularian pole of relative plate motions during the end of the Miocene to the earliest Pliocene resulted in the formation of a long, morpho-structural depression along the DST between the Red Sea in the south and Lebanon in the north (Garfunkel, 1981; Joffe and Garfunkel, 1987), known as the "Dead Sea Rift" (DSR).

The Negev Desert in southern Israel and the Sinai Desert in Egypt are parts of a continuous morphological landscape extending between the DSR (in the east) and the Gulf of Suez (in the west) (Fig. 1). The breakup of the African continent and the development of the Red Sea Rift was associated with uplift of the rift shoulders (Kohn and Eyal, 1981; Garfunkel, 1988; Omar et al., 1989; Omar and Steckler, 1995), forming a structural ridge, which is more than 400 km wide in Saudi Arabia and up to 2.5 km high in Sinai (Fig. 1). The uplifted rift margins dictated the course of the regional drainage systems, which drained its northeastern slopes toward the lower terrain of the Miocene Arabian plate. The regional gradient of the northern parts of the Sinai–Israel sub-plate (north of latitude 30N) is toward the Mediterranean; however there is no information about the pattern of the Miocene drainage network in the areas located east of the DST. Remnants of Miocene fluvial sediments widely preserved in the Negev and eastern Sinai (Figs. 2 and 3) (Picard, 1943; Bentor and Vroman, 1951; Bentor and Vorman, 1957; Garfunkel and Horowitz, 1966; Bartov, 1974) indicate that at least some of these Miocene drainage systems crossed the DSR and the Negev, flowing toward the Mediterranean Sea.

The main goal of the present study was to reconstruct the paleogeographic evolution of the landscape and the fluvial system