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Review of the tectonics of the Levant Rift system: the structural significance of oblique continental breakup

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Abstract

The Levant Rift system is an elongated series of structural basins that extends for more than 1000 km from the northern Red Sea to southern Anatolia. The system consists of three major segments, the Jordan Rift in the south, El Gharb–Kara-Su Rift in the north, and the Lebanese Fault splay in between. The rifted parts of this structural system are accompanied by intensively uplifted margins that mirror-image the basinal pattern, namely, the deeper the basin—the higher its margins, and vice versa. Uplifts also occur along the fault splay section. The Jordan Rift comprises axial basins that diminish in size from the south northwards, and are separated from each other by shallow threshold zones along the axis of the rift, where the margins are also subdued. The Lebanese Fault splay consists of five faults that emerge from the northern edge of the Jordan Rift and trend like a fan between the north and the northeast. One of these faults connects the Jordan and El Gharb–Kara-Su rifts. The Levant Rift and its uplifted margins started to develop in the middle-late Miocene, and most of the structural development occurred in the Plio-Pleistocene.

The Levant Rift system is characterized by its oblique displacement, and evidence for both dip-slip and strike-slip displacement was measured on its faults. Earthquakes also indicate that same mixed pattern, some of them show strike-slip offset, and others normal. It is generally conceded that the amount of normal offset along the boundary faults of the Rift system reaches 8–10 km, but the lateral displacement is disputed, and offsets ranging from 11 to 107 km were suggested. Assessment of the available data led us to suggest that the sinistral offset along the Levant Rift system is approximately 10–20 km. The similarity between the vertical and the lateral displacements, the basin and threshold structural pattern of the Rift, model experiments in oblique rifting, as well as the significant tectonic resemblance to the Red Sea and the East African rifts, indicate that the Levant Rift is the product of continental breakup, and it is probably an emerging oceanic spreading center.

Keywords: Levant Rift system; Continental breakup; Oblique rifting; Splay faulting; Arabian Plate; Red Sea

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1. Introduction

The tectonic model of the Levant, which links the emergent oceanic spreading center of the Red Sea through the motion of various tectonic plates along the Levant Rift, to the westward offset of Anatolia and the closure of the eastern Mediterranean is one of the cornerstones of Plate Tectonics, and was discussed extensively by early modelers (Freund et al., 1968; McKenzie, 1970; McKenzie et al., 1970; Dewey et al., 1973; Le Pichon et al., 1973, and many others). According to these modelers, the tectonic opening in the Gulf of Aden and the Red Sea in the early Miocene pushed the Arabian plate northwards, and thus led to a sinistral displacement of 105 km along the Levant Rift. The motion that drove the Arabian Plate northwards past the Sinai microplate pushed, in turn, the Anatolian plate westwards along the North and the East Anatolian Faults (Fig. 1). The 1000-km-long Levant Rift was considered to be a transform fault (Garfunkel, 1981), and its structure was presumed to resemble that of the San Andreas Fault (Ben-Avraham, 1985). Evidence of extension across the Rift (Ben-Avraham et al., 1979; Mart and Horowitz, 1981) led to slight revision of the conventional model, which considered the Rift to be a "leaky transform fault" (e.g. Garfunkel et al., 1981; Joffe and Garfunkel, 1987; Sagy et al., 2003).

The analysis of the structural displacement along the Levant Rift has been embroiled with controversy

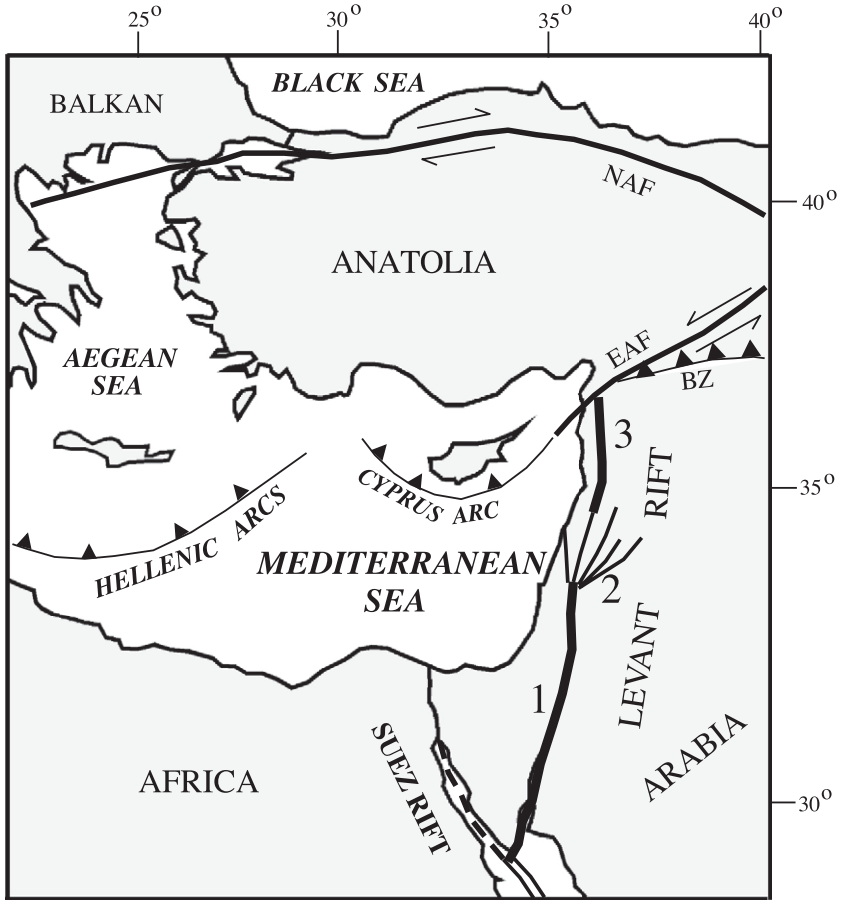

Fig. 1. The tectonic layout of the northern Red Sea, the Levant Rift System, the North and East Anatolian Faults (NAF and EAF, respectively), the eastern Mediterranean and Cyprus and the Hellenic Arcs. The components of the Levant Rift system are (1) the Jordan Rift, (2) the Lebanese Fault splay and (3) El Gharb Rift. The dashed line in the Suez Rift indicates a defunct extension of the Red Sea spreading center that was active in the Miocene, but became nearly inactive since the Pliocene, while the tectonic activity of the Levant Rift accelerated.