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Field evidences from northern Dead Sea Fault Zone (South Turkey): New findings for the initiation age and slip rate

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ABSTRACT

The left-lateral strike–slip Dead Sea Fault Zone (DSFZ) extends from the Red Sea in the south to the East Anatolian Fault Zone (EAFZ) in the north. This study examines the northern part of the DSFZ around Amik Basin and presents surface and subsurface geological evidence for the Quaternary activity and initiation age of the northernmost DSFZ. The DSFZ extends N–S in the south of the Amik Basin where clear geological and morphological evidence exists for faulting. Geological observations around Amik Basin, analyses of borehole data and electrical resistivity profiles within the Amik Basin indicate that the activity of the northern DSFZ started after Pliocene in the Amik Basin. Subsurface data in the basin suggest that the DSFZ offsets a pre-Quaternary basin sinistrally by about 7.9 km. The offset pre-Quaternary basin suggests at least 4.94 ± 0.13 mm/year slip rate for the northern part of the DSFZ. The Karasu Fault Zone (KFZ) extends in an en-echelon pattern along the western margin of the Karasu Valley and it transfers the significant amount of slip from DSFZ to the EAFZ.

1. Introduction

The left-lateral Dead Sea Fault Zone (DSFZ) is a major neotectonic structure in the Middle East and it extends from the Red Sea in south to southern Turkey in north (Fig. 1a). The age of the DSFZ and the total left-lateral offset have been a subject of debate. However, it is agreed that the tectonic deformation associated with the DSFZ began with initiation of sea-floor spreading in the Red Sea and the total slip on the DSFZ has been estimated from geological evidence as about 110 km for the southern section (e.g. Garfunkel, 1981; Quennell, 1984) and about 70–80 km for the northern section (e.g. Westaway, 2003). Geological evidences (e.g. Garfunkel, 1981; Ginat et al., 1998; Makovsky et al., 2008), kinematic models (e.g. Jestin et al., 1994; Westaway, 2003), GPS models (McClusky et al., 2003; Reilinger et al., 2006; Vigny et al., 2006; Alchalbi et al., 2007; Le Beon et al., 2008) and paleoseismological investigations (e.g. Gomez et al., 2003; Meghraoui et al., 2003; Daeron et al., 2004) suggest that the slip rate along the DSFZ varies between 1 and 10 mm/year.

The DSFZ usually presents a simple geometry in the south but it splays into different branches towards the north (Fig. 1a). The location of the DSFZ is clear between the Red Sea and the Ghab Basin in Syria (Fig. 1a) and its neotectonic characteristics are well documented in this part of the fault zone (e.g. Quennell, 1958; Garfunkel, 1981; Quennell, 1984; Hempton, 1985; Steinz and Bartov, 1991; Garfunkel and Ben-Avraham, 1996; Klinger et al., 2000; Brew et al., 2001; Gomez et al., 2003; Mart et al., 2005). However, the location of the northernmost part of the DSFZ and its neotectonic development are still in debate. For example, Muehibenger and Gordon (1987), Perinçek and Çemen (1990) and Lyberis et al. (1992) suggest that the DSFZ splays into branches around Amik Basin and bounds both eastern and western margins of the basin (Fig. 1b). Rojay et al. (2001) also suggest that the DSFZ splays into branches around Amik Basin but they extend a branch through the Amik Basin as a probable fault (Fig. 1b). Tatar et al. (2004) suggest that strike slip on the DSFZ is taken up by the both sides of the Karasu Valley in southern Turkey and significant contemporary transfer of motion from the DSFZ to the EAFZ is transferred by the western margin faults. Recent studies (Akyüz et al., 2006; Karabacak, 2007) suggest that the main strand of the northern DSFZ extends along the western side of the Asi River and Altunel et al. (2006) provide evidence that this branch extends at least 10 km in the Amik Basin (Fig. 2a). Recent studies showed that the northernmost part of the DSFZ is well documented in the south of Amik Basin. However, as it is clear from the above examples, the position of the DSFZ remains uncertain further north of Amik Basin in

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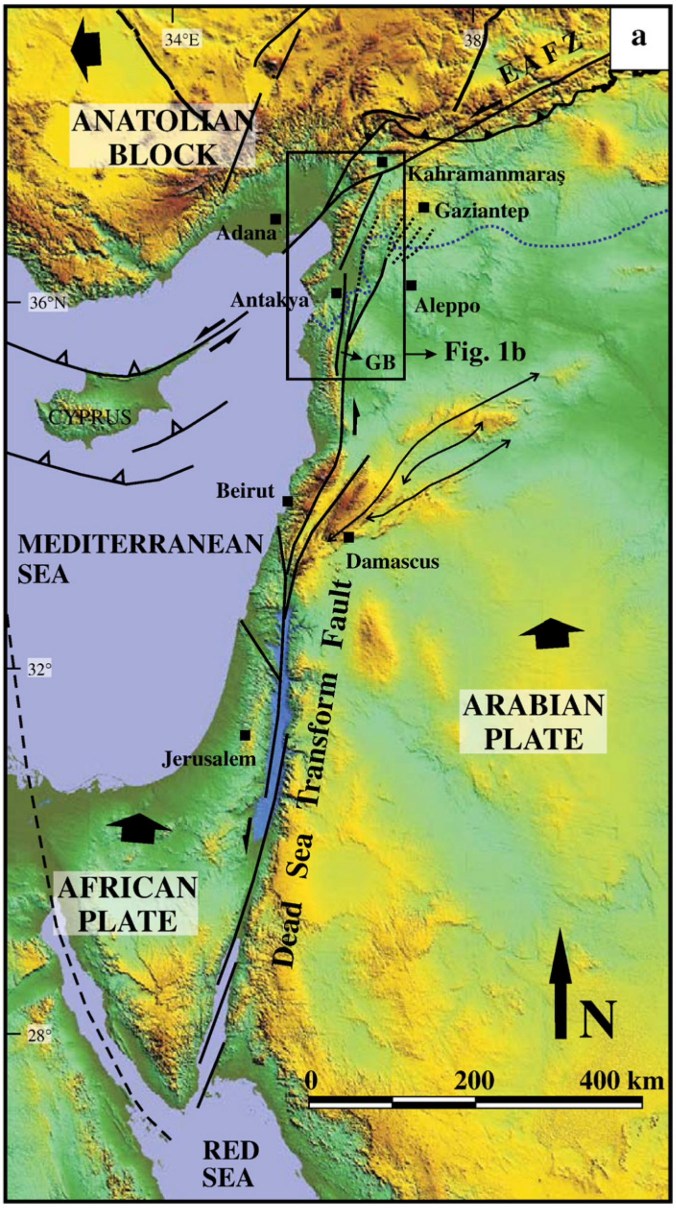

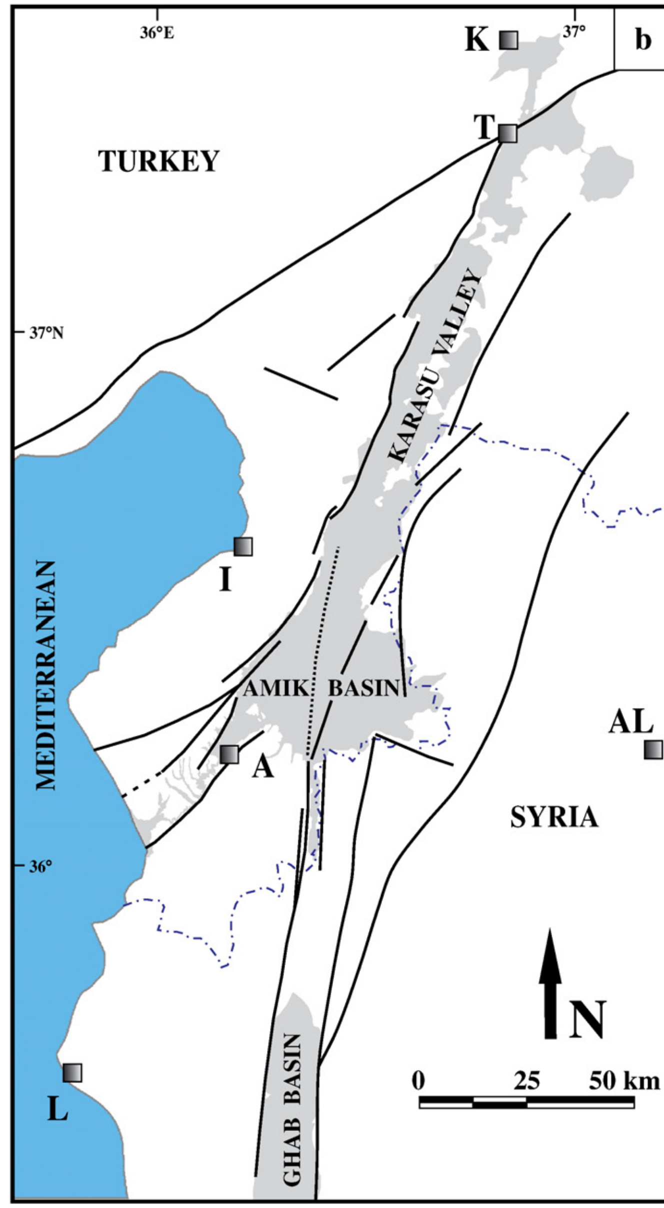

Fig. 1. a. General map of the DSFZ between the Red Sea and the EAFZ with location of the study area. (GB: Ghab Basin). b. Simplified strands of faults suggested in previous studies (Muehibenger and Gordon, 1987, Perinçek and Çemen, 1990, Lyberis et al., 1992, Şaroğlu, et al., 1992, Rojay et al., 2001, Yurtmen et al., 2002, Westaway, 2003, 2004, Tatar et al., 2004) (K: Kahramanmaraş, T: Türkoğlu, I: İskenderun, A: Antakya, AL: Aleppo, L: Lattakia).

previous studies and its connection with the East Anatolian Fault Zone (EAFZ) is under discussion.

The slip rate on the northernmost DSFZ is also under discussion. Previous studies, based on field observations, subsurface geophysical data and GPS data, suggest that the DSFZ splays into a complex en-echelon fault strand in south Turkey and slip is partitioned (e.g. Muehibenger and Gordon, 1987; Perinçek and Çemen, 1990; Perinçek and Eren, 1990; Şaroğlu et al., 1992; Rojay et al., 2001; Adıyaman and Chorowicz, 2002; Yurtmen et al., 2002; McClusky et al., 2000, 2003; Westaway, 2003, 2004). Westaway (2003, 2004) suggest that the slip rate on each branch of the northernmost DSFZ is not more than 2 mm/year. Based on offset archaeological relics in the Amik Basin, Altunel et al. (2006) suggest up to 6.2 ± 0.2 mm/year slip rate for the northern part of the DSFZ. Further north, Seyrek et al. (2007) give 5.57 ± 0.54 mm/year as the overall left-lateral slip rate across the DSFZ in the Karasu Valley with Ar/Ar dates of offset Pleistocene basalts.

The Amik Basin is a 40-km-wide and 50-km-long depression on the northern part of the DSFZ (Fig. 1b). Excluding offset archaeoseismological features observed by Altunel et al. (2006), the basin does not provide field evidence at the surface for faulting due to active sedimentation and agricultural activity. However, considering that the DSFZ continues at least 10 km in the basin (Fig. 2a), it is likely that the fault extends further north. On the basis of this assumption, we carried out detailed field studies around the Amik Basin and along the Karasu Valley (Fig. 1b). In addition, borehole data and electrical resistivity profiles conducted by State Hydrolic Works (DSİ) in the Amik Basin were examined for subsurface distribution of sedimentary deposits. This paper presents field observations from the Amik Basin area and Karasu Valley as well as subsurface data from the Amik Basin. In addition, the paper discusses neotectonic characteristics and initiation age of the northernmost DSFZ on the basis of obtained data. We believe that this study would make a significant contribution