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Quaternary tectonic activity in NW Jordan: Insights for a new model of transpression–transtension along the southern Dead Sea Transform Fault

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ABSTRACT

The Dead Sea Transform Fault (DSTF) constitutes the transform plate boundary between the African and Arabian plates. The southern part of this fault has been traditionally divided into two main segments, the Wadi Araba Fault (WAF) and the Jordan Valley Fault (JVF), connected through the Dead Sea continental pull-apart basin. Active tectonic studies in NW Jordan have traditionally focused on these DSTF structures and have neglected other prominent structures in the region, such as the Amman Hallabat Structure (AHS) and Shueib Structure (SHS) fault systems, which have been considered inactive since the Cretaceous. However, some recent studies have suggested a possible local reactivation of the southern parts of these structures. In this work, we carried out a detailed geological study of the NE Dead Sea Basin to analyze the Quaternary activity of the AHS and SHS based on field observations and structural analyses. Our findings have revealed that the AHS and SHS structures present clear Quaternary activity and accommodate a small part of the deformation of the southern DSTF. In the Quaternary, the southwestern part of the AHS has acted as the northernmost continuation of the WAF, whereas the SHS has acted as a transfer fault associated with NW–SE normal faults with low to moderate throws (meters to decameters) that connect this structure to the JVF. These NW–SE normal faults constitute the northeastern border of the Dead Sea depression (Jericho Valley). They produce a topographic front and separate the sediments of the Jordan Valley in the hanging wall from the Mesozoic sedimentary sequence located in the footwall.

1. Introduction

The Dead Sea Transform Fault (DSTF) accommodates the relative motion along the Arabia and Sinai plate boundary as one of the longest (>1000 km length) and most active strike-slip faults in the world and the source of most of the historical and recent earthquakes in the region (Quennell, 1959; Garfunkel, 1981, 2014; Klinger et al., 2000a,b; Enzel et al., 2000; Wdowinski et al., 2004; Ferry et al., 2007; Marco and Klinger, 2014). The DSTF is a sinistral strike-slip fault system and presents a general slip rate ranging from 4 to 7.5 mm/year (Garfunkel, 1981; Klinger et al., 2000a; Niemi et al., 2001; Marco and Agnon, 2005; Reilinger et al., 2006; Ferry et al., 2007; Daeron et al., 2007; Le Beon et al., 2008, 2010; Marco and Klinger, 2014) (Fig. 1). It has been traditionally divided in two main segments, the southern DSTF from the Gulf of Aqaba to the Sea of Galilee and the northern DSTF from the Lebanese restraining bend to the Zagros Mountains in Turkey. Differences in the offset of geological markers between the northern and southern parts are well known, with the offsets being considerably smaller in the northern part (Chaimov et al., 1990; Abed, 2000; Mart et al., 2005; Le Beon et al., 2008; Searle et al., 2010). However, the differences in slip rates are dependent on the considered timescale: although geological slip rates do not suggest large differences (see compilation in Marco and Klinger, 2014), recent GPS-derived slip rates are clearly lower in the northern DSTF (Le Beon et al., 2008; Alchalbi et al., 2010; Al-Tarazi et al., 2011; Sadeh et al., 2012; Palano et al., 2013). Such deviations in geodetic slip rates on the southern DSTF can be explained by the possible participation of other regional structures, such as the Palmyride Fold Belt, in the stress accommodation (Chaimov et al., 1990; Badawy and Horváth, 1999). The southern DSTF includes two main fault segments connected through the Dead Sea pull-apart basin, the Wadi Araba Fault (WAF), which extends from the Gulf of Aqaba to the Dead Sea, and the Jordan Valley Fault (JVF), which runs from the Dead Sea to the Sea of Galilee (Garfunkel, 1981, 2014; Atallah, 1992). The southern termination of the Dead Sea is well defined, with clear transverse faults connecting the WAF and JVF segments, but the shape and the structure of the northern termination are not well determined (ten Brink and Flores, 2012). Transverse faults in this northern

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termination are not visible in seismic reflection lines, which only suggest a gradual thinning toward the northern end of the basin (Christie-Blick and Biddle, 1985; Al-Zoubi et al., 2007).

Aside from the DSTF, the Amman Hallabat Structure (AHS) and Shueib Structure (SHS) are two of the largest tectonic structures in NW Jordan (Mikbel and Zacher, 1981; Atallah and Mikbel, 1992)