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The kinematics of central-southern Turkey and northwest Syria revisited

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ABSTRACT

Central-southern Turkey, NW Syria, and adjacent offshore areas in the NE Mediterranean region form the boundary zone between the Turkish, African and Arabian plates. A great deal of new information has emerged in recent years regarding senses and rates of active crustal deformation in this region, but this material has not hitherto been well integrated, so the interpretations of key localities by different teams remain contradictory. We have reviewed and synthesised this evidence, combining it with new investigations targeted at key areas of uncertainty. This work has led to the inference of previously unrecognised active faults and has clarified the roles of other structures within the framework of plate motions provided by GPS studies. Roughly one third of the relative motion between the Turkish and Arabian plates is accommodated on the Misis–Kyrenia Fault Zone, which links to the study region from the Kyrenia mountain range of northern Cyprus. Much of this motion passes NNE then eastward around the northern limit of the Amanos Mountains, as previously thought, but some of it splays northeastward to link into newly-recognised normal faulting within the Amanos Mountains. The remaining two thirds of the relative motion is accommodated along the Karasu Valley; some of this component steps leftward across the Amik Basin before passing southward onto the northern Dead Sea Fault Zone (DSFZ) but much of it continues southwestward, past the city of Antakya, then into offshore structures, ultimately linking to the subduction zone bounding the Turkish and African plates to the southwest of Cyprus. However, some of this offshore motion continues southward, west of the Syrian coast, before linking onshore into the southern DSFZ; this component of the relative motion is indeed the main reason why the slip rate on the northern DSFZ, measured geodetically, is so much lower than that on its southern counterpart. In some parts of this region, notably in the Karasu Valley, it is now clear how the expected relative plate motion has been accommodated on active faults during much of the Quaternary: rather than constant slip rates on individual faults, quite complex changes in the partitioning of this motion on timescales of hundreds of thousands of years are indicated. However, in other parts of the region it remains unclear whether additional major active faults remain unrecognised or whether significant relative motions are accommodated by distributed deformation or on the many smaller-scale structures present.
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1. Introduction

The northeastern corner of the Mediterranean Sea, including central-southern Turkey and northwest Syria (Fig. 1), forms the boundary zone between the Turkish, African and Arabian plates. In recent years an abundance of new data has been documented, regarding the sense, rate and history of Late Cenozoic crustal deformation in this region. This multi-disciplinary dataset includes measurements of active crustal deformation from GPS (e.g., McClusky et al., 2000; Reilinger et al., 2006; Alchalbi et al., 2010; ArRajehi et al., 2010; Sadeh et al., 2012; Mahmoud et al., 2013; Palano et al., 2013), palaeoseismic and archaeoseismic studies of slip rates on faults (e.g., Meghraoui et al., 2003; Marco et al., 2005; Akyuz et al., 2006; Altunel et al., 2009), detailed studies of relations between volcanism and tectonics, including geochemical analyses and geochronological studies (e.g., Krienitz et al., 2009; Searle et al., 2010; Ma et al., 2011; Trifonov et al., 2011); measurements of Quaternary slip rates from offset basalt flows or other offset landforms (e.g., Seyrek et al., 2007; Abou Romieh et al., 2009, 2012), documentation of Quaternary rates of vertical crustal motion from studies of fluvial and marine terraces (e.g., Bridgland et al., 2008, 2012; Seyrek et al., 2008), documentation of previously

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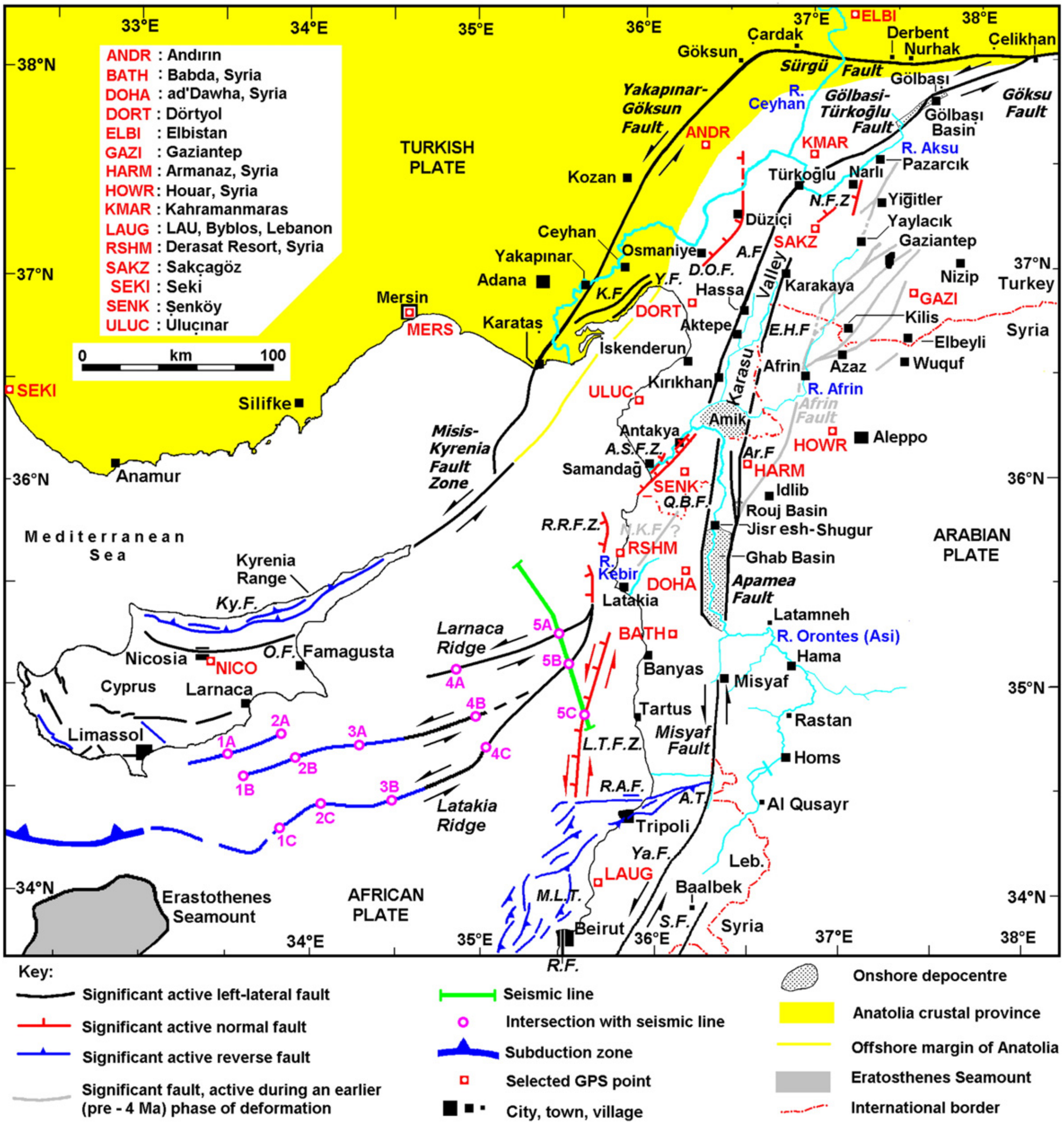

Fig. 1. Regional map, adapted from Fig. 2 of Westaway (2004), which lists original sources of information, and Fig. 1 of Seyrek et al. (2008), showing a schematic interpretation of faults forming the boundaries between the Turkish, African and Arabian plates in central-southern Turkey and NW Syria, in relation to selected GPS points from Reilinger et al. (2006) and Alchalbi et al. (2010). The Anatolian crustal province is unshaded where offshore; its southern limit, at the northern margin of the Arabian Platform, marks the suture of the former Southern Neotethys Ocean. The Jabal Nusayriyah or Syrian Coastal Range runs N–S to the west of the Ghab Basin and the Misyaf Fault. The Amanos Mountains run SSW–NNE to the west of the Karasu Valley between the coast west of Antakya and the northern margin of the Arabian Platform. Normal faults are indicated with hanging-wall ticks; left-lateral faults with lines with no ticks. However, many of the faults depicted are transtensional, the 'strike-slip fault' ornament being used for the major structures. Abbreviations denote particular faults or fault zones discussed in the text, thus: A.F., Amanos Fault; Ar.F., Armanaz Fault; A.S.F.Z., Antakya–Samandağ Fault Zone; A.T., Aakkar Thrust; D.O.F., Düziçi–Osmaniye Fault, with its suggested northward continuation dashed; E.H.F., East Hatay Fault; K.F., Karataş Fault; Ky.F., Kythrea Fault; L.T.F.Z., Latakia–Tripoli Fault Zone; M.F., Misyaf Fault; M.L.T., Mount Lebanon Thrust and associated reverse faults; N.F.Z., Narlı Fault Zone; N.K.F., Nahr el Kebir Fault Zone; O.F., Ovgros Fault Zone; Q.B.F., Qanaya–Babatorun Fault; R.F., Roum Fault; R.A.F., Rankine-Aabdeh Fault; R.R.F.Z, Ras al Basit–Ras Ibn Hani Fault Zone; S.F., Serghaya Fault; Ya.F., Yammouneh Fault; Y.F., Yumurtalık Fault. Mount Lebanon Thrust and associated reverse faults are simplified from Elias et al. (2007). Latakia Ridge, related structures, Cyprus subduction zone, Erastothenes Seamount and intersections with seismic lines are from Vidal et al. (2000a). Faulting onshore in Cyprus is simplified from Kinnaird and Robertson (2013).

unrecognised active faults (e.g., Boulton and Robertson, 2008; Emre and Duman, 2011; Emre et al., 2011, 2012a, 2012b; Duman and Emre, 2013), and clarification of the configuration of active faults in offshore areas using seismic reflection profiling (e.g., Aksu et al., 2005; Hall et al., 2005; Elias et al., 2007; Bowman, 2011). Nonetheless many inconsistencies remain between these different forms of evidence. For example, one team may dismiss the recognition of active faulting by another (cf. Boulton and Robertson, 2008; Karabacak et al., 2010; Karabacak and Altunel, 2013); or one team may model GPS data subject to the assumption of a geometry of active faulting that has been superseded by field studies in the area (cf. Parlak et al., 1997; Seyrek et al., 2008; Mahmoud et al., 2013; Duman and Emre, 2013). The extant literature indeed includes instances where detailed studies by different teams of the same localities are completely contradictory, a notable example being the Latakia area of NW Syria (Hardenberg and Robertson, 2007, 2013; cf. Bridgland et al., 2008; cf., Al Abdalla et al., 2010; see also below). Duman and Emre (2013) have synthesised established knowledge along with significant new discoveries regarding the active faulting in central-southern Turkey (although they provide no indication which are which) and make some attempt to relate these observations to the motions of the adjoining plates. However, as is discussed below (Sections 4 and 5.1), their compilation lacks detail (no site co-ordinates

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