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The effects of plate margin inhomogeneity on the deformation pattern within west-Central Zagros Fold-and-Thrust Belt

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ABSTRACT

Zagros Folded and thrust Belt (ZFTB) is a Cenozoic mountain belt in SSW of Iran and northeast of Arabia that resulted from closure of Neo-Tethys and collision between Arabia passive margin and Central Iran active margin. At this tectonic grain of Alp-Himalayan chain, change of the tectonic regime, degree of basement involvement, and character of accommodation of the deformation, in time and space, has been under debate. The results show that the deformation along the Zagros is not uniformly accommodated. Although the researchers have already paid attention to basement involvement in addition to the sedimentary cover rocks, little has been shown on the role of the basement's rigidity and lower crust's rheology on the deformation pattern along and across the belt. This study tries to address these questions in terms of inversion of slip vector of basement earthquakes, measurement of fault-slip data on the cover rocks, geomorphic and field observations, and existing geodetic and gravity data, with especial focus on Dezful embayment and surrounding area. The results show the Dezful embayment plays an indenter role. It, with the other reentrants, changes the obliquity of Arabian plate convergence, facilitates the escape of the upper crust toward free mechanical boundaries in salients, controls the slip-rate of Zagros Main Recent Fault at the rear of the belt and contributes in forming Zagros Fold-and-Thrust Belt as an orocline. The viscous lower crust helps the strain partitioning by providing a ductile shear base under the rigid upper crust.

1. Introduction

This paper puts an alternate interpretation on the recent kinematics of the central part of the Zagros Fold- and-Thrust Belt: a Cenozoic orogenic belt in S-SW of Iran as a consequence of closure of Neo-Tethys and oblique collision between Arabia and Central Iran (Fig. 1). This NW-trending mountain range extends from Southeast of Turkey to the Oman Line. *Zagros* Fold-and-Thrust Belt (hereafter Zagros), as most orogenic belts, is composed by salients/bends (convex toward the foreland, Fars and Lorestan domains) and reentrants/saddles/recess/tucks (concave toward the foreland, Dezful, Oman, and Kirkuk domains) (Fig. 2) associated with changes of degree of the oblique convergence partitioning (boundary between Fars and Dezful domain, Talebian and Jackson, 2004). The pre- and/or post-orogenic parameters controlling oroclines and related subjects (i.e. inherited basement fault, shape of promontory, décollement level, cover thickness, slab geometry) have been discussed by several authors in different real and analog models of fold–and-thrust belts (Table 1).

In the Zagros belt, controlling factors in promontory shape inferred by previous authors are the presence or absence of a thick décollement level between the cover and the basement (Hormuz salt and other evaporatic formations as Gachsaran; Bahroudi and Koyi, 2003; Davis and Engelder, 1985; McQuarrie, 2004; Sherkati and Letouzey, 2004), the presence of inherited basement faults (normal NW-SE-trending faults, or strike-slip N-S-trending faults; Hessami et al., 2001a; Navabpour et al., 2014), the lateral variation of degree of oblique convergence (McQuarrie et al., 2003; Vernant et al., 2004) or the degree of deformation partitioning due to the presence of a weak fault at the hinterland (Vernant and Chery, 2006). In this study we bring new data that highlight the role of lateral variation of crustal rheology in the accommodation of the Zagros deformation in which the Dezful

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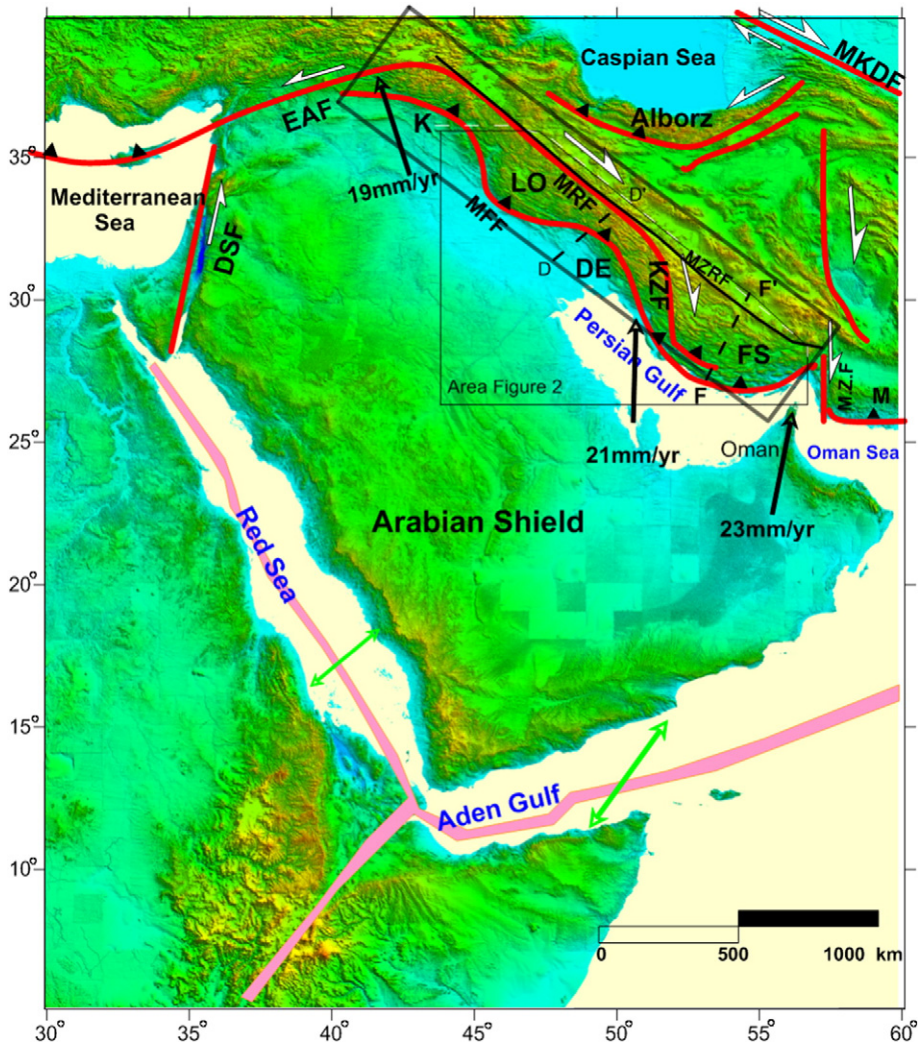

Fig. 1. Tectonic map of Middle East and main structural elements plotted on shaded relief map of SRTM digital elevation model. The Zagros Belt is outlined with a rectangle. Arrows show the relative velocity of Arabia with respect to Eurasia in mm/year adapted from Vernant et al. (2004). The white thick arrows mark strike-slip faults and lines with dog teeth indicating thrust faults. Green arrows (bidirectional arrows) show the Red Sea and Aden Gulf oceanic floor spreading direction. Abbreviations are; MKDF: Main Kope Dagh Fault (Shabanian et al., 2010), EAF: East Anatolian Fault, DSF: Dead Sea Fault, MZRF: Main Zagros Reverse Fault: Main Zagros Reverse Fault, MRF: Main Recent Fault, MFF: Mountain Frontal Fault, KZF: Kazerun Fault, M: Makran, M.Z.F.: Minab Zendan Fault, LO: Lorestan salient, DE: Dezful reentrant, FS: Fars Salient, K = Kirkuk, lines FF' and DD' are profiles presented in Fig. 13.

embayment (hereafter Dezful) plays the role of indenter. We benefit from kinematic analyses of fault striations and focal mechanisms, study of finite shortening trajectories, GPS, geomorphic observations and the interpretation of gravity data.

2. Geological setting

The NW-trending Zagros resulted from the closure of the Neo Tethys Ocean allowing the collision of the Eurasia plate to the North and the Arabia plate to the South. East of the Zagros, the northward subduction goes on below the Makran belt to the north of Oman Sea (Fig. 1). Zagros is separated to Makran belt by the Minab-Zendan transfer Fault zone (Regard et al., 2005). In the Zagros, the continental subduction is inferred no longer to be active (e.g., Hatzfeld and Molnar, 2010) due to slab break-off process proposed occurring during Eocene and Pliocene (Agard et al., 2011) or only partially at Pliocene (Mouthereau et al., 2012). Indeed, the seismic imaging by receiver function method (Paul et al., 2010) suggests slab detachment only for SE Zagros (Fars salient).

The kinematics of Neo-Tethys ocean closure is debated. Talbot and Alavi (1996) suggested a diachronous process like a zip fastener along the passive margin with bends and tucks that compartmentalize the Zagros into different parts with different histories. An obduction phase occurred at the end of Cretaceous based on the timing of thrusting of ophiolitic rocks on the Upper Cretaceous Biston Limestone of Arabia continental margin (Berberian and King, 1981; Alavi, 2004). Recent studies indicate that collision initiated at ~35 Ma with the underthrusting of the rifted Arabian plate beneath the Iranian plate followed by crustal thickening at ~25 Ma (e.g. Mouthereau et al., 2012, see references therein). The main phase of folding has been originally associated with the Pliocene synorogenic Bakhtiyari conglomerates in the Simple Fold Belt (e.g., James and Wynd, 1965; Stöcklin, 1968; Falcon, 1974; Stöcklin, 1974) but new analyses of tectonic/stratigraphic relationships indicated an onset after ca. 12 Ma (Homke et al., 2004; Mouthereau et al., 2007; Khadivi et al., 2010). With folding, inherited NW-trending and N-trending basement faults accommodated shortening (e.g. Talbot and Alavi, 1996; Navabpour et al., 2014). Zagros lies on the passive margin of Arabian plate and is separated from the Central Iran by the Main Zagros Reverse Fault (MZRF), currently inactive and proposed as the suture zone between Arabia and Eurasia (e.g., Yamini-Fard et al., 2006; Paul et al., 2006) (Fig. 1). In the NW Zagros, the Main Zagros Reverse Fault is cut by the parallel Main Recent Fault (MRF), a major dextral active fault that accommodates