Journal of Structural Geology 62 (2014) 65–79

Contents lists available at ScienceDirect

Journal of Structural Geology

journal homepage: www.elsevier.com/locate/jsg

Structural evidence for superposition of transtension on transpression in the Zagros collision zone: Main Recent Fault, Piranshahr area, NW Iran

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ARTICLE INFO

Article history:
Received 6 July 2013
Received in revised form
7 January 2014
Accepted 11 January 2014
Available online 23 January 2014

Keywords:
Collision zone
Main Recent Fault
NW Iran
Piranshahr
Strike-slip fault
Zagros

ABSTRACT

The Main Recent Fault of the Zagros Orogen is an active major dextral strike-slip fault along the Zagros collision zone, generated by oblique continent–continent collision of the Arabian plate with Iranian micro-continent. Two different fault styles are observed along the Piranshahr fault segment of the Main Recent Fault in NW Iran. The first style is a SW-dipping oblique reverse fault with dextral strike-slip displacement and the second style consists of cross-cutting NE-dipping, oblique normal fault dipping to the NE with the same dextral strike-slip displacement. A fault propagation anticline is generated SW of the oblique reverse fault. An active pull-apart basin has been produced to the NE of the Piranshahr oblique normal fault and is associated with other sub-parallel NE-dipping normal faults cutting the reverse oblique fault. Another cross-cutting set of NE–SW trending normal faults are also exist in the pull-apart area. We conclude that the NE verging major dextral oblique reverse fault initiated as a SW verging thrust system due to dextral transpression tectonic of the Zagros collision zone and later it has been overprinted by the NE-dipping oblique normal fault producing dextral strike-slip displacement reflecting progressive change of transpression into transtension in the collision zone. The active Piranshahr pull-apart basin has been generated due to a releasing damage zone along the NW segment of the Main Recent Fault in this area at an overlap of Piranshahr oblique normal fault segment of the Main Recent Fault and the Serow fault, the continuation of the Main Recent Fault to the N.

1. Introduction

The Main Recent Fault (MRF) borders the NE edge of the Zagros fold-and-thrust belt and follows the Zagros suture zone that separates the Arabian continent margin to the SW from the metamorphic rocks of the Sanandaj-Sirjan zone of Central Iran to the NE (Falcon, 1974; Tchalenko and Braud, 1974; Braud, 1987; Berberian, 1995; Talebian and Jackson, 2002). Ophiolites and deep-sea sedimentary rocks were emplaced onto the Arabian plate margin during the Late Cretaceous, due to collision of an island arc with the Arabian plate (Berberian, 1983; Mohajjel et al., 2003; Agard et al., 2005, 2011). Final oblique continent–continent collision resulted in deformation in Zagros fold-and-thrust belt and uplift of the previously collided area in Zagros by steep NE-dipping reverse faults and finally generation of the MRF major strike-slip cutting the Zagros suture zone.

The MRF (Tchalenko and Braud, 1974) has introduced as is a NW–SE oriented major strike-slip fault containing several en echelon segments, along the Zagros collision zone through western Iran (Fig. 1a). Various structural and geomorphologic evidence of dextral strike-slip displacement were presented by several researches. Dextral offsets of 50–60 km have been suggested on the basis of displaced ophiolitic units and major water drainages (Gidon et al., 1974; Talebian and Jackson, 2002). Assuming dextral strike-slip along the MRF was initiated at 3–5 Ma, a strike-slip rate of 10–17 mm y^{-1} is indicated along the MRF. In contrast, GPS measurements indicate that the present slip rate is significantly lower (3 ± 2 mm y^{-1}), than what has been previously expected (Vernant et al., 2004). The two pull-apart basins near the NW end of the MRF give it a total displacement of about 10–15 km at the NW end of this fault (Copley and Jackson, 2006). Later morphological observation agree that maximum total right-lateral offset on the MRF is about 16 km, leading to a slip rate of about 1.6–3.2 mm y^{-1} (Alipoor et al., 2012). Termination faults geometry was introduced in the SE segment of the MRF (Authemayou et al., 2006). All these information are deal with a Major dextral strike-slip fault at the collision zone of the Zagros.

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http://dx.doi.org/10.1016/j.jsg.2014.01.006

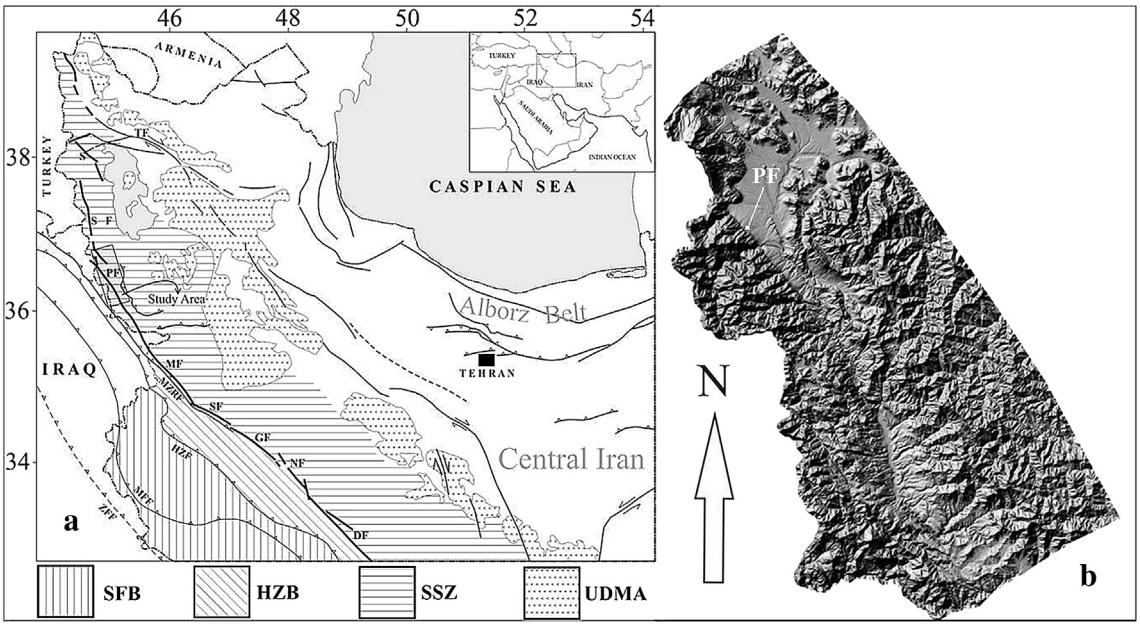

Fig. 1. (a) General tectonic map of NW Iran. Location of the Main Recent Fault (MRF) along the Zagros collision zone. Several segments of the MRF (Tchalenko and Braud, 1974) are shown. Dorud (DF), Nahavand (NF), Garoon (GF), Sahneh, Morvarid (MF) and Piranshahr (PF) faults. The location of the study area is marked in NW part of the map. The other major faults are: Serow fault (SF), Salmas fault (S), Tabriz fault (TF). High Zagros Belt (HZB), Simply folded belt (SFB), Sanandaj-Sirjan zone (SSZ), Urumieh-Dokhtar magmatic arc (UDMA). (b) Satellite image of Piranshahr fault and Piranshahr pull-apart basin generated to the NE of the Piranshahr fault.

The Piranshahr fault (Fig. 1b) is the northwestern segment of the MRF located near the Iran–Iraq border in Kurdistan province (Tchalenko and Braud, 1974). In contrast to the SE segments and termination faults of the MRF (Authemayou et al., 2006), little information is known about the structure of the NW segments due to security problems. All previous geological information about the NW MRF is based on the earthquakes data, air photos and satellite images. Detailed field data has not been previously presented as given in this study.

We aim to present geometrical and kinematic evidence of two different strike-slip fault activities on one single fault segment of the MRF. We introduce for the first time SW-dipping oblique reverse faults cut by oblique normal fault in the Piranshahr area. We give detail structural evidence for two different kinematics superposition of oblique reverse style by oblique normal style faults in the Piranshahr segment of the MRF.

2. Tectonic setting

The Zagros orogen is the result of convergence between the Arabian plate and Iranian micro-continent due to closure of the Neotethys Ocean and subsequent continent–continent collision (Alavi, 1994; Agard et al., 2005, 2011; Mohajjel et al., 2003; Mohajjel and Fergusson, 2013). The suture zone has been identified by exposed ophiolites and deep-marine sedimentary rocks in SW Iran (Ricou, 1976; Kazmin et al., 1986; Mohajjel et al., 2003). The Main Zagros thrust fault is the suture line in the Zagros orogen that divides the metamorphosed hinterland (Sanandaj-Sirjan zone) from the Zagros fold-and-thrust belt. It mark an abrupt boundary between the intense seismicity of the Zagros and the almost aseismic central Iranian plateau to the NW (Berberian, 1995; Talebian and Jackson, 2004).

The Zagros fold-and-thrust belt is divided into two main structural domains: the High Zagros belt and the Simply folded belt (Stocklin, 1968, 1974; Falcon, 1974). The High Zagros belt is a NW–SE trending zone of high topography 10–65 km wide, along the southern border of the Sanandaj-Sirjan zone. It is bordered by the Main Zagros thrust fault to the north and High Zagros fault to the south containing numerous steeply NE-dipping thrust faults and tectonic slices with Paleozoic sedimentary rocks thrust over Cenozoic rocks. The Simply folded belt has a lower topography and is characterized by simple longitudinal folds associated with numerous blind thrust faults (Berberian, 1995).

The timing of collision and location of the suture in Zagros are controversial. Collision has been considered to by some authors to have initiated with obduction of ophiolites and deep-marine sedimentary rocks in the Late Cretaceous (Berberian and King, 1981; Alavi, 1994, 2004). Based on plate tectonic reconstructions and geological constraints from the suture zone, collision is now thought to have occurred in the Miocene (Mohajjel et al., 2003; Agard et al., 2005). A reconstruction based on a global plate motion model suggests that the collision started around 10 Ma (McQuarrie et al., 2003). Tectono-stratigraphic studies provide evidence for propagation of deformation towards the SW since the Eocene (Alavi, 1994; Hessami et al., 2001; Sherkati and Letouzey, 2004), Middle to Upper Miocene (Khadivi et al., 2012) and the main regional folding in the Zagros fold-and-thrust belt is believed to have taken place from the late Miocene and during the Pliocene (Haynes and McQuillan, 1974; Hessami et al., 2001; Sherkati and Letouzey, 2004; Khadivi et al., 2012). Seismic activity in the Simply folded belt is relatively higher than in the High Zagros belt and earthquake focal mechanisms indicate that oblique convergence has been partitioned into reverse slip along NW–SE blind thrusts and dextral strike-slip displacement along the MRF (Berberian, 1995; Talebian and Jackson, 2004).

2.1. Main Recent Fault (MRF)

The MRF is a major seismically active dextral strike-slip fault with a NW–SE trend which follows the Zagros suture and accommodates the strike-slip component of partitioned motion caused by the oblique plate convergence in west Iran (Talebian and Jackson,