Journal of Asian Earth Sciences 94 (2014) 55–67

Contents lists available at ScienceDirect

Journal of Asian Earth Sciences

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

Systematic changes in orientation of linear mylonitic fabrics: An example of strain partitioning during transpressional deformation in north Golpaygan, Sanandaj–Sirjan zone, Iran

Ehsan Moosavi, Mohammad Mohajjel [*], Nematollah Rashidnejad-Omran

Department of Geology, Tarbiat Modares University, PO Box 14115-175, Tehran, Iran

ARTICLE INFO

Article history:
Received 12 February 2014
Received in revised form 28 June 2014
Accepted 2 July 2014
Available online 8 August 2014

Keywords:
Strain partitioning
Shear zone
Transpression
Sanandaj–Sirjan zone
Iran

ABSTRACT

Kilometer-scale, shallowly dipping, NW-striking top-to-the NE reverse and dextral strike-slip shear zones occur in metamorphic rocks of north Golpaygan. These metamorphic rocks are exposed at the NE margin of the central part of the Sanandaj–Sirjan zone in the hinterland of the Zagros orogen. NW-striking top-to-the NE normal shear zones were also found in a small part of the study area. Structural evidence of three deformation stages were found. Pre-mylonitization metamorphic mineral growth happened during D_1. The main mylonitization event was during the D_2 deformational event, following coaxial refolding, synchronous to retrograde metamorphism of amphibolite to greenschist facies in the Late Cretaceous–Paleocene, and before D_3 folding and related mylonitization. We documented the systematic changes in the orientations of D_2 linear fabrics especially stretching lineations and superimposition relations of structures. It is concluded that the dextral strike-slip and dip-slip shear zones were coeval kinematic domains of partitioned dextral transpression. The shallowly dipping reverse and strike-slip shear zones are compatible with partitioning in a very inclined transpressional model. Fabric relations reflect that the top-to-the NE normal shear zones were not produced during deformation partitioning of inclined dextral transpression. The Late Cretaceous–Paleocene strain partitioning was followed by later N–S shortening and NE-extension in the north Golpaygan area.

1. Introduction

Kinematic partitioning of strike-slip and dip-slip components of strain is a common process in oblique convergent plate boundaries. The greatest amount of partitioning occurs when the obliquity angle between plates is less than 20° (Fossen et al., 1994; Fossen and Tikoff, 1998). Strain partitioning also occurs in convergent plate boundary orogens with larger obliquity angles (e.g., Jones and Tanner, 1995; Curtis, 1998).

The occurrence of strain-path partitioning can be evaluated by the study of orientations of lineations and foliations (Mattauer et al., 1981; Ramsay and Huber, 1983; Sullivan and Law, 2007). Lineations are commonly used for structural analysis, strain evaluation, determination of the kinematic characteristics of shear zones (Berthé et al., 1979; Simpeson and Schmidt, 1983) and tectonic transport directions (Ellis and Watkinson, 1987; Shackleton and Ries, 1984; Fossen et al., 1994).

Strain partitioning can be spatial or temporal. In most reported cases, for the spatial case (e.g., Teyssier and Tikoff, 1998; Sarkarinejad and Azizi, 2008), deformation is synchronously localized within pure-shear-dominated and simple-shear-dominated domains. Harland (1971) defined a type of strain partitioning with both temporal and spatial partitioning. In this case, the dip-slip component of deformation can be active during one stage and the strike-slip component in later stage of deformation.

The Sanandaj–Sirjan zone is the metamorphic belt of the Zagros orogen in western Iran (Fig. 1). The Muteh-Golpaygan metamorphic rocks are located at the central NE margin of the Sanandaj–Sirjan zone, close to the Urumieh–Dokhtar magmatic arc in the hinterland of the Zagros orogen (Fig. 1). Tillman et al. (1981) recognized a set of NW-striking normal faults in this area and interpreted it as a result of the Eocene extensional event. Moritz et al. (2006) introduced a low-angle normal fault with associated chlorite breccia between metamorphic and non-to slightly metamorphic rocks. Flat-lying normal sense shear zones those were cut with the high-angle normal faults, as a result of late-stage extension in the early to middle Eocene, as is well documented in the north Muteh Mine area by Moritz et al. (2006). Verdel (2009,

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[*] Corresponding author. Tel.: +98 21 82883434; fax: +98 21 82884435.
E-mail address: mohajjel@modares.ac.ir (M. Mohajjel).

http://dx.doi.org/10.1016/j.jseaes.2014.07.003
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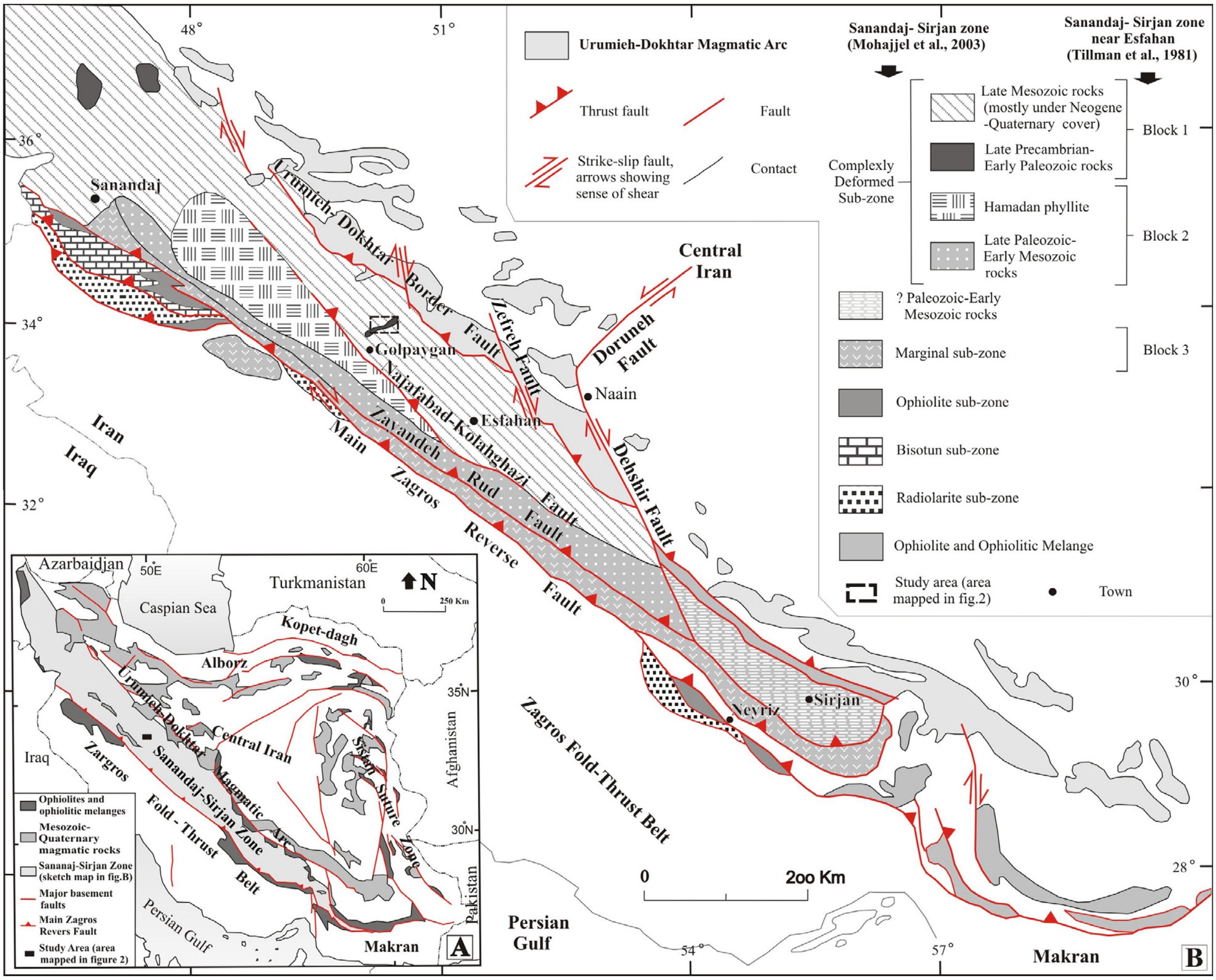

Fig. 1. (A) Tectonic location of the Sanandaj–Sirjan zone in SW Iran and location of the study area (black box). (B) Structural subzones and blocks of the Sanandaj–Sirjan zone (after Mohajjel et al., 2003; Tillman et al., 1981) with location of study area (dashed-line box).

2013) postdated the existence of the structural elements of a metamorphic core complex in the Muteh-Golpaygan area and compared it with the Funeral Mountain Complex in the western United States.

The Muteh-Golpaygan Metamorphic Complex (MGMC) can be divided into two distinct parts: Muteh Metamorphic Complex (MMC) to the north of Muteh village (Fig. 2) and Golpaygan Metamorphic Complex (GMC) north of Golpaygan. Based on Shuttle Radar Topographic Mission (SRTM) digital elevation data (90 m resolution), the highest part of the MMC has an elevation near 2700 m. The GMC, especially its central parts have elevations near 2000 m. Metamorphic rocks in these complexes are mostly developed from Precambrian–Jurassic protoliths initially uplifted due to a transpressional tectonic event during Late Cretaceous time (Mohajjel and Fergusson, 2000). Using amphibole-biotite $^{40}Ar/^{39}Ar$ ages in the MGMC and some structural evidence in the Muteh Mine area, Moritz et al. (2006) proposed a pre-normal faulting sequence of metamorphic and magmatic events for the Cretaceous-early Tertiary time, contemporaneous with a Laramide-equivalent orogeny. $^{40}Ar/^{39}Ar$ cooling ages for the Neoproterozoic granitoids (Fig. 2) in the Muteh Mine area also suggest that low-angle normal faulting was coeval with the early to middle Eocene mylonitization and exhumation of metamorphic rocks (Moritz et al., 2006). In the GMC, there are some shear zones with different structural and kinematic characteristics in comparison with the Muteh Mine area.

In this research, we studied structure of ductile shear zones in the north Golpaygan area (Fig. 2). We aimed to check whether all of the shear zones in the MGMC were formed during a unique deformation model. We focused on structural evidence of mylonitization, kinematic indicators and superimposition relationships in various scales and systematic changes in orientation and kinematics of linear mylonitic fabrics to evaluate strain partitioning and its compatible conceptual deformation models.

2. Tectonic setting

The Sanandaj–Sirjan zone is 1500 km long and 150–200 km wide, extending from east Anatolia in Turkey to the northern part of the Makran accretionary wedge in Iran (McCall and Kidd, 1982; McCall, 1997). It is sub-parallel with the Zagros fold and thrust belt to the southwest and the Urumieh–Dokhtar magmatic arc to the northeast. This arc consists of Mesozoic–Tertiary magmatic rocks formed during subduction of the Neotethys oceanic crust under the Central Iran micro-continent (Fig. 1A). The Sanandaj–Sirjan zone was initially formed during rifting at the initiation of the Neo-tethys ocean in early Permian time between the Central Iran micro-continent and the Arabian plate (Takin, 1972; Sengör, 1984; Alirezaei and Hassanzadeh, 2012). This zone became an active convergent margin when NE-dipping subduction started