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Cenozoic kinematic evolution of southwestern Central Iran: Strain partitioning and accommodation of Arabia–Eurasia convergence

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ABSTRACT

The Yazd block of southwestern Central Iran is located in the back of the Zagros fold-thrust belt and monitors accommodation of Cenozoic shortening within the Arabia–Eurasia collision zone. The Saghand area within the Yazd block exposes a basin-and-range type morphology, which results from NE respectively E–W direction of shortening and a major tectonic change in structural trends within the southwestern Central Iranian block. The NNE-structural trend of various lithotectonic units including the Eocene Chapedony metamorphic core complex in the north is parallel to prominent Cenozoic NNE-trending Chapedony and Posht-e-Badam strike-slip faults. In the south the NNW-trending Anar, Kharanagh–Zarrin, Behabad and Kuhbanan faults are parallel to the Zagros fold-thrust belt and represent dextral strike-slip respectively NE-directed thrust faults, the thrust component representing a back-thrust component to the Zagros fold-thrust belt.

Results of interpretation of satellite images, and structural and geomorphic field observations show a distributed deformation pattern covering a wide domain within southwestern Central Iran. Morphotectonic features like linear mountain ranges and intervening basins (kavirs) are interpreted to result from Neogene to Recent crustal-scale folding with uplifting mountain ranges and subsiding basins. Active thrust faults and evidence for block tilting are common on the eastern side of mountain blocks. Five distinct regional deformation phases respectively paleostress tensor groups have been recognized in the Central Iran from the major structures and through using paleostress inversion techniques for fault slip data. The first phase occurred in the Late Paleocene to Oligocene and is characterized by a subvertical σ_1 and ca. N–S oriented σ_3, which indicate N–S extension associated with late stages of normal faulting possibly due to post-orogenic collapse during exhumation of the Chapedony metamorphic complex. The second phase occurred from Late Oligocene time onwards with an NNE–SSW to NE–SW trending subhorizontal σ_1 and WNW–ESE to NW–SE trending σ_3 patterns due to transpressional deformation associated with a combination of thrusting and strike-slip faulting. The NE–SW to ENE–WSW compressional deformation phase is spectacular evidence of thrust faulting and block tilting affecting the region up to Holocene. This deformation phase is consistent with geodetic, GPS-based kinematic data indicating ca. N10°E motion, which implies strain partitioning with NE–SW shortening and dextral displacement along N-and NW-trending strike-slip faults.

1. Introduction

The convergence between Arabia and Eurasia induced deformation in the Central Iranian plateau in the late Cenozoic. Three end-member scenarios are recently presented to explain various styles of deformation. One model explains the structural evolution as result of lateral extrusion of rigid or slowly deforming blocks via large strike-slip faults that accommodated most of the Arabia–Eurasia convergence (e.g., Allen et al., 2004). The other end-member model suggests the dominance of shortening and crustal-to lithospheric-scale folding (e.g., Bonini et al., 2003; Guest et al., 2007). A third model favours accommodation of tectonic shortening by vertical axis rotation of crustal material (Soffel et al., 1996; Walker and Khatib, 2006).

Large strike-slip fault are found in many regions of active continental shortening and are important elements in accommodating tectonic strain, either by allowing lateral escape of crustal material from the collision zone or strain partition into ca. orogen-parallel strike-slip motion and shortening orthogonal to the orogen (e.g., Molnar and Tapponnier, 1975). In the case of the Anatolian plate, oblique convergence is spatially partitioned into strike-slip-related extrusion and shortening components as in the Zagros fold-thrust belt of southwestern Iran.

Understanding how faults interact in regions accommodating plate convergence involving vertical axis rotation of crustal material is important in order to determine whether the rotations are accommodated by rigid blocks separated by a few major faults (e.g., Molnar and Tapponnier, 1975) or by a diffuse faulting throughout a continuously deforming medium (e.g., England and Jackson, 1989). Vertical axis fault

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rotation appears to be an important process in Central and Eastern Iran (e.g., Jackson and McKenzie, 1984; Soffel et al., 1996). Partly based on Lower Cretaceous limestones from the Saghand region, such a Mesozoic–Cenozoic counterclockwise rotation of western Central Iran has been postulated by Schmidt and Soffel (1984) and Soffel et al. (1996), but was not considered in subsequent studies. Schmidt and Soffel (1984) postulate a ca. 135 degree counterclockwise rotation since Triassic and term the rotating unit Central-East-Iranian microplate. Note that this is only part of Central Iran.

In this paper, we study processes of the Yazd block in southwestern Central Iran accommodating Arabia–Eurasia convergence and present evidence for both ongoing crustal-scale folding and accommodation of convergence in folding and strike-slip motion (Figs. 1 and 2). This region is particularly important in this respect as the structural trend of units and of Cenozoic faults of Central Iran changes from a NW trend in the south to a NE-trend in the north (Fig. 3). The Arabia–Eurasia convergence is still ongoing. The most reliable values for the Arabia–Central Iran convergence vector are provided by recent GPS studies at the Arabian plate scale and are about 25 mm/yr in a direction N10°E (McClusky et al., 2003; Vernant et al., 2004).

This paper presents new data documenting Cenozoic strike-slip faulting in the Yazd block in Central Iran. Neotectonic strike-slip faulting is well established in Zagros (e. g., Bachmanov et al., 2004; Regard et al., 2004; Navabpour et al., 2007; Sarkarinejad, 2007; Mobasher and Babaie, 2008; Sarkarinejad and Azizi, 2008), but the Central Iran is considered to have been relatively stable (Jackson et al., 1995). A recent study in the Yazd block has proposed the active tectonics in this sector of Central Iran (Walker and Jackson, 2004; Meyer et al., 2006).

In this paper, we investigate the Eocene to Recent deformation in southwestern Central Iran (Figs. 1 and 3). We use satellite imagery and field observations, morphostructural studies and structural analysis based on inversion of fault slip data to investigate the significance of faults in the Yazd block of western Central Iran. Another aim is to determine how shortening is accommodated by both distinct conjugate strike-slip faults and large-scale folding.

This work presents for the first time results of outcrop-scale studies carried out along Cenozoic faults from southwestern Central Iran and places the results into a regional tectonic framework. The highly faulted Eocene and Neogene rocks in the Saghand area (Fig. 3) provide an excellent opportunity to study the paleostress history within this region. We also suggest counterclockwise block rotation of some portions of the Yazd block (see below). The record of deformation and stress distribution in southwestern Central Iran reflects the growth and tectonic evolution of the Middle East, and data are critical for evaluating end-member models for continental deformation associated with the Arabian–Eurasia collision.

We use paleostress data that collected along the major faults in the Yazd block of Central Iran to answer several questions relevant for

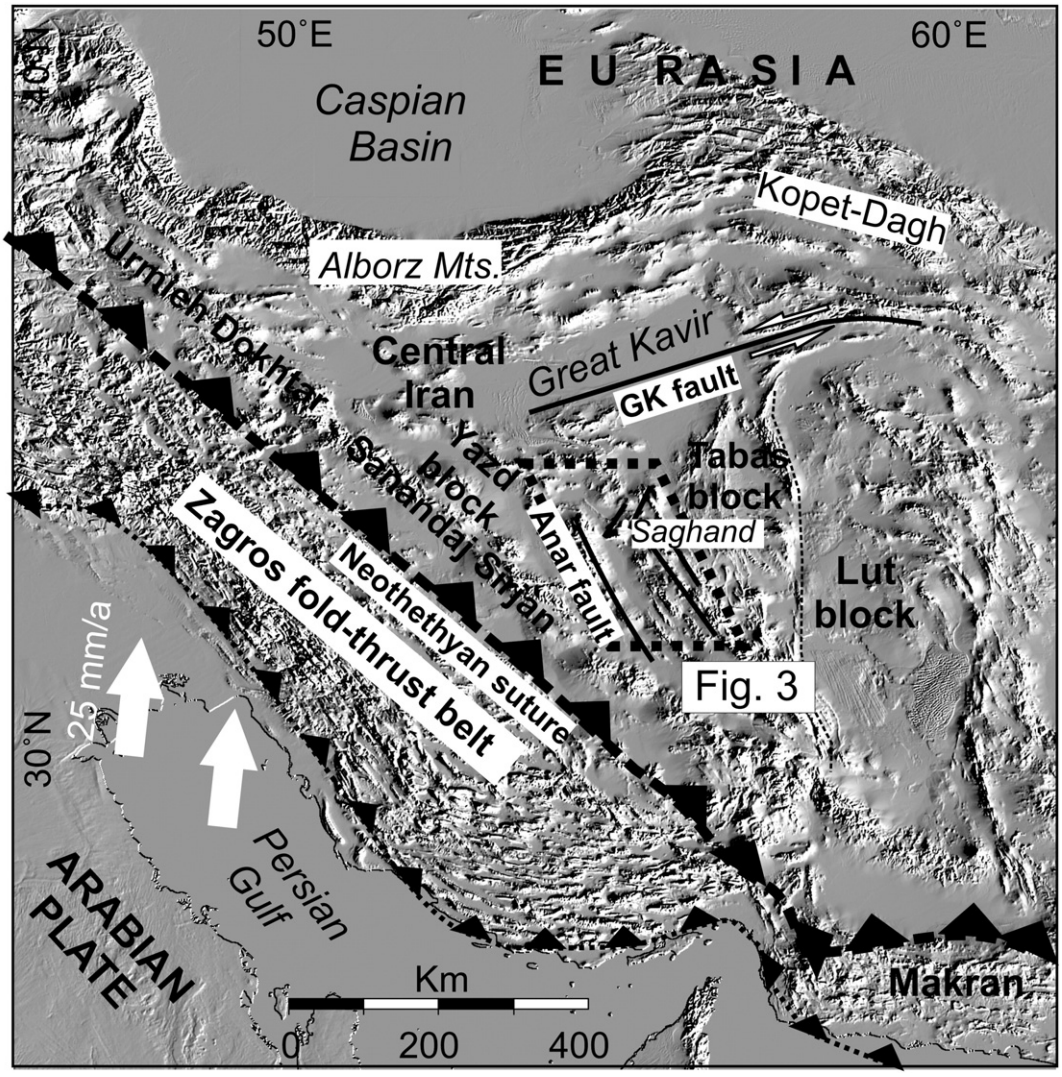

Fig. 1. Digital elevation model of the Arabia–Eurasia convergence zone. Black dashed parallelogram shows the position of study area (Fig. 3). GK fault: Great Kavir fault.