Journal of Asian Earth Sciences 79 (2014) 400–414

Contents lists available at ScienceDirect

Journal of Asian Earth Sciences

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

Control of folding and faulting on fracturing in the Zagros (Iran): The Kuh-e-Sarbalesh anticline

Eugenio Carminati [a,*], Luca Aldega [a], Fabio Trippetta [a], Ali Shaban [b], Hossain Narimani [b], Shahram Sherkati [b]

[a] Dipartimento di Scienze della Terra, Sapienza Università di Roma, Rome, Italy
[b] National Iranian Oil Company, Tehran, Iran

ARTICLE INFO

Article history:
Received 10 May 2013
Received in revised form 4 October 2013
Accepted 8 October 2013
Available online 17 October 2013

Keywords:
Fractures
Fault control
Kazerun Fault
Anticline
Zagros

ABSTRACT

The Kuh-e-Sarbalesh anticline (Fars region), shows a strong and poorly studied curvature in the vicinity of the Kazerun transfer zone. Here we investigated this structure by analyzing the orientation and distribution of fractures in the Oligocene-Early Miocene Asmari Formation (a major reservoir rock of the Zagros petroleum system) and paleo-burial conditions. Far away from the Kazerun Fault, the orientation of fractures is similar to that observed in other folds in the Zagros: two tensional fracture sets (F1 and F2) develop respectively parallel and perpendicular to the fold axis, whereas two shear fracture sets (dextral F3 and sinistral F4) develop at 30° from F2. Closer to the Kazerun fault, F1 and F2 become less abundant, whereas F3 fractures do prevail. F3 dextral shear fractures are associated with dextral shear zones (SZ3). Within SZ3, sets of tensional fractures (F5) occur. F4 shear planes are less abundant than F3 sets and are sometimes associated with sinistral shear zones (SZ4). Within SZ4, sets of tensional fractures (F6) occur. The frequency of F3 and SZ3 structures increases from south to north, suggesting a control by dextral shear along the Kazerun Fault. Average fracture spacing is around 20 cm and fracturing saturation values is larger than 0.7, at 20 km distance from the Kazerun fault whilst spacing is smaller than 1 cm and saturation is as low as 0.32 (typical of well-developed fracture systems) close to the fault highlighting a strong strain gradient from south to north. The orientation of F1 and F2 fracture sets changes from south to north according to the clockwise rotation of the northern part of the fold with respect to the southern part. Inorganic thermal parameters derived from X-ray diffraction analysis of clay minerals indicate that the Asmari formation was deformed at burial depths of 3 km (assuming a geothermal gradient of 20 °C/km). We suggest that the progressive differential advancement of the thrust front produced the curved shape of the Kuh-e-Sarbalesh anticline with associated rotation of the pre-/early-folding F1 and F2 fracture sets observed in the field, consistently with a dextral shear associated with the Kazerun transfer fault.

1. Introduction

The Zagros belt (Fig. 1) is a southwest-migrating orogenic wedge developed from the superimposition of thin-skinned and thick-skinned tectonics (Mouthereau et al., 2006, 2007a, 2007b). Contractional tectonics mainly involves an approximately 7–12 km thick uppermost Neoproterozoic and Phanerozoic sedimentary succession (Alavi, 1991, 1994; Allen and Talebian, 2011). In the Fars region, where the study area is located, the succession is detached along a basal decollement represented by Cambrian evaporites (the Hormuz "series"; Fig. 2). The complexity of the structure of the Zagros fold-and-thrust belt is increased by numerous Cambrian salt diapirs (e.g., Talbot and Jarvis, 1984; Talbot and Alavi, 1996; Mukherjee et al., 2010) and by the occurrence of other detachment layers within the stratigraphic succession (e.g., Sherkati and Letouzey, 2004; Casciello et al., 2009; Vergés et al., 2011).

The front of the Zagros fold-and-thrust belt is characterized by a salient (i.e., by larger advancement of the compressional front) in the Fars region (Fig. 1), where Cambrian evaporites are present at the base of the deformed succession. A recess occurs in the Dezful Embayment, where no such evaporites occur (McQuarrie, 2004; Allen and Talebian, 2011). The differential advancement of the thrust fronts is accommodated by the Kazerun fault, a major transfer zone where dextral strike-slip and/or transpressional earthquakes occur (Sepehr and Cosgrove, 2005). The curved shape of the Kuh-e-Sarbalesh anticline (Fig 1b), that is mainly made up of

* Corresponding author. Address: Dipartimento di Scienze della Terra, Sapienza Università di Roma, P.le Aldo Moro 5, I-00185 Roma, Italy. Tel.: +39 06 49914950; fax: +39 06 4454729.
E-mail address: eugenio.carminati@uniroma1.it (E. Carminati).

1367-9120/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.jseaes.2013.10.018

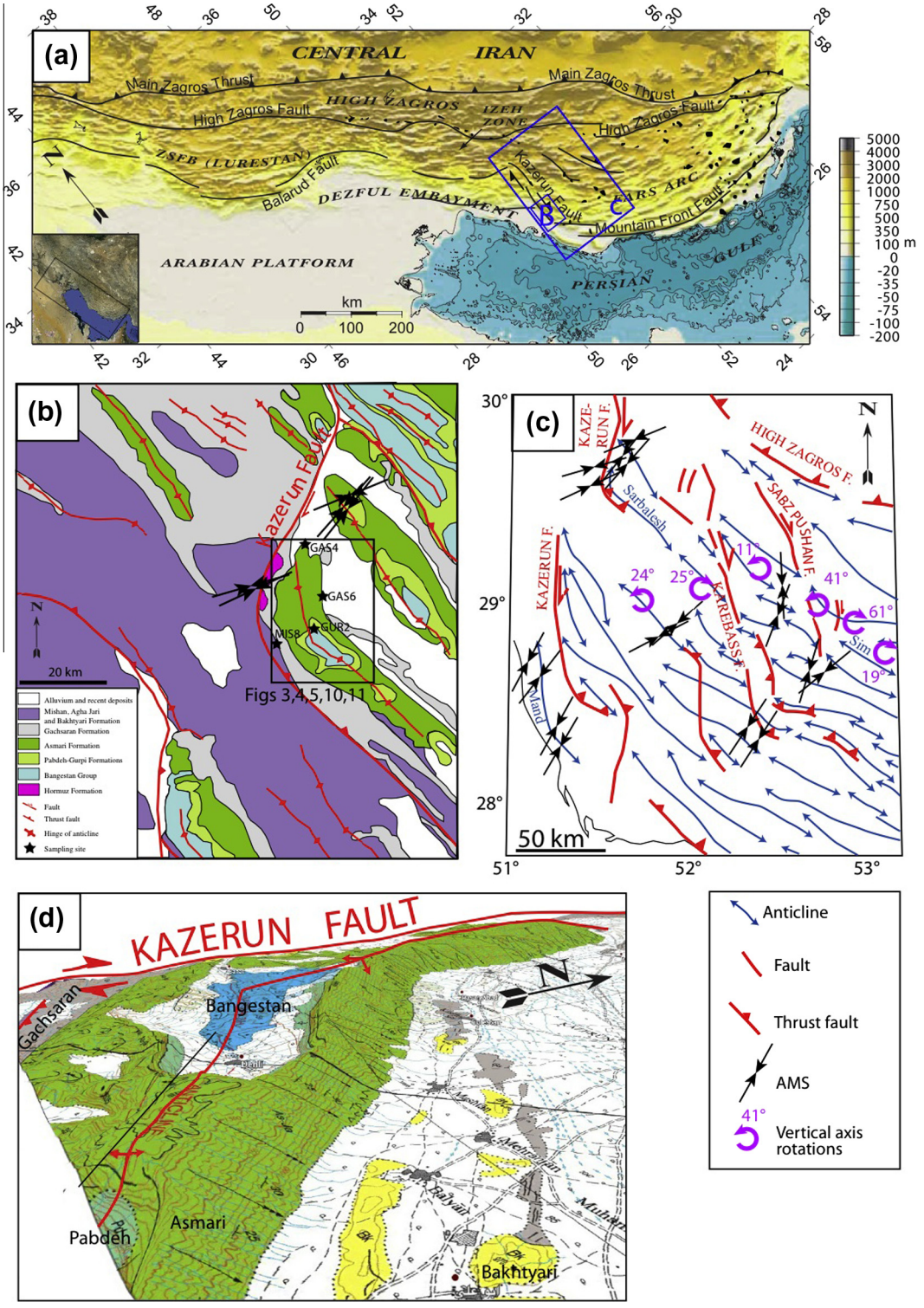

Fig. 1. (a) Simplified map of the Zagros fold-and-thrust belt (modified after Sherkati et al., 2005) showing the location of major salt diapirs (black spots) and of field-work areas (Kuh-e-Sarbalesh anticline). ZSFB: Zagros Simply Folded Belt. (b) Simplified tectonic map showing the relationship between the Kuh-e-Sarbalesh anticline and the Kazerun transfer zone (modified after Sepehr and Cosgrove, 2005). The black arrows show the shortening direction from the anisotropy of low-field magnetic susceptibility (AMS, data after Aubourg et al., 2010). The locations of the samples for X-ray diffraction analysis of clay minerals are also displayed (black stars). (c) Simplified tectonic map of the western Fars area. Main anticline axes and faults are shown. The black arrows show the shortening direction from the anisotropy of low-field magnetic susceptibility (AMS; data after Aubourg et al., 2010). The vertical-axis rotations derived from palaeomagnetic data (Aubourg et al., 2008) are also shown (purple rotation symbols). (d) 3D expansion of the geological map of the Kuh-e-Sarbalesh anticline, showing its curvature and the relationship with the dextral Kazerun fault zone. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)