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Thin-skinned deformation near Shahdad, southeast Iran

M. Mohajjel *

Department of Geology, Tarbiat Modares University, Aleahmad av., P.O. Box 14115-175, Tehran, Iran

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ABSTRACT

Kilometre-scale subparallel folds in the NW–SE trending Shahdad fold-and-thrust belt show active thin-skinned deformation produced by late Pliocene–Quaternary compressional tectonics between the Yazd and Lut blocks of the central microcontinent of southeast Iran. The Shahdad fold-and-thrust belt developed in a Miocene–Quaternary sedimentary sequence with gypsiferous marl overlain by well-stratified gypsiferous siltstone, sandstone, and conglomerate. The geometry of the fold-and-thrust belt is shown in four regional cross sections, which demonstrate common fault-propagation folds developed above thrusts splays and associated with curving ridges. In the northeast, incipient thrusts and back thrusts have developed at the tip of the blind northeast-dying-out sole thrust. However, further west, a major back thrust has brought to the surface the lower part of the stratigraphic succession (Malakhordeh thrust). In some fault-related folds, parts of the folds have been eroded and syntectonic sedimentary strata containing younger gypsiferous conglomerates have been deposited over an unconformity surface. These younger layers are also flexed above the underlying fault-propagation fold as the result of renewed slippage along the active fault. Collapsing has developed in the hinge zones of these folds. The sole detachment fault has developed through the lower plastic gypsiferous marls near their contact with the underlying Paleocene–Eocene volcanic rocks of the Lut block.

1. Introduction

The Central Iran is introduced by Stocklin (1968) as a triangular area limited by the Lut block on the east the Alborz Mountains on the north and the Sanandaj-Sirjan zone on the southwest. Lately, Central- and East-Iranian microcontinent was introduced by Takin (1972). The microplate of central Iran contains three major tectonic blocks of: Yazd block to the west, Lut block to the east and Tabas block in central part (Davoudzadeh et al., 1981; Berberian and King 1981; Alavi, 1991) that are all bordered by mostly dextral strike-slip major faults (Fig. 1). N–S-trending Nayband and Nehbandan faults are the western and eastern borders of the Lut block, respectively (Fig. 1).

Active deformation is well documented in southeastern part of Iran, with the development of relatively rigid blocks between major strike-slip faults (Walker and Jackson, 2002). The N–S-trending Nayband fault system has undergone a total right-lateral displacement of 100–125 km in the last 5 Ma (Walker and Jackson, 2002). This fault forms the western boundary of the topographically depressed Lut block, whereas to the west is the Yazd block that is internally folded and is more than 1500 m higher than the Lut block (Fig. 1).

The dextral strike-slip Nayband fault system consists of three segments, with the Nayband fault to the north, the Sabzevaran fault to the south, and the Gowk fault in the center (Fig. 1). The Gowk fault strikes NNW–SSE, in contrast to the N–S strikes of both the northern and southern segments. The recent dextral displacement along the Gowk fault is 12 km, based on river and stream offsets (Walker and Jackson, 2002). East of and adjacent to the Gowk fault is the Shahdad fold-and-thrust belt (SFTB) of Pliocene to Quaternary age, formed by the convergence of the Lut block and the Yazd block as a result of oblique dextral displacement along the Gowk fault (Walker and Jackson, 2002). Decollement at the base of the SFTB has been proposed along a gently southwest-dipping sole thrust (Fielding et al., 2004). A set of 2–5 narrow ridges make up the SFTB at the surface and are underlain by an inferred gently southwest-dipping detachment (8°) at the base of Neogene molassic sediments (Fielding et al., 2004). Despite strong recent earthquakes caused by the normal displacement of the Gowk fault in this region (Berberian et al., 2001; Walker and Jackson, 2002), very little earthquake activity occurs along the SFTB, and aseismic deformation is inferred (Fielding et al., 2004).

The main goal of this report is to introduce the geometry and kinematic analysis of the fault-related folds in the SFTB, with detailed documentation of abundant incipient back thrusts adjacent to the Lut desert. Four restored cross sections have been drawn across the fold-and-thrust belt. Spatial and temporal evidence for syntectonic deposition is documented, and the style of the fault-related folds in the different domains of the SFTB is presented, together with the amount of shortening observed.

* Tel.: +98 21 44139144; fax: +98 21 88009730.
E-mail address: mohajjel@modares.ac.ir

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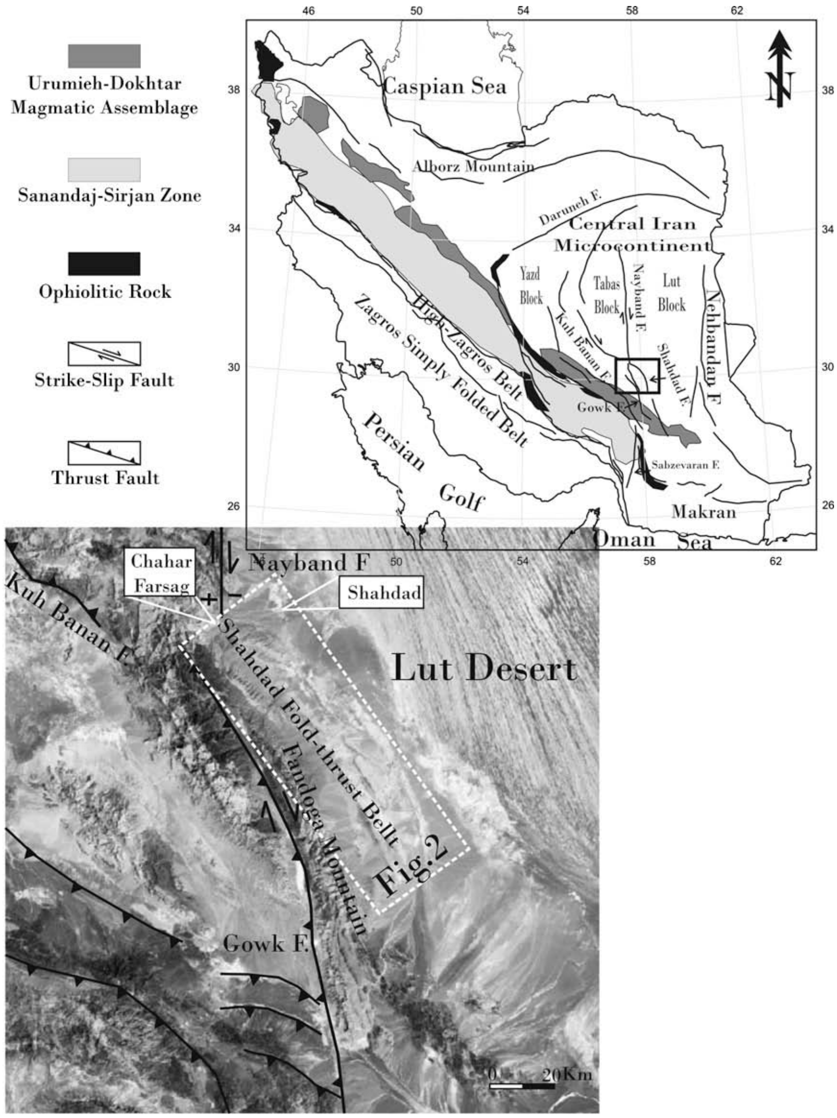

Fig. 1. The main strike-slip faults and blooks in the central microplate of southeast Iran, and the location of the Shahdad fold-and-thrust belt east of the Gowk segment of the Nayband–Gowk strike-slip fault (up). Satellite image of the Shahdad fold-and-thrust belt showing its convex contact with the Lut desert to the east (down).

2. Geological framework

The SFTB has a convex shape to the east against the Lut desert and an approximate N–S-trending straight boundary to the west; along the Gowk fault (Figs. 1 and 2). The SFTB has a length of 120 km and a maximum width of 25 km. The elevation decreases gradually eastwards across the SFTB to the topographically lower Lut desert. Long, straight, subparallel ridges are identified as having formed from fault-related folds. Dissected streams cut across these ridges, indicating that downcutting has kept pace with uplift (Walker and Jackson, 2002). The frontal ridge has developed over 100 km, along the northeastern side of the belt. Less fold ridges occur in the north, whereas more ridges are found to the south of the fold-and-thrust belt. At the western boundary of the fold-and-thrust belt, slices of Palaeozoic–Mesozoic rocks belonging to the Yazd block are thrust over flat-lying the upper younger conglomerates of the SFTB (see below).

Over 3000 m of Neogene detrital and evaporatic deposits occur in the SFTB, including well-stratified gypsiferous marl, sandstone, and conglomerate (Sahandi, 1992; Berberian et al., 2001). In Malakhordeh Mountain, in the northern part of the fold belt (Fig. 2), these deposits are divided into two major rock units: (a) a thick lower unit of pinkish-red gypsiferous marl with upward-increasing siltstone intercalations; and (b) an upper unit of 1200 m of pale gray conglomerate and gypsiferous silty marl, with unconsolidated gypsiferous conglomerate at the top of the succession. The thickness of the stratigraphic succession provides a minimum constraint on the depth of the sole thrust below the SFTB. The Lut block contains several hundred meters of upper Pliocene to Pleistocene lacustrine silts overlying a basement of flat-lying Paleogene andesitic lavas and tuffs (Sahandi, 1992).

3. Structure

The structural style changes along the SFTB from north to south. The frontal ridge is a linear arc structure developed along the eastern edge of the SFTB. In the north, it has a NW–SE trend, which gradually changes to a N–S trend further southwards (Fig. 2). The frontal fault-related fold is well developed and elevated in the central part of the ridge, but gradually loses height towards both its northern and southern terminations. The other ridges in the central part of the fold belt are shorter than the frontal ridge (Fig. 2).