Strike – slip fault system Case Study: Bidhand fault system south Qom in Central Iran

Rouhollah Nadri*

Ph.D. Student of Tectonic, Geology
Corresponding author: Science and Research Branch, Islamic Azad University, Tehran, Iran.
E-mail: nadri@modares.ac.ir

Abstract
The NNW-SSE striking Bidhand strike-slip fault system cut the Cenozoic volcanic rocks of the Urumieh-Dokhtar magmatic arc in south Qom. The structural evidence show at least 16 km horizontal displacements in Eocene volcanic rocks along this fault. Structural evidence indicates later changes in this fault system. The northern segment changes to a reverse fault steeply dipping to northeast. This cased too long compression termination in northwest of the Bidhand strike-slip fault in comparison to the length of the fault in the straight central segment. Young intrusive sills (Miocene) also were emplaced along the fault due to creation of free space during this event. Gabbroic sills in the extension termination of the Bidhand fault at the south-western area was also folded, rotated and thrust to the east due to the later compaction in this area. New fault planes were also generated along the central segment of the Bidhand strike-slip fault that cut the earlier generated fault plane.

Keywords: *Strike slips Fault, fault segment, Urumieh-Dokhtar magmatic arc, Bidhand fault system, Qom, Iran*

1. Introduction
The subduction of the Neo-Tethyan ocean floor beneath Iranian plate built the Zagros Orogenic Belt. This orogenic belt has been proposed to have resulted from the opening and subduction of the Neotethyan oceanic realm and subsequent oblique collision of Afro-Arabia (Gondwana) with the Iranian microcontinent in the Late Cretaceous–Early Tertiary (Berberian and King, 1981; Alavi, 1994; Mohajjel and Fergussen, 2000). Within this collision, three major tectonic elements with NW–SE trends are recognized in Iran (fig 1). (Takin, 1972; Berberian and King, 1981; Sengor, 1984; Alavi, 1994; Ricou, 1994; Mohajjel et al., 2003).
They include the Urumieh-Dokhtar magmatic arc (UDMA), the Sanandaj- Sirjan metamorphic zone and Zagros-Folded-Thrust belt (Alavi, 1994; Mohajjel et al., 2003). The UDMA forms a distinct linear intrusive–extrusive complex, which extends along the entire length of Zagros orogen, with 50 km width and 4 km thick (Berberian and Berberian, 1981; Alavi, 1994). Extrusive volcanism in the UDMA began in the Eocene and continued for the rest of that period, with a climax in Middle Eocene (Berberian and King, 1981). It is generally assumed that the UDMA was the magmatic arc overlying the slab of Neo-Tethyan oceanic lithosphere which was subducted beneath the Iranian plate (Berberian and Berberian, 1981; Alavi, 1994). We suggested an origin relating the UDMA to strike slip faulting. In this zone have dextral strike slip faults that with NNW-SSE striking such as: Dehshir – Baft strike slip fault, Qom – Zefreh strike slip fault, Bidhand strike slip fault and south Saveh strike slip fault with dextral displacement in UDMA rocks (fig 2). The Bidhand strike slip fault system cuts the UDMA in south Qom in the central Iran Basin. The structural evidence show atleast 16

km horizontal dextral displacement in UMDA rocks along this fault. The aims of this paper are (1) to describe and interpret the Bidhand strike slip fault system and structures related with fault, (2) to suggest the conditions of their genesis, and (3) to discuss the fault timing and tectonic evolution in this region.

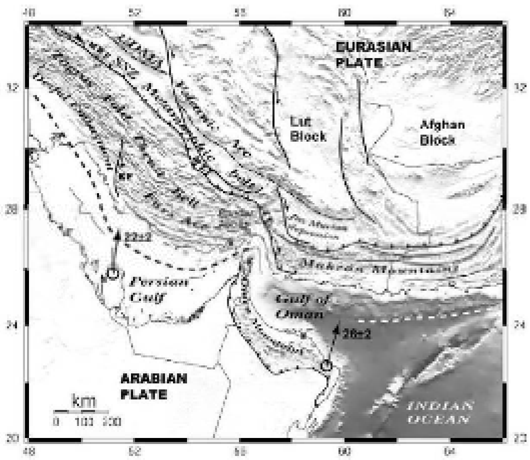

Fig. 1) Structural map of the south-eastern Zagros Mountains and the Zagros - Makran transition zone. KF, Kazerun Fault; ZF, Zendan Fault; SSZ, Sanandajsirjan Zone; UDMA, Urumieh Dokhtar Magmatic Arc. GPS convergence vectors after Vernant et al. (2003).

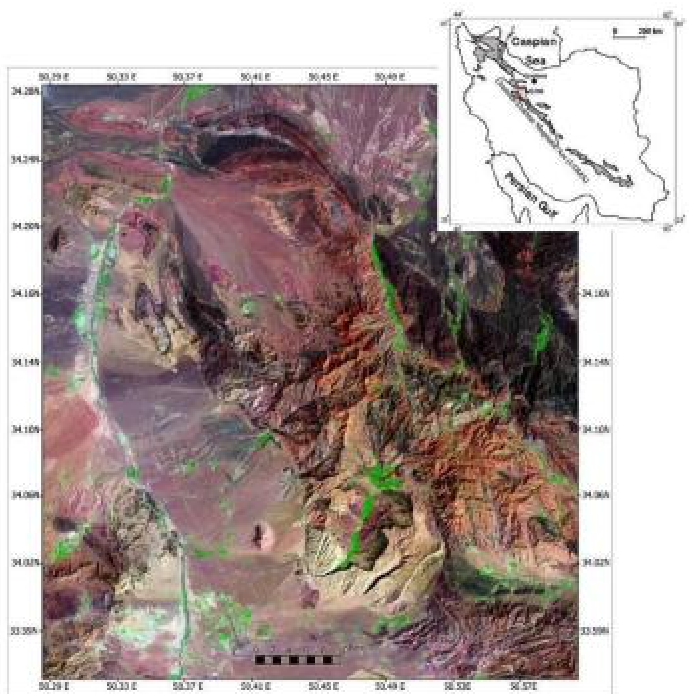

Fig. 2) The Urumieh-Dokhtar magmatic arc (UDMA) with NW-SE trend in Iran (after Aghanabati, 2004) and location of fault in south of Qom province (inset) and Landsat TM bands 7-4-2 (RGB) of study area.

2. Stratigraphy and Geological setting

Tertiary deposits in Central Iran comprise a basal conglomerate followed by a sandstone sequence which rests unconformably on older rocks, and is overlain by a volcanogenic unit consisting mainly of submarine and continental lava flows and dacitic tuffs of Eocene age (Berberian and King, 1981). In Central Iran, the Oligocene consists of 1000 m of gypsiferous and evaporitic red beds (Lower Red Formation), which are overlain conformably by marine limestones and marls Qom Formation. The Qom Formation is overlain conformably by evaporitic red beds of Middle-Late Miocene age (Upper Red Formation) which are in turn overlain by a thick sequence of Pliocene conglomerates (Stocklin and Setudehnia, 1971). The study area is a part of central Iran that includes a Jurassic to quaternary succession with Eocene UDMA rocks. The kinematics of the Middle East region is now dominated by northward convergence of the African (AF) and Arabian (AR) plates against Eurasia (EU). In common with many other orogenic belts deformation in the Zagros Orogen reflects transpression rather than normal shortening across the orogen (Dewey et al., 1998). Many zones with transpression have non-coaxial deformation developed along weak narrow faults whereas in the study area, the strike-slip component of the transpression has occurred over wide zones of deformed rock.

3. Structural analysis of Bidhand Fault System

The NNW-SSE trending Bidhand strike slip fault system cut the Cenozoic volcanic rocks of UMDA in south Qom province in central Iran. The structural evidence show at least 16 km horizontal displacement in Eocene volcanic rocks along this fault. That Length without north and south terminations is about 43 km that isn't continuous but really consists of fault segments with different trends. Structural evidence indicates later changes in this fault system. A change in the strike has also played a significant role in the geometry of the faulting. According Z form geometry (fig 3) of fault and structural evidence we divided this fault to three segments: Venarch segment (northern segment), Abarjes segment (middle segment) and Naragh segment (southern segment).

3.1. Northern Segment (Venarch)

The Bidhand strike slip fault in this area changes to a reverse fault steeply dipping to northeast and form north termination of Bidhand fault. This cased too long (17 km) compression termination in northwest of the Bidhand strike-slip fault in comparison to the length of the fault in the straight central segment. This segment including tow main thrust faults (T_1 and T_2) with E-W trend. In the study area, T_1 thrusting Eocene tuff and shale (E^t_5) on the Oligomiocene alternation of sandstone and marl (OM^s_q) of Qom F. Measurement on the T_1 fault plan shown dips at 55° toward 350°. The E-W trending T_2 thrusted andesitic-basaltic lava (E^v_6) on the Marl, limestone and sandstone (OM_q) of Qom F. The evidence for dextral deformation include S–C fabrics by T_2 activity. In this segment exist 9 folds with tow trending: NW-SE trend (fold 1-4 in fig 3) and W-E trend (fold 5-9 in fig 3). W-E trend folds are related to faulting and overturned folds. All of folds Characteristics in this area shown in table (1).

Table1) Characteristics of all folds that represent in fig3.

Fleuty (1964)	Ramsay (1967)	Ramsay (1967)	(α)	(β)	Trend	D/D.d	Fold name	Fold number
Close	Steeply inclined	Sub horizontal	62	02/310	N300	63/030	Kuh – mil ant.	1
Open	Upright	Sub horizontal	112	08/124	N285	84/015	Bidhand syn.	2
Close	Steeply inclined	Gently plunging	70	03/300	N280	70/010	Aznave ant.	3
Open	Steeply inclined	Sub horizontal	75	30/109	N300	70/030	Kahak syn.	4
Open	Upright	Gently plunging	106	20/285	N280	80/010	Ghale – cham ant.	5
Open	Upright	Sub horizontal	85	06/094	N275	84/185	Kahak ant.	6
Tight	Moderately inclined	Sub horizontal	20	06/282	N265	38/355	Shahrestan ak ant.	7
Tight	Steeply inclined	Gently plunging	11	11/090	N275	65/005	Salafchega n syn.	8
Tight	Moderately inclined	Sub horizontal	10	02/279	N270	47/000	Salafchega n ant.	9
Open	Upright	Sub horizontal	44	06/314	N340	85/250	Neyzar ant.	10
Close	Steeply inclined	Gently plunging	72	19/346	N320	70/050	Ravanj syn.	11

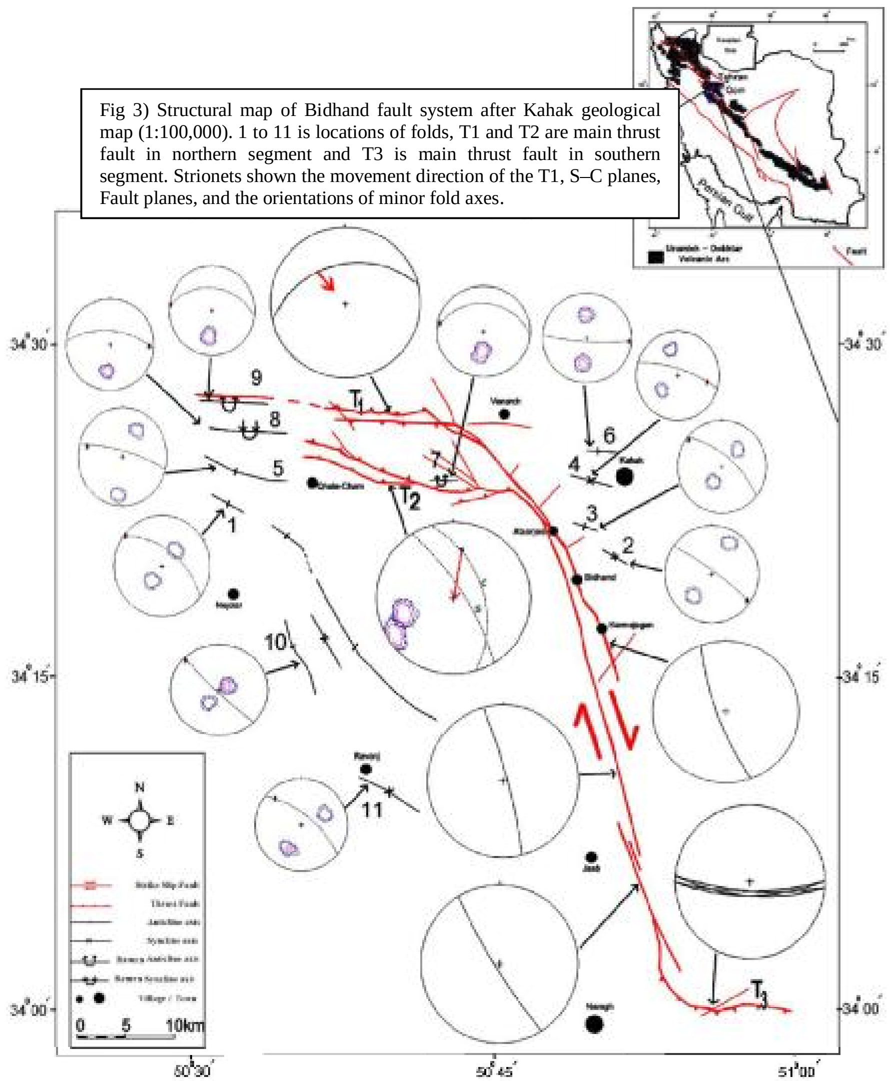

Fig 3) Structural map of Bidhand fault system after Kahak geological map (1:100,000). 1 to 11 is locations of folds, T1 and T2 are main thrust fault in northern segment and T3 is main thrust fault in southern segment. Strionets shown the movement direction of the T1, S–C planes, Fault planes, and the orientations of minor fold axes.

3.2. Middle Segment (Abarjes)

This area is a main segment of Bidhand fault system. The megascopic structural interpretation of Abarjes segment displays enechelon pattern with right overstepping arrangement in this segment. The anticlinals and synclinals axial traces indicates relationship to fault activiation, that could possibly be coeval to the dextral transpression corresponding to a horizontal NW–SE shortening consistent with transpression tectonics at regional scale. Fault zones may begin as simple systems that become more complex in time or the opposite begin complex and evolve toward simplicity. A common type of geometrical complexity at the surface is fault segmentation and overlapping segments. Pull-apart basins, which are formed between such overlapping segments, are commonly shorter than the total offsets on strike– slip faults. This can be explained by changes in the fault geometry and formation of such basins after some slip had accumulated (Marco, 2007). Bidhand fault in this segment isn't uniform and continuous, but it was arranged by right setepping faults segment wich suggested fault plan migration played a significant role in the geometry of this segment, so that new fault planes were also generated along the central segment of the Bidhand fault that cut the earlier generated fault plane.**3.3. Southern Segment (Naragh).**This segment includes south termination of Bidhand fault system. Dextral movement of Bidhand fault caused extension tectonic in this segment. Extension tectonic in the West of fault resulting pinnate fractures and took place gabbro-diorite intrusive rock in this area. Main fault in this segment is T3 with E-W trend that thrusting early Eocene alternation of green tuff, shale and sandston (E_3^{ts}) on Miocene red pyroclastic rocks and dacitic – andesitic lava (M^{tv}).This fault dipping southward. Gabbroic sills (gb) in the extension termination of the Bidhand fault at the south-western area was also folded, rotated and thrust to the east due to the later compaction in this area (fig 4-D).

4. Conclusion

The NNW-SSE striking Bidhand strike-slip fault system cut and displaced the Cenozoic volcanic and sedimentary rocks of the Urumieh-Dokhtar magmatic arc. The compressional and extensional terminations were developed at the western block and do not observed at the eastern one Analog models of restraining stepovers in Bidhand fault Since Early Eocene to Recent shown in fig 4.

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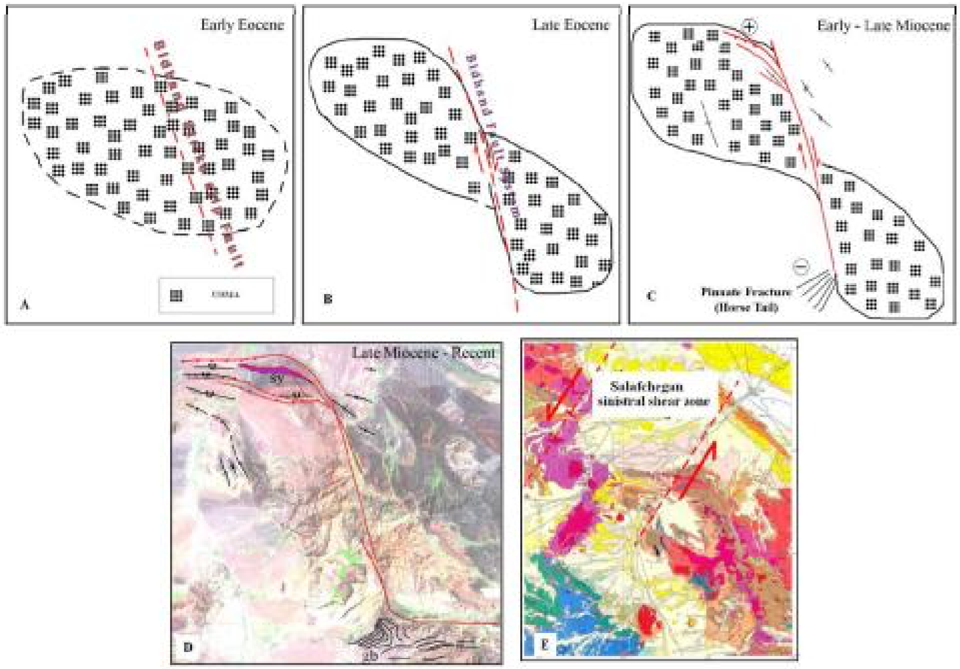

Fig 4) Analog models of restraining stepovers in strike-slip fault systems. A) Early Eocene B) late Eocene C) Early – Late Miocene D)Late Miocene – Recent, E) Salafchegan sinistral shear zone in Geological map of Qom (1:250000)

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