Geometric and kinematic analysis of faults in around of Asef Mountains, north of Shiraz (Folded Zagros Belt)

Neda Rezazadeh[1*], Ramazan Ramazani Oomali[1]

1- Shahrood University of Technologhy, Shahrood, Iran

* Corresponding Author: N_Rezazadeh84@yahoo.com

Received: 26 January 2014 / Accepted: 08 May 2014 / Published online: 10 May 2014

Abstract

In current paper, geometrical relationship between the longitudinal faults of a zone of the folded Zagros, surrounding Asef Mountains (north of Shiraz) that follow the northwest-southeast structural trend (eg. Zarghan, Katah and Sadra faults) has been studied. A western and southern zone of Zagros Mountain Chain called folded Zagros has a length of about 1375 km and a width between 120 and 250 km. The considered area is in the north of Shiraz (Sadra city in the north and near the Zarghan city) and form a part of southeastern zone of folded Zagros. The folded Zagros is considered as one of the tectonically active regions in Iran. Asef Mountains is limited by Katah and Zarghan faults from north and by Sadra faults from south. Sadra, Zarghan and a part of Katah are the faults which passed through the Quaternary sediments, as well as form the boundary of Cenozoic units in the northern and southern slopes. All these faults are located in the same structural domains and have similar geometry and mechanics. Impacts of these faults on the RGB satellite image have been identified like three lineaments. Satellite images and field visits indicate that all these faults have dip-slip reverse component and associate with right-slip component.

Keywords: Faults- Folded Zagros- Katah- Sadra- Zarghan.

1–Introduction

Asef Mountains is located in the north of Shiraz and in the zone of folded Zagros. The general trend of folds and faults is in the northwest-southeast Zagros. Zarghan, Katah and Sadra Quaternary faults are some of the major longitudinal faults in the folded Zagros which obey the northwest-southeast direction. Study area, Zarghan, Katah and Sadra faults as the longitudinal faults and F4 faults as a transverse fault of mentioned zone, has been studied and identified. Geometrical and kinematical relations for longitudinal faults have been studied. Geological map of the area along with the faults and rock units in the zone is observed in Figure 1. Location of the faults on the satellite image is indicated in Figure 2. Folded Zagros Belt which also called Simple Folded Zone of Zagros (Falcon, 1974), is a part of the Zagros Orogeny that is widespread from the border of Iran and Turkey in the northwest to Makran zone in the southeast (where seduction is still active) (Smith *et al*, 2010; Agard, *et al*, 2011). In this study, kinematic characteristics of three major faults around the Asef Mountain as well as features of transverse fault F4 are investigated. Faults in this region also follow the northwest-southeast trend. Rock units that are subject to faulting, belong to the Cenozoic.

2– Methodology

Present article has been written based on the former studies, particularly geological map of Shiraz (Andalibi et, al., 1376), geological map of Kalestan (Oveisi et, al., 1380), telemetry studies and field achievements. In order to structural analyze the faults of the zone, Stratigraphy and morphology evidence for fault surface such as slicken line and fault step surface have been used. Furthermore, in order to studying and interpreting Quaternary faults, some profiles have been drawn along SW-NE direction perpendicular to the fault line.

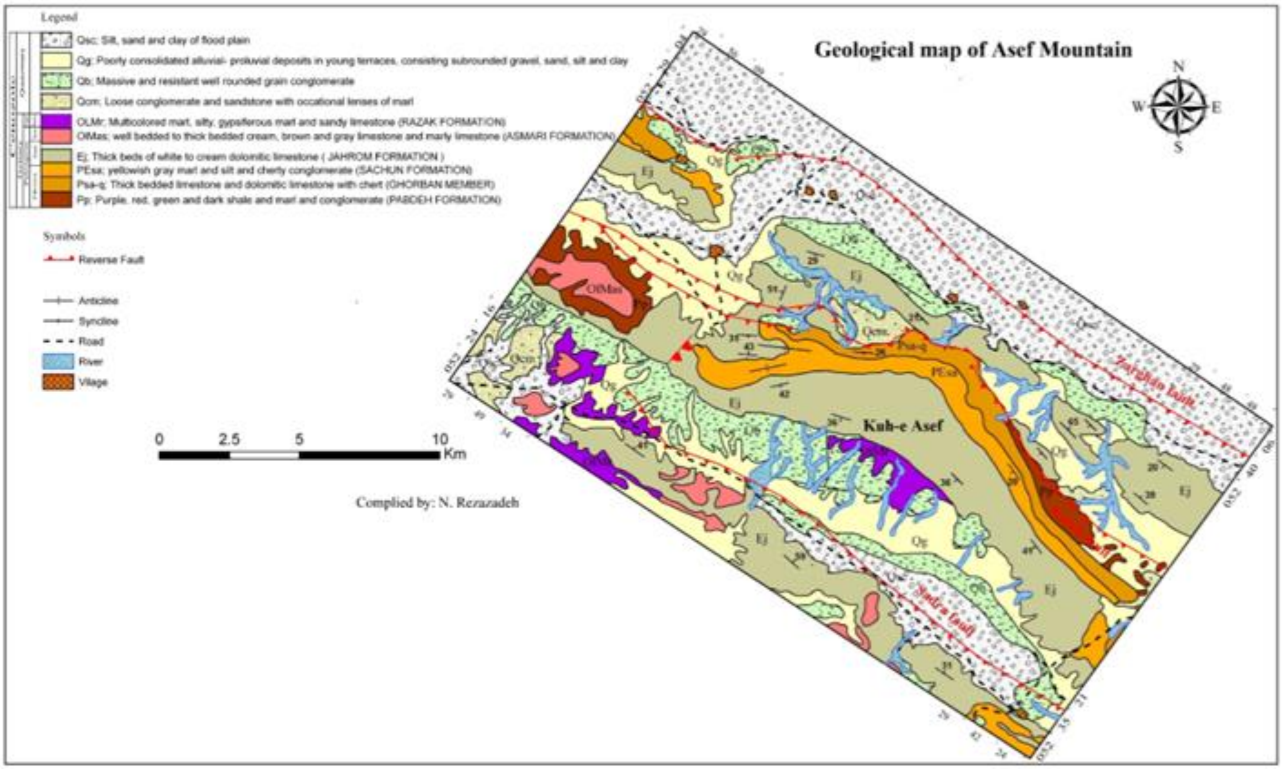


Figure 1) Geological map of the studied area taken from the 1:100,000 geological map of Shiraz and Kaletan and satellite images.

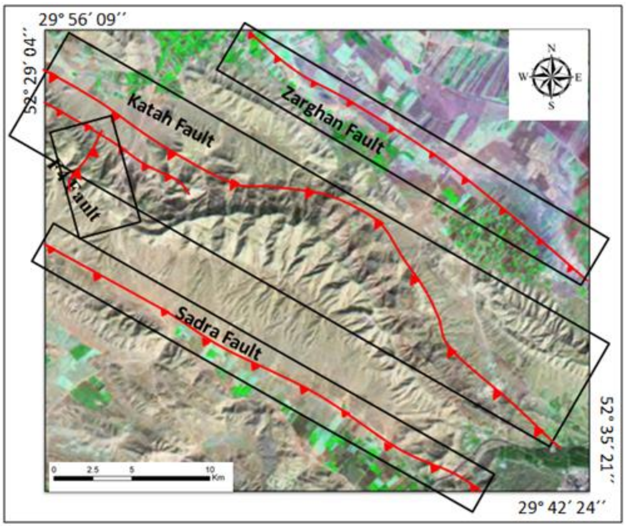


Figure 2) Location of faults in the region on the satellite image RGB.

3– Geological setting

The studied area is a part of the southern half of folded Zagros in the north of Shiraz city and locates between eastern longitudes 52° 29' and 52° 35' degrees and northern latitudes 29° 42' and 29° 56' degrees. Existent rocks in investigated area are thoroughly sedimentary. Based on previous studies, particularly geological map (1:100,000) of Shiraz (Andalibi *et al.*, 1376) and field visits, Cenozoic formations are developed such as Formation of Pabedeh, Jahrom, Sachoun, Qorban, Razak and Quaternary deposits of outcrop. The structural trend of the zone (the trend of folds and faults) follows the structural features of the folded Zagros (Northwest-Southeast).

4–The Faults

4-1- Katah Fault

Katah fault with an approximate length of 28 km is located in the northern part of Asef Mountain. The fault lineation of Katah with NW-SE direction is observable in Figure 2. The geometrical location of the fault is N45W, 78SW and cause to drive dolomitic constructors of Jahrum (Paleocene-Middle Eocene) in the hanging-wall on Quaternary deposits and also driving the Pabedeh formation (Paleocene-Oligocene) in the hangingwall on the Jahrum formation in footwall associated with 65 degrees anti-clockwise sliken line on hanging wall shows a reverse mechanism with a small component of right-track dip-slip on the Katah fault. Figures 3 to 7 indicate images of field certificates for Katah fault including valliage fault, morphological signs of the fault's surface, transport streams, iconic profiles and its stereograms.

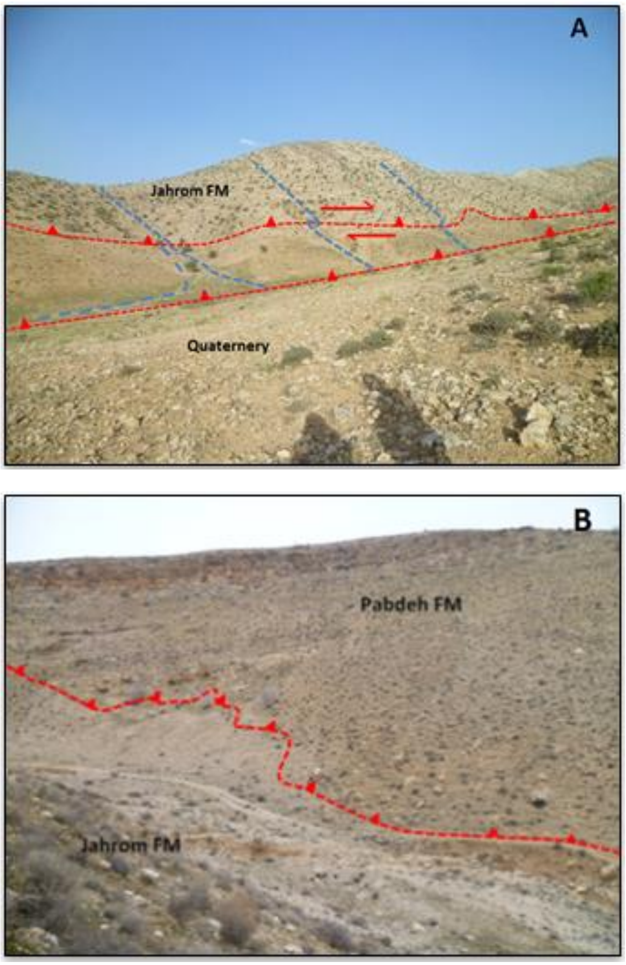
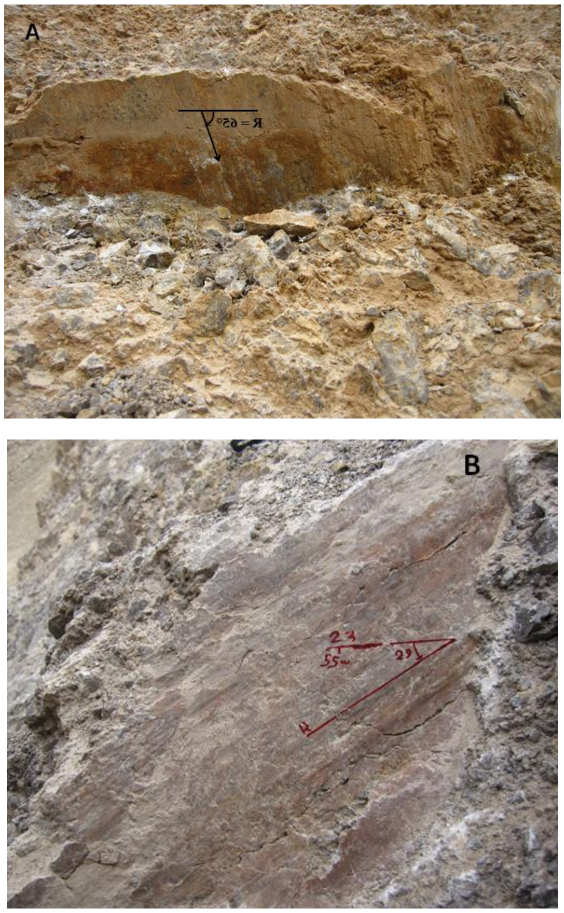


Figure 3a) Outcrop of the Katah fault at station 1 that Jahrum dolomite formation (hanging wall) is located on Quaternary deposits (view to the southeast). b) Katah fault outcrop at station 2, the formations of two sides of Pabedeh and Jahrum.

4-2- Sadra Fault

Sadra fault with a length of approximately 23 km is placed in the northwest of Sadra city around the Soufia mountains in the northeast of Shiraz (East of Bajgah). Sadra fault lineation with NW-SE direction could be seen in Figure 2. It was found during the field observations by moving along the Sadra fault in different stations that the crossing position of this fault is among Quaternary alluvium (Sadra New City).



In this regard, no slicken line and fault sheets have been detected. The direction of this fault is N49°W but its effect has not seen on the hard conductors. According to the 1:100,000 geological sheets of Shiraz and Kalestan and field observations, it can be seen that the gradient of this fault is toward to the southwest. Figure 8 shows some images of the desert outcrops of Sadra fault, and its position on Google earth satellite images.

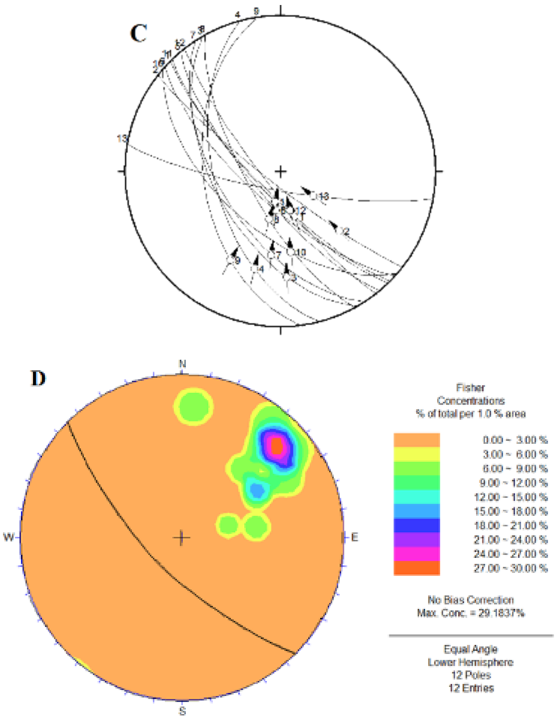


Figure 4a and b) Observed slicken lines along the Kata fault confirmed that the fault is on the right-track moving, these slicken lines are related to hanging wall block. c) Cyclograph images of Kata fault. d) Flow chart of the data centers that indicates 78SW, N45W trend.

Figure 5) Right-track displacement of streams determines the righ-track direction of Katah fault.

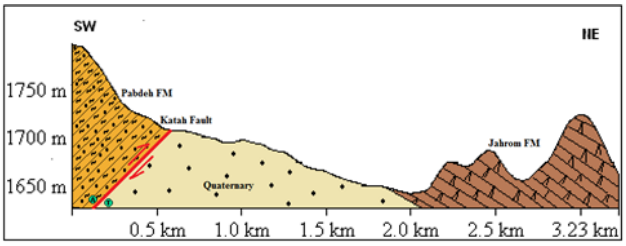


Figure 6) Symbolic section along the southwest-northeast of the Katah fault.

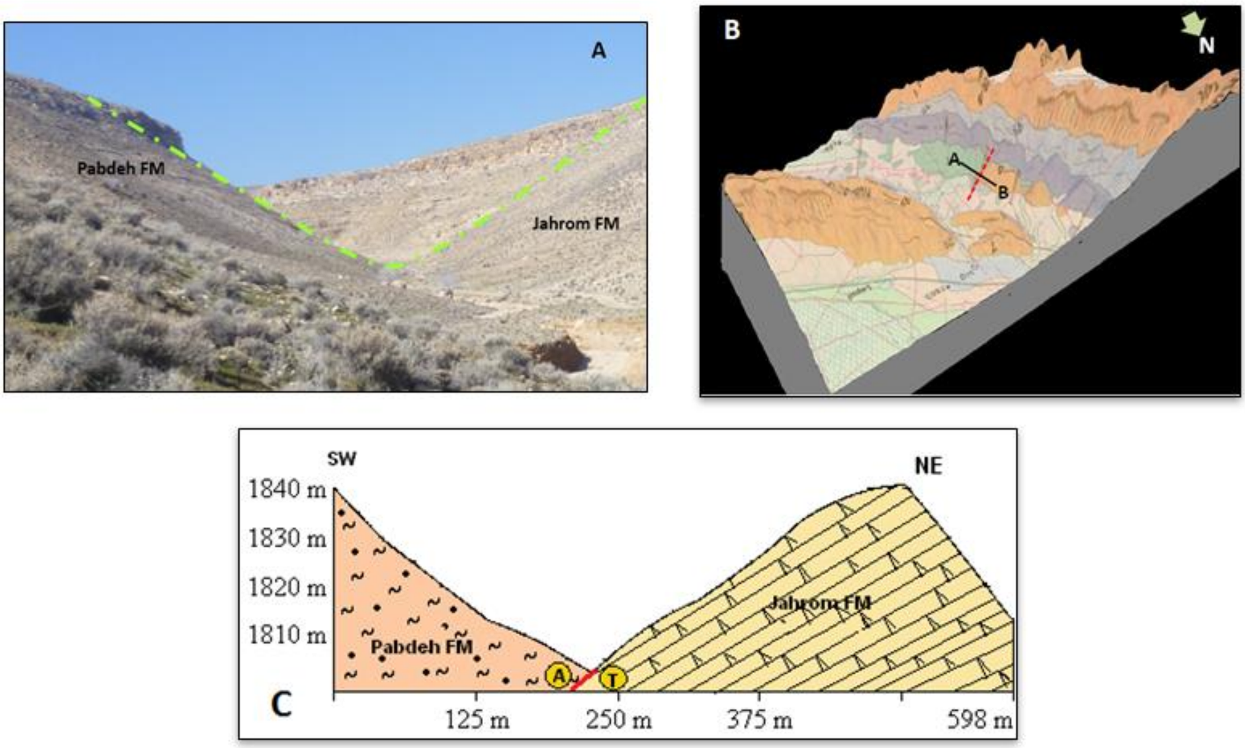
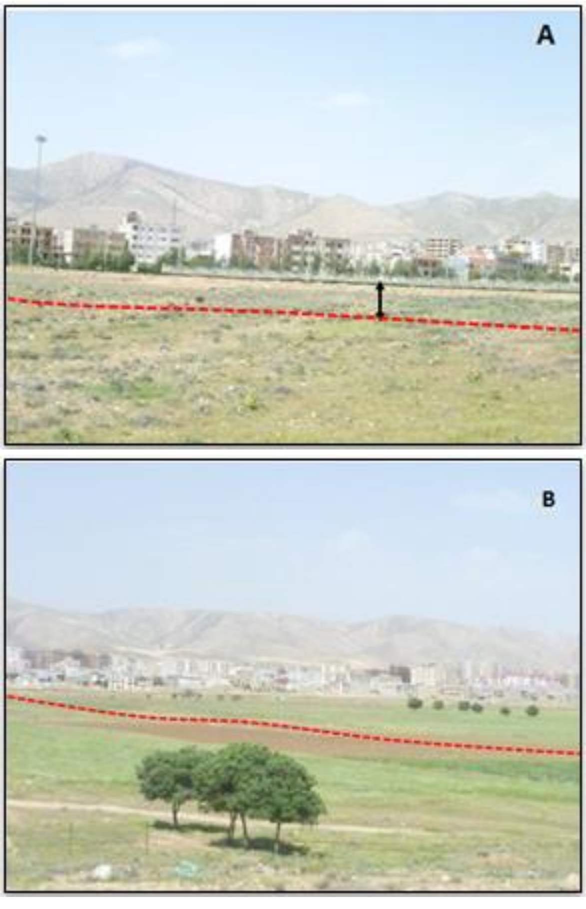


Figure 7a) Valley fault caused by fault activity. b) Three-dimensional image of the valley fault combining the SRTM data and geological map of the zone. c) Transverse profiles of the Valley fault.

According to this fact that Sadra fault passes among Quaternary sediments and no fault sheet and fault scratches and even outcrop are detected from road trenches along this fault, so as to determine the fault geometry, a section along the SW-NE is provided. With regard to this section and studying the gradient of lamination of both Asef and Bajgah mountains and also as well as the same genus of both Asef and Sarda mountains, it could be concluded that Sadra plateau is a synclinal basin, and Quaternary sediments is located on the synclinal basin. It seems that in this area somewhere that be under tension is suddenly raised (locating Jahrum formation on Quaternary sediments) and cause an expulsion. Therefore, slope-slip reverse component could be identified for Sadra fault. It also possible to determine the right-track mechanism for the fault by observing streams around the Sadra fault (Fig. 9).



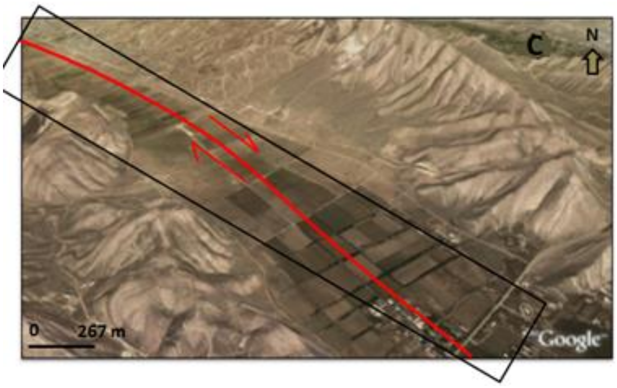


Figure 8a and b) The field outcrop of Sadra fault (view to the southwest). c) Sadra fault location on a Google earth satellite image.

Figure 10 indicates a symbolic cutting of Sadra fault. The impact of Sadra fault on the earth surface in the studied zone can be seen as existent ups and downs in the northern and southern parts of Sadra city. Moreover these ups and downs formed in the city's floor can be easily seen on Google earth satellite images (Fig. 11). it is possible to mention to fault partitions as another geological phase of Sadra fault (Fig. 12). Figure 13a indicates the three-dimensional image of Sadra fault from combining the DEM data and geological map of the region, and Figure 13b shows a transverse profile of the Sadra fault.

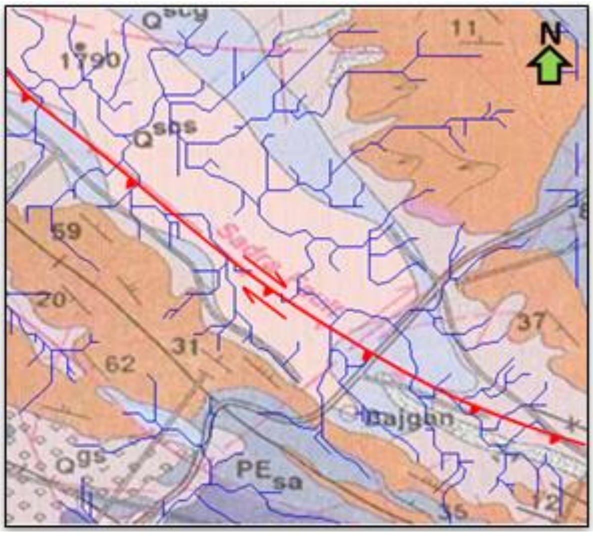


Figure 9) Right-track displacement of streams around the Sadra fault by combining the DEM data and geological map of the area drawn by Global Mapper software.

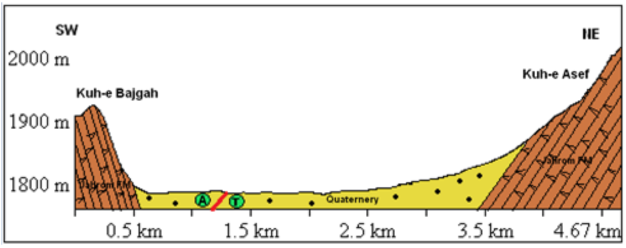


Figure 10) Symbolic section of Sadra fault along the SW-NE.

4-3- Zarghan Fault

There is a fault in the northern zone of Asef mountain called Zarghan which is located along NW-SE trend at relatively close distance to the south of Katah and parallel to it (Figs. 1 and 2). The Zarghan fault with approximately 75 km length is limited to northwest of Beiza city and to the east of Zarghan city and Gadvan Mountain and passes the southwest of Zarghan city.

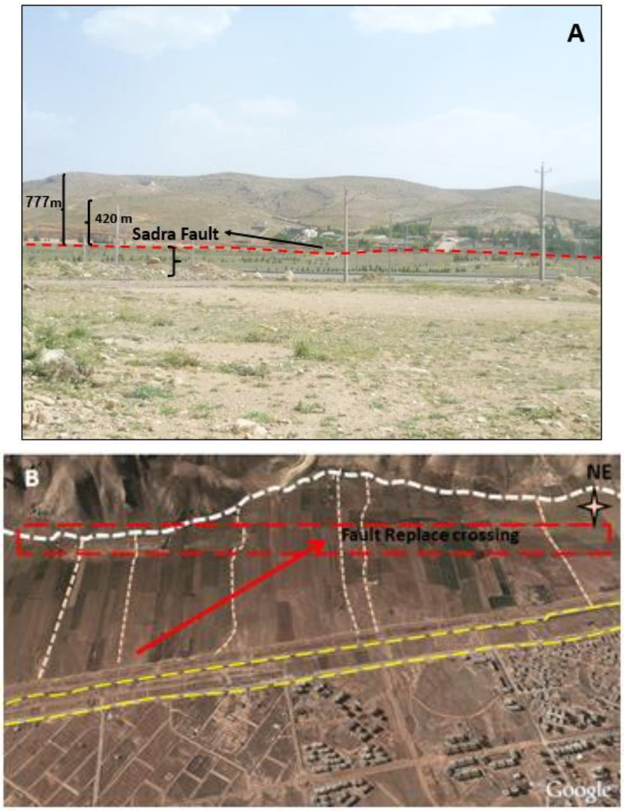


Figure 11a) Field outcrop of the Sadra fault that causes ups and downs in the region. b) Google earth satellite images that shows the ups and downs caused by the Sadra fault performance.

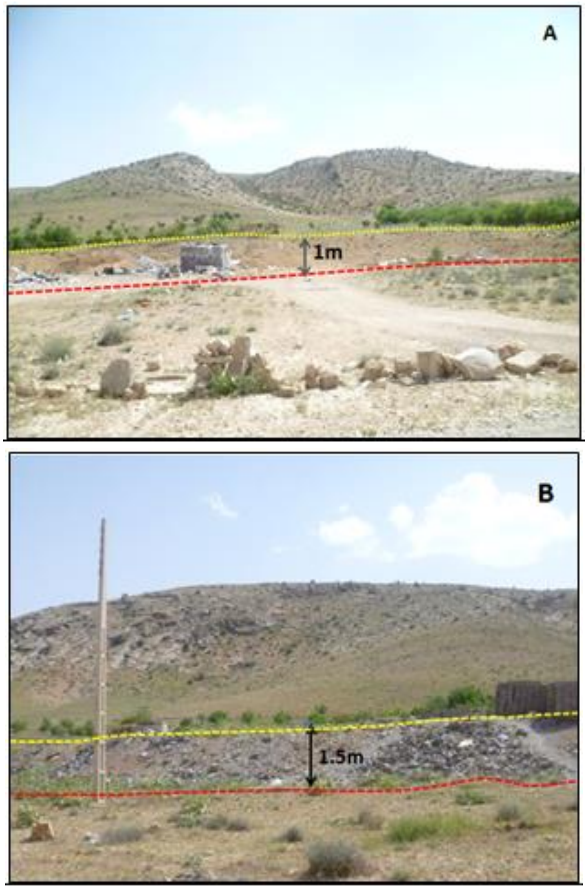


Figure 12) Fault partitions caused by th activity of Sadra fault.

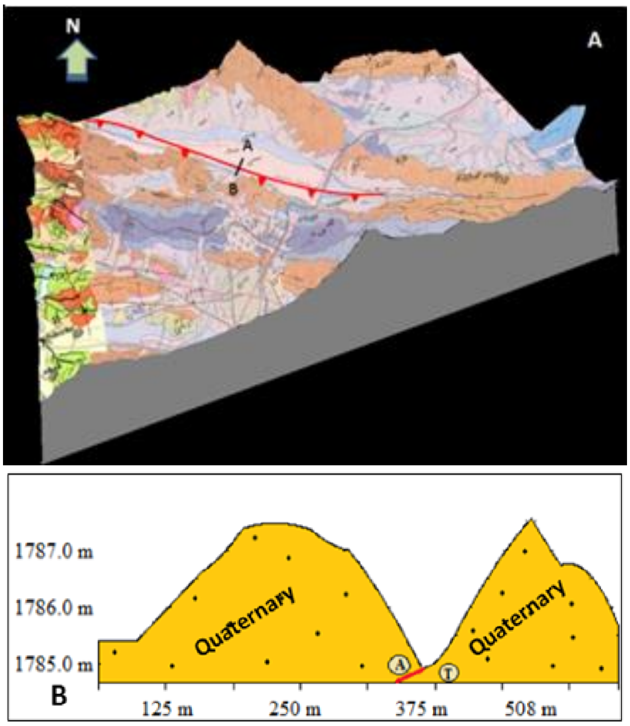


Figure 13a) Three-dimensional image of Sadra fault taken from both the SRTM data and geological map of the area. b) Topographic profile of Sadra fault.

The effect of this fault on the earth surface can be observed in a range of approximately 17 km in the studied area. Figure 14 exposes the field outcrop of Zarghan fault. The direction of this fault is N65°W but its effect has not seen on the hard conductors. Andalibi *et al* (1997) identified Zarghan fault in the southwest and some parts vertically by introducing this fault in 1:100,000 sheet of Shiraz. According to cutting the Quaternary strata by this fault and also in conformity with earthquake evidences (studying seismic data of the region), this fault is of Quaternary and active fault. Therefore, privacy law of structures from this fault should be markedly observed. Considering all the earthquakes that have occurred in this region and in the adjacent it have focal length-slip mechanisms and sometimes reverse slope-slip component and its gradient is toward southwest, so the southern part of the fault is the hanging wall. As a result, privacy law from the fault is at least 5 km and it is recommend that physical extension of Zarghan city continues toward the east and north and be prevented toward the west.

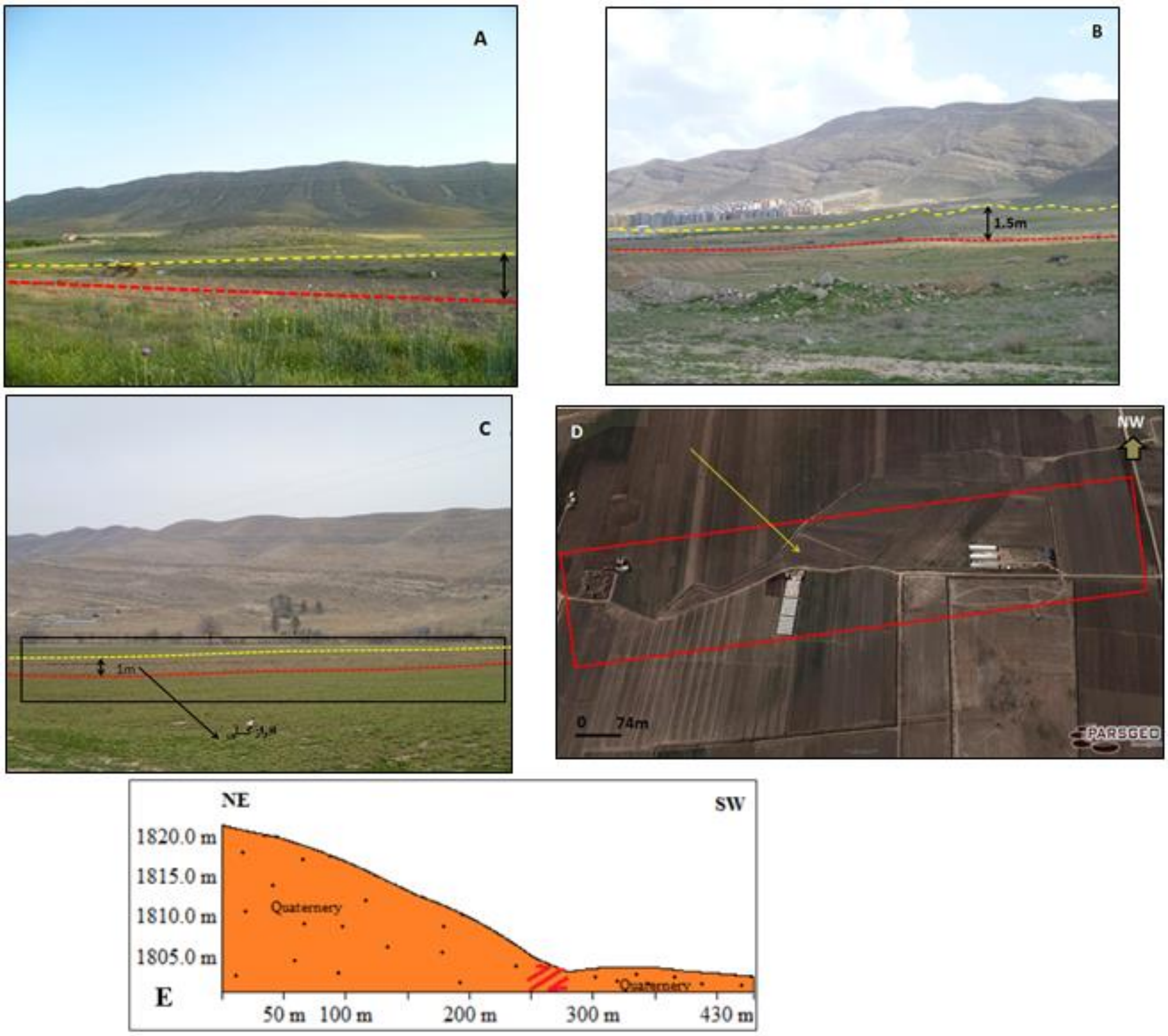


Figure 14a, b and c) The field outcrops of Zarghan fault (view to the southwest), and also the fault partitions due to the performance of fault. a, b, c and d) The fault partitions of the fault in taken from Google earth satellite image. e: Transverse profiles of fault partitions of Fig. 14c.

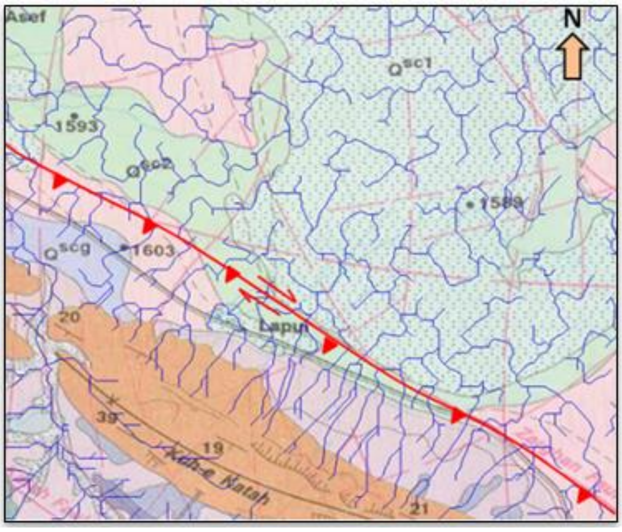


Figure 15) Right-track movitaion of streams in activity of Zarghan fault.

As well as, according to morphological landmarks in the privacy of faults, guideline fall of the northern block and common tectonic regime, pressure with the overall northwest-southeast direction has been identified. Furthermore, fault partitions shows rising the south block and verifies the reverse mechanism for its dip-slip component (Fig. 14c). On one hand, displacement of streams along with Quaternary deposits in right-track way suggest that there is right-track dip-slip component for the fault (Fig. 15). A symbolic section of the Zarghan fault is shown in Figure 16.

It can be stated about geomorphic features of Zarghan fault that the reverse activity of Quaternary Zarghan fault leads to cutting the Quaternary sediments and rising hangingwall of the block and in somewhere causes crags with gentle slopes and different heights.

Another geomorphic image of this fault is formation of fault partitions (Fig. 16). Visual description of the field visits related to the sesecretion, (Fig. 14d) depicts the satellite imagery of the fault associated with fault partitions along the fault lineation as well as drawn cross-section of the sesecretion (Fig. 14e). As can be seen in the cross-section, The vertical displacement of the fault along the fault is lower than horizontal displacement (dip-slip) that obtained from waterways drift. Moreover, Zarghan fault effects on the geomorphic features of waterways in the zone by its own dip-slip right-track activity and move them in right-track way.

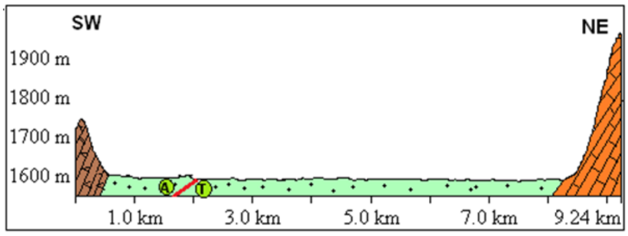


Figure 16) Symbolic section of Zarghan fault along SW-NE direction.

4-3- F4 Fault

The F4 fault is exposed in the trench road at the west of Katah fault (west of Asef Mountain). The geographical fault location with the eastern longitude of 52° 28' 58.5" degree and northern latitude 29° 50' 19" degrees is placed on the boundary between Jahrum dolomite unit and Quaternary deposits (Fig. 17a) with approximately 2 km in the west of Asef mountain. Its position on the geological map of the zone (Fig. 1) and satellite image (Fig. 2) has been named. Figure 17b shows the schematic section of the fault. This fault is a transverse branch of Katah fault and is located within 2 km of it.

The field observations indicate that the fault dip is to the southeast. Jahrum dolomitic unit in Quaternary deposits are located in the hangingwall of the fault so that the reverse performance of faults can be justified.

The fault step surface, hand touching and slicken line proved right-track moving of the fault to be right (Fig. 18). In addition to the field visits and telemetry survey was conducted to reveal the northeast-southwest trend and dip of the inverse function of the fault plays an important role in highlands of the zone and causes creating a valley fault along its own direction (Fig. 19). Figure 20a indicates the location of valley fault caused by the F4 fault performance, and Figure 20b shows the three-dimensional image of combining the SRTM data and 1:100,000 sheet of Kalestan, and also the transverse profile of the valley fault formed by F4 fault is available in Figure 20c.

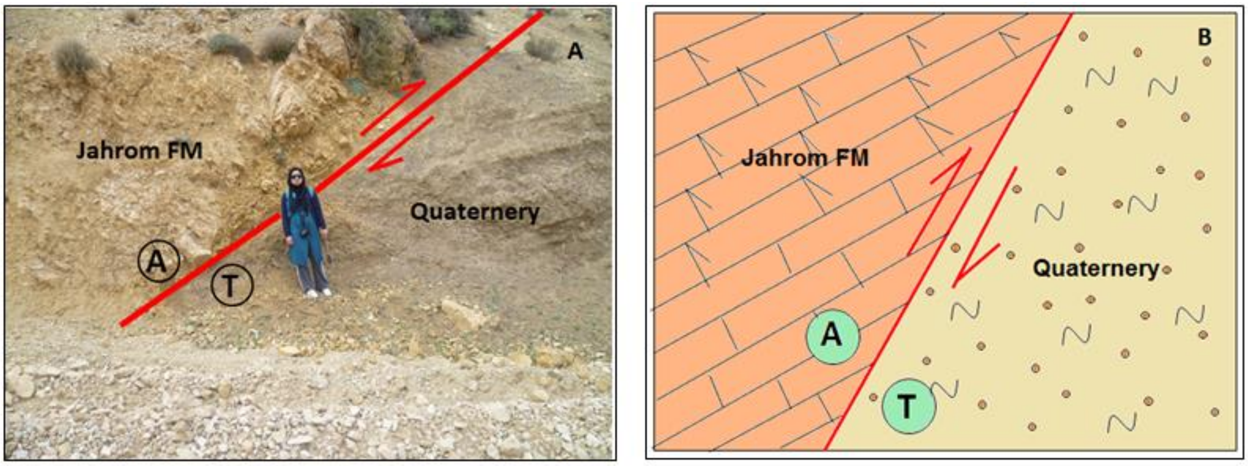


Figure 17a) Driving the Jahrum formation (hanging wall) on Quaternary deposits (footwall) by F4 fault (View to the north). b) Schematic diagram of the F4 fault.

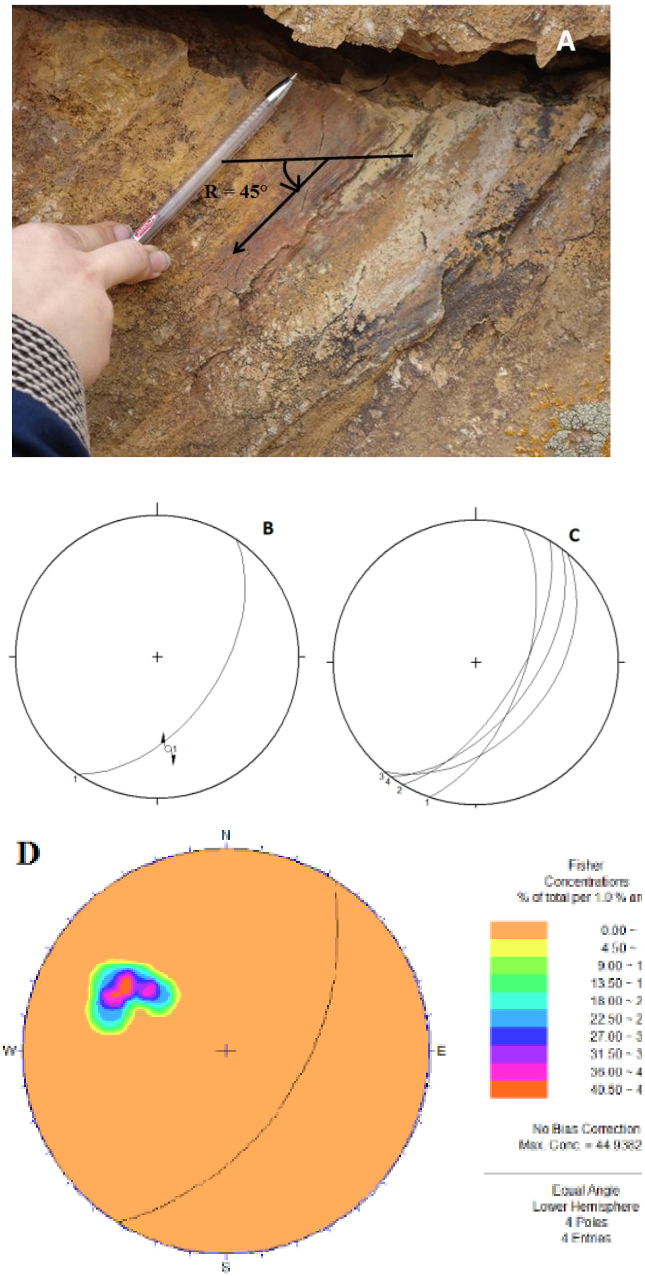


Figure 18a) Slicken line (st.) (view to the west). b) Location of slicken line on the stereographic images at position N34E, 53SE. c) The fault sheets with an average at N33E, S60E. d) Flow diagram of the sheet poles of the fault.

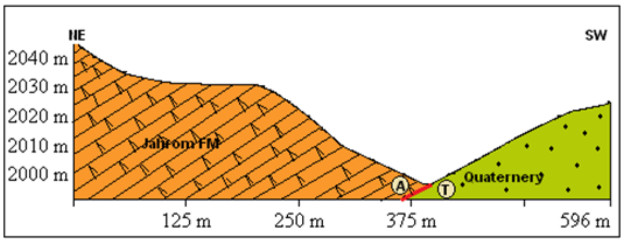


Figure 19) Symbolic section along northeast-southwest of the F4 fault.

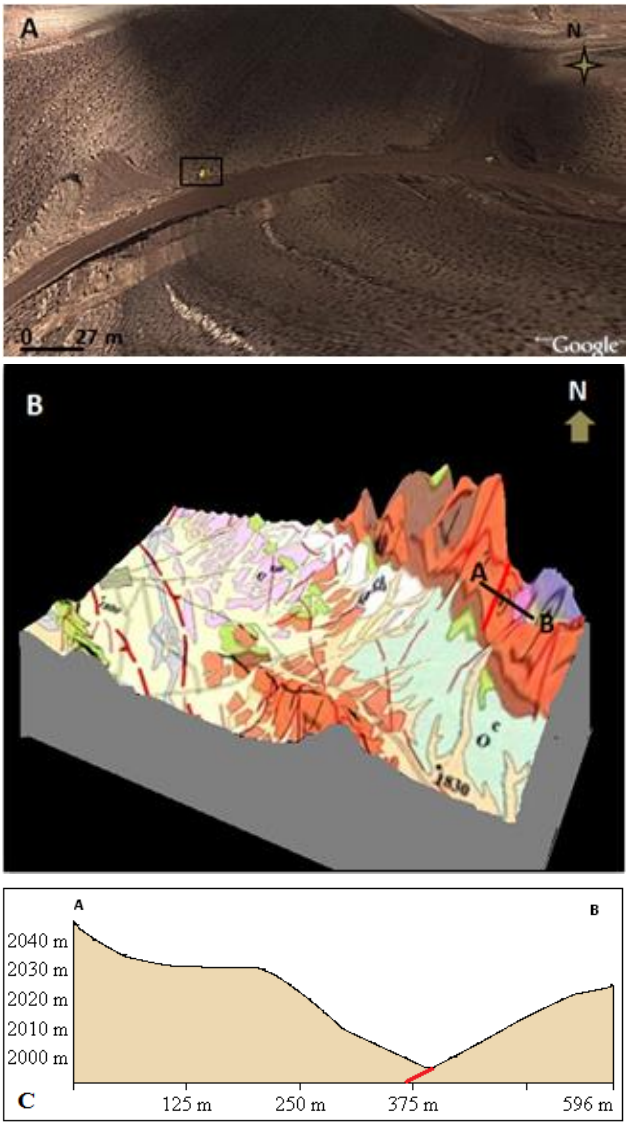


Figure 20a) Valley fault caused by the F4 fault. b) Three-dimensional image of the SRTM data and 1:100,000 map of Kalestan by Global mapper software. c) Transverse profile of the valley fault.

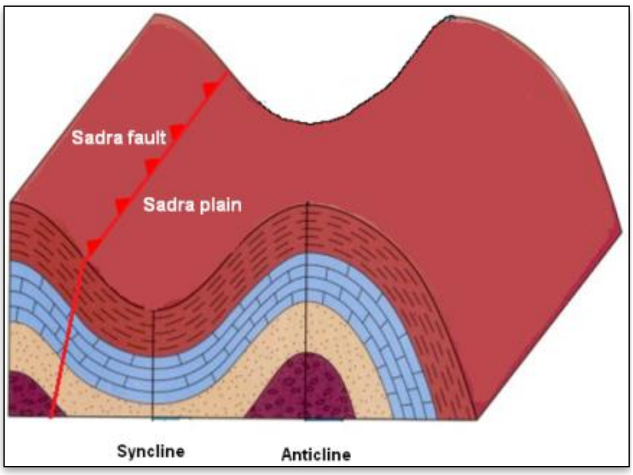


Figure 21) Schematic view of Sadra fault.

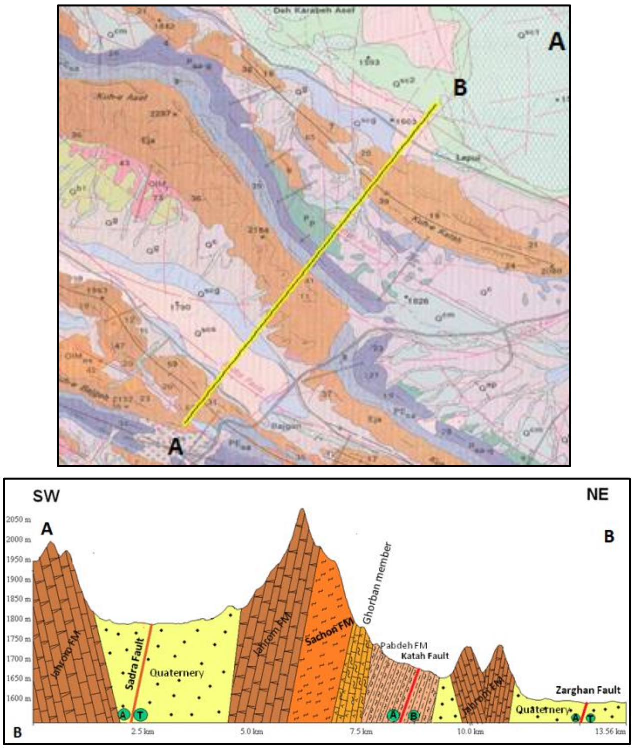


Figure 22) A cross section of the faults in the area along the SW-NE on the shiraz 1:100,000 map. b) A cross-section of studied zone along SW-NE line.

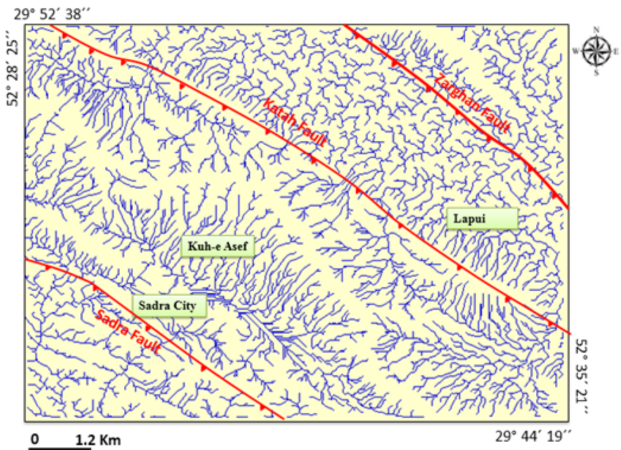


Figure 23) Map of the streams of the zone which obtained from both geological map and DEM data and plotted by Global mapper software.

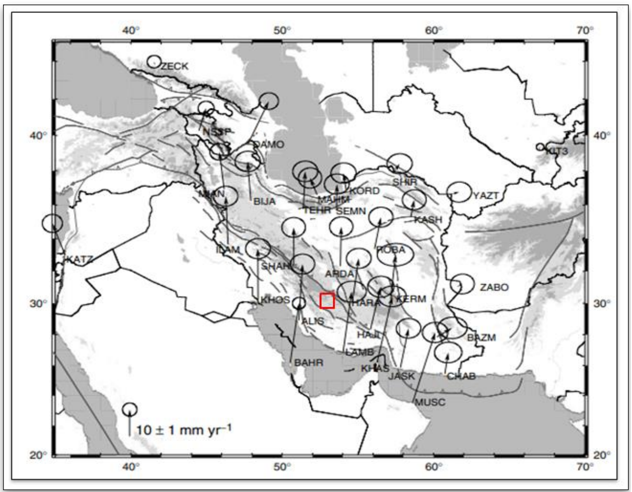


Figure 24) indicating the direction of maximum tension associate with pressure amount in different regions of Iran (from Vernannt et al., 2004), the investigated region in this study is a part of the area marked red on the image along the northwest-southeast toward to maximum tension.

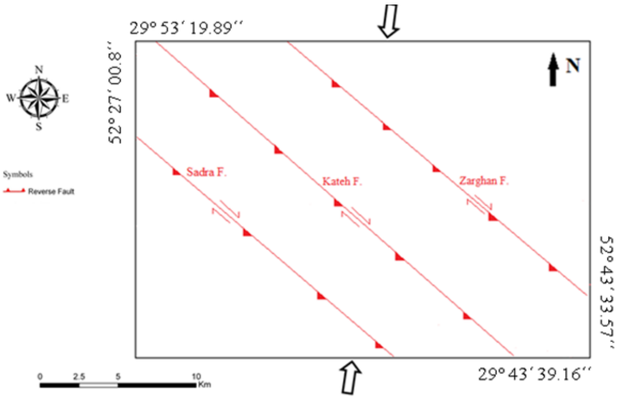


Figure 25: The relationship between the maximum tension with the mechanism of fault in the zone that depicts that right-hand ultrapressure deformation conditions governs on the region.

5–Conclusion

In present study, the structural characteristics and activities of each of the faults were dealt with separately. Three faults Zarghan, Katah and Sadra are of Quaternary faults. With respect to the field visits and harvest observations of the zone on Google earth satellite images and RGB, it was observed that the general trend of these faults is northwest-southeast and obeys a general trend of folded Zagros.

The transverse fault F4 trend of is northeast-southwest and shows a reverse mechanism with a small component of right-track dip-slip.

As mentioned about Sadra fault geometry, there is a structural section along a SW-NE and its geometry was interpreted. According to Figure 21, this fault can be interpreted so that Sadra plateau is a synclinal basin (due to studying layered gradient of both Asef and Sadra mountains) and Quaternary sediments are exposed on the synclinal basin. Jahrum constructor then placed on synclinal basin and somewhere was under the force, suddenly came up and causes a drift that is the fault of Sadra. As mentioned earlier, all three faults are Quaternary and such structures are located in an identical zone (Fig. 22) so it is natural to have a similar mechanism and geometry. According to Figure 23, the waterways cutting can be seen at the site of fault. Considering the field observations, it has revealed that all three faults have reverse slope-slip component. Therefore, according to this fact that the faults of the zone are reverse and all of them pass of around Sadra new city and Zarghan city, and also considering the right-track drift of waterways, all faults have right-track dip-slip component.

Figure 24 shows the relationship between mechanism of the major faults of the investigated zone and maximum tension direction governed on it and it can be stated that the maximum tension direction and geometry and mechanism of the zone are correspond to right-track ultra pressure deformation pattern.

Considering the geometry and kinematics of faults in the area, adding the maximum tension direction to this pattern indicates agreement between the tension direction with geometry and kinematics of the faults (Fig. 25). This mechanism confirms the power of right-track ultra pressure deformation pattern in this part of the Zagros.

Acknowledgments:

The authors would like to thank B. Javidfakhr and N. Hafezi Moghadas for their appreciate comments which help us to improve manuscript.

References:

Agard, P., Omrani, J., Jolive, L. 2011. Zagros orogeny: a subduction-dominated process. Cambridge Univercity Press. Geological Magazine: 148, 692–725.

Andalibi, M. 1997. Geological map scale Shiraz 1:100000.

Falcon, N. 1974. Southern Iran: Zagros mountains, In A. Spencer (Editor), Mesozoic- Cenozoic Orogenic belts. Geological Society of London, Special Publication, 4, 199–211.

Oveisi, B. 2001. Geological map scale Kalestan 1:100000.

Smit, J., Brun, J.P., Cloetingh, S. Ben-Avraham, Z. 2010. The rift-like structure and asymmetry of the Dead Sea Fault. Earth and Planetary Sciece Letters: 290, 74–82.

Vernant, P., Nilforoushan, F., Chery, J., Bayer, R., Djamor, Y., Masson, F., Nankli, H., Ritz, J., Sedighi, M., Tavakoli, F. 2004. Deciphering oblique shortening of central Alborz in Iran using geodetic data. Earth and Planetary Science Letters, 223, 177–185.