Geometric Analysis of Davaran Fault System, Central Iran

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Abstract

One of the main faults of the Central Iran is Davaran Fault system which holds right-lateral strike slip with a pressure component. Contemporary activities of this fault signify the continuity of stresses up to now. Davaran fault system has extended parallel to Davaran Mountains. Most of the drainage networks of this region are located on trend of faults. The faults of this region are classified to 5 groups. These groups include conjugated faults of Riedel and Anti-Riedel (R, R’), normal faults (T), faults parallel with the major fault (Y) and faults approximately parallel with the main fault (P). T Faults are normal faults with tension mechanism. By calculation of sinuosity (Smf) of northeast and southwest mountain fronts of the region and ratio of valley floor width of the rivers flowing in the region to their wall height (Vf), it is specified that this region is active in terms of uplift and tectonics. The rivers have deep valley. Tectonic activity in northeast front is more active than southwest mountain front.

Keywords
Davaran Fault, Tectonic Activity, Tension, Right-Lateral, Iran

1. Introduction

Davaran fault system has extended parallel to Davaran Mountains that is located in the west of Dasht-e-Lut of the Central Iran. This fault is directed from northwest to southeast and is in the west of N-S active fault of Nayband-Gowk. Ancient deposits, older than Quaternary in this region during different periods, have been folded repeatedly through stronger or weaker intensity. These structures are the results of important Alpine tectonic

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movements, especially, tectonic movements of the late Cenozoic period. The study area is situated between 55°30' longitude to 56°45' and 30°15' to 31°30' latitude. The study area is located on the Naïen-Kerman retro arc foreland basin [1]-[3]. Dominant structural trend in Naïen-Kerman province (Figure 1) is NW-SE. From tectonics view, it contains a retro arc foreland basin on the north margin of Urmieh-Dokhtar magmatic arc (SE part). Davaran fault system has developed in this province that forms on southwest part of East-Central Iran microcontinent.

Figure 1. Physiographic-tectonic zoning map of Iran’s sedimentary basins Iran modified from [1]. The study area is shown in the black rectangle.
2. Tectonic Setting of the Study Area

The overall Arabia-Eurasia convergence is known from a combination of Africa-Eurasia and Arabia-Eurasia motions to be approximately N-S in Eastern Iran, with rates of about 30 mm/year at 50˚E and 40 mm/year at 60˚E [4]. Central Iran is a mosaic of various tectonic blocks once separated by minor ocean basins [5] that started to close in the mid-Tertiary [6]. Much of the broader collision zone, however, did not start to deform until the Mid-Miocene or even later [7]. In particular, major deformation of the Zagros folded belt appears that hasn’t begun until the Pliocene, approximate 5 Ma years ago or less [8], which is also the time at which there was a major re-organization of the sedimentation and deformation in the south Caspian Basin [9]. We suspect this time represents the final closure of any remaining ocean basins and the onset of true intra-continental shortening within Iran. We also expect that the present-day configuration of active faulting dates from roughly this time. [10] suggests that the Zagros accommodates about 10 - 15 mm/year of present-day shortening. This estimation is very dependent on the assumptions they made, but is roughly compatible with approximate 50 km of shortening which have occurred in the folded belt of Zagros over the last 5 Ma (Falcon, 1969 & 1974). Thus we expect that 20 - 25 mm/year remains to be taken up north of the Zagros and to be represented as N-S shear in eastern Iran. This reasoning implies that a total of 100 - 125 km of right-lateral slip has occurred on the faults east and west of the Dasht-e-Lut over the last 5 Ma; the total offset may be more if the faults were active before 5 Ma. The available evidence is nonetheless sufficient to suggest that the probable slip rates (approximately 1 - 2 mm/year) and total offset (approximately 12 km) on the Nayband-Gowk fault system are relatively small, and that most of the N-S shear between central Iran and Afghanistan is taken up on the eastern side of the Dasht-e-Lut [11].

Based on previous work on the salt and mud diapirism [12]-[22] and neotectonics regime in Iran [23]-[28], Zagros in south Iran is the most active zone [29]-[44]. Then, Alborz [45]-[78] and Central Iran [79]-[93] have been situated in the next orders.

3. Materials and Methods

The calculated geomorphic indices are suitable for assessment of tectonic activity of the study area. The geomorphic indices studies performed on the digital satellite data from the region and analyzing air photos and field work indicate that regional faults follow five main processes in right lateral shear zone, both in direction and in operation mechanism which may be formed in brittle shear zone (Figure 2 and Figure 3).

The first group of faults in the region is similar to “Y” faults in right lateral shear zone and has right lateral strike slip mechanism. They are formed in parallel direction with the main fault.

The second group has the same mechanism to the main fault but they make an angle of 15˚ - 20˚ with the main fault in direction. The direction of these faults is in accordance with the direction of Riedel group in right lateral shear zone.

![Figure 2. Strain ellipsoid in convergent right lateral zone with five fractures.](image-url)
The third group of faults holds left shear components and has an angle of 60° to 80° with the main fault in direction and they are similar to anti-Riedel faults in the right lateral shear zone. In the fourth group, the faults are at approximately −10° angle with the main fault in direction and have a similar mechanism with the main fault. Their direction is in accordance with the faults in group P in the right lateral shear zone. The fifth group of faults, directed at AZ 20° to 0°, show normal mechanism. They are similar to the faults in group T in the right lateral shear zone.

These shapes and structures form in brittle shear zones and the complete conformity of regional faults with these fractures proves right lateral simple shear with pressure component which affects the region (Figure 2 and Figure 4).

In the other hand, most of drainage networks in Davaran mountain have been placed on the regional faults especially the fifth type faults (Figure 5).

The formulas of mountain front sinuosity (Smf) and ratio of valley floor width to its height (Vf) can be used in order to find active tectonic of the region by drainage network of the region (Figure 6 and Figure 7).

### 3.1. Mountain-Front Sinuosity Index (Smf)

This index represents a balance between stream erosion processes tending to cut some parts of a mountain front and active vertical tectonics that tend to produce straight mountain fronts. Index of mountain front sinuosity [94] is defined by:

\[
Smf = \frac{L_j}{L_s}
\]  

(1)

where \(L_j\) is the planimetric length of the mountain along the mountain-piedmont junction, and \(L_s\) is the straight-
line length of the front. Smf is commonly less than 3, and approaches 1 where steep mountains rise rapidly along a fault or fold [95]. Therefore, this index can play an important role in tectonic activity.
3.2. Valley Floor Width-Valley Height Ratio ($V_f$)

This index can separate v-shaped valleys with small amounts from u-shaped valleys with greater amounts. The calculation formula is in this manner:

$$V_f = \frac{2V_{fw}}{(Eld + Erd - 2Esc)}$$  \hspace{1cm} (2)

where $V_{fw}$ is the width of the valley floor, and Eld, Erd and Esc are the altitudes of the left and right divisions (looking downstream) and the stream channel, respectively [95].

High values of $V_f$ are related to low uplift rates i.e. low tectonic activity in which rivers have relatively wide floor. Low values of $V_f$ refer to deep valleys in which rivers drill valleys actively and mainly are related to active tectonic and uplift.

Mountain-front sinuosity (Smf) of active tectonic is ~1 to 1.6. The sinuosity of mountain fronts with low activity is ~1.6 to 3 and the sinuosity of inactive mountain fronts is ~3 to the values higher than 5; since erosion is high and tectonic is inactive. Therefore, uplift is not occurred, thus the length of curvature line of mountain front increases.

The sinuosity of both sides of mountain fronts (Smf) (northeast and southwest fronts) and ratio of valley floor width of the rivers of the region to its height ($V_f$) were calculated based on satellite images and topographic maps. It was specified that the mean sinuosity of northeast front is equal to Smf = 1.159 and average $V_f$ index relating to the rivers flowing in the northeast front is equal to 0.756. The mean sinuosity of south-
west front is equal to \( Smf = 1.303 \) (Figure 8) and average \( Vf \) index relating to the rivers flowing in the northeast front is equal to 0.511 (Figure 9).

4. Results and Discussion

Through strain geometry in simple shear form was found and the direction of \( R, R' \) shears, normal (T) and trust faults can be anticipated.

Shear fractures (\( R, R' \)) form a complementary system in which \( R \) fractures are more extensive in comparison with \( R' \) fractures while \( R' \) shear with the advancement due to first basement fault operation have a fast rotation in comparison with \( R \) fractures and after some degrees of rotation may become locked and inactive. \( R' \) fractures form only when \( R \) fractures cover each other [96]. \( P \) fractures are also formed by decrease in shear resistance of \( R \) fractures.

Since all basement movements are not absorbed by \( R \) fractures and between two shears of \( R \), shortage axis inclines toward the fracture of \( R \) and also between the two covering \( R \) fractures, a small stress field which can be created new shear with an angle of \(-15\) in relation to the main movement [97]. Tension fractures are located in parallel with the shortage axis and they form the semi-angle between \( R \) and \( R' \).

The T faults form vertically to tension force of the region, they have normal mechanism; for this reason, graben occurs on these faults and consequently they become a suitable place for formation of channels and

![Figure 8. The front of the NE flank of Davaran Mountain, view to the SW.](image)

![Figure 9. A U-shape valley in the NE flank of Davaran Mountain, view to the SW.](image)
drainage network. The calculations showed that the northeast front and southwest front of this mountain are active from tectonic aspect and the northeast front has more tectonic activity and uplift with deeper river valleys in comparison with the southwest front.

5. Conclusions

Davaran fault system is one of the major faults of the Central Iran and the most important cause for the deformation of the region. High clarity of this fault system sediment cut in the present period which is clearly shown in satellite digital data processing and field observation shows the activeness of this fault system. The most faults in this region, are consist with the expected fractures in the classic transpressional shear zones.

The faults of this region are divided into five groups (Y, R, R', P, T). The T faults are normal and have formed due to tension force. In the trend of these faults, some drainage networks have been formed in this mountain region due to graben of bed rocks. The river calculations of the region indicate active tectonic and uplift in the highlands of this region and most of its rivers especially the rivers of northeast fronts of the highlands have more active tectonics, they have deep valleys with high walls. The maximum stress can be result of the convergence of Arabia plate towards Central Iran plate. This movement occurs from early Neogene after the formation of Red Sea between Africa and Arabian plates. This causes Neotethys to close between Central Iran and Arabian plate which still continues and affects Central Iran, while keeping this region tectonically active.

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References


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