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Geomorphic Signatures of Active Tectonics of Darian Area, Northeast of Shiraz, Iran

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Abstract

This paper examines both the relative Active Tectonics of Gadvan anticline based on morphometric parameters and their application in morphology and topography evolution in northeast of Shiraz. In the present study, the analysis including line ament mapping, length density mapping, intersection and the counts of lineaments and also the calculation of three geomorphic parameters (Smf, facet% and Vf) have been conducted. Some of which can be used in the study of morphology. According to the classification of geomorphic indicators, the study area was tectonically detected as an area within tense activity. Therefore, the uplift rate in this area is over the front of the mountain which is estimated about 1/5 to 4 mm per year. In the study, for the extraction of lineaments, automatic and semi-automatic methods along with manual one werealso conducted. Area lineament maps and length density, counts not only specifies areas with anomalous fracture but also can contribute in determining the location of drilling water wells of Darian plains.

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Introduction

Shapes and roughness of the earth is described with respect to the size, height and slope of them and compared qualitatively. Using quantitative measurements, these parameters can be compared more accurately and by means of geomorphic indicators, special features of a region such as tectonic activity are also calculated.

The study area is located in the range of 672,000 to 698,000 and 3,265,000 to 3,290,000 of the length and breadth of the global coordinate system and 30 kilometer of north east of Shiraz (North of Darian District), Fars Province (Fig. 1).

Fig. 1. Geographic location of the study area.

In terms of stratigraphy, the anticline consists of Surmeh carbonate formations with Jurassic, limestone Gradational with Cretaceous, Chile-calcareous with Cretaceous, Darian calcareous with Cretaceous (raw group), Scorpios Chile with Cretaceous and Sarvak limestone with Cretaceous (Fig. 2). The region, in the Zagros zoning conducted by Barbarian (1995), has been located across the plain crackly sheet.

In the vicinity of southeast plunge of the anticline, Hormoz salt formation (Izad Khastsalt dome) due to act of one of the pieces of basement fault and Sarvestan strike-slip faults has been exposed (Fig. 3). Darian plain is also located in the south of this anticline. Examples of fossils in the area (lithiot is fossils at the base of Surmeh formations) can be seen in Fig. 4.

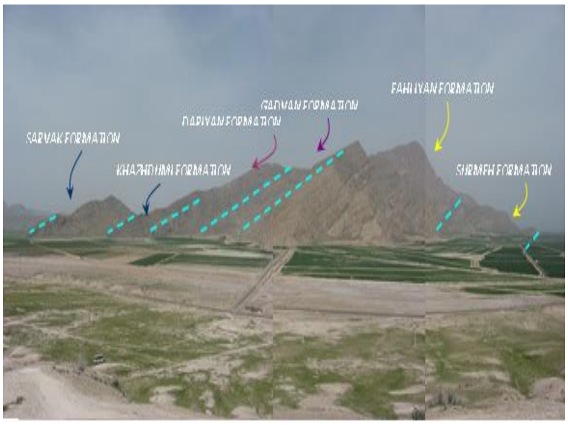

Fig. 2. Schematic of Gadvan mountain anticline with approximate boundaries of formations (towards to the west).

Fig. 3. Schematic of IzadKhast salt dome in the margins of southeastern plunge of Gadvan Mountain.

Fig. 4. Image of lithiot is fossils at the base of Surmeh formation.

The main faults of the region are as follow: 1. Bamoo fault which is part of the length fault of strike-slip faults, the main factor of movement in it is the expulsion. The main departure of this rupture is associated with the last phase of Albina orogeny which is restricted from northwest to Goym fault and south east to Darian one. The average azimuth of the fault is approximately 105 degrees and its slope of the shear is over 45 degrees. 2. The length of Sarvestan fault is about 78 kilometers and its sheer is between N17W to N30W. This fault contains strike-slip movement with normal component and is limited from north to Darian fault and from south to Koohenjanone. 3. Black fault, one of the branches of the Bamoo fault, is located in the north of Bamoofault (North of Se-Talan plain). This leads to Torbor formation stands by the Jahrom one.

4. Kateh fault with reverse mechanism and its strike-slip component in this area (in Gadvan mountain anticline) leads to perching Sarvak formation in the vicinity of Táborone. Goorp iformation has been deleted. Also, fault precipices are the other aspects of geomorphic (Fig. 6). 5. Darian fault measures 30 km and an average azimuth of 150 degrees, located in south of Darian plain. This can be considered as one of the major Bamoo fault having expulsion. The fault joins from the northwest to the Bamoo expulsion and from southeast to Sarvestan one. Geomorphic evidences in the fault suggest the latest movements in a phase equivalent to Pasadenian. Lithology map - topography- the main faults of the region is visible in Fig. 5. The aim of this study is geomorphic Ssignatures of active tectonics of Darian Area, northeast of Shiraz.

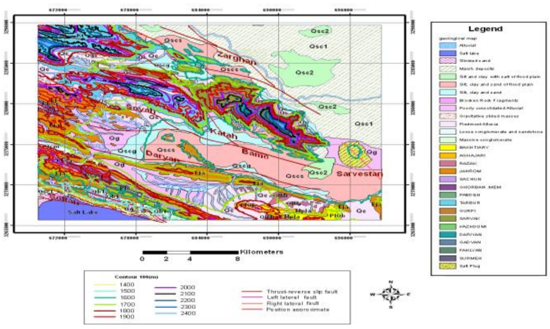

Fig. 5. Lithology map – topography –the main faults of the region.

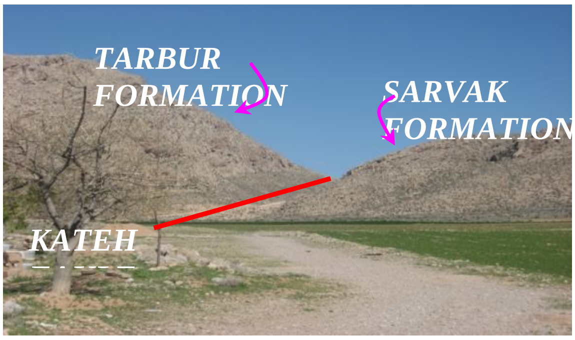

Fig. 6. View of Kateh fault (performance of the fault causes the two formations of Tarbur and Sarvak stand by each other and deletion of Goorpi formation between these two formations).

Material and Methods

Using Landsat 7 satellite images, GIS and remote sensing, lineaments extracted by three methods of manual, semi-automatic and automatic. Finally, the lineament map of the area was produced.

Manual method

To extract lineament manually, different models of topography such as slope mapping, the slope map (Aspect), Shaded Relief Image and three-dimensional models to enhance the interpretation of satellite images was prepared. The advantage of this method is that unrelated lineaments to geologyare easily identifiable (Kocal *et al.*, 2004).

Semi-automatic method

This method is a combination of visual and computer interpretation (Lee *et al.* 2007) which its computer interpretation has been done by applying Laplacian, Directional, Robert, Sobel filters. Filters have different applications in remote sensing and image processing, some of which are image reconstruction, image noise reduction and detection of linear effects.

Automatic method

The most important advantage of this method is a relatively short time to extract lineaments that cannot be seen with the unaided eye. For extraction of lineament using linear module in remote sensing software (PCI-Geomatics), two sets of parameters were used: The parameters used for extracting small lineaments and parameters used for extracting larger lineaments.

Result and Discussion

Geomorphic indicators of active tectonics

Shapes and roughness of the earth is described with respect to the size, height and slope of them and compared qualitatively. Using quantitative measurements, these parameters can be compared more accurately and by means of geomorphic indicators, special features of a region such as tectonic activity are also calculated (Zamani & malek, 1996).

The main purpose of using geomorphic and measurement of morphometric parameters is to study the shape and roughness of the earth quantitatively and numerically. In morphometric studies, required data obtained from topographic maps, aerial photographs and satellite images (Stewart & Hancock, 1994) . Three parameters measured in Gadvan Mountain include:

A. Mountain Front Faceting

Calculated as: $Facet\ \% = L_f/L_s \times 100$

Where, Facet % indicates Mountain Front Faceting, Lf is length of front mountain and Lsis direct line of mountain front. This parameter was introduced for the first time by Wells *et al.* (Wells *et al.*, 1988) and high percentages indicate the activity of the mountain front.

B. Mountain Front Sinuosity

This parameter reflects the balance between intensity and rivers tendency to create an irregular front and vertical tectonic activity on a direct mountain front. Therefore, mountains with vertical tectonic activity have direct front and less depressions and protrusions. Smfvalue will be closer to 1. If the level of uplift decreases or tends to zero, front erosion process will form a maze which becomes more irregular over time. It is noteworthy that the material of mountain front stones and their resistance against erosion can influence on the value of Smf (Doornkamp, 1986).

This parameter is calculated as follows:

$$S_{mf} = L_{mf}/L_s$$

Where, Smfisthe mountain front sinuosity, Lmfmountain front at the intersect of the mountain with alluvium and Lsdirect line of mountain front.

C. Vf Ratio

Cross-section morphology of canalvalley near the mountain front is also useful parameter to measure the vertical digging canals and tectonic activity in the area. (Bull &McFadden, 1977) applied the ratio of the width of valley floor to the average height of valley floor walls as a measure to check the power of digging canals.

The ratio of the valley floor width to its height (Vf ratio) is calculated from the following equation:

$$V_f = \frac{V_{fw}}{[\,(E_{ld} - E_{sc}) + (E_{rd} - E_{sc})\,]}$$

Where, Vf is the ratio of the valley floor width to its height, Vf wis the width of valley floor, Eldand Erdare the heights of the left and right side of valley wall respectively, and Escis the valley floor height from sea level. In Fig. 28-2, the method of determining effective factors in calculating the ratio of Vf is shown. It should be noted that to calculate Vf, data must be measured at a given distance from the mountain front.

The Vf parameter differentiates U-shaped valleys from the V-shaped ones, so that large amounts of Vf represent slow level of uplift and valleys with flat floor and U-shaped. While low values of Vf indicate a high rate of uplift and deep V-shaped valleys.

On Gadvan Mountain anticline 15 fronts for measuring two parameters of mountain front faceting and mountain front sinuosity and 4 fronts for Vf Ratiowere selected. The results can be seen in Tables 1 and 2. Also, based on the data, digital models were developed (Fig.s 7 & 8).

Table 1. The values of Smf and Facet% at 15 fronts of Gadvan Mountain anticline.

Front	L_{mf}	L_s	S_{mf}	L_f	Facet%
1	5010	4300	1/165	2610	60/7
2	5600	4700	1/191	3150	67/0
3	3680	3530	1/042	2450	69/4
4	4430	4130	1/073	3190	77/2
5	1932	1877	1/029	1663	88/6
6	2343	2320	1/010	2252	97/1
7	4700	4650	1/011	4550	97/8
8	2053	2010	1/021	1851	92/1
9	2160	2104	1/027	1976	93/9
10	3840	3765	1/020	3550	94/3
11	6005	5400	1/112	3950	73/1
12	4660	4390	1/061	4135	94/1
13	2563	2455	1/043	2399	97/7
14	6204	5567	1/114	3850	69/1
15	5770	5100	1/131	3650	71/5

Table 2. The values of Vfparameter at 4 fronts of Gadvan Mountain anticline.

Station	Vfw	Eld	Erd	Esc	Vf
1	500	2000	2300	1800	0.714
2	50	2220	1920	1800	0.093
3	50	1970	1860	1800	0.152
4	25	2120	2120	1900	0.057

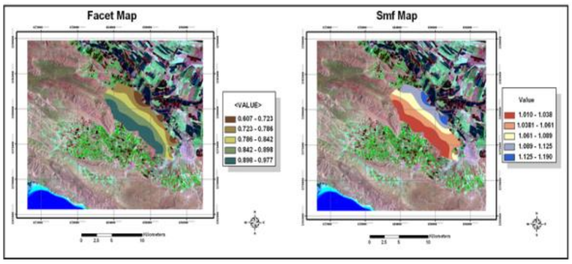

Fig. 7. Digital modelsof parameters Smf and Facet% at Gadvan Mountain anticline.

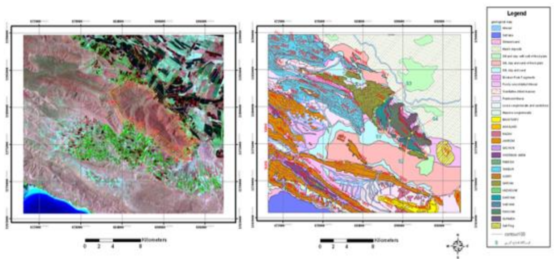

Fig. 8. Position of measuring stations of parameter A:Vf B:Smf,Facet% on Gadvananticline.

Lineament Extraction of the area

Using Landsat 7 satellite images, GIS and remote sensing, lineaments extracted by three methods of manual, semi-automatic and automatic. Finally, the lineament map of the area was produced:

A. Manual method

To extract lineament manually, different models of topography such as slope mapping, the slope map (Aspect), Shaded Relief Image and three-dimensional models to enhance the interpretation of satellite images was prepared. The advantage of this method is that unrelated lineaments to geologyare easily identifiable (Kocal *et al.*, 2004).

B. Semi-automatic method

This method is a combination of visual and computer interpretation (Lee *et al.*, 2007) which its computer interpretation has been done by applying Laplacian, Directional, Robert, Sobel filters. Filters have different applications in remote sensing and image processing, some of which are image reconstruction, image noise reduction and detection of linear effects.

C. Automatic method

The most important advantage of this method is a relatively short time to extract lineaments that cannot be seen with the unaided eye. For extraction of lineament using linear module in remote sensing software (PCI-Geomatics), two sets of parameters were used:

A. The parameters used for extracting small lineaments.

RADI = 10	GTHR= 50	LTHR = 30
FTHR = 2	ATHR = 1	DTHR = 30

B. The parameters used for extracting larger lineaments.

RADI = 11	GTHR = 25	LTHR = 90
FTHR = 4	ATHR = 15	DTHR = 200

Final map of the target area lineament which can be seen in Fig. 7, prepared by means of all maps in different ways.

Using lineament final map, three other maps were prepared:

A. Lineament Counts Density Map (Fig. 8).

B. Lineament Intersect Density Map (Fig. 9).

C. Lineament Length Density Map (Fig. 10).

GIS software was applied in producing these maps. The main application of these maps is to divide lineament counts, lineament length or lineament intersects counts to surface unit. In this method, at first acicular area with radius r is defined and then the circular area defined by a network at a given distance move laterally and vertically on the map.

The result of the calculation, as a point with a specified number, is placed in the middle of the circular. Now using these points, contour map is provided. If the goal is to check the details of small-scale fractures, small radius should be chosen and if the fracture is to be examined in a regional scale, the larger radius should be selected.

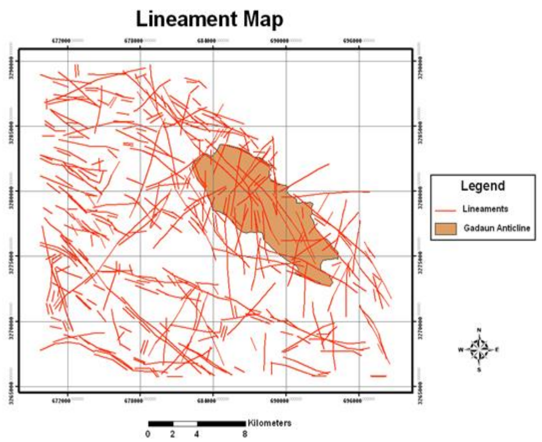

Fig. 7. Lineament map.

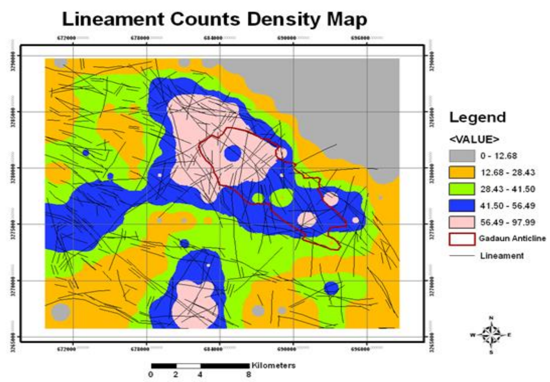

Fig. 8. Lineament Counts Density Map with a radius of two kilometers (pink color indicates the highest density).

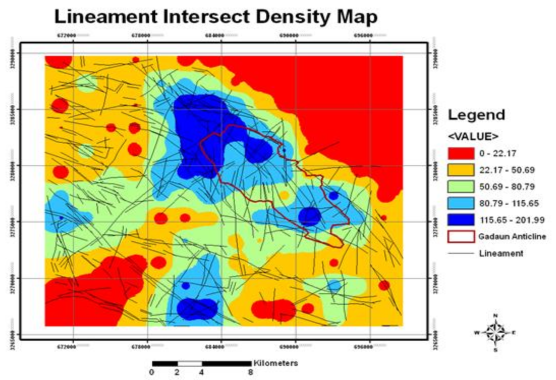

Fig. 9. Lineament Intersect Density Map with a radius of two kilometers (Dark blue indicates the highest density).

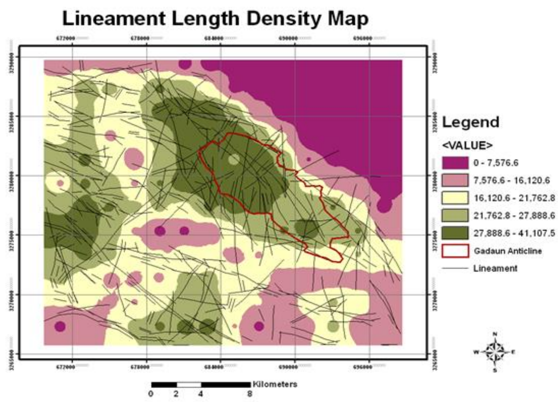

Fig. 10. Lineament Length Density Mapwith a radius of two kilometers (Dark green indicates the highest density).

Conclusion

The similarity between Darianplain and geological prevailing trends represents the tectonic effects of structural factors in shapingit. Generally, strike-slip faults have caused a rotating area, extensional and compression forces and as a result in the above-mentioned area provide space for salt accumulation. This faults make an uplifts in the layers overlying the basement (Oliver, 1987: Naylor, 1986) that the very old exposed formations (Jurassic and Cretaceous in this area) in the vicinity of Izad Khast salt dome due to the functions of slip faults of Sarvestan confirms this fact. Regarding the categorization of morph tectonic indexes (bull, 1978), this area is highly active tectonically. Therefore, the uplift in this area is more than the level of erosion of the forehead of the mountain and is estimated to be about 1.5 to 4mm in a year. Using automatic and semi-automatic methods along with manual ones in extracting the lineaments leads to increasing speed, and accuracy at work.

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