*J. Appl. Environ. Biol. Sci.*, 4(5)167-176, 2014

ISSN: 2090-4274
Journal of Applied Environmental and Biological Sciences
*www.textroad.com*



# Field Evidences and Assessment of Active Tectonic of Southern Shiraz (Fars Province)

**Naser Ebadati**

Islamic Azad University, Islamshahr Branch, Department of Geology

*Received: November 3, 2013*
*Accepted: March 13, 2014*

## ABSTRACT

From the geological units' perspective, different parts of southern Fars province of Iran, especially the range comprising west of Farashband region towards the east of Karzin are located within the Zagros folded belt. Considering the tectonic conditions of the region, attempt has been made in this study, meanwhile evaluating the ground movement analyses and assessment of the young tectonic activities through field study of the evidences as well as reviewing the morphotectonic-seismotectonic indexes, the tectonic activity level is investigated. With this aim in view, integration of the field data and recording of the indexes was performed in GIS software environment in numerical model form. Findings from measurement of the joints, stream graphs, the mountain front foreland, length of the rivers gradients, the seismicity status as well as the young salt domes indicated that in addition to the dynamism and activity of the ground, the uplift velocity in the region is higher than the erosion and this situation shows greater movements in southern limb of anticlines which are accompanied by active faults.
**KEYWORDS:** Fars province, morpho tectonic, field geology, movement index.

## INTRODUCTION

The folded Zagros, 150-250Km in width, includes the regions lying in the southern limit of the Zagros thrust which are known as "the folded belt" [23], "the simple folded zone", [8] and "the mountainous folded belt" [10]. The present data indicate that the folding of this part of Zagros has been more complicated due to the effect of basement faults, presence of salt domes, hidden thrusts, depressions and bendings. There is still no general consensus on the mechanism and the time of foldings. Stockline(1978)[23] and Scherman(1976) [22] believe that the main Zagros folding movements have occurred during the late upper Miocene or lower Pliocene but the structural and stratigraphy evidences indicate that Zagros folding has commenced from the upper Cretaceous but has reached to its peak during the Pliocene with the ultimate outcome of decrease of Zagros initial width for about 20%. The current annual horizontal displacements are estimated to be about 35 to 48 mm and the vertical movements reach to above 2mm [27]. The under study area is comprised of the geographical eastern longitude of 52º.00″ to 53º.00″ and northern latitude of 28°.00″ to 28°.40″ including the southern townships of Fars province and south of Shiraz and the Zagros folded plain. Considering the field evidences and the geomorphological indexes- to be discussed below- an estimation of the active tectonic of the area will be introduced.

## METHODOLOGY

The studies have been performed based on Jahrom 1:250000 and Farashband 1:100000 [21] and Qir 1:10000 geologic map descriptions supplied by National Iranian Oil Company and meanwhile sampling of the field evidences, the measurements were analyzed using the GIS techniques together with the RS reviews and the observation results. On the whole the research procedures were performed through the following steps:

1. Gathering the previous literature, evidences and documentation;
2. Sampling and field operations and measurement of structural elements;
3. Employing the GIS and RS and data analysis;
4. Seismotectonic and active tectonic studies;

### Geological setting

The under study area lies in the tectonic province of southern Iran as part of the Sub-coastal Fars in Zagros simple foldings belt zone [6]. Also based on the Faver classification [10], the under study area has been located in the mountain folded belt and follows the general southeast trend of Zagros folding. Important foldings that constitute the structural feature of the zone include:

*** Corresponding Author:** Naser Ebadati, Islamic Azad University, Islamshahr branch, department of geology
drebadati@iiau.ac.ir

The important anticlines of the under study area include Palang anticline in northern part of the zone Changal anticline on northeast Hygher anticline in northwest and Afzar anticline on southwest of the zone and the main faults include the Qir fault in southwest and Darrehsiyah fault on northeast of the area. The Sayakh (Ghar) anticline lying in the north of the area shares the similar trend with the common axis of Zagros and Narak syncline with the prevailing trend of northwest-southeast, lies in between the two northeastwards Sayakh and the southeastwards Khartoon anticlines. Dehbin suspended syncline in northeast of the area is parallel with Sayakh anticline. From the stratigraphy perspective, quaternary to Cretaceous alluvial deposits (Bangestan group) have outcrop in the understudy area and the most important formations of the area have the following general features according to the geologic map (Fig 1):

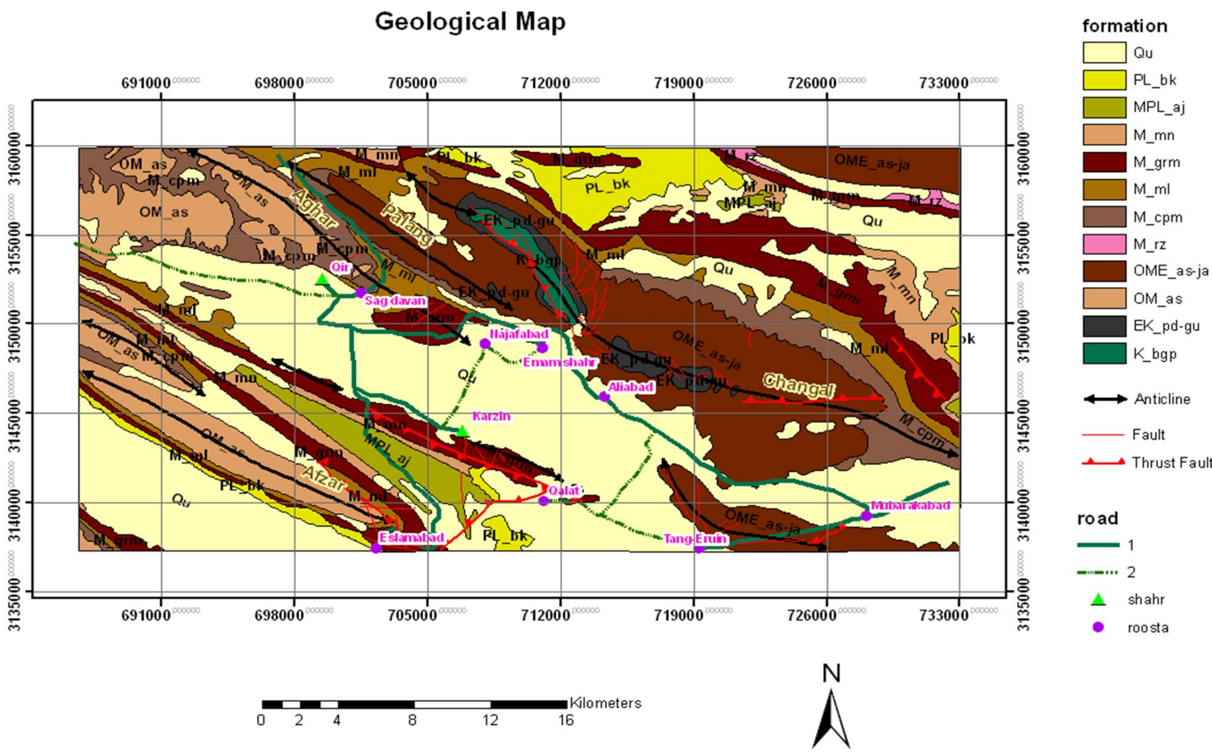


**Fig1-** Geological map of study area

**-**Quaternary alluvial deposits: Includes talus deposits, coarse grained materials, gravel, silt and alluvial trasses.
**-**Bakhtiyari formation: Plio-Pleistocene aged, commonly constituting from thick conglomerate stratums and infrequently accompanied by sandstone, and silt interlayers.
**-**Mishan formation: The Miocene aged sedimentary sequence lies on the Gouri member and constituting from green-gray marls and silt with its apex getting calcareous.
**-**Gachsaran formation: Includes evaporative rocks, marl and lime which are lying on the Asmary formation.
**-**Razak formation: Miocene aged and variable in thickness, it comprises of colored marls, weathered silt and silt lime.
**-**Asmari-Jahrom formation: Oligocene aged, this formation includes creamy to brown colored lime with long cleavage; its base is made of shale and can be divided in three parts.
**-**Pabdeh formation: Lying underneath of the Asmary formation, it includes marl-shale accompanied by lime and clay interlayers.
**-**Bangestan group Cretaceous aged, the Bangestan group is formed by two Sarvak and Kazhdomi lime formation with good bedding and has abundant siliceous nodules in upper layer. Kazhdomi group includes Bitumen shale and dark clay lime and marl.

**Structural geology**

Continuous southward migration of Zagros foreland deformation has created consecutive thrusts and anticlines and has caused reactivation of salt domes simultaneous with Zagros metamorphism. Structural geometry of area basement fault movement effect in sedimentary cover with plastic base has occurred mainly en-echelon with a trend different from that of the main basement fault trend [2,13,14]. The overlapping in between these en-echelon faults can be in compressed or tensile regional forms depending on their geometry and clockwise or counter clockwise mechanism. [26,28].

Through examining and interpretation of seismic lines, the presence of an old height on western part of Changal Palang anticline has been proved. [15].Considering the previous literature and the under taken field studies the structural elements features in the under study area is described as follows:

**Findings**

**Changal anticline:** This anticline, 32 Km in length and about 9 Km in width, is located north eastern of Qir, lying on the Asmary-Jahrom formation. The anticline axis in the middle section features a change in trend from N $135^0$ to N $110^0$ based on which the anticline is divided into two eastern and western parts. Basically this anticline is an asymmetrical south west ward structure with the vergence by far more in the eastern part than in the west. The northern limb in the eastern part lies with low slope in front of the perpendicular to oblique southern limb [15, 18].

The oldest outcrop in the anticline relates to Kazhdomi formation and the youngest one is the Bakhtiyari formation [1].

**Palang anticline:** The only surface outcrop of this anticline is Asmari-Jahrom formation, but Gachsaran formation also outcrops as a narrow strip around this anticline. Feld study results of the streams lengths, the contour lines and the anticline two limbs lengths indicated that the anticline was of symmetrical type. Reviewing the topographical lines of the anticlines two limbs also proved the above conclusion.

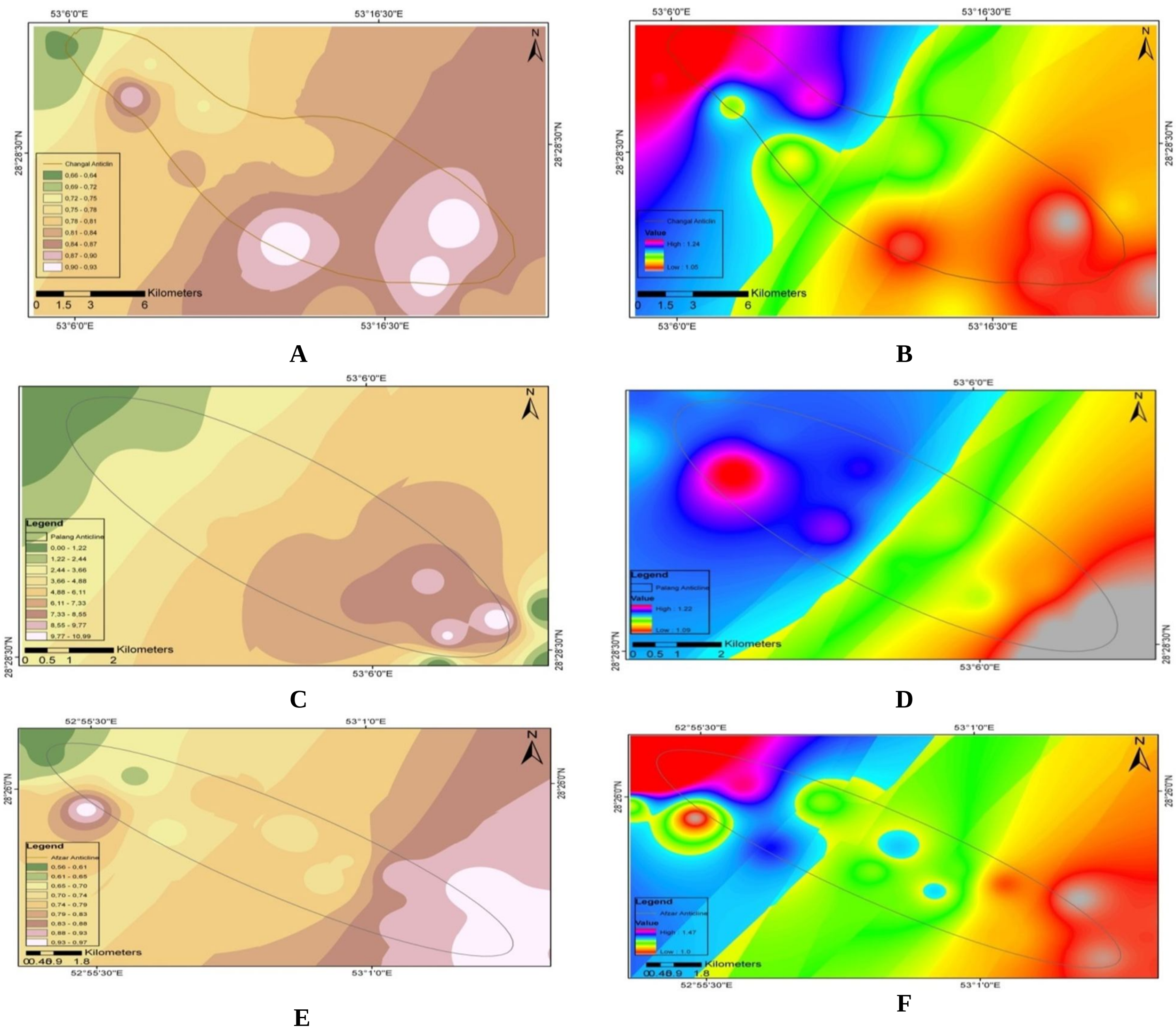


**Fig 2-** Measurement of geomorpic indices (mountain front lineation: A-changal, C-palang, E-Afraz and mountain front sinuosity: B-Changal, D-palang, F-Afraz)

**Afzar anticline:** The breadth of anticline is almost invariable along the anticline's length and the two limbs slop is also identical. The formation outcropped on this anticline is Asmari and the Gachsaran formation is also can be seen around the southern limb of the anticline. The streams lengths along the two anticline's limbs are equal and the contour lines of the limbs are at equal distances apart, all indicative of symmetrical geometry of the anticline.

**Main faults of the under study area**

**Karehbas fault:** Karehbas fault, 160 Km in length, lies 65 Km off the east of active Kazeroun fault and within 35 Km west of Shiraz. As a dextral strike slip fault with almost northward-southward trend, it has caused displacement and elongation of the areas folding for at least 10 Km. Five large salt domes outcrop along this fault which is itself comprised of at least 6 fault sections(Fig.5). The southern section of Karehbas fault turning eastwards constitutes the Sourmeh thrust. The earthquake of September 8, 1992 that struck Daranjan region registering a magnitude of Mb=5.2 related the activity by this fault [4]. Part of the forth section with predominant direction of 348 degrees and length of 30 Km is contained within the scope of map; it commences from 15 Km off west of Firozabad causing dextral strike slip pull apart of more than 6 Km in Sayakh anticline. This fault section cuts the Sayakh anticline axis and causes the salt existing in the anticline core (Mengarag salt dome) to come up to the surface [24]. No outcrop of Karehbas surface was found in the under study area, although some traces are found on satellite images denoting the existence of such outcrops. Figure 3 shows trend of faults and lineation in the area.

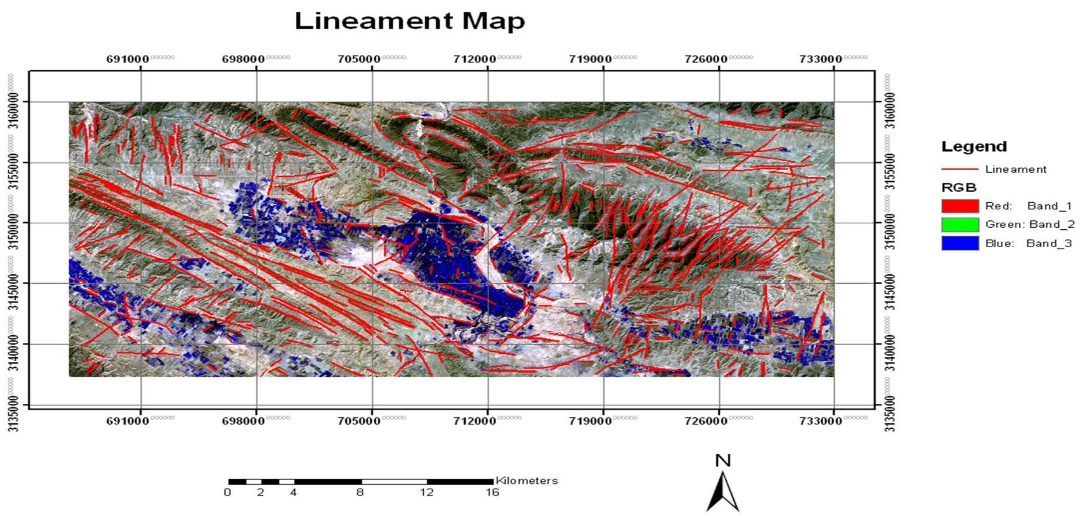


**Fig3-** Faults and lineation bond in the RS software on satellite images

**Qir fault:** This fault has been formed along the Sormeh fault towards the east and almost parallel with the zone's folding southwest of Qir, probably this fault has a thrust mechanism with north east ward slop [4]. The fault's direction is almost eastern-western with overall length of 38 Km. The fault, together with the Sormeh fault, has also been cited as the continuation of curved direction of Karehbas fault trend towards the south east. Considering that the epicenter many of earthquakes with this same trend have gathered around these two faults, it seems like that this trend is highly active. The earthquake of 1972 of Qir (Ms=6.9) is attributed to this fault. Recent studies [25] undertaken in Qir region shows that Qir fault has a reversed dip slip mechanism with a south west wards high slop (60 degrees). Considering the reported length of the fault (surface outcrop) and magnitude of the earthquake released from it, it seems certain that its length is more than 38 Km, part of it being concealed by the sedimentary cover.

**Mountain front fault**: This fault that is in fact restricting the simple folded belt of Zagros towards south and southwest is of high importance from the structural and topographical seismotectonic point of view, so that it can be perceived as the main buried thrust fault[16,17].

The geological evidences like the Asmari formation upper parts’ status and the stratigraphy, seismic and the excavated wells features [8] are indicative of the existence of an at least 6 Km long perpendicular displacement along the thrust fault of mountain front, so that due to the effects of such perpendicular movements along this fault, the folded belts southwestern edge has turned upward along the fault's direction, resulting in appearing of surface asymmetrical folds.

Obviously the mountain front fault consists of several complicated and separate thrust sections of 15 to 115 Km long, the overall length of which reaching up to more than 1350 Km in Iran. These sections of fault (together with their related surface asymmetrical foldings) are segregated from each other through certain en-en-echlon outcrops visible in topographical -morphotectonic terrain features. These sections form a broad arc in Fars (south-center sheet) as well as in Lorestan regions (northwest of Zagros) so that they appear in right and left en-echelon arrays and lie on eastern and western edges of this arched pattern. The mountain front fault has been displaced clockwise by Kazeroun - Borazjan fault for at least 140 Km.

**Sarvestan Fault**: Sarvestan fault has been located in eastern part of Sarvestan plain. This failure is limited northward to Bardaj-Dariyan fault and southward to Kouhenjan fault. Sarvestan failure is 75 Km in length and its direction azimuth angle is 120 to 160 degrees. The azimuth of the fault slip plane slop is 35 to 70 degrees with clockwise movement mechanism and features a thrust component [4].

**Darreh Siyah Fault:** This fault almost lies parallel with Zagros folding around northeast range of the under study area and features a scarp northeastward that crosses the Changal anticline core downstream of the dam axis. The appearance of this fault relates to layer folding and hence is almost parallel with Changal anticline axis [24].

Darreh Siyah is a normal fault with a slop of 53 degrees and azimuth of N87˚E. This fault is located at height 860 m from sea level in Asmary formation on right wing of Salman Farsi dam.

**Sabzpoushan fault**: The path direction of this failure with 51 Km lengths and azimuth of 160 to 180 degrees runs around the western part of Shiraz. The displacement mechanism in this fault is strike slip with clockwise main component and secondary vector for the thrust movement. From the general slip perspective therefore this failure is an oblique fault so that on the main pull apart surface, the vertical drop value is less than the horizontal pull apart along the fault direction. Sabzpoushan I fault is restricted from the north to Bezin failure and from the south to the terminal part which is also the connection point of the Mishwan fault to this section. This failure is a dynamic fault, the movement traces of which could be tracked not only in late Quaternary, but also in the present era.

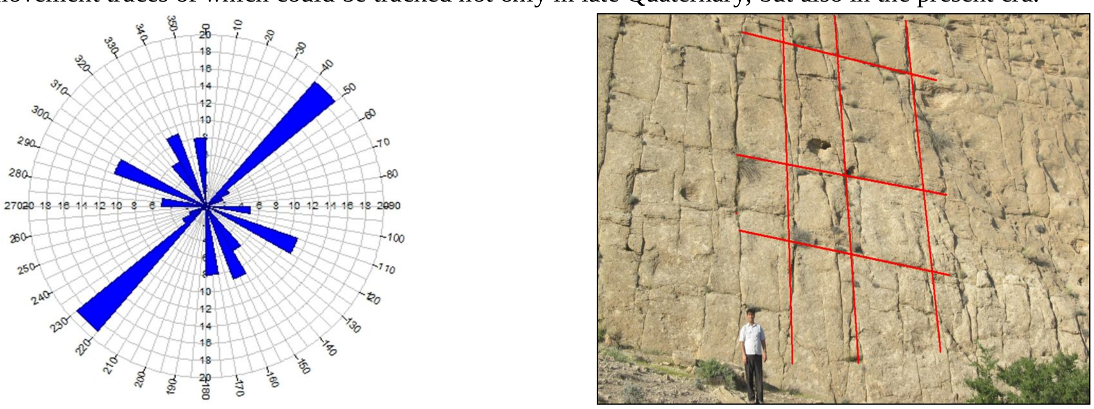

**Fig 4** –Frequency and contribution of fractures in the Asmari formation south of Palang anticline with rose diagram of fractures

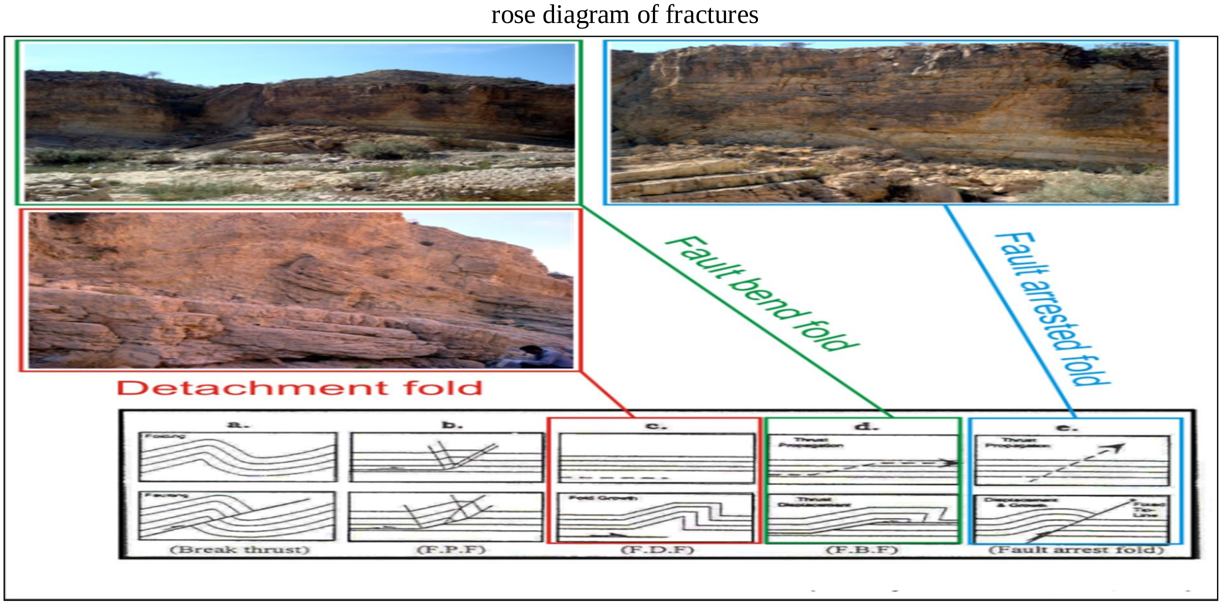


**Fig 5-** Relative of folding with fault overlap in the Karehbas, narak and chartag fault [11]

**Sabzpoushan II fault:** This failure with a length of 25 Km and direction azimuth of 155-180 degrees is part of Sabzpoushan I fault the result of merger of both failures movement mechanisms is the development of a stress field between Sabzpoushan I and II faults[26]. The displacement mechanism in this fault is a strike slip mechanism with clockwise main component and secondary vector for the thrust movement. This failure from the general slip perspective is similar to Sabzpoushan I fault. The fault slop is more than 70 degrees and in depth it connects with Sabzpoushan I shear plain.

**Investigating the geomorphic indexes using GIS**

**Provisioning of lineation maps of the area:** Provisioning of lineation maps of the area: Using the images from the Landsat satellite and GIS, ARS and RS software the area lineation was extracted and ultimately the area lineation map was obtained. In order to extract the lineations, different topographical models like the slop map, the direction slop map, DEM elevation map, shaded elevation map, three-dimensional model, and color combination images were supplied using the satellite images[3,19]. One of the advantages of this method is that the lineations irrelevant to geology could be identified. [10] In order to provide the final lineation map of the area, attempt was made to extract the area lineations and then a unique lineation map of the area is provided. It must be mentioned that for this purpose all the drawing supplied using different techniques have been used and ultimately the final drawing was supplied with the aid of visual interpretation (Fig.6). To obtain information on the manner of distribution and nature of the lineation's density map were supplied using GIS software and for determining the spatial model of the area lineations, the density analysis was performed on the lineation's map[12].

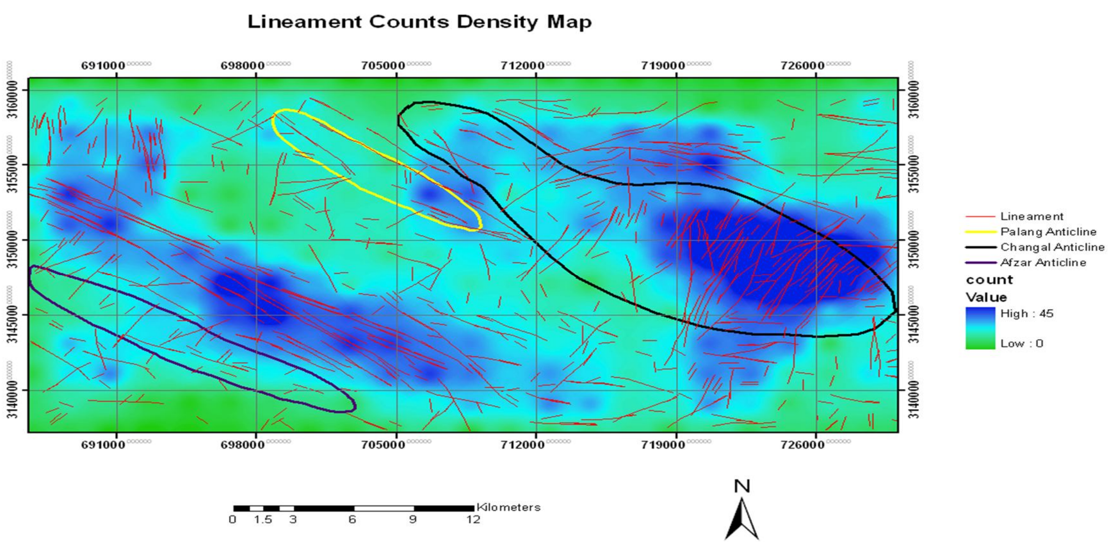


**Fig 6-** Lineament counts density map of area (L>2km)

**Important diapiric structure of the area**

**Mengreg Salt dome (Firozabad salt mountain)**: This salt dome outcrops south of Firozabad township and in the Sayakh anticline axis. This twin dome is 10 Km in length and 5 Kms in width. The northern part is much smaller than the southern part. The forth section of Karehbas fault system has caused dextral strike slip pulling apart in the Sayakh anticline axis. This fault section cuts the Sayakh anticline, causing the salt accumulation in the core of the anticline to come up to the surface. The northward movement of the western block of the fault has then caused part of the salt mass to be displaced resulting in pulling apart of the feeding root of the separated salt mass. This phenomenon has bring about the twin status of the salt dome and inexistence of salt glacier in upper small part compared with the lower main mass is a conclusive evidence supporting this theory [11]. In the lower large part also the dip origin of the salt has been clogged and consequently the salt glacier rate becomes greater than the salt fed from below, resulting in formation of a uniform parabolic profile similar to that of the water droplet mechanism. In general the dome according to Jahani et al. (2007) classification could be classified among the domes accompanied by salt glacier but without mill which is still active[11].

**Jahani salt dome:** Jahani salt dome has been located 20 Km off south of Firozabad and north of Azadegan plain. The outcrop of this dome lies on the eastern part of Karehbas fault fifth section southern terminal. It is 10 Km long and 6 Km width. The salt area in fact is a product of a broad salt glacier that has covered the upper surface of the dome adjacent formations [11]. This dome has an active mill on the northeastern part to the center so that due to low morphology of the southern and southwestern plain, the salt glacier preferential movement orientation is toward it (fig.7). Based on a joint study undertaken by the Geological Survey of Iran and Uppsala University of Switzerland, an annual salt eruption rate of 1m has been obtained. The apex of the Jahani Mountain is located right in the compressive en-echelon of fifth section of Karehbas fault system.

**Fig7-** Uplift Jahani salt dome is cause of low thickness yang alluvium deposits.

**Seismicity features**

Zagros earthquakes are shallow. The earthquakes distribution sections show that although the depth of some earthquakes goes far down to about 60 Km depth, but most of them are focused at around 30 Km depth. so that the seismic focuses are approximately located within a prism of 1500 Km length, 150 Km width and 60 km depth and northwestern-southeastern trend. [21].Falcon(1962) [8,9], considering the distribution of salt domes and the inconsistency between the seismic focuses and specific faults, considers the salt domes and their movement as an influential factor in the Zagros earthquakes.

Compressive stresses imposed on Zagros affect the area basement. This same stresses cause metamorphism of Saudi Arabia sheet and frequency of Zagros earthquakes. Relative frequency of quakes in Bandarabbas-Lar region which are the outcome of additional pressures imposed on the eastern part of Saudi Arabia sheet can be an evidence for this opinion.

Frequency of Zagros earthquakes can be due to Precambrian north-south faults movement. But such faults generally have surface normal or strike slip movements, while the mechanism of Zagros deep earthquakes is indicative of overthrust movement. Approximation of the crust velocity structure in central Zagros was performed using refracted boundary waves. The crust velocity structure plays important role in determining the exact location of earthquakes [25].It's worth mentioning that most of Zagros earthquakes occur without surface faulting. This could be due to the existence of Hormoz series salt layers on the basement boundary and the upper sedimentary cover which meanwhile reducing the energies, prevents them from reaching to the ground surface. Additionally, the existence of Gypsum-Anhydrite sediments relative to Dalan (Permian), Dashtak and Kangan (Triassic), Hyse and Goutina (upper Jurassic) formations especially Gachsaran evaporative formation (Miocene) are among the effective factors in energy decline and preventing from surface faulting[5]. Therefore for an earthquake to have surface faulting, one of the factors, low depth focus or magnitude of higher than 7 on the Richter scale is needed [4]. This zone has frequent shallow focal earthquakes (0 to 70 km seismic focus) with medium to sometimes high magnitude. From the earthquakes happened in the region the following can be mentioned: Silakhor (1908) earthquake with local magnitude of 7.4 Richter, Farsij earthquake with local magnitude of 7.2 Richter and Nahavand (1958) earthquake with local magnitude of 6.8 Richter in western regions of the country and Qir-Karzin (1972) earthquake in Fars province and Khorgo (1977) earthquake, north of Bandarabbas (7.1 and 7.2 on the Richter scale respectively) in southern parts of Iran (Fig.8).

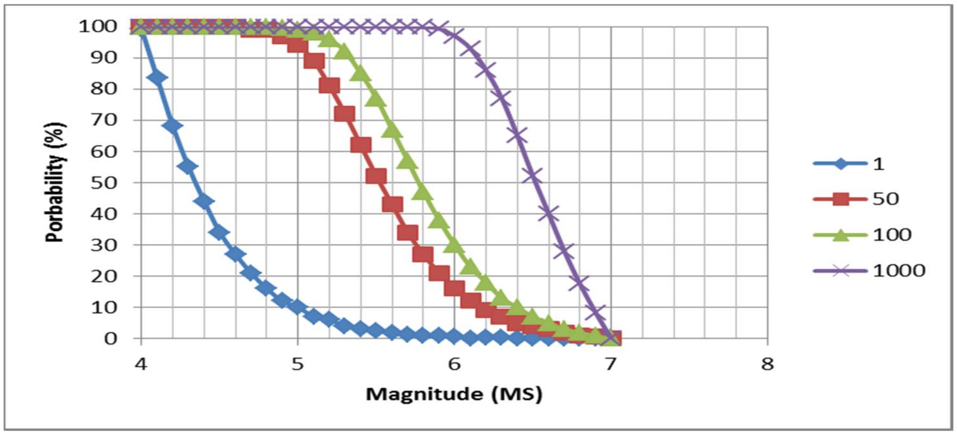


**Fig 8-** Occurrence probability of earthquakes (with different time return: 1-1000 years)

**Area seismic record:** Examining 1º to 1º range of the seismic focus shows that about 820 seismic instances have been occurred in the area, out of which 74 instances have occurred with magnitude of 5 and more than 5 on the Richter scale (Fig.9). This is indicative of high seismicity of Qir and Karzin region. The biggest one of these quakes was the Qir- Karzin earthquake (April, 10, 1972) with magnitude of 6.9 on the MW scale. [7].

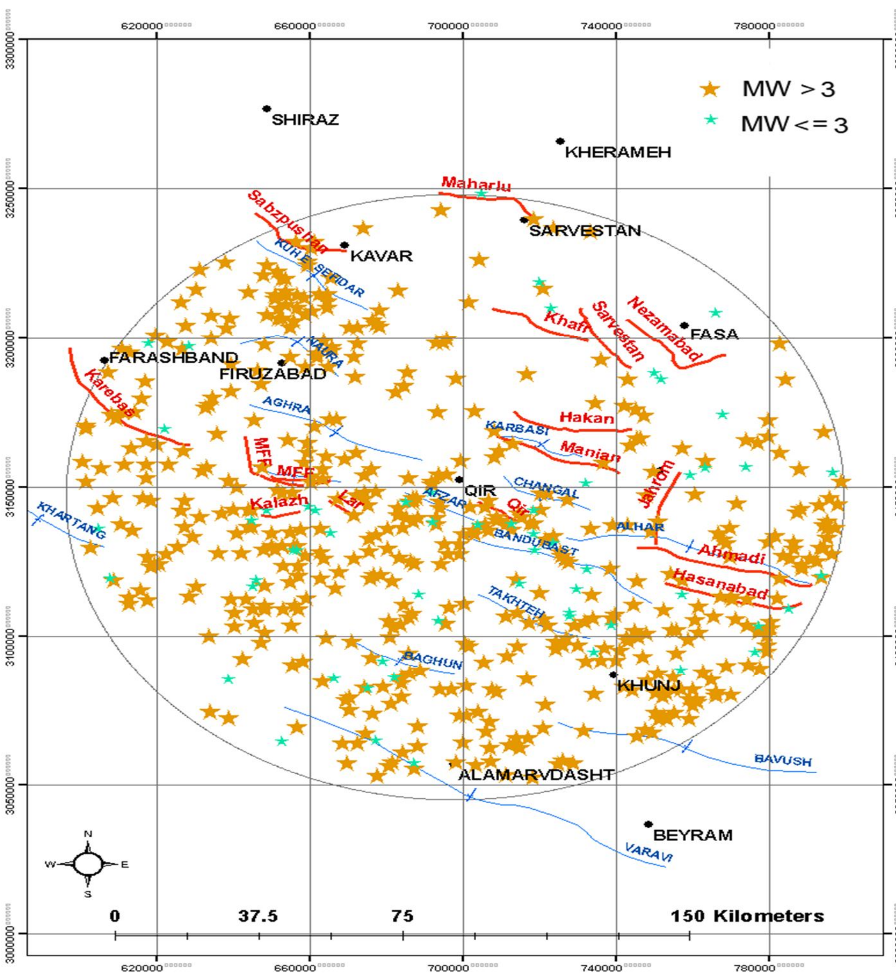


**Fig 9** –Siesmotectonic map of study area(earthquake frequency is at 1951-2011)

**The under study area earthquakes features**

Considering the investigations conducted into equipment earthquakes of the under study range it has been determined that between the years 1951 to 2011 (A.D) a number of about 587 earthquakes with magnitudes of 2.5 to 6.9 on the Richter scale have occurred the best part of which have been the foreshock or aftershock of large earthquakes. 15 earthquakes out of the above figure with 4 Richter magnitudes have occurred along Karehbas fault direction and are attributed to it. The studied earthquakes are relevant to mountain front fault on failure of the foldings. Numerous earthquakes from the year 1052 to 2010 have occurred with magnitudes ranging from 5.5 to 6.8. Studying the earthquakes mechanisms along the Sarvestan fault indicates that faulting has been almost of pure overthrust type and the obtained surfaces have been parallel with the trend of the area geology structures and faults [7].

The seismic focus location of earthquakes in Figure 9 shows that earthquakes concentration around Qir and Sabzpoushan faults and the mountain front has the highest concentration which is an evidence for the high fault activity.

**Conclusions**

1- The geomorphic indexes values obtained in Changal anticline shows that the tectonic activity in southern limb of the anticline is more than the northern limb the cause of which being the southwestward trend of the anticlines.

3- The geomorphic indexes values in Palang anticline do not show considerable difference concerning the two limbs in relation to each other, meaning that tectonic activity in northern and southern limbs of the anticline are almost identical.

4- The morpho tectonic indexes results of Afzar anticline are indicative of its high tectonic activity. Through integration of the obtained results the high activity of this anticline could be attributed to Qir fault. Evidences in Afzar anticline in relation with the two Changal and Palang anticlines are indicative of its higher tectonic activity compare with the other two anticlines.

5- The location and high concentration of seismic focus shows that the under study area is of active seismicity areas so that about 85% of the earthquakes have magnitudes higher than 3 on the Richter scale. The concentration of earthquakes around Qir, Sabzpoushan and mountain front is higher than the other regions; also the seismic analyses around such faults and Karehbas fault show that they are of important and influential faults of the area, having high seismicity power in developing powerful and destructive earthquakes throughout the region.

The two Jahani and Mengreg salt domes have surface outcrop besides these two faults and their creation is obviously connected with the movement of these faults. The penetration of salt is related to the appearance of hollow spaces or pull-apart basins resulting from the movement of fault basement blocks in Karehbas fault system.

**Acknowledgement**

We would like to express our sincere thanks to the respected management of Zaminkv geology and environmental research Center for facilitating the ground for this study and compilation of this paper.

**REFERENCES**

1-Aganabati,A.,(2010);Geological of Iran ,pub. Mine exploration and geological survey of Iran. Tehran,( 1),189p.

2- Alavi, M., (1994). Tectonics of the Zagros orogenic belt of Iran: new data and interpretations, Tectonophysics, 229, 211-238.

3-Bahroudi A., and Talbot, C. J.,2003);The configuration of the basement beneath the Zagros basin, Journal of Petroleum Geology, vol.26 (3), July 2003, pp. 257 -282

4-Berberin, M., Yeats, R.S., (1999). Patterns of historical earthquake rupture in the Iranian plateau, Bull. Seismol. Soc. Am. 89, 120-139.4

5-Beydoun, Z. R., Hughes Clarke, M. W., and Stoneley, R., (1992); Petroleum in Zagros basin: A late Tertiary foreland basin overprinted onto the outer edge of a vest hydrocarbon rich palaeozoic- Mezozoic passive margin shelf, American association of petroleum Geologists, Memoir, 55,PP. 309- 3390

6-Davis, W.M., (1899); The geographical cycle, The Geographical Journal 14, No.5, 481-504

7-Eslami, A.,( 2010);Report of earthquake on the 26/ Nov/2010 south east of Qir-Karzin, institute of geophysics ,Tehran university,78p.

8-Falcon, N. L., (1974); Southern Iran: Zagros Mountains in Mesozoic-Cenozoic Orogenic Belts, Data for Orogenic Studies. Ed. Spencer, A.M., Geo1. Soc. Spec. publ. London, 4, 199-211

9-Falcon, N. L., (1969); Problems of the relationship between surface structure and deep displacements illustrated by the Zagros range, in time and place in orogeny, Geol. Soc. Spec. Publ. London

10-Favre, G., (1975); Structures in the Zagros Orogenic Belt OSCO, Report No. 1233E52. Kazmin , V. G. et al., (1986b). Volcanic belts as markers of Mesozoic – Cenozoic active margin of Eurasia, Tectonophysics, 123

11-Keynezhad,A. , Badakhshan, Gh., Ghavamabadi, M., Rezaei, Z., (2013); Research of Relation of Diapirism with Structural Deformation of the Zagros Basin, based on “Mangarak” and “kuh-Jahani” salt domes (South West of Firoozabad - Fars province),Iranian journal of Environmental Geology,No.24,pp.1-13.

12- Kocal, A., (2004). A methodology for detection and Evaluation of lineament from satellite Imagery, Ms. Thesis, Middle East Technical University,121p.

13-Lacombe,O., Bellahsen,N., Mouthereau,F.,(2011); Fracture patterns is the Zagros simply folded belt (Fars,Iran) conctraints on Early collisional tectonic history and role of basement faults, Geological magazine,148,5-6,940-963.

14-Lacombe, O., Mouthereau, F. , Kargar, S. , Meyer, B.,(2006),Late Cenozoic and modern stress fields in the western Fars (Iran): Implication for the tectonic and kinematic evolution of central Zagros,jour.tectonics,Vol.25,1-27,Tc.1003 , doi:10,1029/2005Tc001831

15-Masibaygi, M.,(2011); Report of structural geology on the anticlines Changal- Palang, Department of subterraneous geology, the national Iranian oil company, No.1, 63p.

16-Mouthereau,F.,Lacombe,O.,Verges,J.,(2012);Building the Zagros collisional orogeny: timing, strain distribution and the dynamics of Arbia/ Eurasia plate convergence, tectonphysics ,Vol.532-535,p.27-60.

17-Mouthereau, F., Lacombe, O., and Meyer, B., (2006), The Zagros Folded Belt (Fars, Iran): Constraints from Topography and Critical Wedge Modeling: Geophysical Journal International, v. 165, p. 336-356.

18- Oveisi , B., Lava, J., Vander beek ,P.,(2007); Rates and Processes of Active Folding Evidenced by Pleistocene Terraces at the Central Zagros Front (Iran), journal of Trust belts and foreland basin ,version 1,pp,267-287,doi:10/1007/978-3-540-69426-7-14.

19-Pirasteh,S.,Pradhan,B.,Safari,H.,Firuz Ramli, M.,(2013);Coupling of DEM and remote-sensing based approaches for semi-automated detection of regional geo structural features in Zagros mountain, Iran , Arabian Journal of Geosciences, Vol.6(1),pp.91-99.

20-Sarkarinejad, K., Azizi, A., (2008); Slip partitioning and inclined dextral transgression along the Zagros Thrust System, Iran, journal of Structural Geology Vol.30 (1),pp. 116-136.

21-Sedagat, M., Dabbaeiatnejad, E., (1996); Geological map of Farashband, scale 1:100000, geology survey of Iran, No.1, and series 1.

22- Shearman, D. J., (1976). The geological evolution of southern of Iran: The report of the Iranian Makran expedition. imp. Coll. Sci. technol. Vol. 142. No. 3. 5ll

23-Stocklin, J., (1968); Structural history and tectonics of Iran; A review, American association of Petroleum Geologists Bulletin, 52(7).

24-Talebi,A.,Ganjavian,M.A.,Mafakherian, A.,Ramazaani,M.,(2013); The analysis of morphotectonical anticlines in the Qir-karzin area (East south of Shiraz),Iranian journal of Environmental Geology,VOl.6,No.21,pp.51-63.

25- Tatar, M., Hatzfeld, D., Ghafori-Ashtiany, M. (2004). Tectonics of central Zagros Mountain belt (Iran) deduced from microearthquake seismicity. Geophys. J. Int., 156:255-266.

26-Tavakolian,A.,(2004);Effect of the Sabzpooshan fault zone on the development of Choghal compression region-Fars region,26th conference of earth sciences, pros. No.1,pp131-134.

27-Walpersdorf, A., Hatzeld, D., Nankali, H., Tavakoli, F. Nilforoushan, M. Tatar, P. Vernant, J. Chery and Masson F.,(2006) Difference in the GPS deformation pattern of North and Central Zagros (Iran), Geophysical Journal International, Vol. 167, Issue 3, p. 1077–1088.

28-Yamato, P.,J. Kaus.B.,Mouthereau, F. and Casteiitori. S.,(2011); Dynamic constraints on the crustal-scale rheology of the Zagros folded belt ,Iran, journal of Geology, Vol.39(9),pp.815-818.