

Geometry and Kinematics of Qom-Zefreh Fault System and its Significance in Transpression Tectonics

NEDA POROZHAN¹, KAMBIZ TEIMOORNEGAD², MOHAMMAD MOHAJJEL³
Geology Department

¹Islamic Azad University Lahijan Branch

²Islamic Azad University Lahijan Branch

³Tarbiat Modarres University

P.O.BOX:1616,Shaqayeq St.,Kashef St.,Lahijan.

IRAN

Neda_porouhan@ yahoo.com

Abstract: - Qom-Zefreh fault system, almost 220 km long cuts Urumieh-Dokhtar magmatic belt in central Iran. According to trend and mechanisms, fault can be divided into three segments of northwest, central and southeast. Geometric analysis of structures related to Qom-Zefreh fault system and their kinematics (such as Natanz fault slice), reflects a dextral strike-slip displacement with small reverse component in some parts of Qom-Zefreh fault. The trend of reverse and thrust faults in relation with Qom-Zefreh faults well as geometric attribute of developed folds with these faults reveals the influence of strike-slip movement at Qom-Zefreh fault on their formation and development. The movement created a positive flower structure in two areas, pressure symmetric areas of south Kashan and south Ardestan. Compared with these two areas, two areas of north Kashan plain in northeastern and southern Zefreh plain-Gav khoni; swamp in southeast have been affected symmetrically by extension areas of this strike-slip fault system. Verity of lens shaped intrusive bodies including Vash granite are found in local extension areas along some segment of this strike-slip fault system. Qom-Zefreh fault as one of basement faults of central Iran is evaluated by general trend of northeast reactivated by convergent tectonic of the Neo-Tethys. Morphological evidence like cuttings and displacement of streams channel and recent alluvial fans along Qom-Zefreh fault provides fact that the mentioned fault has high potential for seismological activity.

Key-Words: Qom-Zefreh fault, positive flower structure, strike-slip faults, Transpression Tectonics, Kashan, Ardestan

1 Introduction

Geometry and mechanisms of strike-slip faults and structures related to the development of these faults have been broadly studied [10]. -Dokhtar magmatic belt with northwest-southeast trend was cut and displaced by faults with north-northwest trend such as Dehshir, Qom-Zefreh, Bidhend and southern Saveh fault systems with dextral strike-slip mechanism [1,2]. Qom-Zefreh fault [7] is recognized as one of these faults that covers an area from southeastern Qom to Zefreh -70 km northeastern Isfahan [9]. pressional areas of two northeast and southwestern termination have overlapping with pressional areas of Bidhend and Dehshir faults termination, respectively. This fault through its displacement played an important role in deformation of Urumieh-Dokhtar magmatic belt deposits and Cenozoic deposits so that its continual activity made them cut and displaced. Qom-Zefreh fault is composed of several segments located in the form of en-echelon [8].

2 Fault Segmentation

Qom-Zefreh fault is divided to three segments that those located between western Kashan and its southeast termination in Zefreh. These three segments include northwest, central and southeast. (figure 1)

2.1 Northwest Segment

Northwest segment of Qom-Zefreh fault separates Kashan and Ravand plain from the of south and southwest high lands. Fault plane ($85^{\circ}/045^{\circ}$) with small rack slicken-lines was measured. there is a height difference measured over 20 meters in the south of Kashan-Isfahan highway on outcrop trend which created this segment fault. This fault by itself represents uplift southern part against downthrow northern part.

2.2 Central Segment

This segment of Qom-Zefreh fault includes average trend of $N135^{\circ}$. Fault plane was measured $75^{\circ}/230^{\circ}$ in the area 6 km from south of Finn and $80/210$ in the area 2

km from south of Zanjanbar. Rake angle equals nearly zero and shows strike- slip movement.

about 55 km .Fault's slip and it's direction equals $80^{\circ}/065^{\circ}$ that shows a strike-slip displacement.

2.3 Southern Segment

Southeastern segment of Qom –Zefreh fault include the trend similar to that of northwest .The segment extends

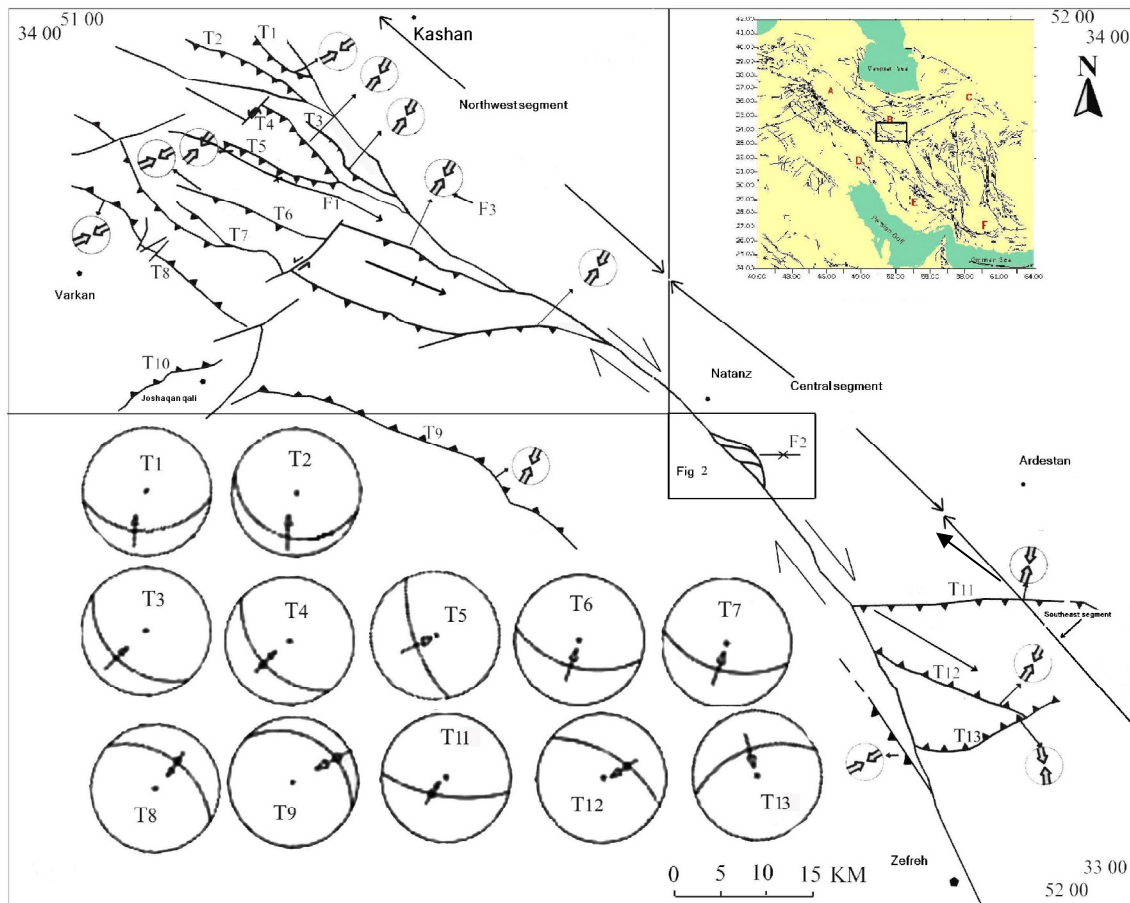


Fig 1: Segments of Qom –Zefreh fault. Geometry and faults mechanism as stereographical projection are illustrated by the following large numbered circles .Stress measured through rake angles of slickenlines of fault planes are illustrated by small circles.

3 Kinematics Indicators in Qom-Zefreh Fault

Kinematics indicators along Qom –Zefreh fault zone include certain structures, showing last movement and recent displacements. Natanz fault slice can be referred to as structural evidence ,representing the fault's late movement (fig2).The slice about 10km long along northwest –southeast and 2.5 km wide rock complex carried over by the slice are surrounded by volcanic rocks formed during middle to upper Eocene so that they formed an island .

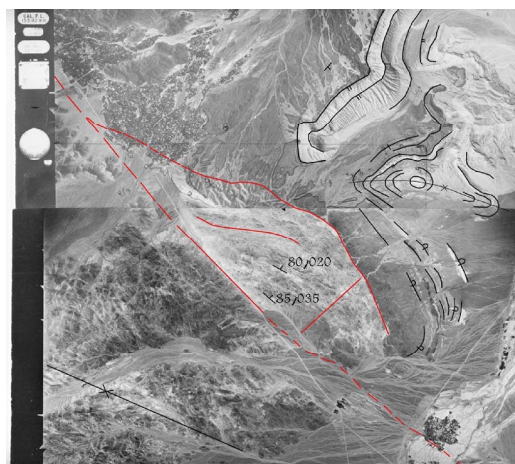


Fig 2: Natanz fault slice.

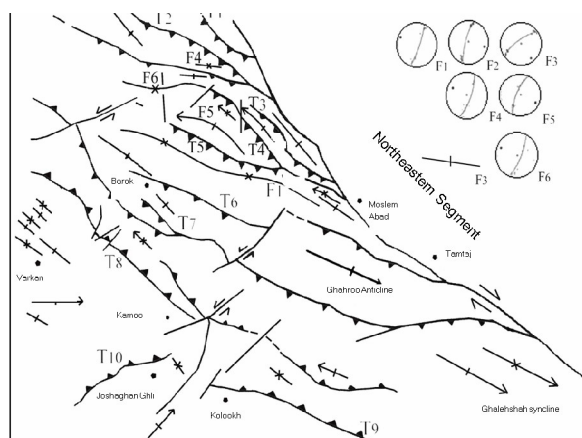


Fig3 : Qom –Zefreh fault and related structures in southern Kashan. Small circles show folds related as stereographic projection.



Fig 4: Some outcrops of Qom formation are found as yellow fault slice.

The Mesozoic rock complex within this slice has an outcrop on northwestern Qaleeshah syncline, 15 km from east of Natanz [12,13]. The outcrop is cut by Qom – Zefreh fault, so it can be concluded that this slice must have passed 20km to receive in its present place i.e. east of Natanz (fig 1 and 3). In the south of Zanzanbar, some pieces of Qom formation limestones, about 10-50 meter wide, can be observed along the fault (fig 4). Abundant morphotectonic evidence including cutting and displacement of streams and alluvial fans leading to plains, all encourage us to conclude that Qom – Zefreh fault has recently moved and displaced by a strike – slip movement. One highly remarkable movement occurred in the east of Moslem Abad along the road from Kashan to Qamsar where the presence of an old alluvial fan at the beginning of plain shows the displacement of a strike – slip movement along Qom – Zefreh fault at least for 500 meters (fig 5).



Fig 5: Displacement of young alluvial fan by Qom – Zefreh fault, Moslem Abad village.

4 The set of faults related to Qom – Zefreh fault in southern and western Kashan

This set of faults is located on the southeast of Qom – Zefreh fault and have slope toward southwest and northeast (fig 3). The set of faults that is closer to the main fault has slope toward southwest. The set includes faults located on the south of Kashan – Isfahan highway (T1), Baronaq (T2), Jaze (T3), Xonb (T4), Gojar (T5), Barzok (T6) and Chal (T7). The mentioned faults are situated closer to each other in northern part and near main Qom – Zefreh fault. Reverse faults including Kamo (T8), Maravand (T9) and Joshaghan – Qali (T10) have slope toward northeast, located farther from main Qom – Zefreh fault and comparatively far from each other.

4.1 Characterizes of some of more important faults

4.1.1 Southern Kashan – Isfahan highway fault (T1)

This fault is indeed the first fault located in the south Qom – Zefreh fault and northwest segment. Shear band of its hanging wall is broadly extended and shows the movement of Qom limestone formation on Pliocene conglomerate. The measurement of fault plane dip and dip direction equals $25^{\circ}/180^{\circ}$ and slicken lines on fault plane were measured are $22^{\circ}/210^{\circ}$. Thus this fault involves reverse movement with small left-lateral component.

4.1.2 Baronaq fault (T2)

The fault located on the south of Kashan – Isfahan highway fault (fig 3), moved syncline of Bozrish mountain (F4) and Qebleh anticline on upper red formation (late Miocene). A study on shear band of this fault, situated in east of Xonjeh, confirms the movement (fig 6). Dip and dip direction were obtained $28^{\circ}/195^{\circ}$.



Fig.6: Shear band of Barounaq fault

4.1.3 Jazeh fault (T3)

This fault with trend of N135° and acute angle reaches Qom –Zefreh fault on it's southeast termination. Dip and dip direction are 47°/225°, and slickenlines are parallel to actual dip (fig3).

4.1.4 Xonb fault (T4)

There are Qom formation deposits on green and gray Miocene marl along Xonb fault .Fault plane was measured 50°/225°.In the west of village Xonb north limb of Xonb returned toward southwest and cut as a result of this fault movement (fig7)

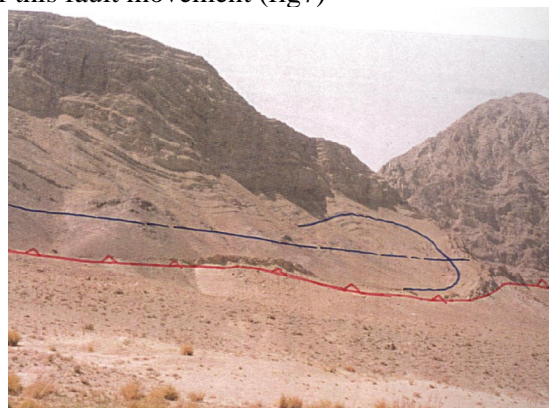


Fig 7: Xonb anticline .North limb of anticline returned southward along with Xonb reverse fault.

4.1.5 Maravand fault(T9)

Maravand fault with N110° trend in southeast changes it's direction to east – west in the north of village Koloukh.

4.1.6 Joushaqan –Qali fault(T10)

This fault returned toward N60°E on it's southwest in the northwest of village Joushaqan –Qali .The fault's reverse mechanism moved northwest block on southeast block.

4.2 The set of fault related to Qom –Zefreh fault in the south of Ardestan zone

In the south of Ardestan , a set of faults are located in northeast of Qom –Zefreh fault and dip southwestward and northeastward .The set of southern faults dip northeastward ,the most important of which are

Bargouhar fault -60°N-(T13) and Marbin-Rengan - 62°/034° (T12).Kochomesqal- Genyan fault (T11),placed in the south of Ardestan dip southward(fig 1).This fault shows left-lateral strike slip movement with reverse component.

5 Structural Analysis

East termination of all reverse and thrust faults that located in Kashan southwest band receive to Qom – Zefreh fault on the southern block of Qom –Zefreh fault in northwestern segment. This jointing shows the fault development relationship with Qom –Zefreh fault [10,11].Reverse and thrust fault in the south of Qom – Zefreh fault in Kashan southwest band are found with two different dip in the north and south .Fault with similar mechanism ,from Chal fault (T7)toward north to southern Kashan –Isfahan fault (T1),all dip southwestward and thrusting northeastward but from Kamo fault (T8) toward south they dip northeastward and thrusting southwestward (fig1 and 3) .On the other hand ,the comparison of fault's slope gradually increases toward southern faults .There is a close relationship between large folds and the movement of faults related to Qom –Zefreh fault .Their trend of axial trend is comparable with the trend of reverse and thrust faults located at this band of Qom –Zefreh fault system(fig 1,3 and 8).

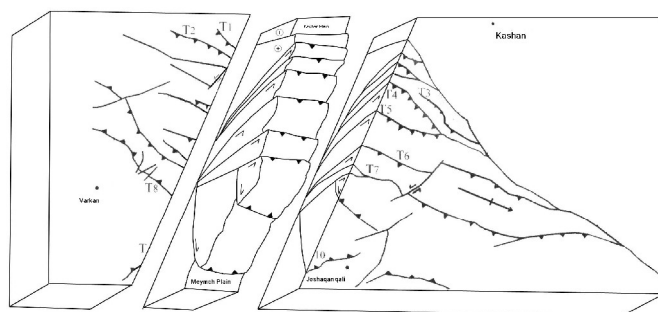


Fig 8: A 3-D (three dimension) profile of positive flower structure at the pressional termination of southwestern Kashan.

The existence movement and geometrical evidence in shear zone of Qom –Zefreh fault for it's strike slip movement from one hand and geometrical arrangement of main Qom –Zefreh fault and related faults in two terminations with small angles between them from other hand demonstrates that pressure termination has been deformation influence of existing pressure in termination and shear movement simultaneous deformation along Qom –Zefreh fault . However this arrangement was interestingly different from morphological pattern and

geometrical arrangement of strike slip faults' structures and that is exchange of dip direction and tendency of thrust faults like Kamo(T8) Maravand (T9) and Joshagan-Qali (T10) in northwest termination and Kochomesqal- Genyan fault (T11) in the southeast termination changes considerably.

The faults' mechanism in two symmetrical areas caused fault set of northwest termination move on Meyame plain in south termination and caused thrusting in southeast termination on Ardestan plain in the north termination. This observation implies that it was not only the strike slip movement of Qom –Zefreh fault in pressure termination that was effective but also fault in general shortening as a result of overriding pressing of the two areas when Qom –Zefreh fault divert from termination makes pressure terminations move in two sides .Therefore, shortening occurred in the area and activation of right – lateral movement of Qom –Zefreh fault were effective as this fault system development and deformation of Cenozoic deposits existing.

The closing of young Tethys ocean in the southwest from late Jurassic has influenced Sanandaj –Sirjan belt [5].since then ,the system was active in Sanandaj – Sirjan belt so that continual progressing deformation is transmitted to Urumieh - Dokhtar magmatic belt [4].Actions of Transpressional tectonic system [5] activate basement faults with prominent north- south trend [6] in central Iran which are placed in Urumieh - Dokhtar magmatic belt including parallel faults of Dehshir , Qom –Zefreh,Bidhend and southern Saveh. The mentioned faults show en-echelon pattern .Basement faults have been activated as young Tethys ocean was closed between Iran and Arabian platform and collision of them. Basin of Kashan deposits including Eocene to Miocene deposits are influenced by prominent strike slip movement of Qom –Zefreh fault .Therefore the development of folds and the activity of thrust faults in pressional areas ,i.e. southern and western Kashan zone and southern Ardestan zone continue to occur.

On the one hand two areas of northern Kashan plain in northwest and Gavekhuni swamp plain in southeast are symmetrically effect by extension in extensional areas of Qom –Zefreh strike slip fault system and then they have subsidence.

6 Conclusion

Geometrical and movement evidence along Qom – Zefreh fault shows prominent right-lateral displacement which in turn formed two symmetrical terminations of positive flower structure in pressural terminations in southwestern Kashan (Fig.8)and southern Ardestan ,Structural evidence found in central part represents the

greatest right-lateral displacement (about 20 km) from Eocene. Cenozoic deposits of this part of Urumieh - Dokhtar belt have been deformed in this fault system.

References:

- [1] M. Alavi, *Tectonic map of Middle East*, Geological Survey of Iran, 1991.
- [2] M.Mohajjel, *Structure and tectonic evolution of Paleozoic- Mesozoic rocks, Sanandaj–Sirjan zone , western iran* ,Ph.D thesis ,university of Wollongog,Astrailia,1997.
- [3] M.Mohajjel,C.L.Fergusson , Dextral transpression in late Cretaceous continental collision,*Journal of Structural Geology* ,vol 22, 2000, pp.1125-1139.
- [4] M.Mohajjel , *The influence of en– echelon extension spaces in lens shaped intrusive bodies in Kashan - Ardestan area .A pattern formation of Oroumieh – Dokhtar volcanic arc* .2000,,19th conference of geosciences , Geological Survey of Iran.
- [5] M.Mohajjel,C.L.Fergusson ,M.R.Sahandi ,Cretaceous- Tertiary convergence and continental collision , Sanandaj –Sirjan zone,western Iran ,*Journal of Asian Earth Sciences* , Vol 21, 2003, pp.397-412.
- [6] M.A.A.Nougol Sadat ,*Shear zones and structural bending in Iran ,structural analysis results of Qom area* ,Report No.55, Geological Survey of Iran ,1995.
- [7] M.H.Nabavi, *An introduction to Iran's geology*, Geological Survey of Iran, 1986.
- [8] N.Porouhan , *Deformation analysis of Qom –Zefreh fault ,Kashan - Ardestan area*,M.S thesis,University of Tarbiat Modarres,2002.
- [9] J. Radfar , *Geology map of Kashan ,1:100000 scale*, Geological Survey of Iran, 1990 .
- [10] A.G.Sylvester,Strike slip faults, *Geology Society of America bulliten* ,vol.100 , 1988 , pp.1196- 1230.
- [11] R.J.Twiss, E.M.Moores , *Structural geology* , Free man Company ,New York ,1992.
- [12] A.Xalatbari ,M.Alae, *Geology map of Natanz , 1:100000 scale* , Geological Survey of Iran, 1990 .
- [13]M.Zahedi, *Geology map of Kashan ,1:250000* , Geological Survey of Iran, 1990 .
- [14] M.Zahedi,M.Ramati, *Geology map of Tarq , 1:100000 scale* , Geological Survey of Iran, 2002 .