Stratigraphical evidences of the Qom – Zefreh Fault system activity, Central Iran

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Abstract

In the Urumieh-Dokhtar volcanic zone, there are nearly parallel faults to the Zagros zone.They were formed during collision of the Arabic plate with Central Iran plate. The northwest-southeast trending of Qom-Zefreh Fault system has long been recognized as major faults in Central Iran. The general aim of this research is to identify the activity period of this fault and the extent of its effects on stratigraphy. For this purpose, we used the stratigraphical evidences on the geological maps and the stratigraphic columns which can help to determine the history of this fault system where caused regression and transgression during the geological time. The results indicate that oblique motion of Arabia with respect to Eurasia is partitioned in the Qom-Zefreh Fault system. Therefore, the southeast segments (the Kashan and the Zefreh faults) activity has been started from the Upper Cretaceous. However the northwest segments (the Qom and the Ravand faults) activity may be considered from the Pliocene. Activity of the Qom Zefreh Fault system as one of the major inter-continental fault systems is younger than in northwest parts.

Keywords: Stratigraphical evidences, Qom-Zefreh Fault system, Central Iran, Upper Cretaceous, Pliocene.

1- Introduction

The Iran plateau is bounded on the North by the Alborz and Koppeh Dagh deformed zones and on the South by the Zagros fold-and-thrust belt and the Makran accretionary wedge. It is a multiply convergent orogen between Arabian, Eurasian and Indian plates. The identification of movement mechanism of major faults in basement, extent and time of their activities are important effects for evaluation of paleogeography of the Iran plateau. One of the major fault systems in Iran parallel to the Zagros zone is the Qom-Zefreh Fault. It is one of basement faults in central Iran which is evaluated by general trend of northeast reactivated by convergent tectonic of the Neo-Tethys. In this research we have attempted to determine the extent of the Qom-Zefreh Fault effects on stratigraphy and facies changes. We used the geological maps and the stratigraphic columns for the purpose. It seems the sedimentology and stratigraphical evidences in conjunction with tectonic setting of the Qom-Zefreh Fault system can help to determine the history of this fault system.

2- Tectonics and geological setting of the Qom-Zefreh Fault system

Some of the Arabia-Eurasia convergence is accommodated in the Zagros Mountains (Walker and Jackson, 2002). The main feature of the Zagros Mountains is a linear, asymmetrical folding, which forms a 200-300 km wide series of ranges extending for about

1800 km from the northern tip of the Arabian plate through Iraq and the southwestern part of Iran as far as the Strait of Hormoz (Berberian, 1995). The Zagros fold-and-thrust belt consists of four parallel tectonic zones from the southwest to northeast As illustrated in (Figure 1) as follows: (1) the Mesopotamian-Persian Gulf foreland basin, (2) the Zagros fold-and thrust, (3) the Sanandaj-Sirjan zone and (4) the Urumieh-Dokhtar Magmatic Arc (Alavi, 1994). The Sanandaj-Sirjan zone is a metamorphic belt that was uplifted during the Late Cretaceous continental collision under dextral transpression.

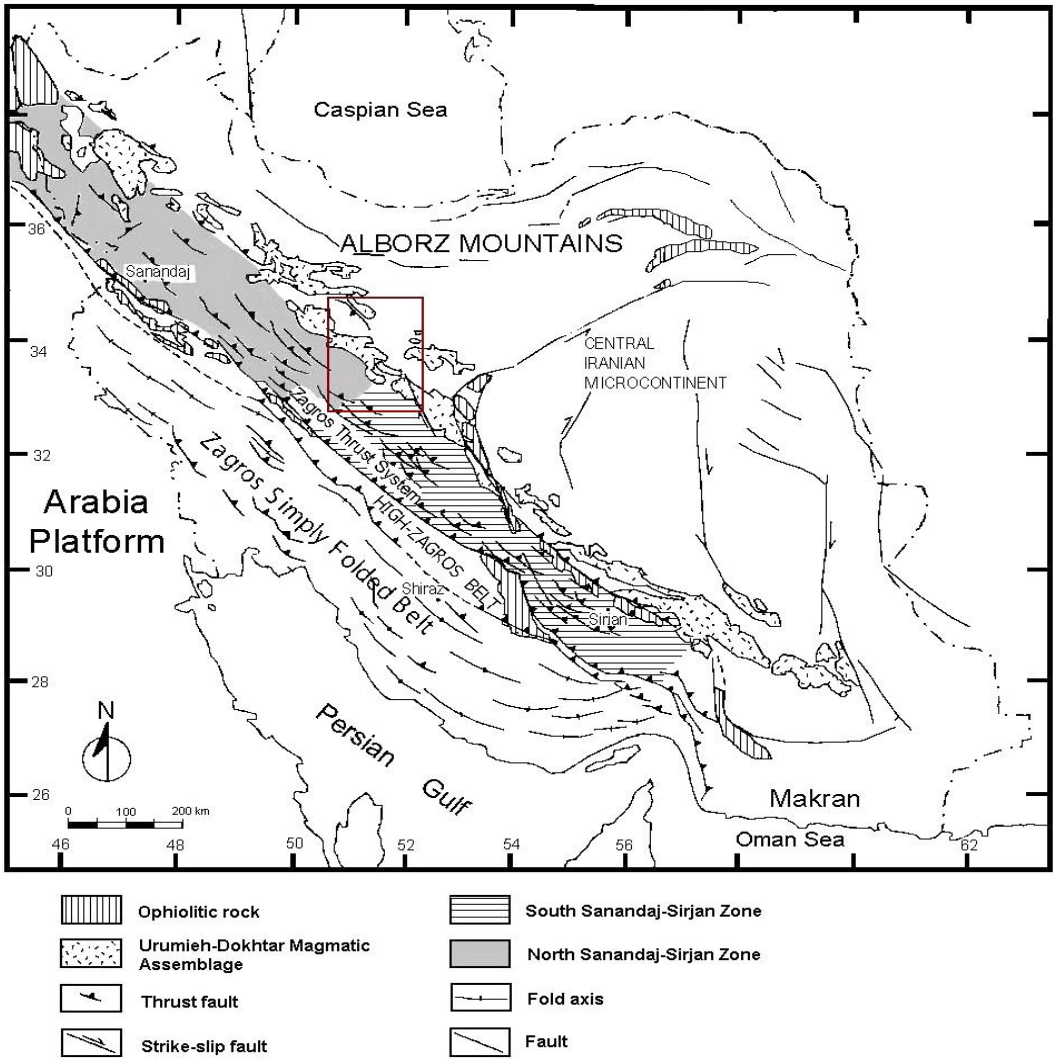

Figure 1) The geological and tectonic map of Iran with the location of study area (modified after Mehdizadeh, 2007).

The Urumieh-Dokhtar magmatic zone may be considered as an active axis from volcanic point of view in late Cretaceous and Eocene and from aspect of plutonism in Oligocene and Miocene. This zone 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 (Alavi, 1994). The Qom-Zefreh Fault system is recognized as one of these faults that covers an area from southeastern Qom to Zefreh 60 km northeastern Isfahan (Safaei *et al*., 2008). Pressional areas of two northeast and southwestern terminations 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 (Mehdizadeh, 2007).

3- Geometry of the Qom-Zefreh Fault system

Berberian (1976) is supposed that the Qom-Zefreh Fault system with a length of over 250 km extends from highlands of the south of the Qom to highlands of the Zefreh village in 60 km NE of Isfahan. Geometric analysis of structures related to Qom-Zefreh Fault system and their kinematics reflects a dextral strike-slip displacement with small reveres component in some parts of Qom-Zefreh Fault system (Poroohan *et al*., 2009). Such proposed situation for the Qom-Zefreh Fault system includes a few sharp curvatures and on the basis of these curvatures at least four segments can be considered for this fault (Fig. 2). The Qom Fault is the first segment of the Qom-Zefreh Fault system, which its general trend is 130º and it has about 60 km length and crosses 5 km in south of the Qom. The second segment is Ravand Fault, which has a general trend of 160º-170º and a length of about 50 km.

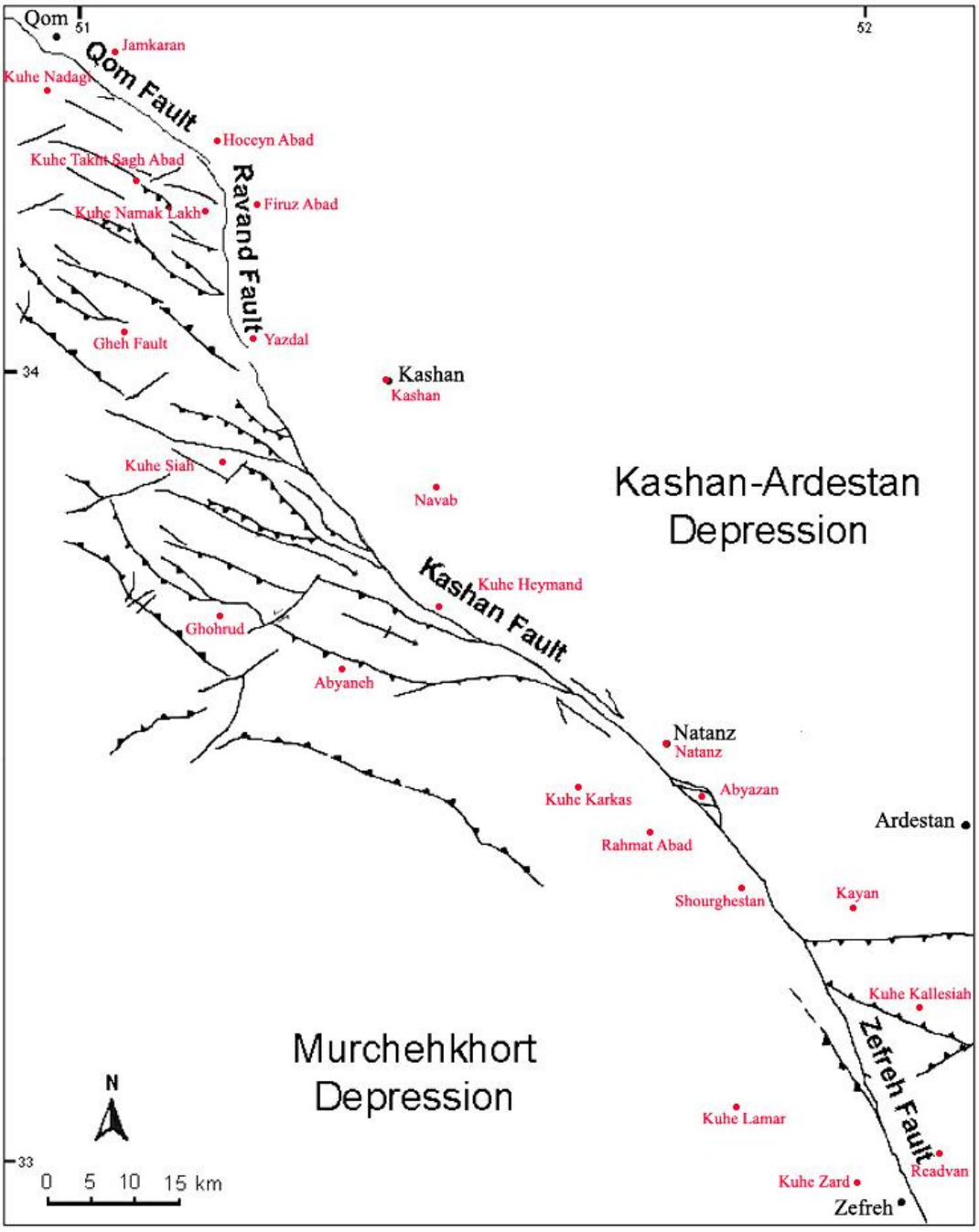

Figure 2) Geometry and segments of Qom–Zefreh Fault system (Red circle shows studied points-prepared by Mehdizadeh, 2007).

The Kashan Fault is the third segment of the Qom-Zefreh Fault system, which has a general trend of 140º and a length of about 60 km. the forth segment is the Zefreh Fault, which is about 80 km long and its trend is 170º. The Qom-Zefreh Fault system includes a number of important branches, which have the same situations. The branched faults include dextral components. On the basis of structural correlation of branched faults with the Qom-Zefreh Fault system, it can be concluded that they have simultaneously started their activities with this fault. Most measured faults with general trend of 135º have thrust mechanism with dextral component and their average dips are 50º-60º southwest. However, the dip direction of some faults is southeast. Faults with N-S trend, dextral component and sometimes normal mechanism are observed. Faults with east-west trend often include thrust mechanism with dextral component (Fig. 2). The dip direction of some of these faults is either toward south or north for some other faults (Safaei *et al*., 2008).

4- Seismic evidences of the Qom-Zefreh Fault system activity

The Qom-Zefreh Fault system is one of the major and active faults in the west of Central Iran, which a number of historical and instrumental events have been recorded in its direction. These earthquakes are less than around areas in particular the Zagros, but their magnitudes are usually more intense. Historical earthquakes have been recognized on and around of this fault that dated on 1577, 1775, 1778, 1890 and 1895 with magnitudes 5.5, 5.0, 6.2, 5.3 and unknown magnitude, respectively. As above stated, using changes in fault geomorphology and fault trace orientation we have defined four segments in this fault system, namely Zefreh, Kashan, Ravand and Qom segments. The recognition of these segments is important because it may have implication in assessment of seismic hazard for the Kashan region. Although it is hard to make a good correlation between fault activity and historical earthquakes in region, the segments in particular Ravand and Kashan segments show clear geomorphic evidence for repeated surface faulting events (Hessami *et al*., 2007). The investigations of Hessami *et al*., (2007), Jamali *et al*. (2010) and Allen *et al*., (2011) show the thrust faults and active folds in the study region manifest themselves in the geomorphology. The stream patterns indicate deflection of streams toward the northwest and the southeast by the growing fold. Also, deep incision of rivers which crosses active anticlines also indicates uplift at depth on thrust faults beneath the anticlines. The active blind faults which leave clear signatures in geomorphology should be seriously considered as a seismic source while assessing seismic hazard in the region.

5- Stratigraphical evidences of the Qom-Zefreh Fault system activity

The Figure 3 shows the geological map of the study area. Upper Triassic-Jurassic and Cretaceous sequences are mainly continental, clastic sediments, limestone and marl, respectively. Paleocene-Eocene sequence is conglomerates, limestones, volcanic rocks and tuffaceous sediments. Neogene and Miocene are sequence mainly red beds of Neogene (Oligo-Miocene), shallow marine the Qom formation (Oligocene). In the study area, in addition to Eocene volcanic rocks, there are also younger volcanic rocks of Oligocene and Miocene age. Eocene volcanic rocks as pyroclastic accompanying lava and interbeds of tuffite, sandstone, shale and nummulitic limestone are overlained disconformably on Cretaceous limestone. It may be argued that this disconformity is due to activity of equivalent phase of Laramide (Safaei *et al*., 2008). This event, occurring in Late Cretaceous–Eocene, played a great role in the geological evolution of Iran. It started under a compressional regime, followed by an extension one. The

compressional regime, that was associated with significant intrusive magmatic activities, led to the closure of the oceanic basins and Neotethyan rifts. In some areas, slices of the oceanic crust have obducted onto the continental margins producing what we now call ophiolite assemblages or colored mélanges. Due to activity of equivalent phase of Pirenean, the Oligo–Miocene limestones (The Qom Formation) are overlain disconformably on Eocene units. As it is seen from evidences, this tectonic event is a full energetic compressional event that its symptoms are classified as follows:

- Sedimentary conditions change (Facial) and sedimentary disconformities and folding.

- Most basins are in continental condition.

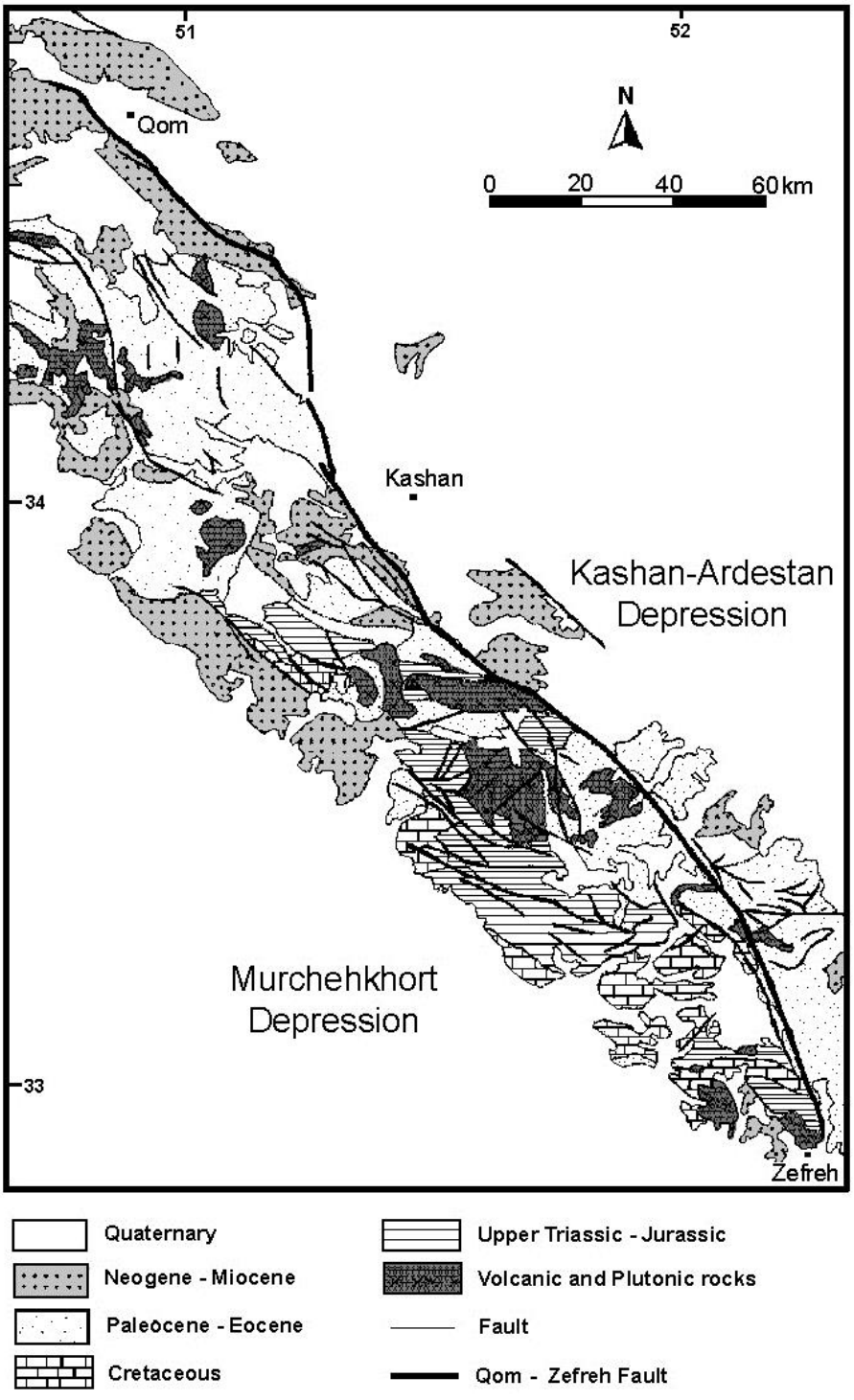

Figure 3) The map geological map of the study area (prepared by Mehdizadeh, 2007).

Also, the effect of equivalent orogenic phase of Pasadenian is a low degree angular disconformity between formations of Pliocene (Upper–Red formation) and Plioctocene (equivalent conglomerate of Baktiari Formation). This phase is related to Iran in Zagros zone and Central Iran from obvious Tertiary tectonic phases. In this event, magmatism is very serious and they can be followed in many points in Iran such as Urumieh-Dokhtar zone (Ghorbani, 2002). The Qom-Zefreh Fault system has affected Mesozoic and Cenozoic Formations. Therefore, the beginning time of activity of this fault and its effect on sedimentary basins, in particular the Kashan and the Zefreh Fault may be considered from the Upper Cretaceous.

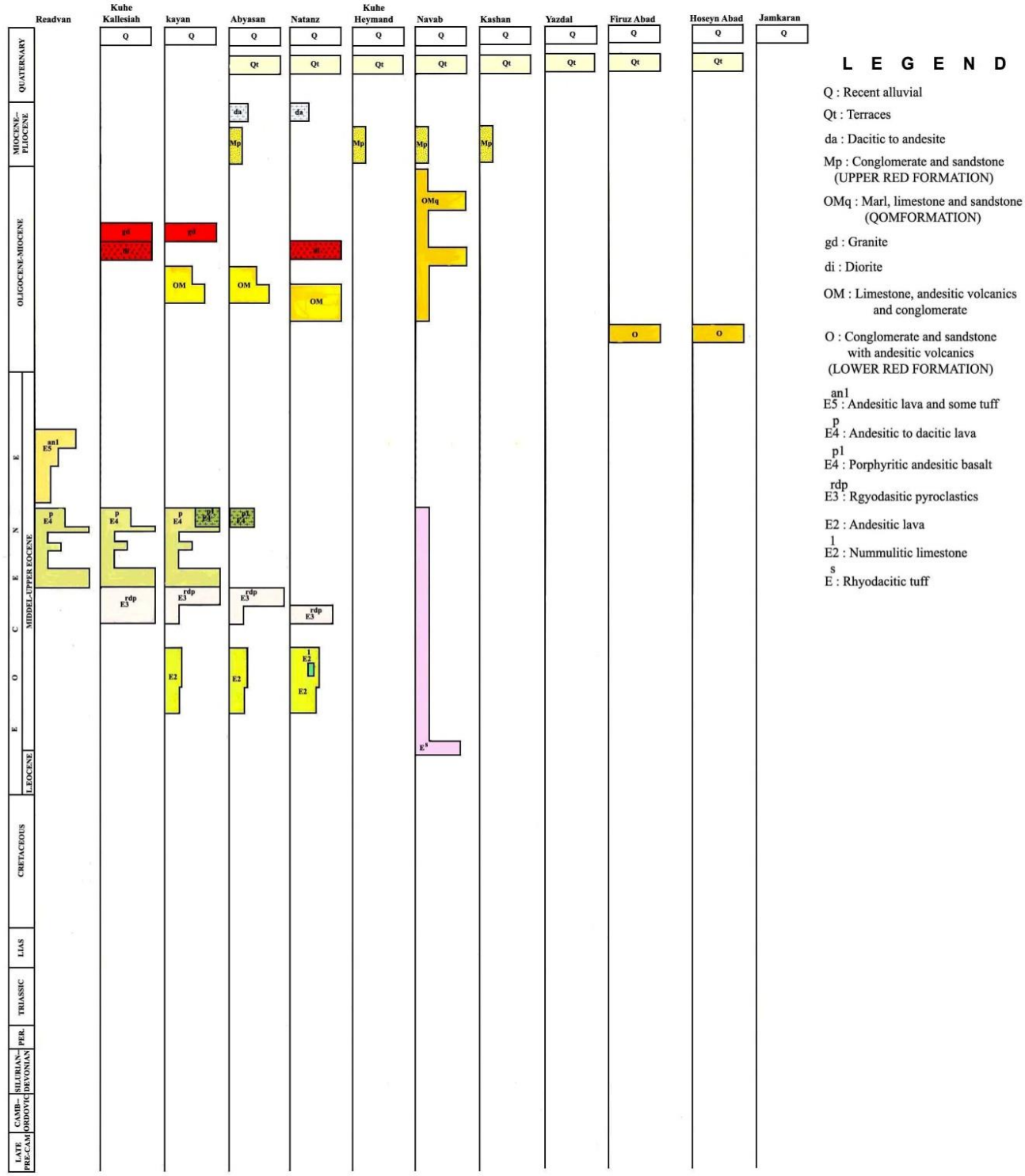

Fig 4) The stratigraphic columns in the stations of the east flank of the Qom-Zefreh Fault system.

As can be seen from the geological maps and the stratigraphic columns in the west flank of this fault (e.g. Kuhe Zard, Kuhe Lamar, Shourghestan, Rahmat Abad, Kuhe Karkas, Abyaneh, Ghohrud stations) (Figs. 2 and 4), there is the Upper Cretaceous sequence, while these limestones do not see in the east flank of this fault (e.g. Readvan, Kuhe Kallesiah, Kayan, Abyazan, Natanz, Kuhe Heymand, Navab stations) (Figs. 2 and 4).

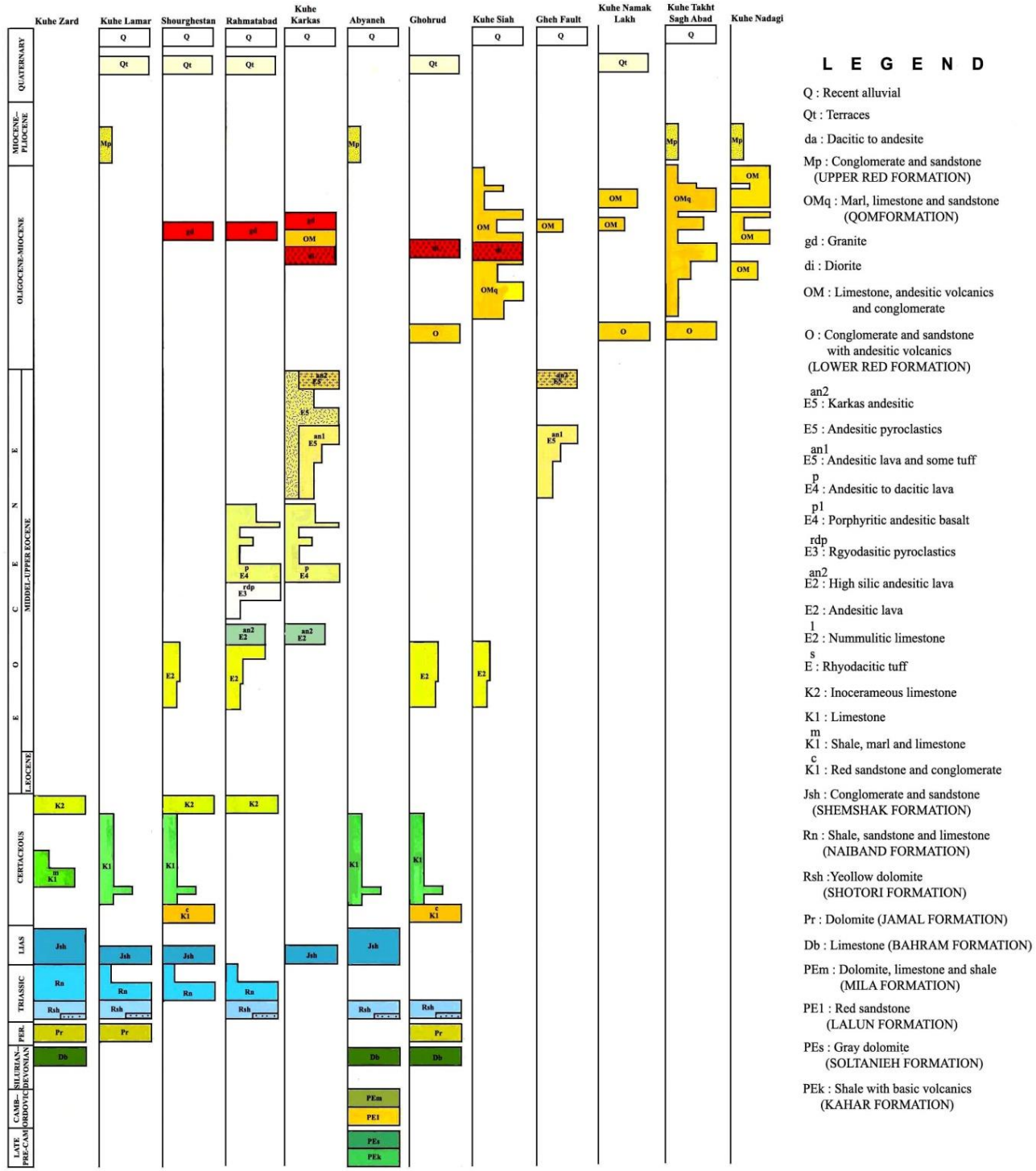

Figure 5) The stratigraphic columns in the stations of the west flank of the Qom-Zefreh Fault system.

Several faults have affected the western flank of this fault. Field studies (Safaei *et al*., 2008) over the sequences in this flank are as Upper and Lower Cretaceous carbonates, Jurassic shale and sandstone (Shemshak Formation) and Triassic clastics (Naiband Formation). Due to intense faults activities in the study area, extensive displacements of formation sequences

are observed. The important point is the lack of distribution of the Upper Cretaceous units. On the other hand, the Kashan Fault has a component of right lateral slip associated with a thrust that puts Eocene volcanic rocks of the Urumieh-Dokhtar zone against Quaternary alluvial clastics to the northeast. Also, the Zefreh Fault is a sharply defined, linear, right-lateral strike-slip fault (Allen *et al*., 2011).

But in the study area, the Ravand Fault in particular, due to the dextral strike-slip movement of the Qom and Kashan Faults in Eocene made an extension area between them. The extension and opening in this area caused intrusion volcanic materials. The Ravand and Qom faults do not have any clear activity until Pliocene and after that this fault acted as independent, and displaced the stratigraphic sequences. Also, as can be seen from the geological maps and the stratigraphic columns in the east flank (e.g. Kashan, Yazdal, Firuz Abad, Hosein Abad, Jamkaran stations) (Figs. 2 and 5) and west flank (e.g. Kuhe Siah, Gheh Fault, Kuhe Namak Lakh, Kuhe Takht Sagh Abad, Kuhe Nardagi stations) (Figs. 2 and 5) of these faults, they have affected Cenozoic formations. Therefore, the beginning time of activity of these faults and their effect on sedimentary basins may be considered from the Pliocene. Poroohan *et al*. (2009) suggested that the Ravand Fault may be as a young and independent Fault than the Qom and Kashan Faults. The Ravand Fault offsets Oligo-Miocene strata right-laterally by ~4 km, close to a point where the range front turns back to a northwest-southeast trend, and Eocene volcanics and Oligo-Miocene strata are thrust to the northeast (Morley *et al*., 2009). The anticlines deform the strata within the basin to the north (Morley *et al*., 2009). Tertiary strata, including Upper Miocene marls, are tightly folded and thrust west of Qom city. Conglomeratic strata mapped as Pliocene lie unconformably above the folds, although they are in places also tilted. Several NNW-SSE right-lateral faults cut across these folds and thrusts. The Qom Fault is ~10 km long and offsets folded strata by ~5 km. The restoration is necessarily approximate because the fold geometry does not match up simply across the fault; fold vergence and thrust dip direction reverse across the strike-slip faults, perhaps indicating that folding/thrusting and strike-slip faulting were at least in part synchronous. Smaller, parallel right lateral faults occur for up to 10 km further west, with right-lateral offsets up to ~500 m (Allen *et al*., 2011).

6- Conclusions

The stratigraphical studies and movement evidences of the Qom-Zefreh Fault system shows in this Fault system there are two structural trends, NW-SE (Qom and Kashan Faults) NNW-SSE (Ravand and Zefreh Faults). This confirms that there are various structural trends from Urumiyeh-Dokhtar magmatic zone toward middle parts of the Central Iran zone. It is probably due to the affected stress and the reflection of brittle behavior of the Central Iranian crystalline basement that has produced faulted and rotated blocks with different forms and dimensions as well as the complexity of the morphostructures.

Also, stratigraphy of the Qom-Zefreh Fault system from Late Precambrian to Quaternary affected by orogenic phases (e.g. Laramide, Pyrenean and Pasadenian) that played a significant role in the geologic history of this fault system. Such that, activity of the Qom-Zefreh Fault system as one of the major inter-continental fault systems is younger than in northwest parts. In fact, the Kashan and the Zefreh Faults activity has been started from the Upper Cretaceous. But the Qom and the Ravand Faults activity may be considered from the Pliocene. It is suggested that the Qom-Zefreh Fault system is located in the central Iran zone and correlated with its tectonic environment.

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