The movement potential evaluation of the major Quaternary faults in Tehran Quadrangle

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Abstract

Introduction: Seismicity is closely related to active Quaternary faults. As a new parameter, FMP is defined to quantify earthquake risk along active faults. The landforms in Tehran quadrangle are mainly controlled by two sets of Quaternary faults, striking northwest-southeast and east-west. The questions are: what are the activity levels of these faults? And will these faults cause destructive earthquakes?

Aim: The present study evaluated the movement potential of the major Quaternary faults in Tehran Quadrangle.

Materials and Methods: A new method is used to evaluate fault activity by considering the mechanical relationships between fault geometry and regional tectonic stress field. This method has been used to evaluate the fault movement potentials of all the major Quaternary faults in Tehran quadrangle.

Result: The fault movement potential of the northwest striking fault set ranges from low to high, suggesting that some fault sets have the sufficient potential for generating destructive earthquakes, except the Telo-e-paeen fault, Kuh-e-Sorkh fault and Bayejan fault. The fault movement potential of the east-west striking fault set like North of Tehran fault is medium, suggesting that this fault set has not the sufficient potential for generating destructive earthquakes.

Conclusions: According to this research, the contemporary movements potential along fault zones of various orientations are different under the action of present-day regional north – northeast compressive stress field in studied region. The Mosha fault zone, Niavaran fault, Pishva fault zone, Nava fault, EmamZadeh Davood fault and Pourkan-Vardij fault have high FMP (0.9 or 90%) and the Kuh-e-Sorkh fault zone has very low FMP (0.0 – 0.5).

Keywords **:**Quaternary Faults, Alborz , Tehran , Movement potential **,** Tectonic stress

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Introduction

Seismicity is closely related to active Quaternary faults. This attracts many researchers to investigate the quantitative relationships between them. As a new parameter, FMP is defined to quantify earthquake risk along active faults byLee et al.[1] Therefore, we use it for evaluation of earthquake risk in Tehran quadrangle.

The landforms in this area are mainly controlled by two sets of Quaternary faults, striking northwest-southeast and east-west (Fig. 1) The questions to be addressed in this paper are: (1) what are the activity levels of these faults? And (2) will these faults cause destructive earthquakes? Previous work regarding these topics was mainly based on seismotectonic analyses. [2] In this paper, we use a new method (1) to evaluate fault activity by considering the mechanical relationships between fault geometry and regional tectonic stress field. This method has been used to evaluate the fault movement potentials of all the major Quaternary faults in Tehran quadrangle.

The major Quaternary faults in Tehran quadrangle

Quaternary faults are well developed in Tehran. The faults in the studied area were classified into two sets based on their strikes:

1) northwest-southeast [3- 6] and 2) east-west. [7- 9]

The east-west fault set can be subdivided into two major faults: North Tehran thrust and Kahrizak fault zone. All of the other major faults belong to the northwest-southeast fault set (table 1).

The dominant fault mechanism is thrusting, but some significant faults like Mosha fault system and Nava fault have left-lateral strike slip component. [10] The dip angles are very variable and change between 20 to 80 degree (table 1).

In summary, most of these fault zones are active in current tectonic regime (CTR) and characterized by microseismic events and geomorphic indices (Fig. 2) because most of them formed mountain front faults system in the southern flank of the Alborz belt, except Mosha fault system, Nava fault and Bayejan fault.

In the following sections, we will evaluate the earthquake risk along these faults, and discuss which fault is most favored to move under the influence of present-day tectonic stress field. We make this evaluation based on the relationships between tectonic stress orientation and fault geometric properties. [1]

Theoretical model for analysis of fault movement potential

The fault movement potential (FMP) is closely related to tectonic stress (σ), fault plane geometry (G) and the physical property of the medium within and on both sides of the fault (P). FMP is the function of these factors [1]:

$$\mathrm{FMP} = f(\sigma, G, P) \qquad (1)$$

Although a geological medium is generally heterogeneous and very complicated, however it can be taken as homogeneous and isotropic in statistical view of our case. This region is the border zone of Alborz – Central Iran structural zones and thus, geological concepts and tectonic settings are similar along it. Based on this consideration, and for the purpose of simplification in the theoretical derivation, Lee et al. also take the geological medium containing the faults as a homogeneous, isotropic and elastic material. Therefore fault movement potential can be simplified as:

$$\mathrm{FMP} = f(\sigma, G) \qquad (2)$$

Finally, according to some researches, [11,12] Lee et al. define FMP to quantify the relationship between fault movement potential as a normalized factor by the following equations:

$$FMP = \begin{cases} 0 & \theta \in (0°,30°) \\ \dfrac{\theta - 60°}{30°} & \theta \in (30°,60°) \\ 1 - \dfrac{\theta - 60°}{30°} & \theta \in (60°,90°) \end{cases} \qquad (3)$$

θ is the angle between the regional maximum principal compressive stress orientation (σ_1) and the normal line of fault plane.

Regional tectonic stress orientations

Tectonic stress means an additional stress to lithostatic stress state, in the other words, the part of stress deviated from lithostatic stress. Earthquake focal mechanism solution is one of the commonly used methods in the study of contemporary tectonic stress field.

Therefore, we use results of some researchers [13, 14] and our field study to estimate the regional maximum principal compressive stress orientation (σ_1). The statistical result shows that the average attitude of σ_1 is 15º, 40º.

Fault movement potential results and their analysis

The fault movement potential of the major Quaternary faults in Tehran quadrangle are calculated using the equations (3) and the regional stress orientation as well as the fault plane attitudes (Fig. 3. The results are shown in table 1.

Table 1: The calculation of fault movement potential in Tehran Quadrangle

Name of fault zone	No.	Dominant Attitude of fault (Dip Dir.)	Normal line of fault plane	θ	FMP
Mosha	1	323,55	35,143	88	0.1
Mosha	2	333,20	70,153	83	0.2
Mosha	3	015,60	30,195	51	0.7
Mosha	4	020,50	40,200	58	0.9
Mosha	5	025,50	40,205	57	0.9
Mosha	6	010,65	25,190	50	0.7
North of Tehran	7	055,30	60,235	76	0.7
North of Tehran	8	342,47	43,162	79	0.5
North of Tehran	9	350,35	55,170	82	0.3
North of Tehran	10	335,60	30,155	77	0.4
North of Tehran	11	330,75	15,150	75	0.5
North of Tehran	12	000,45	45,180	70	0.7
North of Tehran	13	000,40	50,180	74	0.5
North of Tehran	14	040,30	60,220	75	0.5
North of Tehran	15	350,40	50,170	78	0.4

Comtinue table 1

Kahrizak	16	342,68	22,162	68	0.7
Parchin	17	000,50	40,180	66	0.8
Parchin	18	020,35	55,200	72	0.6
Niavaran	19	345,70	20,165	64	0.9
Pishva	20	035,65	25,215	40	0.3
Pishva	21	057,50	40,237	57	0.9
Pishva	22	057,58	32,237	50	0.7
Kuh-e-Sorkh	23	030,80	10,210	27	0.0
Kuh-e-Sorkh	24	036,30	60,216	75	0.5
Telo-e-Paeen	25	050,35	55,230	71	0.6
Bayejan	26	002,40	50,182	73	0.6
Bayejan	27	010,35	55,190	74	0.5
Nava	28	010,55	35,190	58	0.9
Nava	29	005,60	30,185	56	0.9
Daryacheye Sahoon	30	000,70	20,180	53	0.7
Daryacheye Sahoon	31	030,50	40,210	56	0.8
EmamZadeh Davood	32	035,55	35,215	50	0.7
EmamZadeh Davood	33	040,53	37,220	52	0.9
Pourkan-Vardij	34	025,50	40,205	57	0.9
Pourkan-Vardij	35	045,50	40,225	55	0.8

1. The northwest striking fault set have small to large angle between the normal to the fault planes and the compressive principal stress along these fault zones. The fault movement potential of this fault set ranges from low to high, suggesting that some fault sets have the sufficient potential for generating destructive earthquakes, except the Telo-e-paeen fault, Kuh-e-Sorkh fault and Bayejan fault. Although, the 1983 (mb=5.4) earthquake occurred at Bayejan fault and the 1979 (mb=4.6) and the 1993 (mb=4.6) earthquakes occurred at Kuh-e-Sorkh fault zone. [15]
2. The east-west striking fault set like North of Tehran fault (Fig. 4) have medium angle between the normal to the fault planes and the compressive principal stress along these fault zones. The fault movement potential of this fault set is medium, suggesting that this fault set has not the sufficient potential for generating destructive earthquakes.

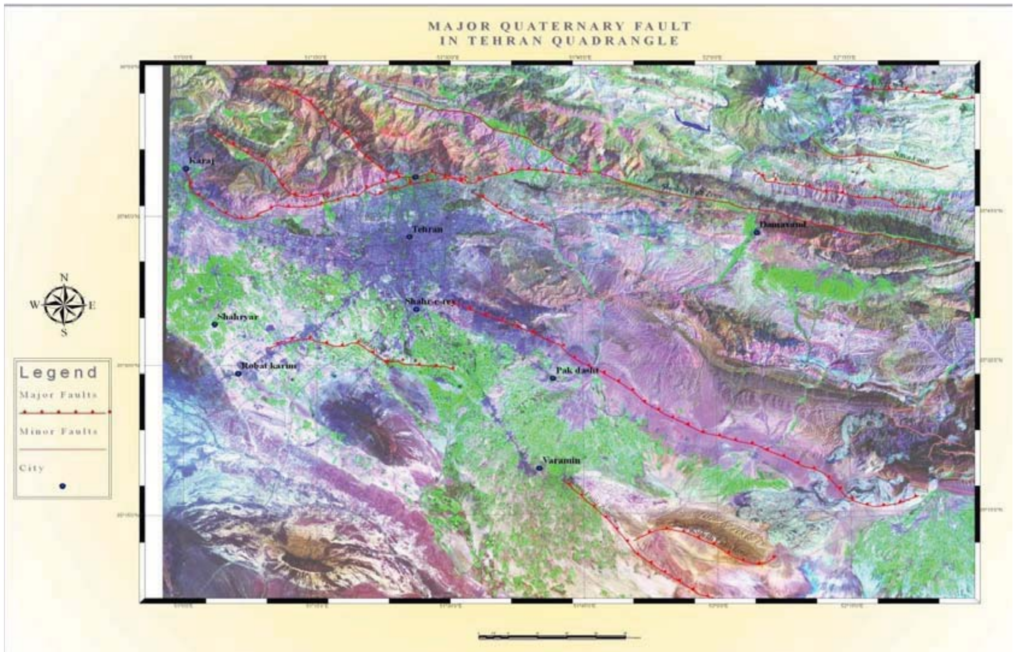

Figure 1- Major Quaternary Fault Movement Potential map in Tehran Quadrangle

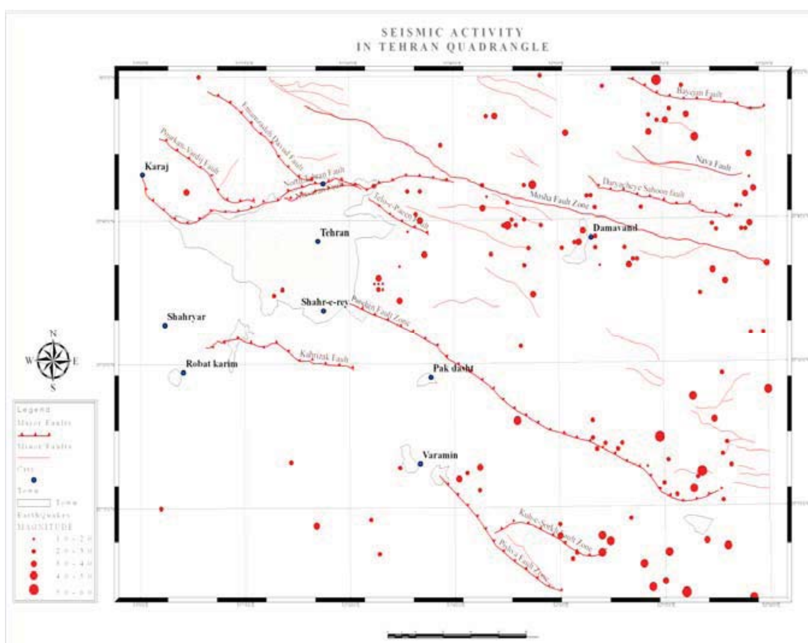

Figure 2-Seismic activity in Tehran Quadrangle

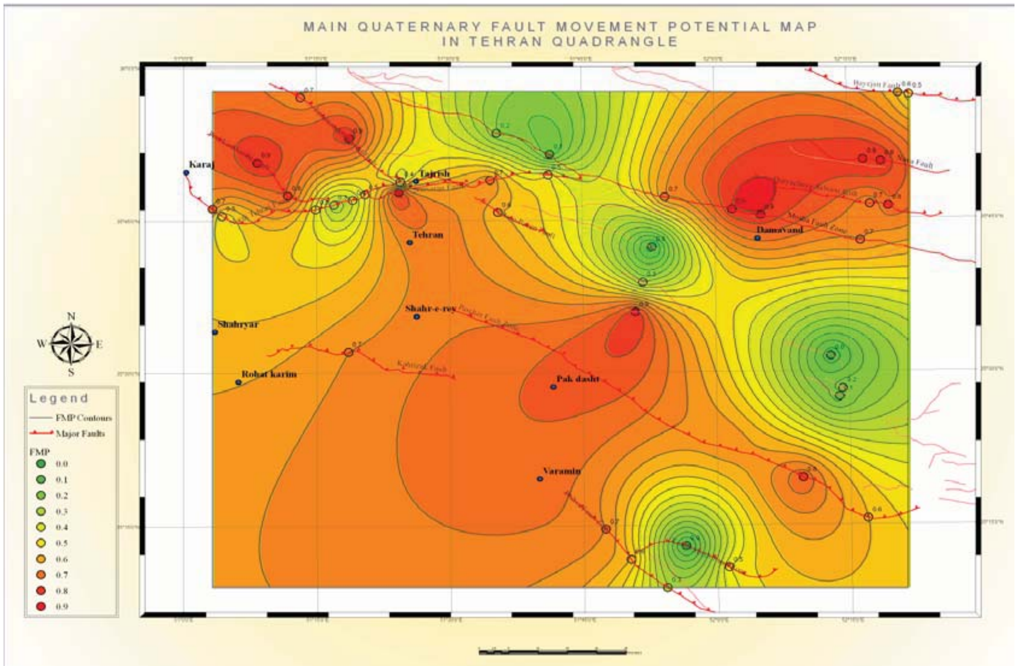

Figure 3- The fault scarp derived by Mosha fault system activity
near to Ardineh village (a view to the northeast)

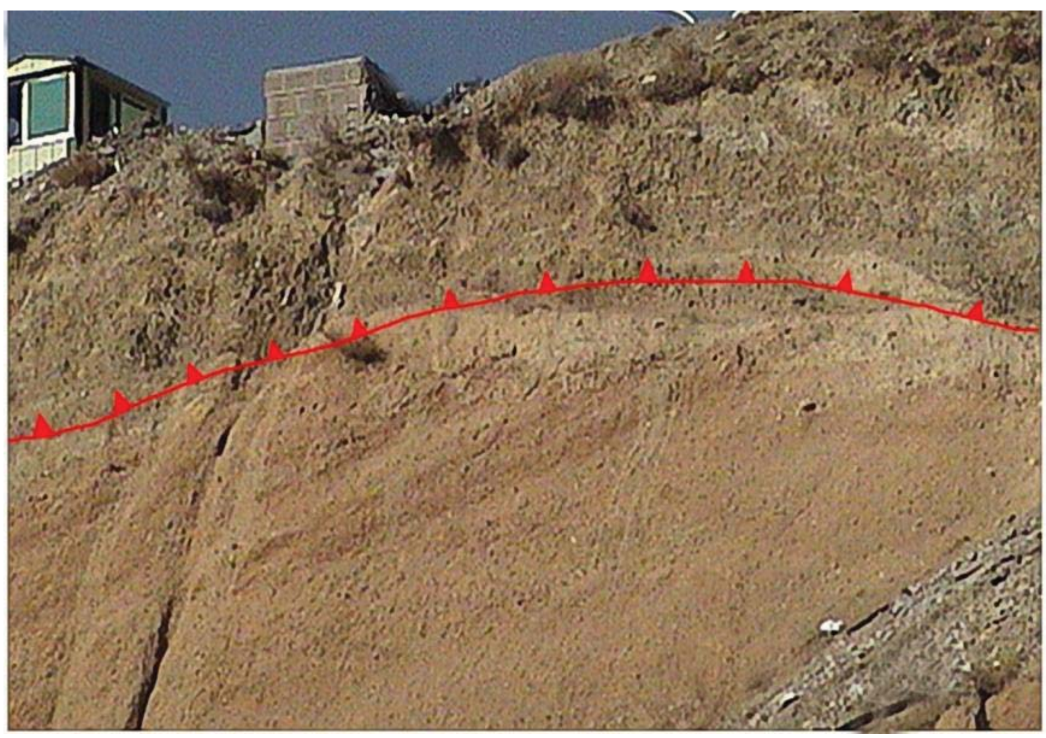

Figure 4: The North of Tehran fault outcrop in Hesarak
(a view to the north)

Figure 5: The fault scarp derived by Mosha fault system activity near to Ardineh village (a view to the northeast

Conclusions

According to this research, the contemporary movements potential along fault zones of various orientations are different under the action of present-day regional north – northeast compressive stress field in studied region. The Mosha fault zone (Fig. 5, Niavaran fault, Pishva fault zone, Nava fault, EmamZadeh Davood fault and Pourkan-Vardij fault have high FMP (0.9 or 90%) and the Kuh-e-Sorkh fault zone has very low FMP (0.0 – 0.5). Kuh-e-Sorkh fault zone and Bayejan fault are prone to big earthquakes; however both of these fault zones don't have high movement potentials.

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