ارزیابی توان حرکتی گسلهای کواترنری در منطقه مرزی البرز ــ ایران مرکزی، از خاور تهران تا خاور سمنان

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The Movement Potential Evaluation of the Major Quaternary Faults in Alborz-Central Iran Border Zone, from the East of Tehran to the East of Semnan

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چکیده

گسلهای کواترنری اصلی در منطقه مرزی البرز ـ ایران مرکزی را می‌توان به سه دسته با راستاهای چیره شمال خاوری، شمال باختری و خاوری ـ باختری تقسیم کرد. در این مقاله، از الگویی که توسط Lee et al.(1997) ارائه شده، برای ارزیابی توان حرکتی این گسلها استفاده شده است. این الگوی نظری، مبتنی بر روابط بین ویژگیهای هندسی گسلها و میدان تنش زمین ساختی ناحیه‌ای است. نتایج نشان می‌دهند که به‌رغم نبود پیشینه لرزه‌خیزی قابل توجه، مناطق گسلی شمال سمنان و سرخه، دارای بیشترین توان حرکتی در منطقه مورد مطالعه هستند.

کلید واژه‌ها: گسلهای کواترنری ، البرز، ایران مرکزی، توان حرکتی، تنش زمین ساختی

Abstract

The major Quaternary faults in Alborz – Central Iran border zone can be classified based on their strikes into three sets: northeast, northwest and east – west. In this paper, we have used a model to evaluate their movement potential that presented by Lee et al. (1997). Their theoretical model is based on the relationship between fault geometrical characteristics and regional tectonic stress field. The results show that the north Semnan and the north Sorkheh fault zones are of the highest movement potential in the area, despite the lack of their seismic records.

Keywords: Quaternary Faults – Alborz – Central Iran – movement potential – tectonic stress

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 by Lee et al., (1997). Therefore, we use it to evaluate the of earthquake risk along Alborz-Central Iran border zone from the east of Tehran to the east of Semnan.

The landforms in this area are mainly controlled by three sets of Quaternary faults, striking northeast, northwest and east – west, respectively (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 works regarding these topics were mainly based on seismotectonic analyses (Berberian et al. 1993 & 1996). In this paper, a new method (Lee et al.,1997) is used to evaluate fault activity by considering the mechanical relationship between fault geometry and regional tectonic stress field. This method has been used to evaluate the fault movement potential of all the major Quaternary faults in Alborz – Central Iran border zone, from the east of Tehran to the east of Semnan. This research took about 3 months and all attitudes have been arranged by right hand rule.

The major Quaternary faults in Alborz – Central Iran border zone

Quaternary faults are well developed in Alborz – Central Iran borders zone from the east of Tehran to the east of Semnan. They were classified into three sets based on their strikes: northeast, northwest and east west.

The northeast striking fault set

The northeast striking fault set is the major paleogeographic fault set (Alavi Naini, 1972) in studied area. The faults in this set are multistaged active fault

inferred to have significant effects on the development of the southern foreland fold and thrust belt of Alborz Mountain. The fault set striking 053º - 072º with high dip angles, can be subdivided into three major faults: the north Sorkheh fault zone, the north Semnan fault zone and Attary fault zone.

The northwest striking fault set

This fault set comprises three fault zones striking 306º - 324º with high dip angles. Among them, the Parchin fault zone and Pishva fault zone are the major Quaternary fault zones. The Kuh-e-Sorkh fault zone is a minor Quaternary fault zone between the two major fault zones.

The east-west striking fault set

The faults of this set are well exposed and can be traced intermittently for a long distance (more than 55 km) in a nearly east – west trend. In this set, there are two major Quaternary fault zones, the Garmsar fault zone and the Sorkheh Kalut fault zone in the north of the Garmsar fault zone.

In summary, all of these fault zones are active in current tectonic regime (CTR) and characterized by microseismic events and geomorphic indices, because they formed mountain front faults system in the southern flank of the Alborz belt.

In the following sections, we will evaluate the earthquake risk along these faults, and it has been discussed that which fault is most favored to move under the influence of present-day tectonic stress field. This evaluation has been made based on the relationship between tectonic stress orientation and fault geometric properties proposed by Lee et al., (1997).

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 properties of the medium within and on both sides of the fault (P). FMP is the function of these factors (Lee et al., 1997):

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

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, thus geological concepts and tectonic settings are similar along it. Based on this consideration, and for the purpose of simplification in theoretical derivation, Lee et al., (1997) also take the geological medium containing the faults as a homogeneous, isotropic and elastic material. Therefore, fault movement potential can be simplified as:

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

Finally, according to Lokajicek et al., (1988) and He (1989) researches, Lee et al., (1997) 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 Jackson et al. (1995), Jackson et al. (2002), Allen et al. (2003) 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 10º, 207º.

Fault movement potential results and their analysis

The fault movement potential of the major Quaternary faults in Alborz – Central Iran border zone from the east of Tehran to the east of Semnan are calculated using the equations (3) and also the regional stress orientation as well as the fault plane attitudes. The results are shown in table 1.

1. The northeast striking fault set has 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 medium to high, suggesting that this fault set has the sufficient potential for generating destructive earthquakes, especially along the north Sorkheh (Fig. 2) and north Semnan fault zone (Fig. 3).

2. The northwest striking fault set has small to 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 ranges from low to medium, suggesting that this fault set has not the sufficient potential for generating destructive earthquakes,

except the middle part of Kuh-e-Sorkh fault zone.

3. The east-west striking fault set has 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. Although, the 1945 (mb=4.6), 1982(Ms = 5.4) and the 1988 (mb=5.5) earthquakes occurred at the intersection of the Garmsar fault zone with the southeast continuation of Parchin fault zone.

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 north Semnan and the north Sorkheh fault zones have high FMP (0.8 or 80%) and the Parchin fault zone has a very low FMP (0.0 – 0.1). The region, where the SE continuation of the northwest striking Parchin fault zone intersects the east – west striking Garmsar fault zone is prone to big earthquakes, however both of these fault zones don't have high movement potentials.

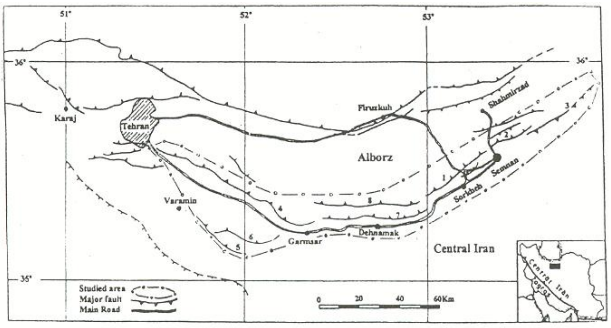

Figure 1- The major faults in Alborz – Central Iran border zone, from east of Tehran to east of Semnan. Note: 1. North Sorkheh fault zone, 2. North Semnan fault zone, 3. Attary fault zone, 4. Parchin fault zone, 5. Pishva fault zone, 6. Kuh-e- Sorkh fault zone, 7. Garmsar fault zone, 8. Sorkheh Kalut fault zone, modified from Berberian et al. (1996).

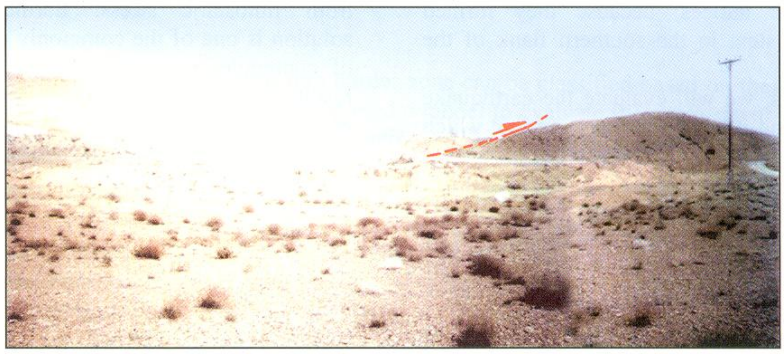

Figure 2- The north Sorkheh fault zone (a view to the east)

Figure 3- The north Semnan fault zone (a view to the west)

Table 1- Calculation of fault movement potential in Alborz – Central Iran border zone from the east of Tehran to the east of Semnan.

No. and name of fault zone	Dominant Attitude of fault	Normal line of fault plane	θ	FMP
1. North Sorkheh	053°,40°-48°NW	42°-50° , 143°	65°-66°	0.8
2. North Semnan	057°,40°-50°NW	40°-50° , 147°	64°-65°	0.8
3. Attary	060°,36°-55° SE	35°-54° , 330°	70°-78°	0.4 -0.6
4. Parchin	307°,49°-55°NE	35°-41° , 217°	28°-33°	0.0 -0.1
5. Pishva	324°,50°-58°NE	32°-40° , 237°	36°-40°	0.2 -0.3
6. Kuh-e- Sorkh	306°,30°-40°NE	50°-60° , 216°	40°-51°	0.3 -0.7
7. Garmsar	086°,40°-45°N	45°-50° , 176°	43°-48°	0.4 -0.6
8. Sorkheh kalut	088°,42°-47°N	43°-48° , 178°	42°-46°	0.4 -0.5

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