

Variation of Seismic a-value in Central Alborz Mountains, Iran

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Abstract — Central Alborz area is one of the quite sensitive places that there is probability of happening Earthquake in that. Preparing the seismicity maps, performing proper programs and making assure places in front of Earthquake are some of the ways for decreasing damages. For the prospering seismicity maps, we need some information include: basic information, like geological unites, faults, knowing about place and quantity of historical earthquakes. The object of this project is recognition and separation of different zones in central Alborz in the view of seismicity. So that, we used United States Geological Survey web site (USGS) for extraction seismic data, GIS 9.3 for statistical analyses of information layers and combination these and studying the different, effective factors on risk zoning. We calculated a-value and prepared the a-value zoning maps. The results of this study indicate that the central Alborz due to seismic values of a can be divided into three zones with different tectonic regimes of eastern, central and western divide.

Keyword — Central Alborz, Earthquake, GIS, Risk Zoning

1. INTRODUCTION

Earthquakes cause more damage in lees time among natural disasters, so that they are often associated with the social, economic and the political shocks. Therefore, seismicity evaluations of an area are very important in the worldwide.

Iran is a high seismicity region. Several destructive earthquakes have occurred in various parts of Iran in the past few decades such as Manjil-Rudbar ($M_s=7.3$, 1990) [3] and Bam ($M_w=6.5$, 2003) [6] earthquakes. Studies of seismicity of Iran were investigated by many Earth Scientist such as Nowroozi (1971, 1976), Berberian (1976, 1979), Shoji-Taheri and Naizi (1981), Nabavi (1977), Pourkermani and Asadi (1995), Tavakoli and Ghafory_Ashtiany [1], [11].

Ashtari *et al.* (2005) described that The Alborz ranges extend for a distance of 960 km across northern Iran with an average width of 100 km, separating the Caspian lowland from the Iranian Plateau and merging with the Kopeh Dagh toward the east [14]. Central Alborz is one of the most seismicity areas in Iran. Berberian and Yeats (2001) described the Alborz mountain range surrounding the south Caspian sea shows strong tectonic activity with several destructive earthquakes in the past [8].

There are many statical methods for seismicity study which one of them is Gutenberg-Richter law [5] that expresses the relationship between the magnitude and total number of earthquakes in any given region and time period of at least that magnitude.

$$\log N = a - bm \quad (1)$$

Where N is an incremental frequency of occurrence of earthquakes having a magnitude $\geq M$ and a-value and b-value are constants.

The object of this project is recognition and separation of different zones in central Alborz in the view of seismicity. So that, we used USGS for extraction seismic data, GIS 9.3 for statistical analyses of information layers and combination these and studying the different, effective factors on risk zoning. We prepared the specifications table of Earthquakes happened from 1973 to 2014 in Excel software. Then, we make needed layers in GIS and make grids in our studied area. Our gridding was including 32 squares. Finally, we calculated a-value by Gutenberg-Richter law and prepared the a-value zoning map.

2. ALBORZ SEISMOTECTONICS PROVINCE

Many Seismotectonics studies have been done in Iran [10], [2]. Berberian [2] divided Iran into four major structural-geological units (Fig. 1) separable on the basis of regional difference in structural-geological characteristics which are include: zagros active folded belt, central Iran, Kopeh Dagh ranges and Alborz Mountains (from Bandar Pahlavi to Gorgan)

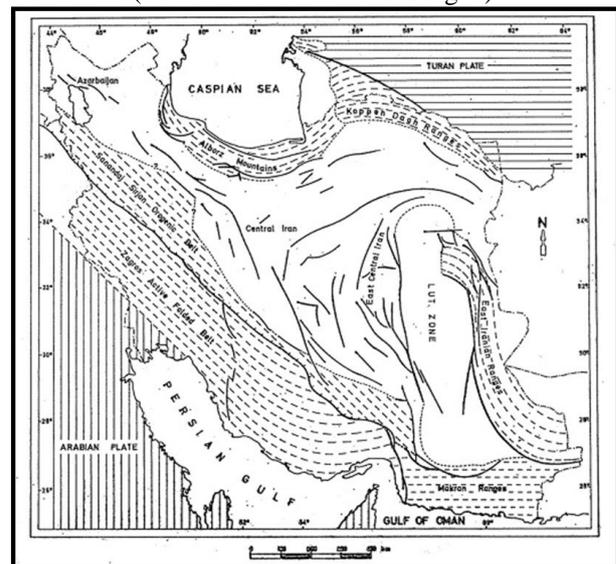


Fig. 1 Iranian main seismotectonics units [2]

The Alborz range constitutes a broad arch which forms the southern border of the vast depression of the Caspian Sea. The western part of the range shows structural axes trending NW-SE, roughly parallel to the northern part of the Zagros main thrust, to the Zanzan fault and to the structural alignments of the little and great Caucasus. On the other hand, the eastern part of the Alborz range is characterized by structural axes trending approximately NE-SW, parallel to the Great Kavir Fault (Central Iran). These two different structural trends just meet in the central Alborz range [9]. Average altitude of Alborz is variety from 3000 meter at interior belt to 28 meter at coastal line of south Caspian from open seas level [13]. Alborz range is shown on fig. 2 provided by Zamani and Agh-Atabai [14].

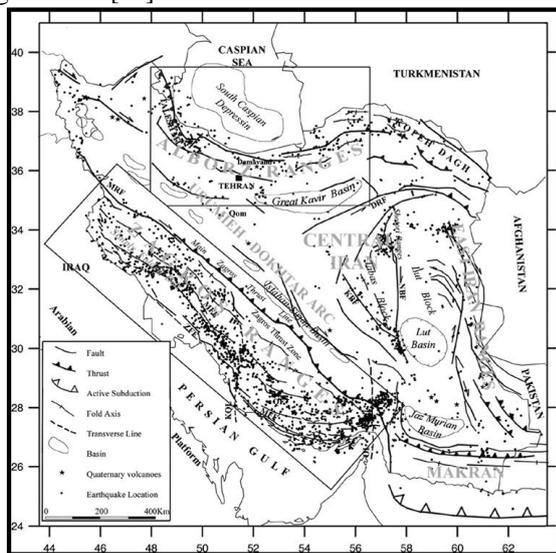


Fig. 2 Simplified Seismotectonics Map of Iran by Zamani and Agh-Atabai [14]

Stöcklin [10] divided the Alborz Mountains to six structural zones include: Gorgan spur, northern Neogen zone, north-central zone, south-central zone, southern tertiary zone and southern frontal uplift.

Tchalenko [12] subdivided the Alborz Mountains into seismotectonics provinces according to study the 20th century seismicity include: the northeastern Alborz, northwest Alborz, southeastern Alborz and southwestern Alborz province.

Many destructive historical earthquakes have been occurred at this area such as Buyin-Zahra and Manjil-Rudbar. Ambraseys (1968,1974) discussed the seismicity of north central Iran from 4th century B.C. to 1900A.D, and shown that with one exception the areas active during this period have also been seismically active since 1990 [2].

The region refereed in this study is situated between 48 to 58 east longitudes and 35 to 37 north latitudes. The detailed fault map of study area provided from Arial photos, satellite images and other done studies in this region [7], [8]. The Alborz fault map is given in Fig. 3.

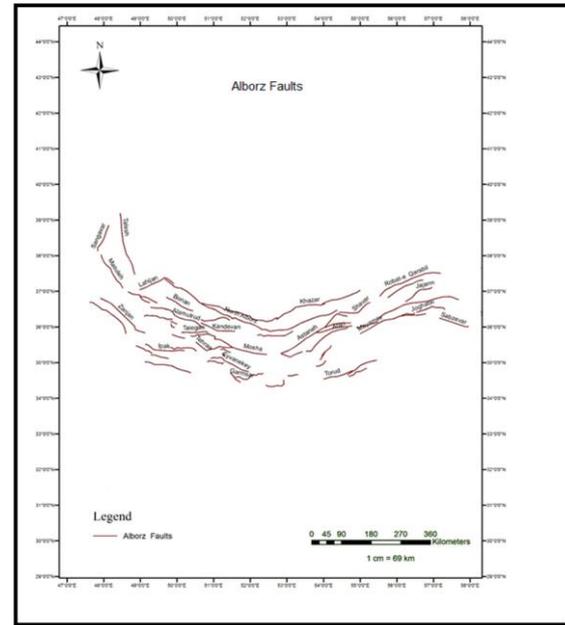


Fig. 3 Simplified Alborz Fault Map

3. METHODOLOGY AND RESULTS

Earthquake risk assessment is dependent to recorded data so that providing the catalog consist of historical and instrumental data is most important. In fact, it is first stage of seismicity in one region. We used USGS catalog [4] to create our suitable and reliable catalog for seismic studying. The instrumentally recorded earthquakes during 1900 to 2013 are presented. From 1900 to 1924, no recorded earthquake was reported for the region and from 1924 to 1973, our data have not continues so that we eliminate them to increase the study accuracy. Finally, the locally recorded earthquakes during 1973 to 2014 in magnitude ≥ 4 are analyzed and discussed. The summery of data is given at table1 and the year-frequency diagram of these earthquakes is given in Fig. 4. As can be seen in Fig. 4, the most abundant of occurred earthquakes in central Alborz is related to 1990, 2002 and 2004 years.

Table (1) seismic data of study area for earthquake with magnitude ≥ 4

Magnitude (Mb)	number
4-4.5	253
4.5-5	215
5-5.5	27
5.5-6	6
6-6.5	4

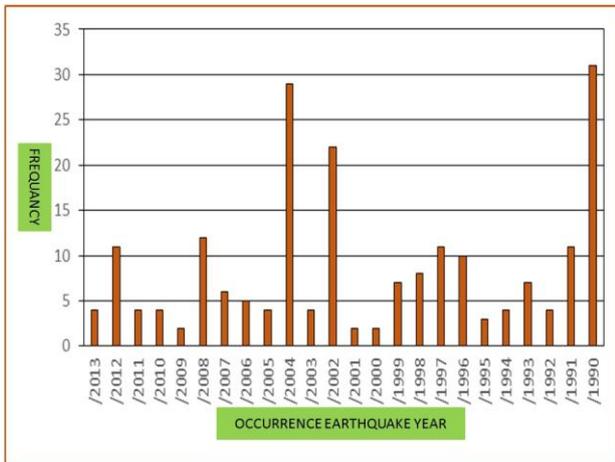


Fig. 4 year-frequency diagram for instrumentally recorded earthquakes in study area during 1990-2013, The horizontal axis shows the years and the vertical axis shows how frequency the earthquakes occurred

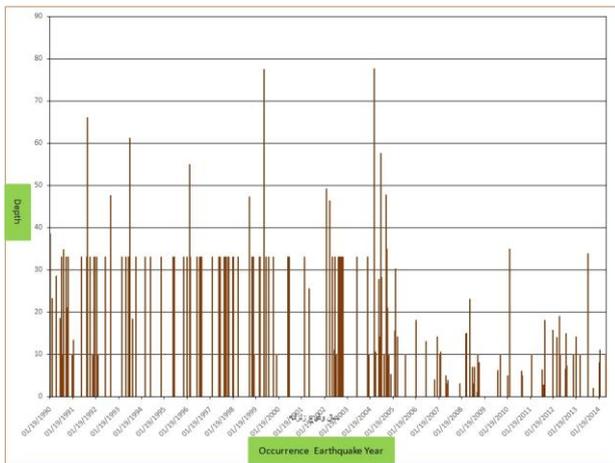


Fig. 5 year-depth diagram for instrumentally recorded earthquakes in study area during 1990-2014, the horizontal axis shows the years and the vertical axis shows the depth of occurred earthquake

Although the depth of earthquake data are not accuracy in Iran but they can be used in primary statistic analysis. Fig. 5 indicates year-depth diagram for instrumentally recorded earthquakes in study area. According to this diagram (Fig.5), maximum depth of earthquakes is related to earthquakes has been occurred in 1999 and 2004. Almost, more earthquakes of central Alborz have low to moderate depth from 1990 to now.

At the second stage, we divided the study area in to 32 squares with dimension of $2^{\circ} \times 2^{\circ}$ in Arc Map, which overlaps 1° with each other, to consider the details better (Fig. 6). Then a-value was calculated by Gutenberg-Richter method for each square (Fig.7). Obtained value of a-value extracts from diagrams and inters to Arc Map. Finally a-value contour and zoning maps of central Alborz were drawn for interpretation by 3D Analyst (Figs. 8 to 10).

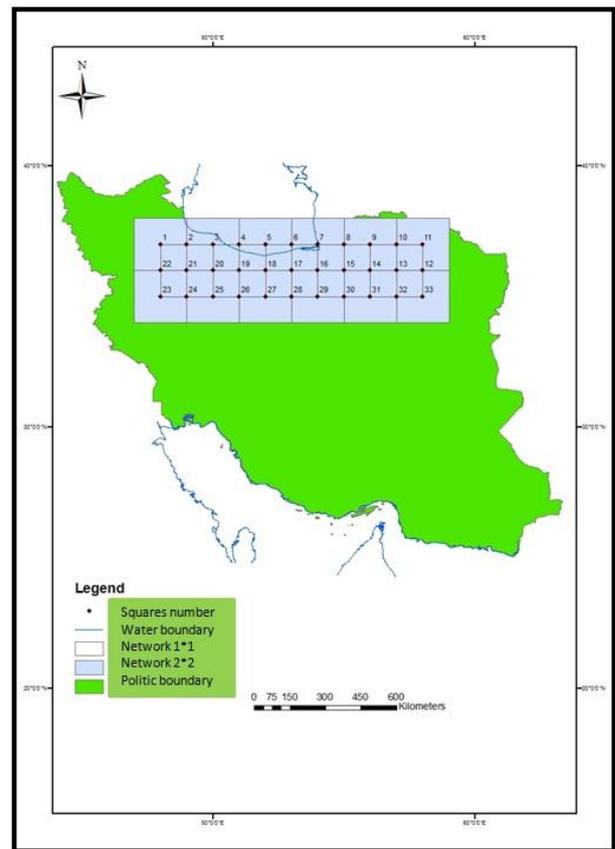


Fig. 6 gridding of study area, 32 square with dimension of $2^{\circ} \times 2^{\circ}$

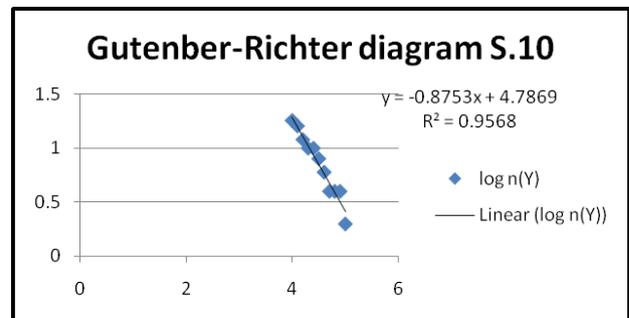


Fig. 7 Gutenberg-Richter diagram for square 10

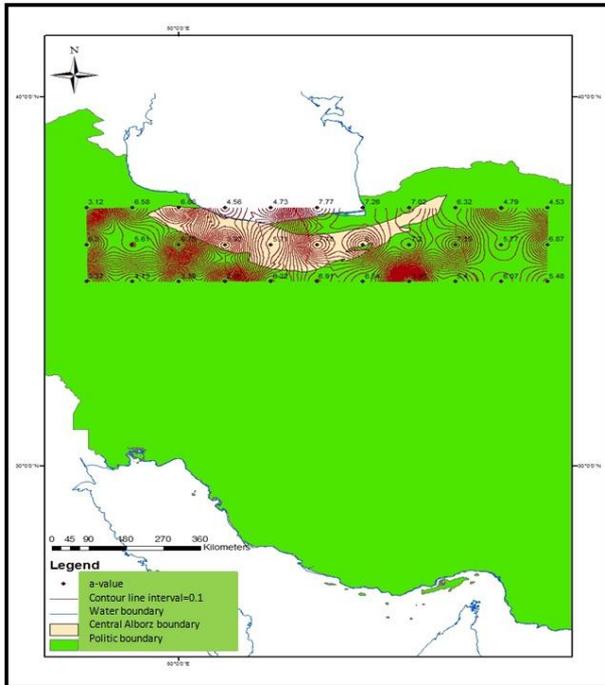


Fig. 8 a-value contour map of central Alborz, interval contour is considered 0.1

The a-value is one of the constants of Gutenberg-Richter law. This constant indicates number of earthquakes and their density. Density and magnitude has inverse relation which an increase in the value of a-value results in a decrease in the density. So that, the probability of big scale occurrences is less and the recurrence interval of earthquake is more (Fig. 7).

According to a-value contour map, we can divide central Alborz into three zones. Western and eastern zones have divergent contour lines but in central zone these line are convergent. This indicates that there is different tectonics regime in these zones. Values of a-value also are different in three zones which western, eastern and central zones have minimum, maximum and moderate value, respectively. More distance of contour lines means a-value gradient is uniform.

As mentioned above, if the distance between contours lines increase, the value of a-value and the tectonic activity decrease but the magnitude of occurred earthquakes increase. Fig. 9 indicates earthquakes with magnitude more than 6 on a-value contour maps which shows the earthquakes with more magnitude has been occurred in divergent contour with less value of a-value.

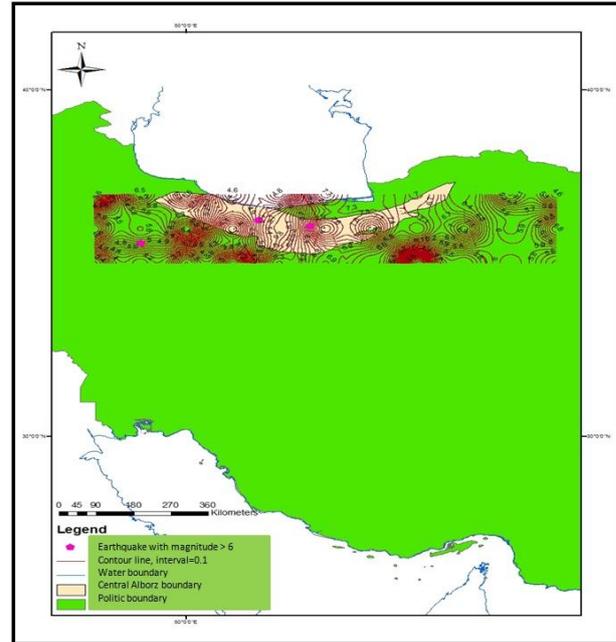


Fig. 9 earthquakes with magnitude more than 6 on a-value contour maps, interval contour is considered 0.1

Values of a-value are variety from 2.76 to 8. The a-value in western zone is less than other ones because of less tectonic activity. According to fig. 10, the magnitude of earthquakes reduces from west to east in central Alborz. Whereas numbers of them increase which this shows that seismicity in central zone is more than other zones.

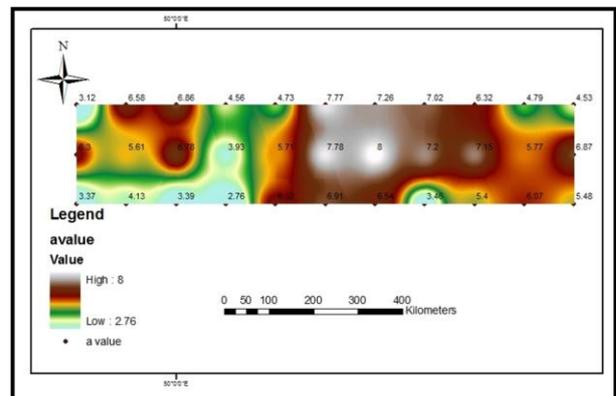


Fig. 10 a-value zoning map of central Alborz

4. CONCLUSION

Our results suggest that the central Alborz can be divided in to three zones based on changes of a-value parameter. These zones are western, central and eastern zone of central Alborz.

In the eastern zone, the contour lines are more divergent and a-value reduces. The number of earthquake is low and the most of earthquakes have intermediate depth.

In central zone, the contour lines are convergent and a-value increases. The number of earthquake is high but their depth is low. This zone has small fault segments.

In the western zone, the contour lines are less divergent so that the tectonic activity is less than eastern zone. But the magnitude of earthquakes is more. This zone has great fault segments.

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AUTHOR'S PROFILE



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