Spatial Analysis of A-Value and B-Value Variability in Alborz

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***Abstract*— This study was conducted to evaluate seismic hazard parameters (a-value and b-value of the Gutenberg–Richter) and Magnitude of completeness (M_c) in Alborz area. The b-value explains the relative density of small and large earthquakes which is a key issue in seismic hazard studies and a-value is concerned with regional seismicity level, so studying these parameters can be of great help particularly in mega cities with high rate of population. This study area is situated in Azerbaijan-Alborz seismotectonic province. For this assessment first, earthquake catalog and data have been collected from ISC, USGC and BHRC from 1990 to 2010. Magnitude of completeness has been estimated 3.5 so for the magnitude equal or bigger than 3.5 the catalog is complete. After processing data, eliminate aftershocks and fore shocks and homogenize the catalog. Spatial distributions of the estimated a-value and b-value in Iran have been obtained by dividing the area in small grids (0.5°x0.5°). The b-value in the study area is from 0.55 to 1 and a-value ranges from 3.4 to 4.1.**

Keywords-component; Seismicity parameters ; b-value; a-value; Spatial analysis

I. INTRODUCTION

Iranian plateau could be described by recent volcanic, active faults and high surface elevation along the Alpied earthquake belt. Tectonic studies show that the Iranian plateau has a very high density of active faults. Earthquake data of Iran indicate that most activity is concentrated in this region. Thus, this area is vulnerable to destructive earthquakes [1]. An effective seismic hazard map, which can facilitate new seismic designs is necessary particularly in high population zones [2] and on the other hand first step for making seismic hazard maps is calculation of earthquake parameters so earthquake parameters are essential factors of seismic hazard analysis [3]. Distribution of earthquakes in a period of time could express the seismicity of the area. One of the power-law relations commonly employed in seismicity studies is the frequency-magnitude earthquake distribution, which predicts the distribution of earthquakes with respect to magnitude:

$$\text{Log } N = a - bM \qquad (1)$$

In Eq. (1), M is magnitude, a and b are constants and N is number of earthquakes equal to or larger than M. The b-value in the most cases is close to unity for long time periods and large areas and shows relation of small and large earthquakes hence plays a key role in the seismic hazard study. Seismicity can be related as a scale to discuss the temporal and spatial earthquake activities in a region in different scales. One of the tools to provide such discussions is estimating the frequency-magnitude (Gutenberg-Richter) distribution [4] .In this study the seismicity parameters of the frequency-magnitude distribution have been estimated.

From the other point of view the a-value is concerned with regional seismicity level, so studying these parameters can be the first step for seismic hazard analysis [5].

High and low stresses cause earthquake series with low and high b-values respectively [6], [7], [8].

Some more researchers calculated seismic parameters for different seismic provinces in Iran [9],[1]. These studies calculated earthquake hazard parameters from historical and instrumental data. Nowroozi and Ahmadi (1999) divided Iran in different seismic zones which includes Alborz, Azarbaijan, Central-Iran, East-Iran, Kope-Dagh, Makran and Zagros[9]. Seismicity parameters have been computed for each zone. Our study area covers the Alborz zone in their research. Tavakoli and Ghafory- Ashtiany, 1999 divided study area in 20 seismic provinces, which our study area was categorized in their 15th province [1].

The objective of this research is to evaluate b-value and a-value based on Gutenberg-Richter relationship for Alborz area and map spatial distribution of these earthquake parameters in this area.

II. TECTONIC OF THE AREA

The Persian Plateau locates within the continental collision zone between the Eurasian and the African plates with recent volcanic, high mountain ranges and active faults. The collision between the two plates uplifted mountain ranges like the Alborz and the Zagros in Iran. One of the main regional tectonic features is the Central Iranian Block that consists of Tabas, Lut, Posht-Badam and Yazd blocks. Most destructive earthquakes show good coincides with these tectonic ties [10].

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Researchers can roughly divide the active faults of Iran to reverse and strike-slip faults. Central Iran is bounded by Alborz in northeast, Kope-Dagh in the north, Zagros in south and south-west, Makran in Southeast and Helmand in east. This region has gone under different mountain building phases especially within early Paleozoic, middle Triassic, early Jurassic and early Cretaceous [11]. The seismicity pattern of the Persian Plateau shows the non-uniform distribution that is concentrated across the active fold-thrust mountain belts [12].Destructive earthquakes are one of the features of the regional seismicity. Many urban and industrial complexes have been developed near the mountain foothills that are usually bordered of active faults, so great earthquakes along such faults has been destroyed many cities during historical and recent times [13].

The Alborz range, northern Iran, deforms by strain partitioning of oblique shortening onto range-parallel left-lateral strike-slip and thrust faults. Deformation is due to the north–south Arabia–Eurasia convergence, and westward motion of the adjacent South Caspian relative to Iran [14]. The study area includes the Tehran city and adjacent area. This area has experienced large events for many years. Figure 1 shows distribution earthquakes in the study area by a number of earthquakes per Km^2.

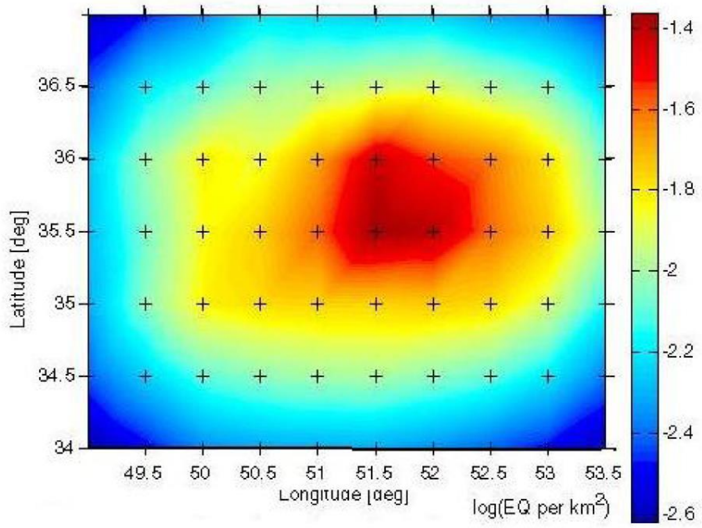

Figure 1. Distribution earthquakes in Alborz

III. METHODOLOGY

A. Data

This research is based on earthquake database from ISC, USGC and BHRC catalogs. Earthquakes have been used for this assessment from 1990 to 2010.

Before and after the main shock, foreshocks and aftershocks happen and since the complete list of earthquake usually do not follow the Poisson distribution, all foreshocks and aftershocks must be excluded from the catalog by windowing method in time and space domains by Gardner and Knopoff [15].

Analysis started by elimination of aftershocks and foreshocks , According this algorithm all events under the time- magnitude and distance- magnitude curve were considered as dependent events and should be eliminated from catalog for further analysis. Clearly, an incomplete catalogue can considerably change the b-values and missing small events will cause a decrease of b-value.

Magnitude of completeness (Mc) is the minimum magnitude, which above that all earthquakes are reliably recorded, so assessing the magnitude of completeness is prerequisite to seismicity analysis. Mc magnitude was estimated from the observed frequency magnitude distribution. Mc is magnitude of completeness where the frequency–magnitude curve starts to deviate from a linear trend. Mc was calculated about 3.5 for this region.

B. Data processing

ZMAP (version 6.0) was used to calculate the b-value and a-value. ZMAP software used least square method and maximum likelihood method using maximum curvature in performing. The research location has been divided into several grids (0.5˚x0.5˚) to map the b-value (Figure. 2) and a-value (Figure. 3).

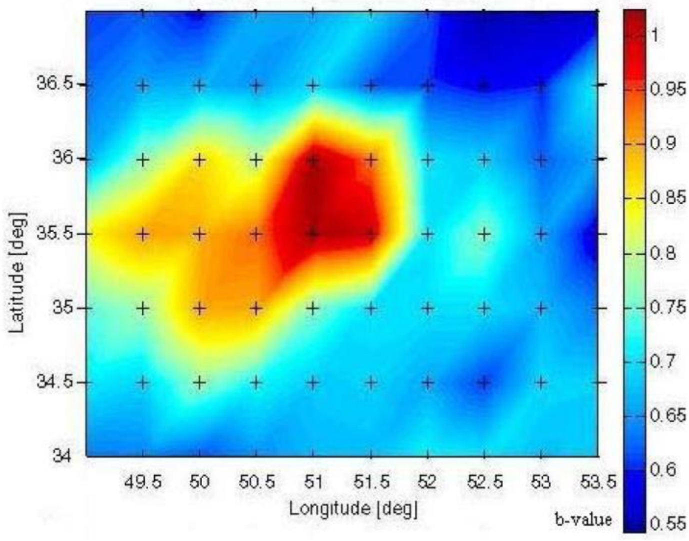

Figure 2. Variation of b-value

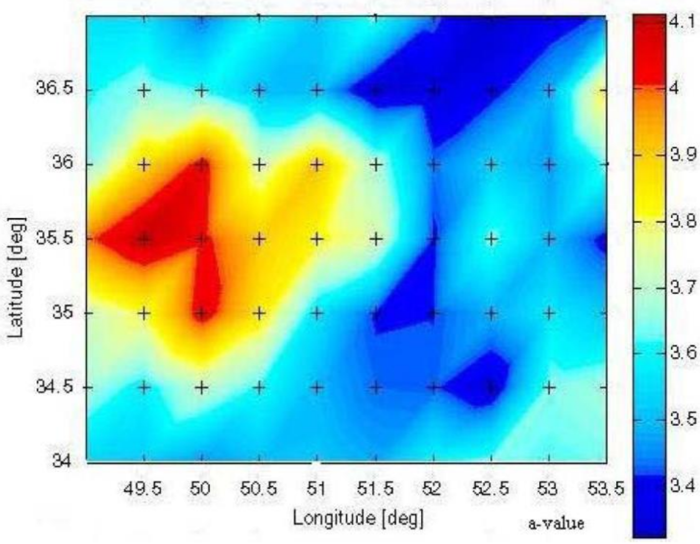

Figure 3. Variation of a-value

IV. RESULTS AND DISCUSSIONS

In this study, the parameter of Magnitude completeness (Mc) played an important role in determining the b-value and a-value which calculated around 3.5. Determination of b-value using maximum likelihood method was highly affected by the Mc. Using historical data could cause higher Mc and missing some events, so the first step toward understanding the characteristics of an earthquake catalog is to discover the starting time of the high-quality catalog. Some researchers have been suggested starting time for different regions in the world [16]. In this study, data from 1990 (only instrumental) were used.

The significant results of this research are generation of b-value and a-value map. According Figure2 b-value changes between 0.55 and 1. The dominant value of b is around 0.7. Spatial distribution map of b-value in this study shows less than unity in the whole study area, this amount is matched with previous studies in Continental zones [17].

According Figure2 it is obvious that regarding the spatial distribution of b-value study area could be divided in two parts, east part and western part. East part shows lower value of b.

Comparing Current research and fault map in Iran by Berberian[18] indicates that thrust-fault event are associated with lower b-values , so b-value is likely to be also dependent on the focal mechanism.

Guthenburg Richter relation is a key issue in the statistic assessment of earthquakes and seismic hazard analysis. Comparing Figure 1 and Figure2 shows that if less earthquakes happen in smaller magnitude b-value will be higher and if more earthquakes happen in bigger magnitude b-value will show smaller amount. some scientists believe that b-value is constant and the researches which show the temporal and spatial distribution of this value are effected by statistical or data errors[19],[20].on the other hand most studies show that with good quality and quantity data temporal and spatial distribution of b-value could be reliable[21], [22],[23], [24].

In this presentation, we accept the explanation of Scholz (1968) and Wyss (1973)[6],[7] and we expect an inverse correlation between the magnitude of observed b and the level of stress accumulated in and around the source volume.

Table 1 shows the comparison between b-value in this study and previous studies .In both previous research b-value was calculated less than this research .In previous studies historical and instrumental data were considered but in current research only instrumental data after 1990 were used .

Table1 . Comparison between seismicity parameters in this study and previous studies

Region	Nowroozi and Ahmadi, 1986 (Alborz Region)	Tavakoli and Ghafory- Ashtiany, 1999 (15^{th} Region)	This study
b-value	0.49	0.52	0.70

A-value is concerned with regional seismicity level and related to number of events and period of time. Figure3 shows the distribution a-value, this value changes from 3.4 to 4.1 and dominate value of ‘a’ is around 3.5. Comparing this study and Nowroozi and Ahmadi (1986) [9] their a-value is systematically lower than our study. This can be attributed to the improvement of seismic station coverage in this study, although the regions for two studies are not exactly the same.

V. CONCLUSION

This research studied seismic hazard parameters of Iran. The significant results of this research was generation of b-value and a-value map. Seismic parameter that can indicate earthquake activity in a research location was a-value. The b-value range in the study area was from 0.55 to 1 and range of a-value was 3.4 to 4.1. Magnitude of completeness has been estimated 3.5, Spatial analysis is just one part of an integrated research about the vulnerability characteristic of a region of the earthquake, therefore other studies related to geotectonic, geology, fault row, as well as earthquake history can help in supporting the calculation and analysis of seismic hazard in the region to mitigate earthquake disaster.

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