The Analysis of the Characters of the Central Alborz Zone Earthquakes (400 B.D to 1998 A.C), caused by Active and Seismogenic fault, Determination of Small Model of Alborz Geological Zone, Iran

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Abstract— The main objective of this paper is to analyze the characteristics of central Alborz earthquakes as seismotectonic small model of Alborz range. The central Alborz is a subdivision of Alborz range's geological zone, located in north of Iran. The historical and the measured earthquakes data in the selected area have been selected from 400 B.C to 1998 A.C choosing different references whose magnitudes are more than 4. The conclusion of research shows that 32% of central Alborz's earthquakes have a magnitude of more than 5 with a maximum of 7.6 recorded on the Mosha-Fasham thrust fault. Most of the earthquakes epicenters occurred on and around the Caspian and fewer earthquakes happened on or around Mosha-Fasham. On the contrary, most of the focal depths of earthquakes distributions are around Mosha-Fasham. The central Alborz borders the Caspian in north and Mosha-fasham thrust faults in south, which is a big horst that was uplifted by the active fault mechanism. Since many villages and towns including the city of Tehran Capital of Iran exist in central Alborz which will be influenced by central Alborz seismisity.

Keywords—Earthquakes data, Earthquakes characteristics classification. Seismogenic faults

INTRODUCTION

There are 27 cities with more than 30000000 population of Iran in Alborz Ranges and the surrounding areas on active faults or at distances 1 to 35 km away from these faults [8]. Since many villages and towns including the city of Tehran with more than 10000000 population exist in central Alborz, with few big cities in south of it, Qazvin, Karaj, Garmshahr, Semnan, which will be influenced by central Alborz seismotectonic. Therefore, the study of the central Alborz as a model of Alborz range is the purpose of this research.

The central Alborz geological zone is a subdivision of Alborz geological unit in the north of Iran whose earthquakes focal depth, location, magnitude, active and seismogenic faults are studied as small model of Alborz geological zone crust deformation and seismogenity. In Alborz Ranges many intense and destructive earthquakes occurred with low focal depth.

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The shallow focal depth of central Alborz earthquakes are the reason for low thickness of Iran crust under Alborz zone, which, based on gravimetric map, is about 35 km [4].

Some of the Alborz Ranges' active faults are strike-slide and others are reverse and thrust faults. Furthermore, the Alborz Ranges consist of many flexure-slip folds [7]. The Alborz range strike direction is NW-SE, E-W and SW-NE. The three directions were observed in the selected area, which is the main reason of this research. However, in the centre of selected area Damavand volcano has outcropped where the central Alborz strike direction has changed (Fig. 1).

The Iranian crust ranges is known as part of the Alpine-Himalaya system in western Asia, between the Arabian shield in the southwest and the Turan plate in the northeast (Fig.1). The Iranian crust is divided into different structural geology units and the main faults are at the border of units. The Iranian crust and its faults were impacted by three tectonic forces: the first is the Arabian shield compress with NE-SW direction towards southwest. The second is the subduction of Oman oceanic crust under Makran range in southeast while the third force is Caspian oceanic crust that is depressed under Alborz ranges in north (Fig. 1).

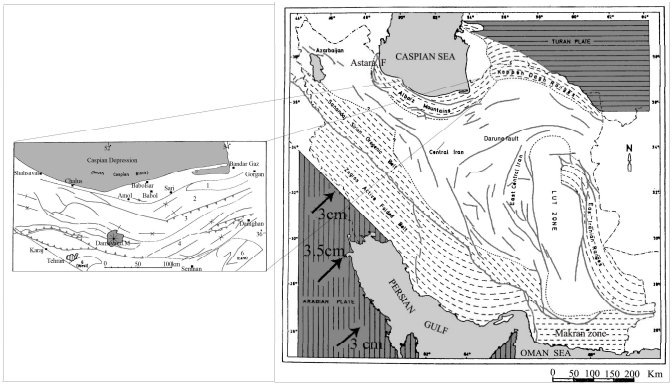

Figure1- The structural geology units of Iranian crust and situation of research area (after Nabavi and Berberian 1976, Dercor and et. al 1986). The figure shows three effective forces of Iranian crust deformation, the first of which is the Arabian plate compressing in southwest with NE-SW

direction(3-3.5 cm/year), as a consequence the Iranian crust folded and faulted during geological time. The second is Oman oceanic crust in southeast that sub-ducts under Makran range, with W-E direction. The third is Caspian oceanic crust depression in the north of Iran.

The central Alborz earthquakes data (149 earthquakes) that have been collected by IIEES from 400 B.C to 1992 A.C with different references is selected for this research. The earthquake information includes earthquake time, epicenter, magnitude, depth and reporting source.
From the above data and analyses, the following remarks are concluded.

-22% of central Alborz earthquakes have a magnitude: M ≥ 5 and are dangerous with high hazard.

-Many earthquakes focal depth are not deep. 40% of these are at 30-35 km and about 2% are at 20-25 km. The low value of focal depth is the reason that indicates central Alborz crust thickness is not very deep.

- Most of the earthquakes are located on Caspian (khazar) thrust fault, in north of Central Alborz (Fig.2 and Fig.4).

-The historical earthquake maximum magnitude is 7.6 occurring on Mosha-Fasham or Pishva fault and the historical maximum earthquake magnitude inside the selected area is 7.2 occurring on Baijan fault (Fig.2 A).

- The earthquakes focal depth on Caspian fault is less than those on Mosha-Fasham fault (Fig. 4).

- The maximum and minimum values of focal depth of the central Alborz earthquakes are 50 and 2-10 km, respectively (Fig.3).

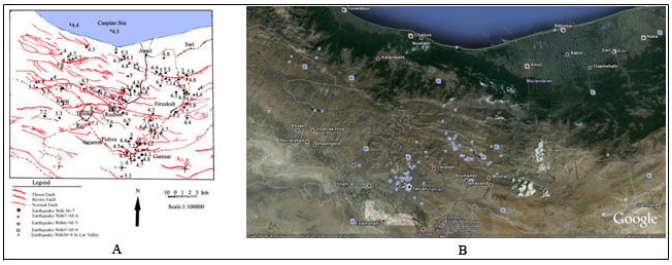

Figure 2- Seismotectonic map (A) and satellite image (B) of the central Alborz. The first was prepared on the basis of earthquakes' location and their magnitude data. The map shows situation of earthquake magnitude on related faults and their surroundings. The satellite image shows many cities in central Alborz that is located in active faults adjacent and around which will be influenced by central Alborz earthquakes.

Geological and tectonic setting

The Alborz range is a geological zone located in the north of Iran. Its geological subdivision traditionally used in studies considers a scheme for the Alborz suggested by Gansser and Huber [5] which was based on 1:250000 geological maps [6].
The central Alborz located in the middle of Alborz geological zone had been studied by Aseereto [2] and Allenbach [1]. Geological survey of Iran published central Alborz and east Tehran geological maps in 1:100000 scale in the year 1997. This map was prepared based on geological information studied by AllenBach [1] Assereto [2], and Amini and Khalatbari [3].
The central Alborz is divided into two structural geology units from south to north (Fig.3) as follows:
1-Northern unit: This unit contains folding belt of Mesozoic and Cenozoic sedimentary rocks. It is bordered by the Caspian and Alborz thrust faults (Fig.3).
2-Southern unit: This unit has formed the main Alborz and is composed of Paleozoic and Mesozoic sedimentary rocks. Mountains are very high in this unit and Mosha-Fasham thrust faults have been uplifted Alborz (Fig. 3).

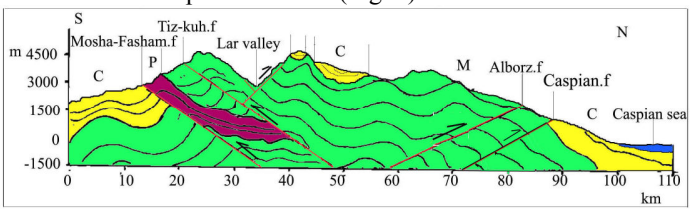

Figure3- Figure shows the geological cross section from Caspian sea in north and Tiz kuh in South of central Alborz, P=Paleozoic formation, M= Mesozoic formation and C= Cenozoic Formation.

The tectonic setting of central Alborz is composed of many long folds and faults (Fig. 1). The strike direction of folds is NE-SW in east, E-W in middle and NW-SE in west. The Main faults are Mosha-Fasham in south, Alborz and Caspian thrust fault in north (Fig.1 andFig.3). Other faults in the area are located between them.

Earthquakes data classification

The central Alborz historical and instrumental earthquakes data (149 earthquakes) were collected by IIEES (2007) during 400 B.C to 1992 A.C from ABM, CCP, NOW, MOS, VSGS, PEK, CGS, ISC and other center. At the beginning, earthquakes with magnitude larger than M=4 have been selected. Then depth of reported earthquakes was compared with magnometric map and Iran's Total intensity map and earthquakes with reasonable depth have been selected. It worth mentioning here that according to Iran's magnometric map estimated maximum depth of earth surface under the central Alborz zone is 35 kilometers, which shows the depth of crust deformation for example displacement and faults activity . Therefore reported earthquakes deeper than 50 kilometer are removed from this analogy. In order to detect the source of earthquake faults, the map of earthquakes' expansion on and around central alborz main faults is prepared. At first, map of central alborz faults is prepared according to Iran's tectonic map, Nabavi and Berberian map in 1983(Fig. 1). Then each earthquake, according to its epicenter properties is precisely located on the faults map and seimothectonic map of central alborz is created. In next step, geological, Berberian and Ambersiz data of faults which are source of earthquakes are estimated according to earthquake's expansion on direction or around faults (on hanging or footwall) (Fig.2). Then, selected

earthquakes' properties like magnitude, focal depth and source fault are classified.
The frequency percent of earthquakes magnitude of central Alborz is as follow:

- 32% of earthquakes' magnitude: M=4-4.5

-37% of earthquakes' magnitude is M= 4.5-5

-12% of earthquakes magnitude is M= 5-5.5

-4% of earthquakes magnitude is M= 5.5-6

-1% of earthquakes magnitude is M= 6-6.5

-6% of earthquakes magnitude is M=6.5-7

-6% of earthquakes magnitude: M= 7-7.5

-2% of earthquakes magnitude is M= 7.5-8

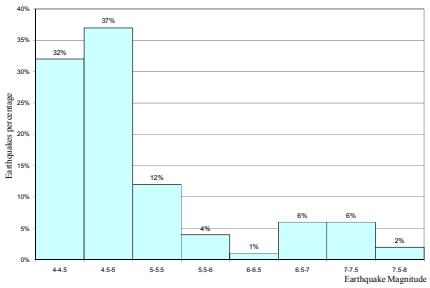

Figure 4- Classification of central Alborz earthquakes magnitude based on collected data.

15 percent of giant and high damaging earthquakes ($M \geq 6$) occurred in the central Alborz.

The frequency percent of earthquakes focal depth of selected area is as follow:

-6% of earthquakes focal deep is 0-10 km

-23% of earthquakes focal deep is 10 - 20 km.

-6% of earthquakes focal deep is 20 -30 km.

-47% of earthquakes focal deep is between 30 -40 km.

-18% of earthquakes focal deep is more than 40 km.

Focal depths of the central Alborz earthquakes are next to ground surface (Low depths earthquakes), which shows earthquakes to be very seismogenic and of high hazards. However, the maximum earthquakes focal depth (40 km) illustrates that the depth of central Alborz deformation is next to the border of crust and mantle under Alborz ranges.

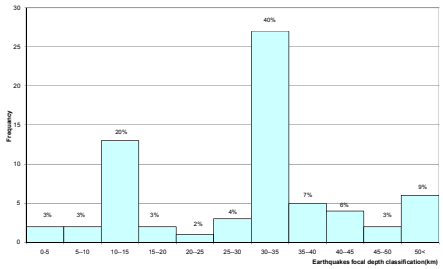

Figure 5- Classification of central Alborz earthquakes focal depth based on analyzed data.

The frequency of earthquakes origin (fault) in selected area is as follow:

-20 earthquakes is located on Mosha-Fasham thrust fault in south of central Alborz region.

-11 earthquakes are located on Garmsar fault in the southeast of the region.

-25 earthquakes are located on Caspian fault (khazar) in the north of the region.

-11 of earthquakes are located on Baijan fault in the middle of the region.

-33 of earthquakes are located on few faults in different parts of the region.

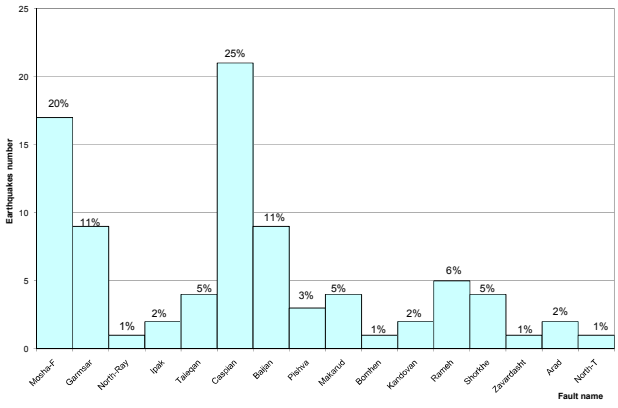

Figure6- The central Alborz earthquakes sources (faults).

The Mosha-Fasham, Alborz and Caspian thrust faults are the main source of earthquakes for the selected area. The Mosha-fasham fault located in south, and Alborz and Caspian fault are in the north of central Alborz (Fig 4).

Distribution of earthquakes depth

The distributions of the central Alborz earthquakes depth are shown in figure 3. In this figure and based on earthquake focal depth distribution, the deeper earthquakes focal are located along Mosha-Fasham fault plan and shallower ones are in Caspian and Alborz fault plan. However, some earthquakes of Caspian and Alborz focal depths are 10 km and other depths are more than 30 km. But in Mosha-Fasham fault plan, the earthquakes focal depths are different and start from 15 km while depth from 30 to 50 km are located around its plan. The distribution of central Alborz earthquakes around Mosha-Fasham, Caspian and Alborz faults shows the crust deformation to be concentrated on south and north border, which implies that central Alborz block, was uplifted by Mosha-Fasham and Caspian thrust faults mechanism in south and north.

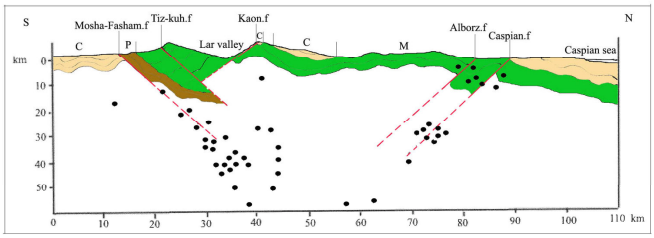

Figure 4- Schematic diagram of central Alborz illustrating the earthquakes sequence along the south and north faults plans that are pointed on the basis of earthquakes location and focal depth. The central Alborz structural geology is composed of a big horst which was uplifted by Mosha-Fasham and Caspian thrust fault mechanism P=Paleozoic, M= Mesozoic and C= Cenozoic.

Therefore, the central Alborz, structurally, is a big horst. However, the distribution of more earthquakes focal depth on or around Mosha-Fasham fault indicates high Alborz crust deformation is located in south border where central Alborz is adjacent to central Iran geological zone (Fig.1) which Tehran and other cities is located(Fig.2 A and B). Figures and Tables

Discussion and Conclusions

The crust of Iran contains many folds and main faults with different directions. The main direction is NW-SE formed by Arabian shield compress force (Fig. 1). The other direction is E-W created by Oman Sea oceanic crust subduction under Makran zone (Fig. 1). The third is NE-SW formed by Caspian Sea oceanic crust depression, with a resistance against compress force and Daruneh fault mechanism. Furthermore, the N-S direction existing in west of Caspian sea plus the Caspian crust resistance, are affected by the Astara fault (Fig. 1).The destructive earthquakes of Iran's crust are created by compress force, crust shortening and main faults displacement.

The central Alborz tectonics and structural Geology is complicated. In the south, the existing young Damavand volcano is located on an area, which contains changes of structural direction of the central Alborz. To the right of Damavand, the structural direction is NW-SE (Zagros zone direction) and to the left, it is NE-SW. That is the reason for Caspian oceanic crust depression under Alborz ranges where it bended toward the south (Fig.1). The seismotectonic of the selected area is active and contains many active faults. Since many villages and towns including the city of Tehran capital of Iran exist in central Alborz, with few big cities in south of central Alborz, Qazvin, Karaj, Garmsar, Semnan, which will be influenced by central Alborz seismotectonic, the study of seismotectonic behavior of central Alborz earthquakes is very important and vital. Therefore, the study of the central Alborz as a model of Alborz range is the purpose of this paper.

Conclusions

1- Central Alborz has 15% earthquakes with magnitude more than M=6 and proves to be seismogenic. It can be very dangerous for Tehran and few big cities that are located on north and south of central Alborz.

2- Central Alborz earthquakes focal depth is 10 to 40 km located next to ground surface with earthquakes hazard, which indicates that earthquakes are of low depth type.

3- Low focal depth of the central Alborz earthquakes is the reason for low depth of Alborz crust (about 35 km).

4-The Mosha-Fasham in the south and the Caspian thrust fault in the north of the central Alborz are the main faults with an earthquake origin. These faults are next to the border of the central Alborz zone.

5-In the central Alborz, the probable maximum earthquake magnitude is more than M= 7.5.

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