Environment and Ecology 37 (4) : 1154—1160, October—December 2019
Website: environmentandecology.com ISSN 0970-0420

Investigating the Increase in the Rates of Earthquakes in the Southwest of the Zagros Mountains (Comparison of the Present and Past Decades)

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Received 26 February 2019; Accepted 24 May 2019; Published on 27 June 2019

ABSTRACT

By examining the number and frequency of earthquakes of 4 or more in the southwest of the Zagros belt from 2000 to 2010 and comparing it with the earthquakes between 2011 and 2018 (the time of writing this research) it can be seen that the total number of earthquakes with a magnitude greater than 4 in the area and between 1972 and 2010 has been 78 earthquakes and from 2012 to 2018, 122 earthquakes of magnitude 4 or more have occurred in southern Iran. Further investigations revealed that during the special years and months, the number and frequency of earthquakes has increased dramatically and their migration from one region to another is significant; so the comparison of the frequency of earthquakes over the past two decades with the present indicates a 55% increase in earthquake rates of more than 4 between 2012 and April 2018 in southern Iran. The main reason for this significant increase in earthquakes is the movement of Saudi Arabia toward Iran.

Keywords Earthquake, Southern Iran, Zagros, Increase in rate, Comparison.

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INTRODUCTION

The Zagros mountain belt, which is part of the active Alp-Himalia Mountains belt has experienced earthquakes in the past two decades that have been unconventional compared to the ones that have occurred in the past and it shows a significant increase. Given that earthquakes are part of natural disasters and its exact time and place is not foreseable and it can cause huge economic and social damages and most importantly it can take the lives of humans significantly, it is necessary to monitor the process of increase in earthquake occurrences by looking deeply what has occurred and use the past experiences to light up the future knowledge so as to decrease the damages of

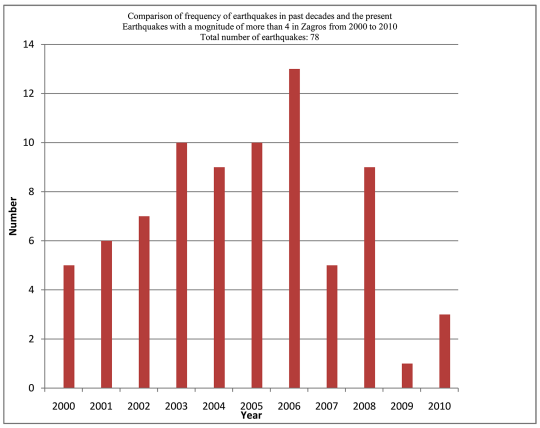

Fig. 1. Comparison of frequency of earthquakes in past decades and the present earthquakes with a magnitude of more than 4 in Zagros from 2000 to 2010. Total number of earthquakes : 78.

earthquakes by the help of the related organizations and define a clear strategy in this regard.

Based on the mentioned facts, in this research that was done for the first time by the method of comparison, the statistics related to earthquakes occurred between 2000 and 2010 were compared with 2011 to April 2018 (the time of writing this research). Significant results were obtained that will be presented here. We hope that the obtained results can be useful for strategic use by planners of the related organizations (Fig. 1).

Background of the study

Many scientists have studied the Zagros folded belt, some of which have been about the condition of earthquakes and their features in this region. Some of the most important of these include:

(1) The selected earthquake regions in the Zagros Mountains, which result in the determination of the depth of the earthquakes in the range of 5-15 km, and the major deformations created in this zone is due to the activity of rocky faults. (2) Earthquakes of March 25th in Fin area in Iran views faults in vertical degrees in the fault of the Zagros belt, resulting in aftershocks at depths of 10 to 30 km due to events occurring at a depth of 20 to 25 km. Also, the depth of the rupture above is limited to about 5 to 6 km and at a depth of 9 to 10 km below, which is highly consistent with the depth of the morphology of the salt layer of Hormoz (Roustaie et al. 2010). (3) The results obtained from new ideas on the seismic belt of Zagros in Iran show that the depth of earthquakes with a magnitude of more than 6 is about 4 to 9 km that can be cut off in their sedimentary cover, which is consistent with the depth of saturation layer (Nissen et al. 2011). (4) An investigation of the central mechanism of the earthquake and active shortening in the Zagros belt of orogeny resulting in the rareness of surface rupture in this zone is due to the presence of soft layers.

MATERIALS AND METHODS

With regard to the fact that the southeast region of Zagros is a part of the active section of Zagros folded belt, to study more precisely, overhead photos of different regions were observed and the regions in which earthquakes with a magnitude of 4 and more had occurred were extracted and recorded from the website of Geophysics Institute of Tehran University (Table 1).

Table 1. Central mechanism and magnitude of earthquakes of Zagros orangery belt.

Number	Mechanism	Magnitude	Region	Year	Month
1	Reverse	5	Southeast of Zagros	2018	Jan
2	Reverse	5.5	Southeast of Zagros	2018	Jan
3	Strike slip	5.3	Southeast of Zagros	2018	Jan
4	Reverse	4.8	Southeast of Zagros	2018	Jan
5	Reverse	5.2	Southeast of Zagros	2018	Jan
6	Reverse	4.9	Southeast of Zagros	2018	Jan
7	Normal	4.9	Southeast of Zagros	2018	Jan
8	Reverse	5	Southeast of Zagros	2018	Apr
9	Reverse	5.5	Southeast of Zagros	2018	Apr

Table 1. Continued.

Number	Mechanism	Magnitude	Region	Year	Month
10	Reverse	4.9	Southeast of Zagros	2017	Jan
11	Strike slip	4.6	Southeast of Zgros	2017	Jan
12	Strike slip	4.5	Southeast of Zagros	2017	Jan
13	Strike slip	4.4	Lorestan	2017	Jan
14	Reverse	5.2	Southeast of Zagros	2017	Jan
15	Reverse	4.9	Southeast of Zagros	2017	Jan
16	Reverse	4.7	Southeast of Zagros	2017	Jan
17	Reverse	5.2	Southeast of Zagros	2017	Jan
18	Reverse	4.5	Southeast of Zagros	2017	Jan
19	Strike slip	4.4	Southeast of Zagros	2017	Jan
20	Strike slip	5.4	Southeast of Zagros	2017	Jan
21	Strike slip	4.8	Southeast of Zagros	2017	Jan
22	Strike slip	4.6	Zagros-Kordestan	2017	Jan
23	Reverse	5	Southeast of Zagros	2016	
24	Strike slip	5	Southeast of Zagros	2018	
25	Strike slip	4.4	Southeast of Zagros	2016	
26	Strike slip	4.7	Southeast of Zagros	2016	
27	Strike slip	4.3	Southeast of Zagros	2016	
28	Reverse	4.5	Dezful's embayment	2016	
29	Reverse	4.7	Boundary of Bandarabbas	2016	
30	Reverse	4.5	Southeast of Zagros	2015	
31	Strike slip	4.6	Southeast of Zagros	2015	
32	Reverse	4.3	Southeast of Zagros	2015	
33	Reverse	4.2	Bandarabbas	2015	
34	Reverse	4.9	Dezful's embayment	2015	
35	Reverse	4.7	Boundary of Bandarabbas	2015	
36	Strike slip	4.6	Southeast of Zagros	2015	
37	Reverse	4.9	Southeast of Zagros	2015	
38	Reverse	4.7	Southeast of Zagros	2015	
39	Reverse	4.8	Southeast of Zagros	2015	
40	Reverse	4.3	Zagros-Lorestan	2015	
41	Reverse	5.1	Zagros-Lorestan	2015	
42	Reverse	5.2	Zagros-Lorestan	2015	
43	Reverse	4.7	Southeast of Zagros	2015	
44	Reverse	5.3	Southeast of Zagros	2014	
45	Reverse	4.9	Southeast of Zagros	2014	
46	Strike slip	4.6	Lorestan	2014	
47	Strike slip	4.8	Southeast of Zagros	2014	
48	Reverse	5	Southeast of Zagros	2014	
49	Reverse	5.2	Southeast of Zagros	2014	
50	Reverse	4.9	Southeast of Zagros	2014	
51	Strike slip	5.3	Gheshm	2014	
52	Reverse	4.6	Southeast of Zagros	2014	
53	Reverse	4.5	Southeast of Zagros	2014	
54	Strike slip	4.1	Kordestan	2014	
55	Strike slip	4.5	Southeast of Zagros	2014	
56	Reverse	4.9	Boundary of Bandarabbas	2014	
57	Reverse	5.4	Southeast of Zagros	2014	
58	Strike slip	4.6	Southeast of Zagros	2014	
59	Reverse	4.5	Dezful's embayment	2014	Aug
60	Reverse	4.6	Dezful's embayment	2014	Aug
61	Reverse	6.2	Dezful's embayment	2014	Aug
62	Reverse	5.7	Dezful's embayment	2014	Aug
63	Reverse	4.7	Dezful's embayment	2014	Aug
64	Reverse	4.7	Dezful's embayment	2014	Aug
65	Reverse	5.1	Dezful's embayment	2014	Aug

Table 1. Continued.

Number	Mechanism	Magnitude	Region	Year	Month
66	Reverse	5.4	Dezful's embayment	2014	Aug
67	Reverse	5.9	Dezful's embayment	2014	Aug
68	Reverse	4.6	Dezful's embayment	2014	Aug
69	Reverse	5.2	Dezful's embayment	2014	Aug
70	Reverse	5.6	Dezful's embayment	2014	Aug
71	Reverse	4.6	Dezful's embayment	2014	Aug
72	Reverse	4.8	Dezful's embayment	2014	Aug
73	Reverse	5.3	Dezful's embayment	2014	Aug
74	Reverse	4.9	Dezful's embayment	2014	Aug
75	Reverse	4.7	Dezful's embayment	2014	Aug
76	Reverse	4.6	Dezful's embayment	2014	Aug
77	Reverse	5.8	Dezful's embayment	2014	Oct
78	Reverse	4.4	Dezful's embayment	2014	Oct
79	Reverse	4.1	Dezful's embayment	2014	Oct
80	Strike slip	4.8	Boundary of Bandarabbas	2014	Oct
81	Reverse	5	Southeast of Zagros	2014	Oct
82	Strike slip	5.2	Boundary of Bandarabbas	2014	Oct
83	Reverse	4.3	Southeast of Zagros	2014	Oct
84	Reverse	4.9	Southeast of Zagros	2014	Oct
85	Reverse	4.9	Southeast of Zagros	2014	Oct
86	Reverse	4.9	Southeast of Zagros	2014	Oct
87	Reverse	5	Lorestan	2013	Apr
88	Reverse	4.9	Southeast of Zagros	2013	Apr
89	Reverse	6.3	Southeast of Zagros	2013	Apr
90	Reverse	5.3	Southeast of Zagros	2013	Apr
91	Reverse	4.5	Southeast of Zegros	2013	Apr
92	Strike slip	4.6	Southeast of Zegros	2013	Apr
93	Reverse	4.6	Southeast of Zagros	2013	Apr
94	Reverse	5.2	Southeast of Zagros	2013	Apr
95	Reverse	5.2	Southeast of Zagros	2013	Apr
96	Strike slip	4.5	Southeast of Zagros	2013	Apr
97	Reverse	4.4	Southeast of Zagros	2013	Apr
98	Reverse	4.9	Southeast of Zagros	2013	Apr
99	Reverse	4.5	Southeast of Zagros	2013	Apr
100	Reverse	4.9	Southeast of Zagros	2013	May
101	Reverse	4.7	Southeast of Zagros	2913	May
102	Reverse	4.9	Southeast of Zagros	2013	May
103	Reverse	4.6	Southeast of Zagros	2013	May
104	Reverse	4.8	Southeast of Zagros	2013	Jul
105	Reverse	4.5	Southeast of Zagros	2013	Jul
106	Reverse	4.6	Southeast of Zagros	2013	Jul
107	Reverse	4.2	Lorestan	2013	Jul
108	Reverse	4.6	Bandarabbas	2013	Jul
109	Reverse	4.2	Southeast of Zagros	2013	Jul
110	Reverse	5.6	Kordestan	2013	Jul
111	Reverse	5.7	Kordestan	2013	Jul
112	Reverse	4.7	Kordestan	2013	Jul
113	Reverse	4.6	Kordestan	2013	Jul
114	Reverse	5.5	Kordestan	2013	Jul
115	Reverse	4.6	Southeast of Zegros	2013	Jul
116	Reverse	4.2	Southeast of Zagros	2013	Jul
117	Reverse	5.3	Dezful's embayment	2012	
118	Reverse	5.1	Dezful's embayment	2012	
119	Reverse	5	Lorestan	2012	
120	Reverse	4.9	Larestan	2012	
121	Strike slip	5.2	Southeast of Zagros	2012	
122	Reverse	4.7	Southeast of Zagros	2012	

Table 2. Comparative statistics of the number of earthquakes based on the mechnism.

The central mechanism of the earthquake	Number
Reverse	96
Normal	1
Strike slip	25

RESULTS

By looking at the above (Tables 1, 2) it is observed that in the southeast of Iran, most of the earthquakes are related to reverse faults and the least are related to normal faults. On the other hand, from total 30 cases of earthquakes in 2013 only 19 cases have occurred in April, May and July and only in shoreline Fars region.

In addition, from total 43 cases of earthquakes in 2014, only 21 cases have occurred in August and October, and only in Dezful's embaymet.

Based on the mentioned facts, comparison of the frequency of earthquakes in the past two decades and the present shows a 55% increase in the rate of occurrence of earthquakes with the magnitude of more than 4 in Zagros (Figs. 1, 2). X_1

$$\frac{\Delta X}{X_1} = \frac{121 - 78}{78} * 100 = 55\%$$

With deeper analysis of earthquakes with the magnitude of 4 and more in Zagros and extracting them from the geophysics Institute of Tehran University, it was clear that in specific years and months the number and frequency of earthquakes have increased significantly and their migration from a region to another is noticeable.

For instance, in 2013 out of a total number of 30 earthquakes with a magnitude of 4 and more, 19 cases have occurred only in April, May, and July and in the arc of Fars. Also, in 2014 out of a total number of 43 earthquakes with a magnitude of 4 and more, 21 cases have happened only in August and October and in Dezful's embayment. After drawing a conclusion

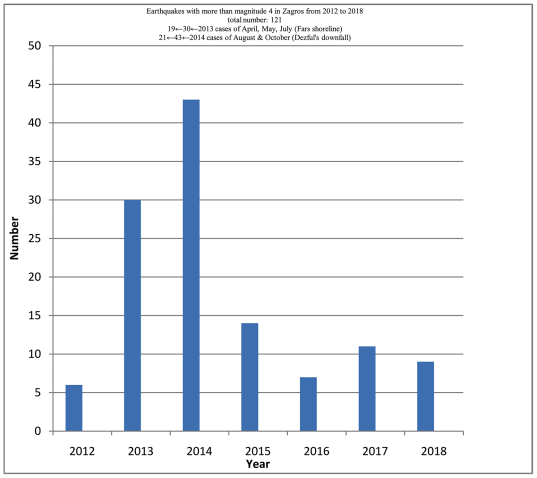

Fig. 2. Comparison of the frequency of earthquakes in the past two decades and the present.

from these points, the following points are noticeable : (1) Has there been a change in the number of Seismograph Machines in that period ? (2) Why is it that when earthquakes migrate from one region to another, their frequency becomes more? (3) Given that the creep is a time-taking phenomenon, why does the number of earthquakes in this migration increase dramatically?

It is worth mentioning that at the time of writing this research, seismic data of 2011 was not available in the system of Geophysics Institute of Tehran University.

Determination of compression of Arabic plate in Iran

Based on the ideas of researchers in geology and geophysical data and regional topography, generally the place of collision of Arabic plate with Iran is northwest and southeast and in terms of topography, it has two downfalls called the Dezful's embayment and the Karkuk embayment in Iraq. It has also two arcs, one in Shoreline of Fars from Boushehr to Hormoz strait and the other in Lorestan. Therefore, the approximate boundary of the collision of Arabic plate

Fig. 3. Determination of approximate boundary between Iran and Arabic plate.

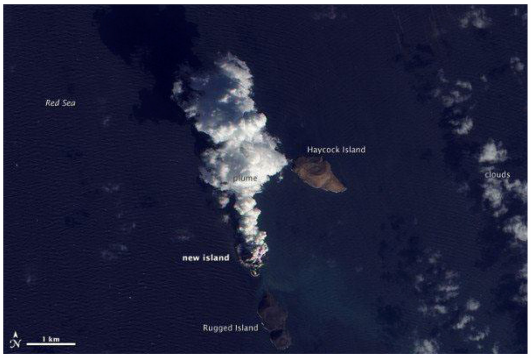

Fig. 4. An image of volcanic activity and formation of new islands in the Red Sea.

with Iran is drawn as shown in (Fig. 3).

Investigation of the activity of the Red Sea in the current decade

The eruption of the volcanoes of the "Zubair" archipelago in the Red Sea began in 2007 in the area. Four years after the eruption of the volcanoes, NASA released images of the west coast of Yemen, in which new islands were seen. This issue confirms the birth of a new ocean or the opening and expansion of the Red Sea and the separation of Africa and Saudi Arabia.

DISCUSSION

By investigating the seismic activities from 2000 to 2010 and comparing them with earthquakes in 2012 to 2018 it is observed that the number of earthquakes occurred in the current decade has increased significantly compared to the past decade and it shows a 55% increase.

Deeper study on the rate of opening of the Red Sea shows that the first new volcanic activities have been created since 2007 and 4 years after the first eruptions, that is in 2011, the first islands were created in the western coasts of Yemen in the Red Sea (Fig. 4). The symmetry of the formation of new islands in the Red Sea and the increase in seismic rates in southern Iran, which have begun since 2011, are totally in line with each other. Therefore, on a regional scale, there are other interesting and remarkable results. The geographical direction of the three major features, Zagros mountains, the Persian Gulf and the Red Sea is located northwest-southeast and they are located in almost one direction. On the other hand, we know that, based on Irish and Pratt's theory of isostatic creation, for the Zagros mountain range, the Persian Gulf downfall is observed as a geosynclinal. By the opening of the Red Sea floor and the movement of Arabic plate and its collision to Iran, it is expected to observe new rates of earthquakes compared to the past. Seismic data of Geophysics Institute of Tehran University about earthquakes with magnitude of 4 and more from 2012 to 2018 (the time of writing this research) and its comparison with past decade earthquakes, that is from 2000 to 2010 also show significant increase in the rate of these earthquakes and their conformity with the beginning of volcanic activities in the Red Sea. All these points indicate the Arabic plate becoming closer to Iran and its collision with Iran and thus the increase in the rate of new earthquakes.

This article obviously confirms the increase of the rate of earthquakes in the south of Iran and seeks the attention of managers and the related planners in order to try to decrease the effects and pain and damages caused by earthquakes.

REFERENCES

Nissen E, Tata M, Jackson JA, Allen MB (2011) New views on earthquake faulting in the Zagros fold-and-thrust belt of Iran. Geophys J Int 186 : 928—944.

Roustaie M, Nissen E, Abbassi M, Gholamzadeh A, Ghorashi M, Tatar M, Parsons B (2010) The 2006 March 25 Fin earthquakes (Iran)—insights into the vertical extents of faulting in the Zagros Simply Folded belt. Geophys J Int 181 : 1275—1291.