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Investigating the risk of Fin earthquake in Hormozgan province

Zandi Lak Asma *✉

Bachelor student of GIS and RS, Firozabad Higher Education Center, Firozabad, Iran.

✉ asmazndy994@gmail.com

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Abstract

The current shape of the Iranian plateau is related to the alpine orogenic events, and the Iranian plate is located in the seismic belt due to its location at the convergence of two tectonic plates. This research has investigated the earthquakes of Fin region, located in Hormozgan province. Due to the destructive impact of earthquakes on human life, which causes a lot of financial and human losses, the study of earthquakes has always been a challenging and important issue for humans. Radar interferometry with the help of satellite images is a new method in the field of remote sensing studies. May it be used in this research. In this method, the displacement map of Fin area of Hormozgan was prepared and considering the spatial distribution data of earthquakes in Fin area as well as the geological features of this area, it can be said that a displacement of +2.7 cm in the area in the form of uplift, They have a good correlation with the location of earthquakes concentrated in the south and southeast part of the region, and on the other hand, the displacement of -4.2 cm indicates the extension of subsidence in most parts of the region. From the geological point of view, it can also be said that the displacement values in the more resistant carbonate units (Asmari and Jahrom formations) are lower than the displacement in the comparatively detrital and evaporite units (Mishan, Aghajari and Bakhtiari formations).

Keywords: Radar interferometric method, Earthquake, Fin region, Hormozgan province

Introduction

The current structure and shape of the Iranian plateau are related to the events of the Alpine orogeny in the Cenozoic era, which plays a positive role by creating mineral and hydrocarbon reserves and creating negative thrust faults and earthquakes in this plateau (Ramazani Gourabi 1371). Our country is located in the middle part of the Alpine-Himalayan orogenic belt, where the Alborz and Zagros mountain ranges are the result of the events of this orogenic belt. The Iranian Plateau is known as a hard and fragile

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continental crust that is enclosed between two large tectonic plates (the Eurasian plate in the north and the African-Arabian plate in the south). The presence of large and active faults and the occurrence of numerous earthquakes in this plateau This is theory.

From the geological point of view, the seismic zone in Iran includes the Zagros, Alborz and Central Iran areas, which are under pressure due to the movements of the tectonic plates around them. Fractures are created in the form of faults and joints, the main faults in the continental crust of Iran have three main trends: northwest-southeast, north-south, and northeast-southwest, which are the main trends. It has made Iran one of the most important earthquake-prone regions in the world (Aqhanbati, 2013). The energy caused by the convergence between the Iranian plate and the neighboring plates is stored in the crust, and as the pressure increases and the yield point of the rock units is reached, the geological layers of failure are created; By creating a fracture, the stored energy is converted into kinetic energy and propagated in the form of earthquake waves. When the earthquake waves reach the surface, they cause the displacement and rupture of the surface of the crust and can cause uplift and subsidence of the land, collapse and landslides in the mountains, as well as the destruction of structures and many human and financial losses for cities and villages. Due to the presence of many faults, the occurrence of earthquakes in Iran is mostly related to faults. As a result of the current unevenness of the Iranian plateau, it is young and related to the last stages of alpine orogeny, and on the other hand, it was enclosed in a large tectonic plate, so it is not tectonically and seismically calm and is still active to reach its isostasy balance (Zamardian , 1381).

So far, humanity has done many studies to understand the dangers of earthquakes, and there are still many questions in this field. For risk management and risk assessment of earthquakes, it is very necessary to comprehensively identify, model and prepare their map (Howells, 1983). One of the new methods in the field of seismic investigation is the use of remote sensing studies. In recent years, the radar interferometric method is a new type of telemetry study that is carried out with the help of satellite images and investigates the movement of the earth's surface in connection with earthquakes.

The subject of research in this article is Fin region, located in the north of Hormozgan province, where large earthquakes occurred in the year 1400 (Figure 1). The purpose of this research is to investigate the earthquakes located in the Finn region and to investigate their effect on the surface morphology and other aspects of these earthquakes.

Study Area

Fin city with an area of 2940.778 hectares and a population of 3976 people is a part of Bandar Abbas city, which is in the north of Hormozgan province and northwest of Bandar Abbas city in the geographical coordinates of 15.55 to 54.55 east longitude and 27.37 and 27.38 north latitude at a distance of 59 kilometers from Bandar Abbas. is located (Figure 2). This city is one of the rare and real examples of city gardens in the country with its vast and dense palm groves and streets that are generally free of buildings. This city with a height of 325 meters above the sea level has a relatively flat

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topography and relatively scattered vegetation except for palm groves. Geologically, Fin region is located in the structural-sedimentary zone of folded Zagros, where the anticlines with an almost east-west trend form the heights of these regions. There are salt domes in the southeastern part of the Zagros area, unlike the northwestern part, and three salt domes can be seen in the Finn region. The faults in this area have an east-west and north-south trend. In terms of stratigraphy and rock units in the Fin region, the presence of the Hormuz salt series, which is the oldest geological layer in the region, followed by the Bangistan group, the Sachun formation, the Karaj formation, the Asmari formation, the Jahrom formation, and the Razak formation , Mishan formation, Aghajari formation, Bakhtiari formation and the Quaternary units of the present age are located.

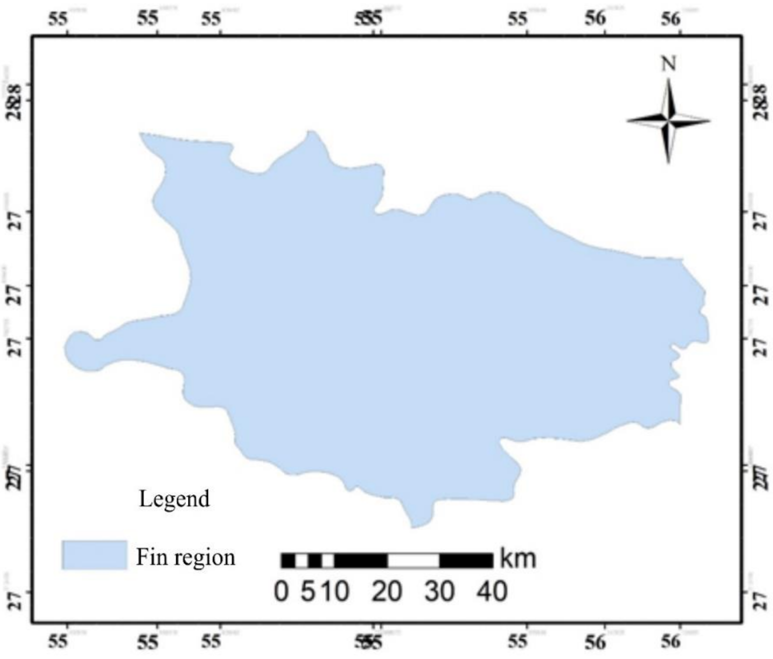

Figure 1. Fin city region

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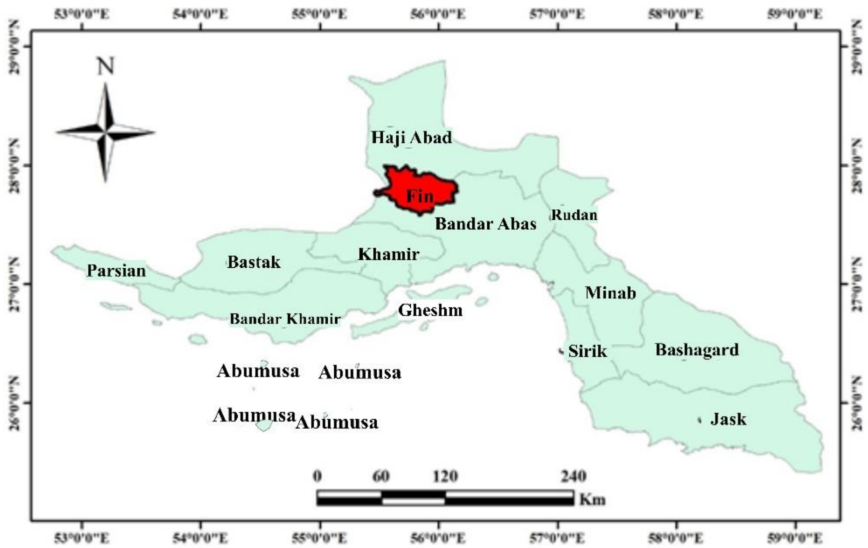

Figure 2. Location of Fin city in Hormozgan province

Research Method

To carry out this research, he first studied documentary and library sources to better understand the problem in question, and in this regard, a library study was done in the geographical context of the Finn region, as well as in the fields of geology, seismology and telemetry using satellite images. In the next step, the required data such as geological map, topography and seismology were collected from the Geological Organization and Seismological Institute of Tehran and for the initial processing of the digital and raster files of the data mentioned above in the spatial database. And the GIS software environment has been investigated and analyzed. This research is a kind of telemetry survey and study; which is carried out on the earthquakes that happened in Fin area, Bandar Abbas city with the help of radar interferometric method (InSAR). With the help of the radar interferometry method, with the help of satellite images, it is possible to identify and determine the movement of the earth's surface at any moment of the day and night and in any weather condition.

1-Radar interferometric method (InSAR)

One of the powerful tools for monitoring the subsidence phenomenon is the radar interferometric method. By comparing the phases of two radar images taken from the same area at two different times, this method is able to determine the changes of the ground surface in that time period. Processing of images by radar interferometric method is done in six steps to finally obtain a map of land surface displacement changes. In the first stage, the raw data (satellite images) are entered into the software and converted into single perspective mixed images (SLC), and then the second to fifth stages are: geometrical registration of the images, preparation of interferometry, removal of topographic effect and Filtering and phase recovery are done so that in the sixth and last step, the construction of the displacement map from the studied location is finished with ground reference. In the following, the six steps of creating a displacement map are explained:

1-1. Data entry

Data input can be in the form of raw images and mixed SLC individual data. In this study, raw data is used and it is converted into single-view mixed data by measuring and circuit calibration files.

1-2. Geometric registration

Geometrical errors cause displacement, change the shape of complications on the image. Therefore, it is necessary to remove or reduce these errors from the images. Various factors are effective in creating these geometric errors. The first problem is created by the process of mapping the external 3D reality on the 2D image screen. The displacement caused by the height difference can be seen both in satellite images and in aerial images. The rotation of the earth during imaging is also one of the factors causing distortion and displacement in the images, which can also be helped by changing the position of the platform or sensor. Oblique view, curvature of the earth, geometry and imaging system, and the large viewing angle of the sensor also change the shape and dimensions of the complications, which creates an unrealistic image. Defects in the sensor as well as the impossibility of accurate calibration in sensors are also the origin of some geometric errors in the images (Ebrahimi, 2016).

Unlike maps, remote sensing images do not have a specific coordinate system from the beginning. In addition to removing and reducing geometric errors, geometric correction also applies a specific coordinate system to the images and to some extent gives the images the features of a map in terms of geometry.

1-3. Interference formation

SLC images are mixed images that contain amplitude and phase information. The result of the complex product of two radar images is an interferometer. To obtain the interferometer, usually each pixel signal of the first image is multiplied by the complex conjugate of the second image. The signal of a pixel in the radar image is expressed as a complex number 〖Ae〗^(i∅), where A is the amplitude, i is the radiation angle, and ∅ is the phase of the radar image.

The phase difference for any point on the ground in the interferometer is a number that varies between 0 and 360 degrees. For a set of points on the earth (the 360-degree range of phase change can be displayed with 256 gray levels and in the form of fringes that represent the difference between 0 and half the value of the wavelength, i.e. 2.89 cm) with different levels (Rahmanfar and colleagues, 2005).

1-4. Topographic component

Another important component in creating the phase difference of interferometer images is the topography component. There are two methods for this (Rockwells et al., 2003). The use of three data sets (or more), which are called three passes for short. In this method, a view interference is created using the phase difference of the first and second images, and the second view interference is created from the phase difference of the second and third images. Then the two interferences of the resulting view are subtracted from each other to obtain the subtraction view interference. The second method is to use two sets of data together with an elevation model. In this method, only two radar images are used. One view interference is created by using an initial digital elevation model (DEM) and accurate satellite location information at the time of imaging, and the other view interference is obtained from the phase difference of the first and second images. Then these two interferometers are subtracted from each other to remove the effect of the height of the ground. What remains indicates change or displacement.

At the end of this stage, Goldstein's adaptive filter is used to reduce the noise of the interferometers (Goldstein and Werner, 1998).

1-5. Phase correction

In this step, the recovery of the absolute value of the phase is performed using the hidden phase, which is called phase recovery (Raucoules et al, 2003). This step is one of the most difficult steps in processing radar images due to the discontinuities and the existence of noises. There are different algorithms to do this step. One of them is the cutting lines algorithm presented by Goldstein et al. in 1988. In this algorithm, regions with high noise with low correlation are ignored in removing the phase ambiguity. Another is the minimum flow value algorithm proposed by Chen and Zebker in 2000, which works based on a triangular irregular network (TIN). This algorithm is an optimal algorithm in the world for phase recovery, and one of its advantages is the high density of the triangular network. In this algorithm, phases with low quality are ignored and phases with high quality are used in image processing. This action prevents low-quality regions from influencing high-quality regions, which in turn leads to the best possible phase recovery (Werner et al, 2003).

1-6. reference ground

In this step, the phase recovered in the previous step is georeferenced by the digital height model. so that it can be adapted to the place of study.

Research Findings

Hormozgan province includes the sedimentary-structural zones of Makran, Zagros and central Iran, and the intersection of these zones, each of which has a different pattern in terms of seismicity, has caused the concentration and diversity of seismicity in this province. The earthquakes of the last few years in the region of Qeshm, North of Bandar

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Abbas, Haji Abad, etc., are an indication of the seismic activity of this province in recent years. Multiple earthquakes in the areas close to each other in this province are related to the earthquakes. different In this, it shows the region in such a way that in some cases it is not possible to distinguish between the aftershocks of an earthquake and the foreshocks of the next earthquake in that area. Seismic studies (Fatami Aghda, 2016) show that more than 678 earthquake events have occurred in Hormozgan province in the last 3 years, 10 of which have a magnitude greater than 5.

According to the statistical data of the Research Institute of Seismology and Earthquake Engineering from seismographic stations in Hormozgan province and South Fars based on machine earthquakes (recording of seismographs after 1900 AD), so far 41 cases of earthquakes have occurred in the Fin area. Hormozgan province occurred during the years 1936 to 2022, the distribution of surface earthquake centers in this region shows the highest concentration of earthquakes in the south and southeast parts of the region, and several earthquakes can be seen in a very scattered form in the north and west of the region (Figure 3).). Major and major earthquakes occurred in this region, only 6 are larger than 5 on the Richter scale, of which 2 earthquakes were recorded in the north of the region, 3 in the southeast of the region, and 1 in the south of the region.

According to the report of the Institute of Seismology and Earthquake Engineering, the two Fin earthquakes that occurred on November 23, 1400 with a magnitude of 6.4 and 6.3 respectively at a depth of 15 and 14 meters at a distance of 24 kilometers from the city of Fin; It caused damage to houses and injured and killed several people. It has also caused the mountain to fall.

The depth of the earthquakes in the Finn area varies between 5 and 55 meters and most of them occurred at a depth of 10 to 20 meters. On the other hand, it can be said that these earthquakes have a magnitude between 3 and 6.4 on the Richter scale and the earthquakes are of great magnitude. 4 Richter are the most frequent in the Finn region.

The biggest earthquake in the Fin region was the earthquake on November 23, 1400 with a magnitude of 6.4 on the Richter scale and a depth of 15 meters in the southeast of the region; And the smallest earthquake in the region was on March 10, 1384, with a magnitude of 3 on the Richter scale and a depth of less than 5 meters in the west of the region.

The displacement map, obtained with the help of radar interferometric method, shows the dispersion and amount of displacement in the fin area (Figure 3). When the displacement is positive, it is called rise and when it is negative, it is called subsidence. According to the pattern of changes in the displacement map, the most displacements in the Finn region are related to the east, south, and southeast of the region, which have occurred as positive displacements, which are known as raised surfaces. There is also negative displacement in the region, which is known as subsidence, and they are mostly concentrated in the parts of the north, east, and center of the Finn region, and on the other hand, negative displacements are more widespread than positive displacement.

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According to the displacement map of the region, displacement values in the rising or positive state (2.7 cm) are less than the subsidence or negative state (4.2 cm).

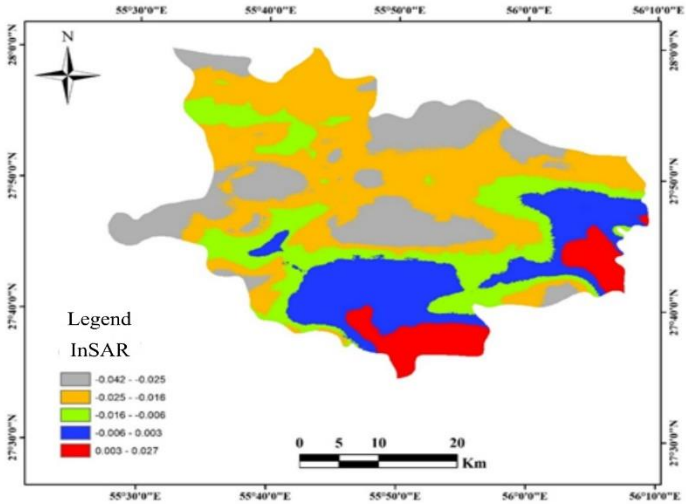

Figure 3. Earthquake displacement map of Fin region

Faults have seismic power and if they are active, they cause small and large earthquakes. There is a two-way relationship between faulting and seismicity in a region; The frequency of faults or the presence of a main fault can cause an earthquake, and on the contrary, the occurrence of many earthquakes or a large earthquake can form a fault or increase the frequency of fractures. In this way, both factors increase the seismicity of the region (Darvishzadeh, 2013).

The existing fault in the east of Fin region of Hormozgan is related to the almost north-south trend, with the concentration of the surface center of earthquakes in the south and southeast of the region, it can be said that this fault has a greater effect than other faults in causing earthquakes in the region. The maximum effect of this fault is about 4829 meters around its trend.

In general, the geological structure of the area north of Bandar Abbas consists of a series of folds in the form of anticlines and bent dips, which have an approximate east-west trend. The anticlines in the Fin area have a core of calcareous units (Asmari, Jahrom and Bangistan Group formations) and ridges of clastic, evaporite units (Mishan, Aghajari, Bakhtiari formations).

The abundance of salt domes of the Hormoz series in Hormozgan is one of the characteristics of this region, and the number of their surface outcrops reaches about 118. A number of these salt domes are also present in the Finn region, which have had a great impact on the sedimentary environment in this region due to their ability to dissolve, extreme erodibility and lithology (chalk, salt, and igneous intrusive masses).

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According to the stratigraphy of the Fin region, most of this area in the south and north is formed by rock, debris and evaporite units (sandstone, conglomerate, shale, marl, chalk and andrite) with relatively low resistance, which Bakhtiari formations, Aghajari, Mishan, Razak and Quaternary sediments are among these rock units. The central parts of the region are also formed by rock units, mainly carbonate (limestone and dolomite) with high resistance.

According to the dispersion and concentration of the surface center of the earthquakes that occurred in the Fin region, most of the earthquakes were concentrated in the south and southeast of the region and the stronger earthquakes occurred in these regions, on the other hand, the formation in the south and southeast of the region; rock units; Rubble and evaporites have relatively low resistance and have been more affected by earthquakes than rock units mainly carbonated.

Conclusion

Considering the location of Hormozgan province in the three sedimentary-structural zones of Zagros, Makran and Central Iran, the seismicity pattern in Hormozgan province is varied and on the other hand due to the location of this province in the convergence of tectonic plates and also the presence of important fractures such as the main fault Javan Zagros, the prison fault, as well as the activity of salt domes in this area of Hormozgan province are located in the active and seismic zone, the development and population growth in recent decades; It has increased the population density and construction in Hormozgan. According to the records of historical and systematic earthquakes, geological conditions and the increasing development of this province, it can be said that Hormozgan province and Fin region have a high risk of earthquakes and are considered high-risk areas in terms of earthquakes.

With the findings of this research; With the help of radar interferometric method, the location of the epicenter of earthquakes and taking into account the geology (rock units and structures) of the Fin region, the following results can be obtained about the seismicity of the Fin region of Hormozgan:

According to the data of seismographic stations, 41 earthquakes occurred in the Finn region between 1315 and 1401. The most intense one with a magnitude of 4.6 on the Richter scale occurred in 1400 and the weakest one with a magnitude of 3 on the Richter scale occurred in 2006.

The distribution of the surface centers of earthquakes in the Fin region is more concentrated in the south and southeast of the region, and several earthquakes can be seen in a very scattered manner in the north and west of the region, about 80% of the earthquakes have a depth of 10 to 15 meters and about 60% They also have a magnitude greater than 4 Richter and less than 5 Richter.

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According to the displacement map obtained for Fin (Figure 3), most of the displacements occurred in the Fin region; It includes the east, south, and southeast of the region and is characterized as a positive displacement (rise), which has a very good correlation with the location of the earthquakes in this area. The amount of displacement almost from north to south of the Finn region has a positive trend and gradually tends to rise from subsidence. The positive displacement or rise has been mostly associated with the earthquakes that occurred in the region.

The amount and pattern of displacement in the region has a good correlation with the type of geological units, and it can be pointed out that the resistant units (Asmari and Jahrom formations) have shown less displacement, but the units with low resistance (Razak formations, Mishan, Aghajari, Bakhtiari) have more movement.

The only fault located in the east of the Fin region with an almost north-south trend has a good correlation with the concentration of the surface center of earthquakes in the south and southeast of the region, it can be said that this fault has a greater effect than other faults in causing earthquakes in the region. The maximum effect of this fault is about 4829 meters around its trend.

The two earthquakes that occurred on November 23, 1400 in the Fin region, which also caused the mountain to fall, were similar to the earthquake on April 5, 1385, and probably the cause of both earthquakes can be considered the activity of a single fault.

There are several methods for calculating the displacement rate, the most suitable of which is the use of satellite image data and radar interferometry. The unique advantages of this method include low cost, very high accuracy, speed and scope of study of the region (Najmeh, 2019).

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