THE GACHIN FAULT ZONE AS THE MAIN CAUSE OF THE RECENT DEFORMATIONS ON THE SEDIMENTARY COVER AND THE 2014 MAY 27 EARTHQUAKE IN THE SOUTH OF QESHM ISLAND

Zeinab DAVOODI
Assistant Professor, Imam Khomeini International University, Qazvin, Iran
davoodi.zeinab@gmail.com

Keywords: Gachin Fault, Recent Deformation, Sedimentary Cover, 2014 May 27 Earthquake, Qeshm Island

ABSTRACT

The SE of Zagros belt is dominated by the left-lateral strike-slip faults. The NE-trending Gachin fault zone is one of the main transverse faults that cross cut the major structures of Bandar Abbas zone and continued to the Persian Gulf, in which deformations of the fault are overprinted on the major structures. The Qeshm fault trace shows a left-lateral bending because of the reactivation of Gachin fault zone. Based on the field, remote sensing and sismotectonics studies, the Gachin fault zone is the main cause of the recent deformations on the Quaternary sediments in the Qeshm Island and the surrounding areas. The activities of Gachin fault zone are continuing to present time. Migration of the earthquakes to the SW shows that this fault is the main cause of 2005/11/27 and 2014/5/27 earthquakes in the area

The northeast ward movement of the Arabian Plate towards Central Iran is in favour for the reactivation of Gachin fault zone. Therefore, it is proposed that such convergence can account for the reactivation of similar fault zones in the Zagros Fold-Thrust Belt.

INTRODUCTION

The Qeshm island lies in the eastern Persian Gulf, about 10 km off the Iranian mainland (Fig. 1b). It is about 110 km in length but as little as about10 km wide, and trends ENE, parallel with the mainland coast. Geologically, the island is part of the Zagros folded belt, which is made of marly sediments. There are three major anticlines in the island, trending EEN-WWS, NW-SE and NE-SW (Fig. 2). There have been few documented studies about seismicity of the island (Alinaghi, 2007 and Nissen et. al., 2007). Active faults in the island have been investigated in this article and the main cause of the recent deformations as earthquakes was introduced. The Qeshm island marks the southern edge of the Zagros fold system where seismicity of Zagros diffuses into the Persian Gulf (Fig. 1b). Based on historical records a few destructive earthquakes have inflicted damages on the island in the past centuries. The location of earthquakes (of the twentieth century) in iran shows that the island has been the locale of only a few background events, see Fig. 1. Nevertheless, in 2005 November 27 and 2014 May 27 with Mw = 5.9-5.3 earthquakes (Fig. 2), the relative seismic quiescence of the island ended and a number of moderate and small earthquakes shook the island.

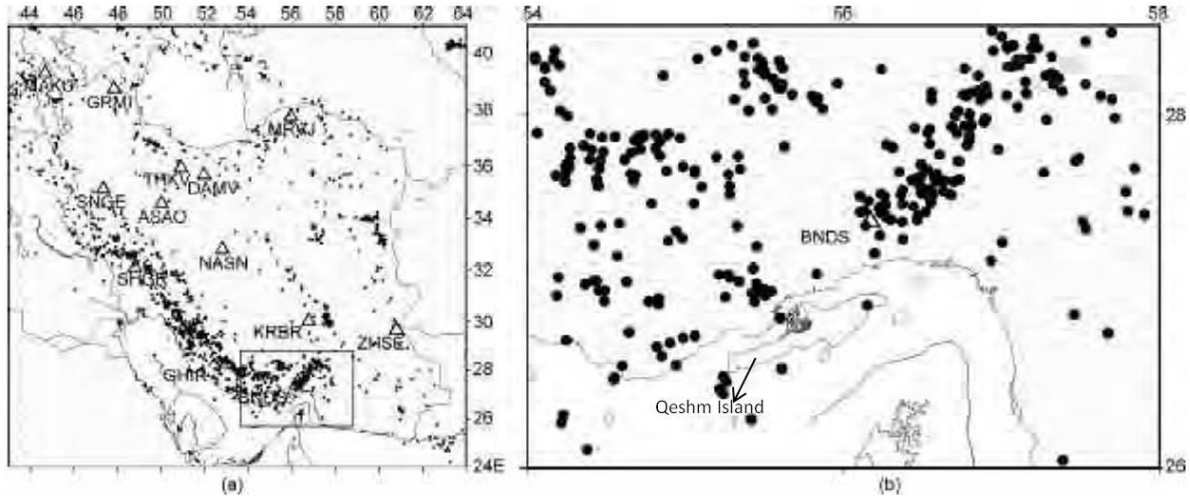

Figure 1. a. Seismicity of Iran from 1900 to the end of 2004 (Alinaghi, 2007). The study area has been marked on the map as square. b. The study area as part of the southeast Zagros and the Qeshm island with seismicity are shown as filled circles.

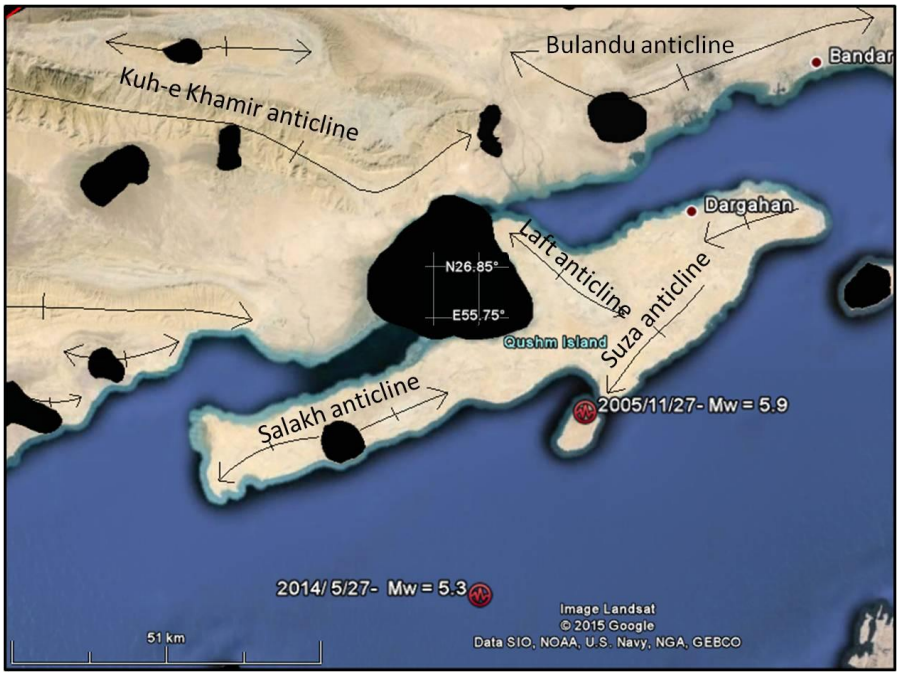

Figure 2. The hypocentre of 2005/11/27 and 2014/5/27 earthquakes on the satellite image of study area (red circles). Major fold axes are marked with black lines on the Qeshm satellite image. Black coloured polygons are salt domes.

In this paper, we combine the surface geological information on the satellite images with seismology of two main earthquakes (27 November 2005 and 27 May 2014) together with field observations to estimate the source of these earthquakes and investigate the result of recent deformations in the Qeshm Island. The purpose of this paper is also to document deformations along the Gachin fault zone and recognition of the fault pattern on the surface. The manuscript is also aimed at determining geometric and kinematics variations of structures along the Gachin fault zone for better understanding the effect of the fault zone on structural development of the Zagros fold-thrust belt.

GEOTECTONIC SETTING

The Zagros Fold-Thrust Belt is one of the youngest mountain belts, located in the middle part of the Alpine mountain system. The NW-SE trending belt developed during the collisional stage between the Arabian Plate and Central Iran in the late Cretaceous (Ricou et al., 1977). The belt has been grouped into different structural subzones including the High Zagros, the Zagros Simply folded belt and the Bandar Abbas zones in the study area (Berberian, 1995) from NE to SW. The High Zagros zone, known as Imbricate Zone, marks the northeastern part of the orogenic belt. This zone is separated from the Iranian plate along the Zagros orogeny suture zone (Main Zagros Thrust) (Fig. 3). The Zagros Simple Folded zone, known as the Bandar Abbas zone in the studied area, has major folds and thrust faults parallel to the Zagros fold-thrust belt.

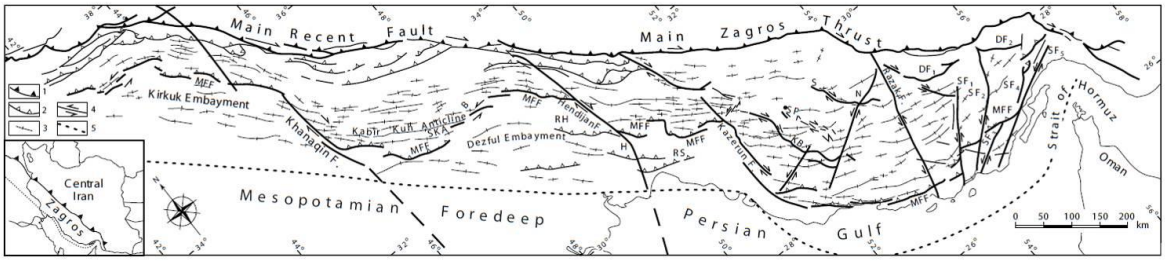

Figure 3. Structural map of the Zagros fold and thrust belt, showing major faults and anticline axes (Hessami et al., 2001).

Thrust faults and related folds are the main structural elements of the belt. These major structures are transversely cross cut by two sets of subsurface fault zones developed during the late Alpine Zagros orogeny (Falcon, 1969; Furst, 1990; Ameen, 1992; Barzegar, 1994; Hessami et al., 2001; Yassaghi, 2006) (Fig. 3). The first set oriented NNW-SSE shows right-lateral strike-slip movement such as the Izeh, Kazerun, Sabzpushan and Sarvestan fault zones. The second set, NE-SW-oriented, has left lateral strike-slip movement such as Balarud, Nezamabad, Firuzabad and Razak fault zones (Fig. 3).

METHODS

In this paper, to realize the recent deformation, subsurface and surface data analyses are done. Subsurface data is include of the depth and focal mechanism of earthquakes and the surface data is the geometry of structures such as fold and faults on the cover sediments. Remote sensing study of the satellite images was utilized for initial recognition of the exposed structures in the Qeshm Island and around it. Surface patterns such as; topography, drainage pattern, spectral reflection of rocks, bending of fold axes, geometry of young folds with en echelon pattern were used for recognition of the fault zone. Upon the results obtained from the remote sensing study, some areas on the Island were selected for detailed field studies. Seismological approaches such as earthquake hypocentral locations and focal mechanism studies play an important role in the understanding of present activities in the area. Therefore, a seismic map of the region has also been used. The sources of seismic data are on-line moment tensor catalogs, such as CMT (Centroid Moment Tensor), USGS (United States Geology Survey) and IIEES (International Institute of Earthquake Engineering and Seismology). Here we focused on the two last main earthquake 2007 /11/27 and 2014/5/27 with Mw=5.9-5.3.

STRUCTURS ALONG THE GACHIN FAULT ZONE
MAJOR (IMAGE SCALE) STRUCTURES

The SE of Zagros belt (Bandar Abbas area) is dominated by the left-lateral strike-slip faults that are detected by furst (1990) and are named with numbers on the Fig. 4.a. The general trends of folds north of the Qeshm island in the mainland Iran, being part of the Zagros system, from northwest to southeast, are

changed in the trend of structures from west and central Zagros towards southeast Zagros where seismicity and mountain ranges disappear into Makran region (Fig. 3 and 4a). Remote sensing studies of satellite images, along Gachin fault zone, show the presence of structures such as curvilinear geometry of the major fold axial traces (Fig. 4b) and bending of major reverse fault traces (HZF, High Zagros Fault; MFF, Zagros Mountain Front Fault and ZFF, Zagros Foredeep Fault) (Figs 3). These signs can be seen along the other left-lateral strike-slip faults in Bandar Abbas zone (Furst, 1990; Fig. 4a). Also as seen in Figs. 4b and 5, the Qeshm thrust fault has left-lateral bending as result of left-lateral Gachin fault.

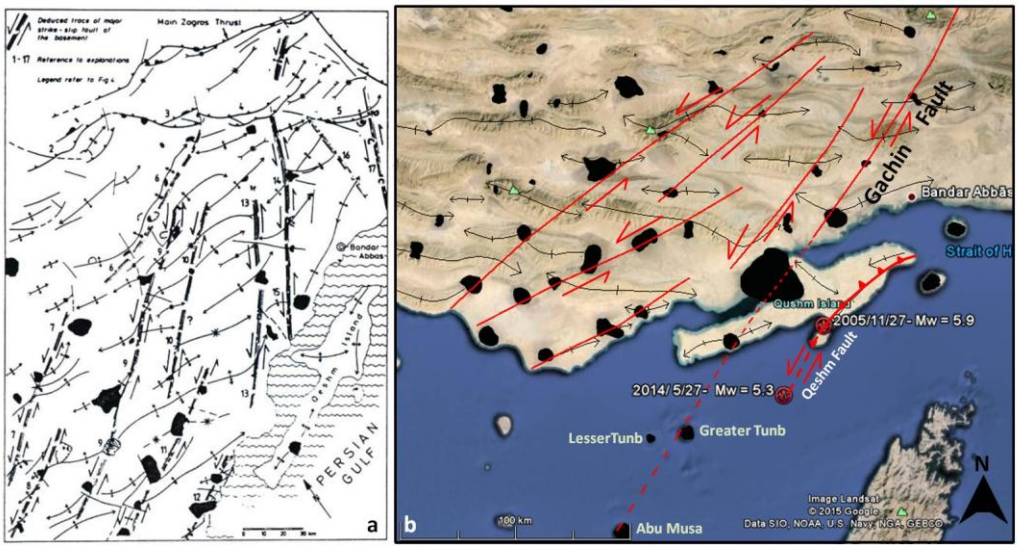

Figure 4. a.The left-lateral stike-slip faults in the Bandar Abbas area (Furst, 1990). b. The satellite image of the study area shows left-lateral strike-slip faults and fold axes traces. Black coloured polygons are salt domes.

MINOR (OUTCROP SCALE) STRUCTURES

The NE-trending Gachin transverse fault zone has influence on the structures of the entire cover sediment in the Bandar Abbas zone and Qeshm Island. Minor structures with different orientation than the behavior of the belt major structures, which can only be recognized in the field, were studied in detail along the Gachin fault zone. These structures, which are referred as younger structures in this study were overprinted on the belt major structures. For example, some of the minor folds with NE-SW trending are mapped in the Qeshm Island and north of Namakdan salt dome; these folds are outcropped on the Quaternary sediments (Figs. 6 and 7a). Also in this selected area (Fig. 6), the streams are affected by some minor right-lateral strike-slip faults within Gachin deformational fault zone (Fig. 7b).

Figure 5. The satellite image of the study area shows Gachin fault (No. 15 on Fig. 4a), Gohreh fault (No. 13 on Fig. 4a), Qeshm fault and location and focal mechanism of 2005/11/27 and 2014/5/27 earthquakes.

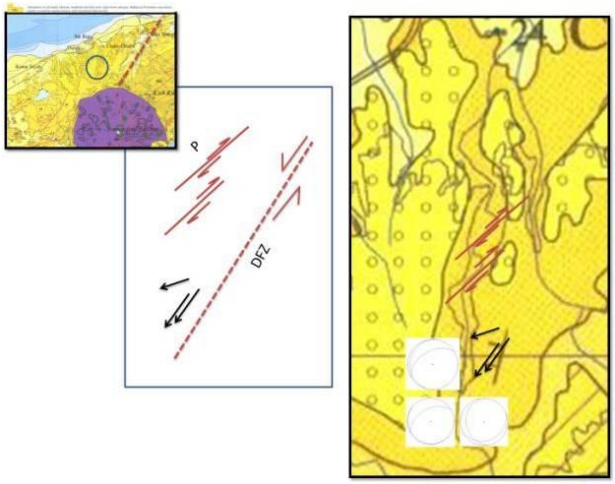

Figure 6. The structural map of some minor folds and faults on the Quaternary sediments of Qeshm Island along the Gachin fault zone. The positon of this figure shows on the Figure 5. DFZ: Gachin Deformation Fault Zone.

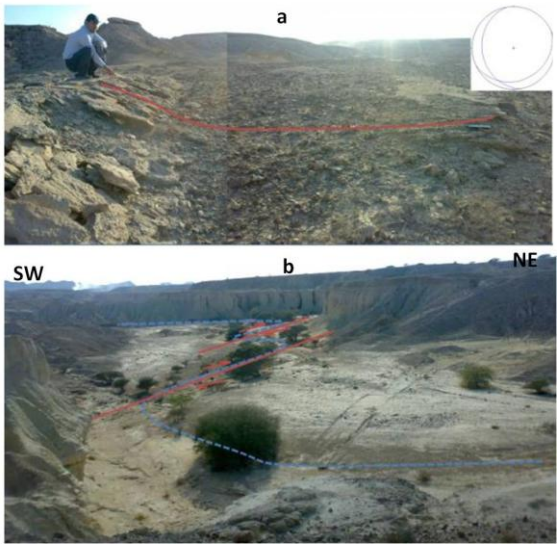

Figure 7. a. Photo of a minor fold on the Quaternary sediments of Qeshm Island. The stereonet shows the fold axes. b. The offset of streams along right-lateral minor faults within the Gachin fault zone in the Island.

EARTHQUAKES

As the seismological approaches such as earthquake hypocentral locations and focal mechanism studies play an important role in the understanding of present activities of the area, the seismic map of the region has been used. The last main earthquakes in the area are 2007 /11/27 and 2014/5/27 with Mw=5.9-5.3. Sources of seismic data are on-line moment tensor catalogs, such as CMT (Centroid Moment Tensor), USGS (United States Geology Survey) and IIEES (International Institute of Earthquake Engineering and Seismology). These earthquakes have strike-slip focal mechanisms (Fig. 5).

DISCUSSION AND CONCLUSIONS

The SE of Zagros belt (Bandar Abbas area) is dominated by the left-lateral strike-slip faults that are detected by furst (1990). In this article we believed that the Gachin Left-lateral strike-slip fault zone trending N-030 is the main cause of the recent deformations on the Quaternary sediments in the Qeshm Island and Surrounding areas based on the field, remote sensing and sismotectonics studies.

Remote sensing studies of the satellite images along the fault zone show presence of structures such as curvilinear geometry of the major faults and fold axial traces and Salt dome outcrops (Fig. 4). Other significant structures such as minor folds and faults can only be mapped at field. These minor structures can be recognized on Quaternary sediments in Qeshm Island.

The activities of Gachin fault zone are continuing to present time. This can be constraint by epicentral locations of few earthquakes occurred with left-lateral focal mechanism parallel to the Gachin fault zone especially the 2005 November 27 and 2014 may 27 earthquakes (Fig. 5). The epicenter of these earthquakes and their aftershocks are along a curved line as a continuation of the Qeshm reverse fault with strong left-lateral component to the south (Fig. 5). So the Qeshm fault trace shows a left-lateral bending on Fig. 5 because of the reactivation of Gachin fault zone.

The Gachin Strike-slip fault is continues to the SW of the fault No. 15 (Fig. 4a) toward the Abu Musa salt dome. It can be concluded that, reactivation of this fault is the main cause of 2005/11/27 and 2014/5/27 earthquakes in the area. Migration of the earthquakes to the SW shows that the present activities at the Gachin fault southern parts are greater than its northern portion.

The northeast ward movement of the Arabian Plate towards Central Iran is in favour for the reactivation of Gachin fault zone. Therefore, it is proposed that such convergence can account for the reactivation of similar fault zones in the Zagros Fold-Thrust Belt like Gachin fault zone (Davoodi and Yassaghi, 2009).

REFERENCES

Alinaghi A (2007) Moment Tensor Inversion of Some Events of Qeshm Island Earthquake Sequences Using INSN Broadband Data, JSEE, 9 (3): 153-157

Ameen MS (1992) Effect of Basement Tectonic on Hydrocarbon Generation, Migration and Accumulation in Northern Iraq, AAPG Bull., 76: 356-370

Barzegar F (1994) Basement fault mapping of E Zagros folded belt (SW Iran) based on space-born remotely sensed data, In: Proceedings of the 10th thematic conference on geologic remote sensing: exploration, environment and engineering. San Antonio, Texas, 455- 466

Berberian M (1995) Master “blind” thrust faults hidden under the Zagros folds: active basement tectonics and surface morphotectonics, Tectonophysics, 241: 193-224

Davoodi Z and Yassaghi A (2009) Syn- to post-collision role of Izeh transverse fault zone in deformation of the Zagros fold-thrust belt, Journal of Trabajos de Geología, 29: 206-212

Falcon L (1969) Problems of the relationship between surface structure and deep displacements illustrated by the Zagros range, In: P. KENT, G. SATTERTHWAITE and A. SPENCER (eds): Time and place orogeny. Geol. Soc. London: 9-22

Furst M (1990) Strike-slip faults and diapirism of the South-Eastern Zagros ranges, Proceedings in symposium of diapirism, Bandar Abbas, Hormozgan, Iran, 2: 149-181

Hessami K, Koyi HA and Talbot CJ (2001) the significance of strike slip faulting in the basement of the Zagros fold and thrust belt, J. Petrol. Geol., 24: 5-28

Nissen E, Ghorashi M, Jackson J, Parsons B and Talebian M (2007) The 2005 Qeshm Island earthquake (Iran)—a link between buried reverse faulting and surface folding in the Zagros Simply Folded Belt, Geophys. J. Int

Ricou LE, Braud J and Brunn JH (1977) Le Zagros, Mém.Hors-sér. Soc. Géol. Fr., 8: 33-52

Yassaghi A (2006) Integration of landsat imagery interpretation and geomagnetic data on verification of deep-seated transverse fault lineaments in SE Zagros, Iran, Int. J. Remote Sens., 27, 18-20: 4529-4544