A Reconnaissance Report on two Iran, Makran Earthquakes; 16 April 2013, Mw7.8, Gosht (Saravan) and 11 May 2013 Irar (Goharan), Bashagard, SE of Iran

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Introduction

Iran experienced 2 strong earthquakes in April and May 2013, in the Makran ranges within 25 days of each other. The first earthquake occurred on 16 April 2013, with a magnitude of Mw7.8 in the Saravan region in the eastern end of Iranian Makran, and the second happened in western Makran, on 11 May 2013, with a magnitude of Mw6.2 in the Irar, Bashagard region, close to the Minab-Zendan Fault zone. This report tries to summarize the reconnaissance reports and early seismological and earthquake engineering evaluations on these two strong earthquakes.

1. Seismicity of the Makran belt.

The most known earthquake in the Makran region is the 27 November 1945 M8.2 earthquake on the coastline of the Makran (370km south of the epicenter of the 16 April 2013 Mw7.8 earthquake). Two other important earthquakes in the epicentral region of the 2013 earthquakes were the Mw7.0 18 April 1983 Saravan earthquake and the Mw7.2 18 January 2011 Dalbandin, Pakistan earthquake.
2. Gosht (Saravan) Makran, Iran Earthquake of 16 April 2013

On 16 April 2013, a Mw7.8 earthquake occurred in the western end of Makran, Iran. At 10:44 UTC (15:14 local time), April 16, 2013, an earthquake struck the Saravan region in southeastern Iran (Figures 1 and 2). The earthquake had reportedly 41 victims and more than 180 injured people. One of the victims was reported from Iran (in the village of Ghaderabad of the city of Khash) and the 40 others were reported from Pakistan (Figures 3 and 4). The early financial assessment of the earthquake losses by the governary general of Sistan and Baluchestan province of Iran shows a loss of about 50 million USD (Iranian Mehr News Agency, 17 April 2013). The Mw was assessed to be 7.8 and a depth of 63km was assigned by IIEES. The focal mechanism is found to be mostly extension faulting and the fault trend is evidently ENE-WSW (Figure 2). According to the EMSC reports it was almost pure normal faulting (Figure 2), with a focal depth of 84 km. Other reports on Focal mechanisms (i.e. by USGS) show mostly normal faulting with a little strike-slip component. According to the deep depth of this event, this event can be associated with the subduction of the oceanic lithosphere of the Arabian plate beneath the Makran ranges. The tectonic setting in this area was studied by several geologists and seismologists such as Byrne et al (1992) and Musson (2009) that explained a subduction zone for this area.

A map of earthquake occurrences, which contains instrumentally and historically recorded earthquakes, is shown in Figure 5. The epicenter of the earthquake lies in the mountainous topography region; however, the surrounded area of the epicenter is moderately populated (about 98,000 people live within a distance of about 100km from the epicenter). The shock was felt strongly in Gosht (assessed VI+, 35 km southwest of the epicenter), Saravan (VI, 60 km S) and Zahedan (VI, 190 km NW) and less strongly in Masqat (IV, 650 km S) and the Persian gulf Islands (IV, >700 km W) as well as the strong shaking felt in the high rise buildings of Dubai, Doha, Manama and even in Kuwait (Figures 3 and 4).

2.1. The Earthquake Intensity and damage distribution

The epicenter of the Saravan earthquake of 16 April 2013 of Mw 7.7 occurred about 35 km NE of the city of Gosht (about 5,800 inhabitants based on the census of 2006, Figures 6 and 7), and the epicentral region was a sparsely populated area. Partial damages were observed in the villages of Kelk, Kuh-e Sefid, Posht-Kuk, Kuhisar, Tighab, Dashtu, Bandaran, Petkuk, Kelekgili, Kelekvajeh, Ghaderabad, and Gol-e Pichak, all located around the city of Gosht. The event destroyed 300 houses, left 1,000 homeless and damaged 500 more houses in nearby villages, primarily in the Pakistan region (Figures 3 and 4). Surface fissures are found near Gosht and in the Village of Gol-Pichak (Figure 8).

2.2. Strong Motions

According to BHRC (The Iranian Building and Housing Research Center), this event was recorded by 33 sets of digital 3 component accelerographs in the Iran Strong Ground
Motion Network, from which 6 accelerograms having a recorded PGA greater than 100 cm/sec$^2$ are shown in Table-1. The peak acceleration was recorded at the Sabz-Gaz station (198 cm/sec$^2$) with a 91km hypocentral distance. The corrected accelerograms as well as the velocity and displacement time-histories are presented in Figure 9, for Gosht Station, and the response spectra for this three component record is presented in Figure 10.

The intensity and PGA ShakeMaps developed in this study are shown in Figure 11, based on magnitude, finite fault and strong motion data.

2.4 Disaster Management

Just after the earthquake, the assessment and evaluation teams as well as rescue teams from the Iranian Red Crescent Society were dispatched to the quake-stricken area, which is a sparsely populated rural area between the provincial cities of Saravan and Khash in the Iranian Sistan-and-Baluchestan province. The major part of the search and rescue operations were performed in the first 12 hours after the earthquake. The earthquake has caused no major casualty in engineered structures in the macroseismic epicenter. The tremor was powerful enough to be felt as far away as New Delhi, India, where it rocked tall buildings (Figure 3). It was also felt in the Persian Gulf's littoral states of Bahrain, Kuwait, Oman, Saudi Arabia and the United Arab Emirates (Figure 3) causing a panic for most of the people living in the tall buildings in the Persian Gulf states and the major cities in Kish Island (780km), Dubai (750km), and Abu-Dhabi (780km), Doha (1200km) and Manama (1400km) approximate distances to the epicenter. 40 people are reported to have been killed in Baluchestan province of Pakistan near the Iran border. There are reports of damage in several houses that were destroyed in Pakistan due to earthquake in Mashkel and the Panjgur District near the Iran border.

3. Irar, (Goharan, Bashagard) SE Iran earthquake of 11 May 2013, Mw6.2

The earthquake occurred at 6:38 local time in a sparsely populated region, close to the Minab-Zendan fault Zone, which marks the western end of the Makran ranges (Figure 12). The recent seismicity in the Makran zone (Figure 13) shows that the earthquakes of 16 April and 11 May 2013 are the major events in this region during the last nine years. The cluster of the foreshock, main shock and the first 8 days of aftershocks is presented in Figure 14. There was a foreshock of Magnitude mb5.0 on 9 May 2013, at 12:31 a.m. (local time), which produced a preliminary alert mid-day and resulted in the evacuation of the residents, in order to be temporarily relocated to the local tents named as "Kapar" (Figure 15). Therefore during the main shock there was only one victim (a 2 year old girl) in Irar.

3.1 Causative fault and ground fissures

The epicenter was located close to Irar, 10km north of Goharan, about 25km north of Sardasht (Figure 16). The focal mechanisms are reported to be mostly strike-slip (Figure 17). According to the existing faults in the region, the Manujan fault (Figure 18) with a right
lateral strike-slip movement and a NW-SE trend having a slip towards the east (Figure-19) is expected to be the causative fault. The location of the epicenter and the fault slip towards the east might be a justification for a depth between 20 to 25km for this earthquake (Figure 19). This fault is parallel to the Minab-Zendan-Palami fault zone (Figures 16 and 18). The surface fissures, observed around the road from Goharan to Irar (kilometer 5, north of Goharan, and just at the end of this road (Figure 20). However it does not present the systematic evidences of surface fault rupturing, it continues in an en-echelon NE-SW direction near Irar, for about 5kms, and the fissure segments mostly have azimuths of N320 to N330.

3.2 The Earthquake Intensity and Damage Distribution

The shakemaps are developed in this study immediately after the mainshock (Figure 21) showing the maximum assessed intensity to be VI+ around the epicenter. The visit to the epicentral region showed that the macroseismic epicenter was located in Irar village, that experienced an intensity of VI+ (EMS98) (Figure 22) and the intensities are assessed to be VI in Goharan, Sardasht and Bolbolabad, and V in Jakdan, Patahk and Senderk, V in Minab and Jask and III in Bandarabbas (Figure 22).

3.3 Strong Motions

The strong motions of this earthquake was recorded by the accelerometric stations of the Building and Housing Research Center (BHRC; http://www.bhrc.ac.ir/portal/Default.aspx?tabid=1276). There are 2 records obtained in Senderk and Sirik (Table 2). The most important records was obtained in Senderk having the highest PGA of 16.7 cm/sec², after correction (Figures 23 and 24), at a hypocentral distance of 49km. The accelerograms recorded in Senderk are presented in Figure 23 and the response spectra are presented in Figure 24. There are some ground fissures in the road from Irar to Goharan (Figure 25), as well as a major rock slide about 5km north of Goharan (Figure 26). There is an old rock slide (possibly related to a previous earthquake in the same location, with the same size of dislocated rock blocks, but no document is found yet on such probable historical earthquake.

3.4 Disaster Management

The population of Goharan in about 6,000 and the all of the villages around Goharan have about 9,000 inhabitants. Most of the observed damage was in Irar village (Figure 27), where some buildings were extensively fissured and out-of-use. The casualties were evidently intensified in the aftershock that occurred in 18 May (M5.7). The urgent sheltering performed first by the people themselves using their hand-made tents (Kapar’s) and then by Iranian Red Crescent Society; IRCS (Figure 28). There are some walls collapsed in Irar (Figure 29) and some shear cracks (Figure 30). The damages were slight in Goharan, for instance in Goharan Municipality no major casualty was observed (Figure 31), however the temporary shelters are installed by IRCS (Figure 32). 3,612 tents have been installed in the region.
4. Conclusions

There were two strong earthquakes in the Makran belt of Iran, in April and May 2013, but there were only 2 people killed, due to the population situation in this region of Iran (which is very sparsely populated), and the depth conditions (both of the events had the depth more than 20km). There is some evidence that the normal faulting in this subduction zone especially in the 16 April 2013 earthquake might be a precursor to major thrust faulting (based on the similar consequences in Chile; Malgrange et al, 1981), therefore it is a major warning for a major possible disaster in this range in Iran and Pakistan in the future.

References

3. CSEM, Euro-Mediterranean Seismological Centre; 2013; http://emsc-csem.org
Figure-1: The epicenter of the Gosht (Savaran), SE Iran, western Pakistan, by Norwegian Refugee Council (from https://www.relief-web.int).
Figure-2: The quick moment tensor solutions (EMSC).
Figure-3: The Iso-seismal map of the 16 April 2013, Gosht, Saravan Earthquake (Mw7.8) showing a very vast region in SW Asia, where the earthquake is felt (by more than 100 million people from northern India to all over Pakistan and SSE of Afghanistan and most part of southern Iran, to all over Persian Gulf shorelines).
Figure-4: A close-up view of the macroseismic epicenter, in the isoseismal map of the 16 April 2013 Ghost (Saravan), SE Iran earthquake (Mw7.8).

Figure-5. Seismicity map of Earthquake region.
Figure-6: The damages in the epicentral region of Gosht, Saravan Earthquake, 16 April 2013, Mw7.8 earthquake (Photo by AFP).
Figure 7a.

Figure 7b:

Figure 6a) a fissure in a house in Gosht, Figure 6b) The electric power supply column declined during the mainshock in Gosht, Saravan.
Figure-8a)

Figure- 8a) Surface fissure near Gosht, Figure 8b): The surface fissure in Gol-Pichak village (nearby Gosht) created during the mainshock of 16 April 2013 Mw7.8 earthquake.
Figure-9: The Accelerometers obtained in Gosht Station, Acceleration (Column; left), Velocity (Column; Center) and Displacement (Column; right). (Ghost, Saravan, 16 April 2013 Earthquake).
Figure 10: The response spectra obtained in Gosht Station, PSA (left), PSV (Column; Center) and PSV (Column; right), (Ghost, Saravan, 16 April 2013 Earthquake).
Figure-11: ShakeMaps of the event generated by the IIEES.
Table-1: The Strong Motion records obtained in the Gosht (Saravan) Earthquake of 16 April 2013, Mw7.8, after processing (based on records obtained by Building and Housing Research Center; BHRC; [http://www.bhrc.ac.ir/portal/Default.aspx?tabid=1260](http://www.bhrc.ac.ir/portal/Default.aspx?tabid=1260)). The 2 records having a PGA greater than 10 cm/sec2 are shown in the table.

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Figure-12: The General Situation of the Makran subduction Zone and Zendan fault zone in the SE of Iran (Musson 2009).
Figure-13: The Seismicity of the region (since 1 January 2004 to 25 May 2013, based on the data base of CSEM)

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Figure-18: a selected part of 1:100,000 Scale geological map of the region, on which the major faults of the epicentral region of the Irar (Bashagard) earthquake of 11 May 2013 are projected (from; Geological Survey of Iran, Taherui Quadrangle, 1:100,000).

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Figure-21c:

Figure-21d:
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Figure-26a:
Figure-26b

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Figure-27: Damage to a building in Irar, created during the mainshock and the aftershock of 18 May 2013.
Figure-28: temporary sheltering in Irar, in "Kapar’s" and the tents installed by the Iranian Red Crescent Society.
Figure-29: Damage to the buildings in Irar, created during the 11 may 2013 earthquake.
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Figure-31: Municipality of Goharan, resisted to the mainshock of the 11 May 2013 earthquake.
Figure-32: Temporary shelters in Goharan, by Iranian Red Crescent Society after 11 May 2013 earthquake.

Table-2: The Strong Motion records obtained in the Irar (Goharan, Bashagard) Earthquake of 11 May 2013, Mw6.2, after processing,

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