Mormori (Ilam) SW Iran's Earthquake of 18 August 2014, Mw6.2: A Preliminary Reconnaissance Report

By:

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Abstract:

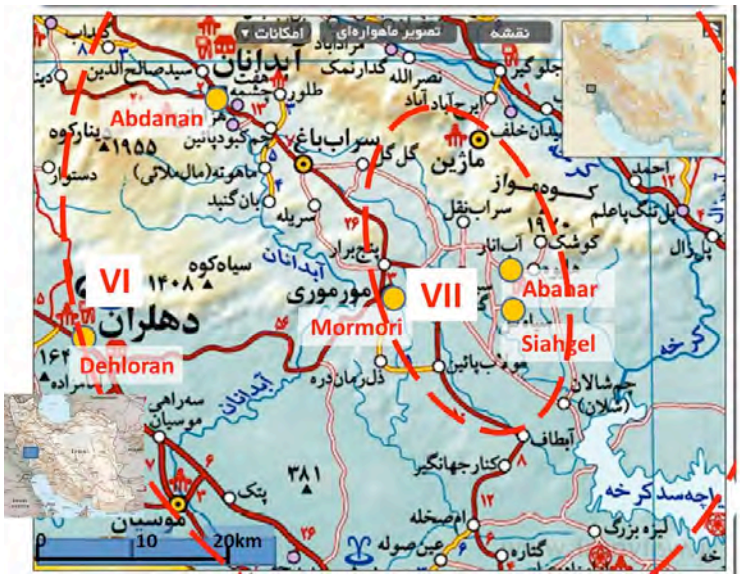
The Mormori (Abdanan, Ilam) Earthquake of August 18, 2014 (Mw6.2) occurred at 7:02 a.m. (local time) (2:32 a.m. GMT) near the small town of Mormori, between the Ilam and Khuzestan Provinces of SW Iran (Figures 1, 2 and 3), 40Km from Dehloran and 38km from Abdanan. The initial estimate of the earthquake depth is estimated to be 10km. The earthquake had two foreshocks on August 17, 2014; one at 3:45 pm with Mb4.6 and one at 7:17 pm (local times) with Mb4.8. These two foreshocks led to the evacuation of many citizens; fortunately during the mainshock no one was killed. 250 people were however reported injured and about 12,000 were made homeless. About 2500 tents have been distributed in the meizoseismal zone by the Iranian Red Crescent Society. The earthquake occurred near the Balarud E-W directed fault (a part of the Zagros Mountain Front Flexure; ZMFF) and the Dalpari fault (NW-SE trend) that is traced about 10km to the west of the epicenter.

Based on the location of the epicenter, the distribution of the aftershocks, and the major direction of displacements (NE-SW to E-W) it is concluded that the Dalpari thrust fault with a NW-SE trend was the causal fault for this earthquake. This report is prepared to summarize the results of a preliminary reconnaissance visit as well as to provide a conclusion on the available scientific information on this specific swarm-type earthquake in south Zagros of Iran.

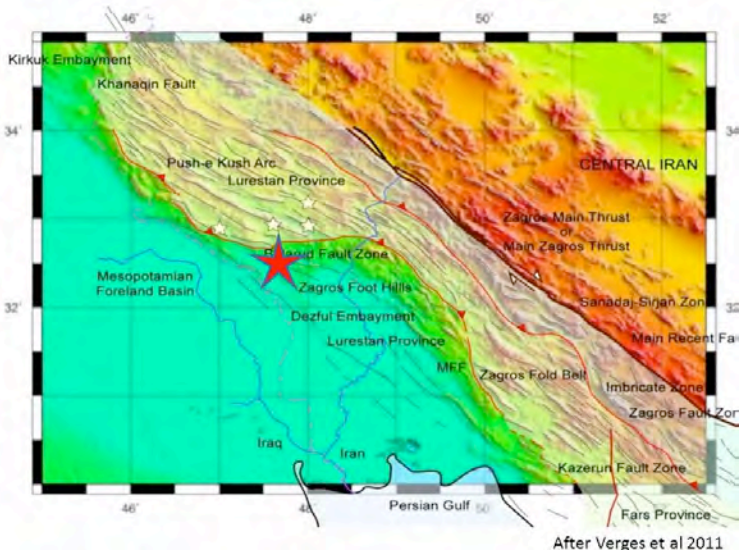
Introduction:

The epicenter was located in the Zagros foothill zone (Figures 1b and 2). The anticline of Kabir-Kuh is located to the north of the epicenter. The great pre-historic Seymareh Landslide (12km width and 16km length) is located 30km north of the epicenter (on the northern flank of the Kabir-Kuh anticline; Figure-2). It is estimated that this mega-landslide occurred in the early Holocene time (11000y ago). A major (M7.5-8.0) earthquake may have triggered such mega landslide.

The small town of Mormori has a population of 3,700, and is located about 35km from Abdanan, a city with a population of 31,000. The cities of Dehloran and Mousian are about 40km from the epicenter and have populations of 27,000 and 2,500, respectively. The city of Darreh-Shahr is about 70km to the epicenter and has about 19,000 inhabitants. An estimated 4,000 people were exposed to a shaking intensity of VII (EMS98) during the Mormori earthquake , and about 160,000 are estimated to have experienced shakes of intensity VI+ . The epicentral region has an elevation ranging from 350 to 500 meters above sea level (Figure-1a) with the highest point at the great Kabir-kuh Anticline with 2790m (one of the longest anticlines in the Zagros belt with the axis length of 170km) (Figure-2).



a)



b)

Figure-1: a) The Epicenter and b) major Structural Units in the SW Zagros of Iran (after Verges et al 2011). The epicenter of the 18 August 2014 earthquake is marked with a star.

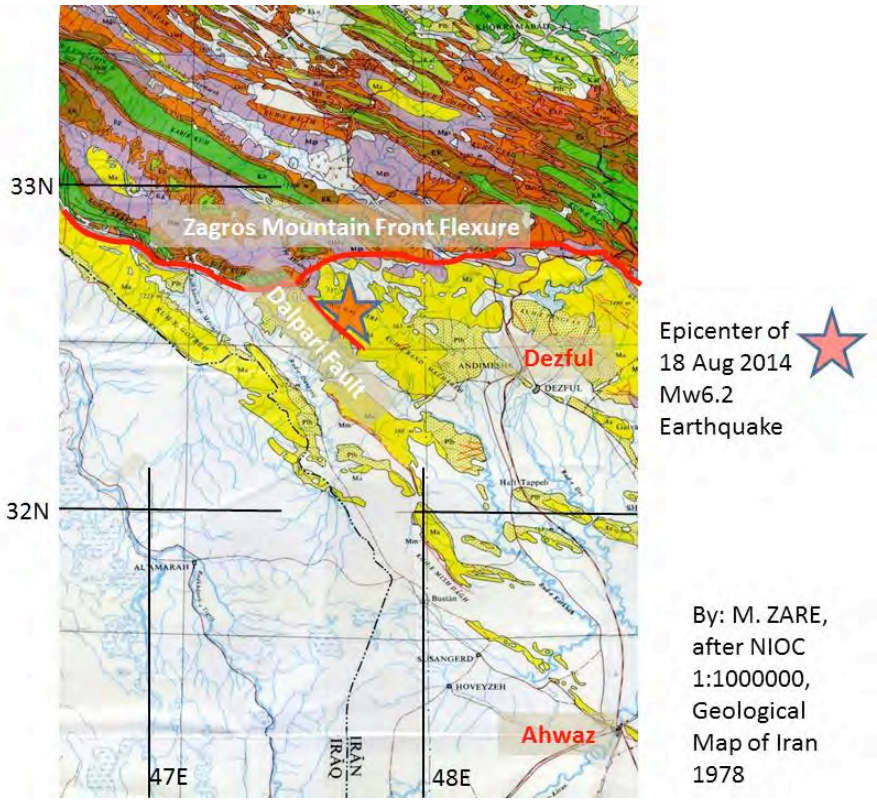


Figure-2: The faults traces are mapped on the Geological map of NIOC, 1:1000000 Scale (1978).

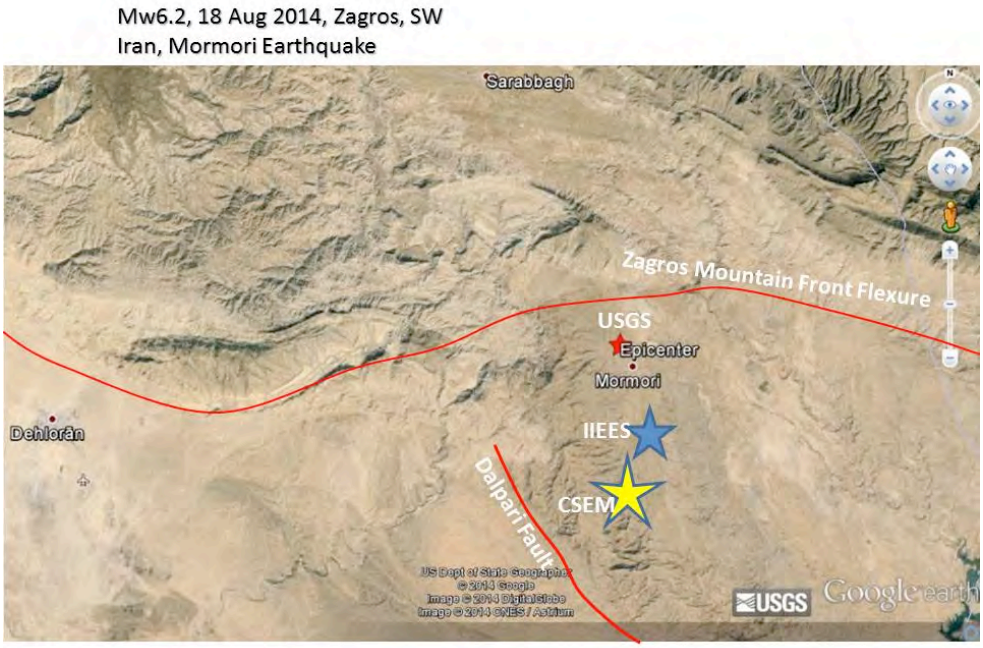


Figure-3: The epicenter of the 18 August 2014 earthquake as reported by USGS, IIEES and CSEM, mapped on google map, compiled from the local fault traces.

Seismicity:

The seismicity associated with the epicentral region of this earthquake is determined by the seismicity along the ZMFF and the Zagros Main Recent Faults (Table-1). The major seismicity is related to the Andimeshk Seismic Trend (Zare 1991), with an E-W trend. The region within 100 km of the epicenter has experienced strong earthquakes in the past, including in 872 AD (M6.8) and 1955 (mb6.0; Figure-4). There might have been a great archaeo-event 10000 years ago (early Holocene) which triggered the major landslide of Seymareh (Kabirkuh) which has a width of 12km and a length of 16km (greatest ever known mega-landslide in Iranian Plateau). Based on the background seismicity of the region and on the major landslide of Seymareh (Kabirkuh) located about 70km north of the meizoseismal zone of the Mormori 2014 earthquake, it is recognized that the region could be a seismically hazardous region and prone to strong earthquakes in the future.

The foreshocks, mainshock and aftershocks are listed in Table-2 (based on a report by CSEM) for the first 3 days after the mainshock. This list indicates that this earthquake generated a significant number of aftershocks. There are 36 aftershocks with M>4.5 and 8 with M>5.0 in the first 20 days after the mainshock, that might be a sign of another mainshock (with M>6.0) in coming 60 days.

Table-1: The seismicity of the region around Mormori 18 August 2014 Mw6.2 earthquake (for M>5.5) in a region with a radius of 150km.

Historical and instrumental recorded seismicity within 150 to the Epicenter of Mw6.2 Mormori Earthquake of 18 Aug 2014, for M>5.5

Date			Time			Coordinates									
Y	M	D	HH	MM	SSS	Lat.N	Lon.E	FD	mb	Ms	Mw	ML	Efa	Ref	Region
872	06	22				33.200	47.200	0	.0	6.8	.0	.0		Amb	Symareh
1457						31.900	46.900	0	.0	6.1	.0	.0		Amb	Dejleh
1909	01	23	02	48		33.000	49.000	0	.0	7.4	.0	.0	*	Amb	Silakhor
1917	07	15	17	58		33.500	46.500	0	6.3	5.6	.0	.0		Amb	
1927	11	12	14	46		32.390	46.970	0	6.0	5.6	.0	.0		Amb	
1939	11	04	10	15		32.600	49.020	0	6.0	5.7	.0	.0		Amb	
1941	06	10	20	38		33.500	46.840	0	.0	5.5	.0	.0		Amb	
1952	08	13	14	30	35	33.750	47.750	81	5.6	.0	.0	.0		NOW	
1955	12	04	14	02	12	33.370	48.800	65	6.0	.0	.0	.0		NOW	
1955	12	17	08	06	30	33.500	49.000	0	5.7	.0	.0	.0		BCIS	
1962	06	29	22	35	40	32.340	48.800	58	5.6	.0	.0	.0		NOW	
1976	11	07	11	07	60	33.235	47.963	51	5.5	.0	.0	.0		NEIC	
1977	06	05	04	45	10	32.636	48.086	40	5.8	5.7	.0	.0		Amb	
1980	10	19	17	24	10	32.762	48.572	42	5.3	5.8	.0	.0		NEIC	
1983	05	28	11	35	60	32.594	48.581	18	5.6	5.1	.0	.0		NEIC	
1994	07	31	05	15	39	32.557	48.369	43	5.3	5.3	5.6	.0		NEIC	
1998	08	05	14	27	00	33.210	46.250	33	5.6	.0	.0	.0		NEIC	
2001	03	23	05	24	11	32.950	46.620	33	.0	.0	5.5	.0		NEIC	
2006	03	31	01	17	03	33.580	48.800	15	5.7	.0	.0	.0		ISC	

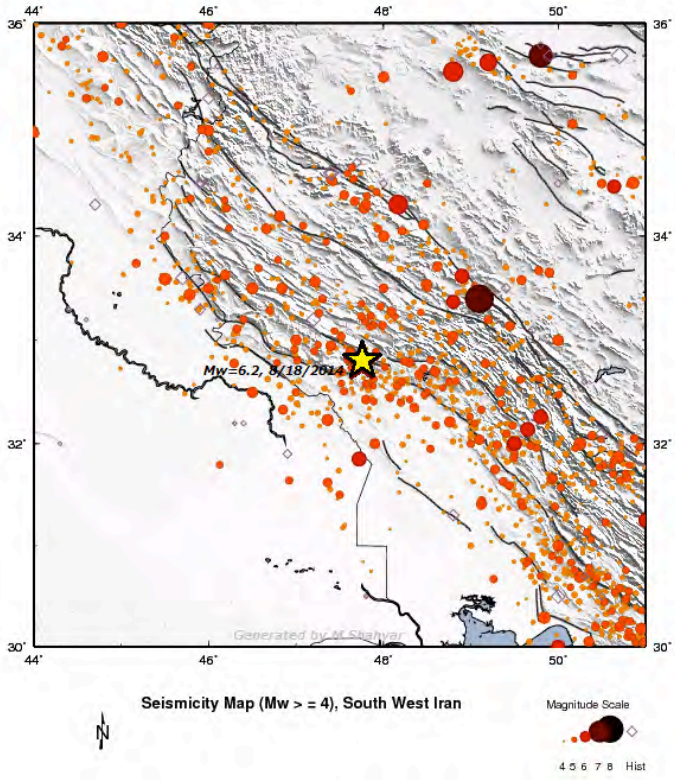


Figure-4: The instrumental Seismicity of the epicentral region of Mormori 18 August 2014 Mw6.2 earthquake.

Table-2: The foreshocks, mainshock and the aftershocks of Mormori 18 August 2014 Mw6.2 earthquake, as reported by CSEM web site (in the 1st 3 days after the mainshock).

forsheocks and Aftershock reported by CSEM from the epicentral Zone of Mormori, Iran Earthquake from 17 August 2014 up to 21 August 2014

Citizen Response		Date & Time UTC	Latitude degrees		Longitude degrees		Depth km	Mag[+]	Region name
			1 2 ›						
6	F	2014-08-20 10:14:15.5	32.51	N	47.79	E	10	5.6	IRAN-IRAQ BORDER REGION
		2014-08-19 21:32:17.5	32.64	N	47.56	E	10	5.2	IRAN-IRAQ BORDER REGION
		2014-08-19 17:59:11.7	32.57	N	47.65	E	10	4.6	IRAN-IRAQ BORDER REGION
		2014-08-19 10:32:53.0	32.49	N	47.68	E	10	4.8	IRAN-IRAQ BORDER REGION
		2014-08-18 21:44:27.4	32.45	N	47.58	E	6	4.7	IRAN-IRAQ BORDER REGION
		2014-08-18 18:54:58.8	32.70	N	47.70	E	10	4.6	IRAN-IRAQ BORDER REGION
		2014-08-18 18:36:18.5	32.54	N	47.75	E	10	4.6	IRAN-IRAQ BORDER REGION
7	F	2014-08-18 18:08:23.7	32.46	N	47.74	E	10	5.9	IRAN-IRAQ BORDER REGION
		2014-08-18 17:40:29.8	32.65	N	47.71	E	10	4.6	IRAN-IRAQ BORDER REGION
		2014-08-18 11:51:34.3	32.62	N	47.54	E	10	5.7	IRAN-IRAQ BORDER REGION
		2014-08-18 11:23:03.3	32.53	N	47.56	E	10	4.9	IRAN-IRAQ BORDER REGION
		2014-08-18 11:06:53.3	32.59	N	47.60	E	10	4.7	IRAN-IRAQ BORDER REGION
		2014-08-18 11:01:40.7	32.63	N	47.66	E	10	4.8	IRAN-IRAQ BORDER REGION
		2014-08-18 08:05:27.4	32.66	N	47.49	E	10	4.9	IRAN-IRAQ BORDER REGION
		2014-08-18 06:59:01.1	32.72	N	47.88	E	10	4.6	IRAN-IRAQ BORDER REGION
2	F	2014-08-18 05:25:51.7	32.58	N	47.72	E	10	5.7	IRAN-IRAQ BORDER REGION
		2014-08-18 04:39:31.4	32.64	N	47.77	E	10	4.6	IRAN-IRAQ BORDER REGION
		2014-08-18 04:20:46.6	32.76	N	47.57	E	50	4.7	IRAN-IRAQ BORDER REGION
		2014-08-18 03:11:31.1	32.65	N	47.58	E	10	4.7	IRAN-IRAQ BORDER REGION
		2014-08-18 03:01:35.2	32.49	N	47.54	E	20	4.8	IRAN-IRAQ BORDER REGION
		2014-08-18 03:01:35.2	32.49	N	47.54	E	20	4.8	IRAN-IRAQ BORDER REGION
7	IV	2014-08-18 02:32:05.5	32.58	N	47.62	E	10	6.2	IRAN-IRAQ BORDER REGION
		2014-08-17 14:47:20.3	32.56	N	47.59	E	10	4.8	IRAN-IRAQ BORDER REGION
		2014-08-17 11:24:17.2	32.59	N	47.71	E	10	4.6	IRAN-IRAQ BORDER REGION

Focal Mechanisms

The focal mechanisms (FM) are presented in Figure 5 based on CSEM and USGS reports for the mainshock and the aftershocks. These figures show that the FM's are representative for a compressional mechanism with a minor strike slip component. Based on the FM's reported for the main event and aftershocks, the fault plane having a NW-SE trend and the slope towards NE having a minor right lateral strike slip component might be presented as the fault plane. With such specifications, the possible causal fault might be represented by the Dalpari fault. The distribution of aftershocks in NW-SE direction (Figure-6) is in agreement with such conclusion. There are evidences of major NE-SW to E-W direction movements in the epicentral region, as well as distribution of more damages towards the east of Mormori (possibly a fling step effect?) that may refer to NW-SE direction of the fault with a slope towards the NE.

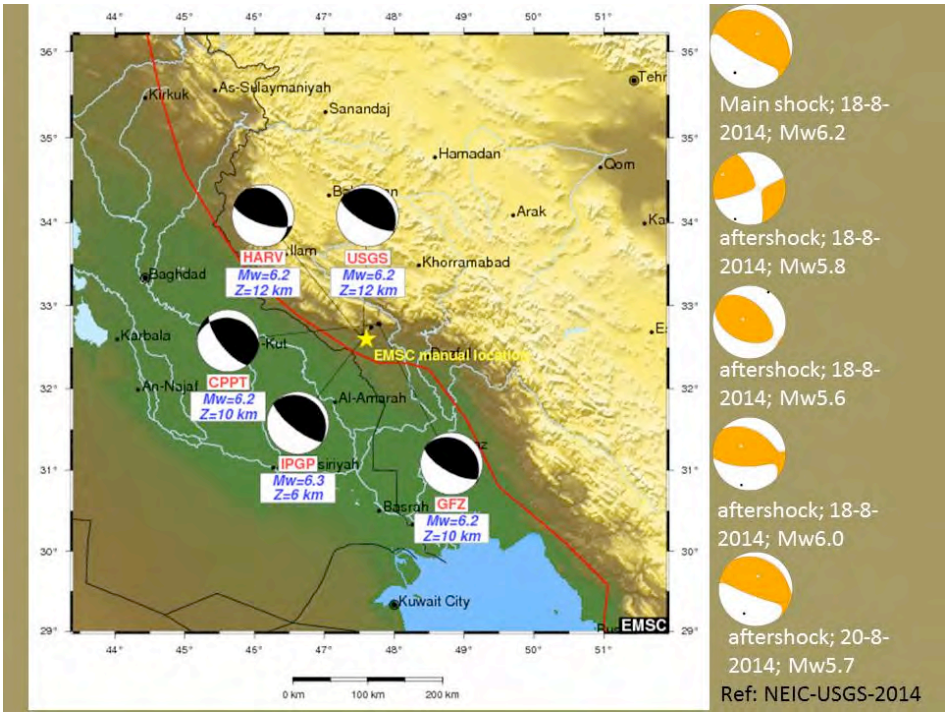


Figure-5: The focal mechanisms of the mainshock and the aftershocks of the Mormori 18 August 2014 Mw6.2 earthquake, as reported by CSEM and USGS web sites (19 Aug 2014).

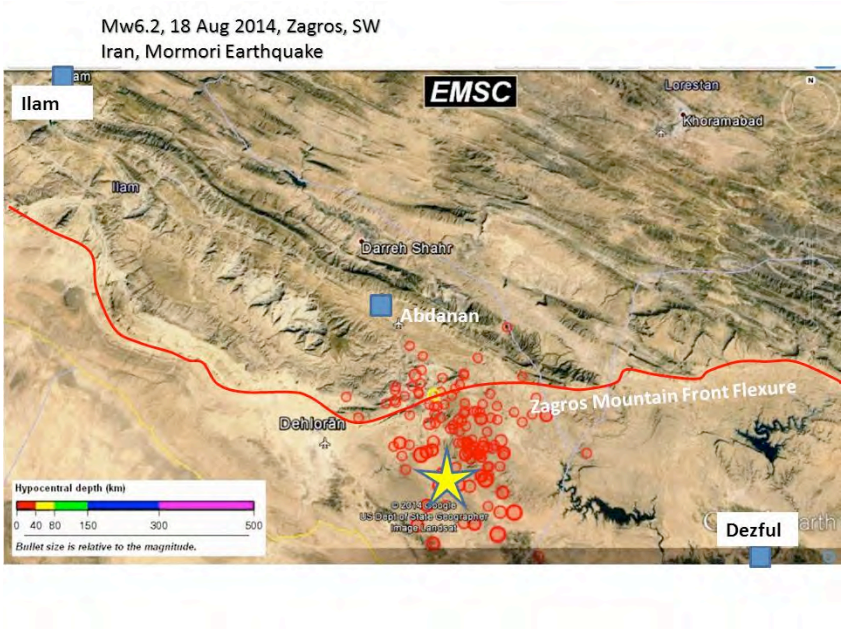


Figure-6: The distribution of aftershocks in the first 3 days after the Mormori 18 August 2014 Mw6.2 earthquake.

Damages

The field investigations indicate the concentration of damages in Mormori and the villages of Abanar and Siahgel (Figure-1a). The damages can be classified based on geotechnical features and damages to buildings.

<u>Geotechnical damages</u>

The landslides start on the road from Darreh-Shahr to Abdanan (20 km from Darreh Shahr) in the topographic level of 1500m (Figure-7). These slides caused fissures and subsidence in the road (kilometer of 32 from Darreh-Shahr; Figure-8), followed by debris slides during the aftershocks.

Figure-7: Darreh-Shahr to Abdanan Road (20km from Darreh-Shahr) caused the road block (about 52km to the epicenter.)

Figure-8: Road from Darreh-Shahr to Abdanan (32km from Darreh-Shahr): Fissures and land subsidence caused by the 18 August 2014 earthquake (about 42km distance to epicenter).

Buildings

To the north of the epicenter partial damage occurred to historical and archaeological buildings (including "Posht-Ghaleeh", "Hezardar" Castel, "Imamzadeh Pirmohammad", as well as the historical bridge of "Gamishan").

Most of the damage to buildings was reported from the small town of Mormori (a population of about 4,000) and the villages of "Abanar" and "Siahgel" (Figures-9 and 10). There were some damages to residential buildings of "Maskan-e Mehr" (social apartments built in the last decade in Iran for low-income people) in Abdanan. These new buildings were delivered to their tenants and owners last year. The extent of the damage observed in these buildings is an indication of the low quality of their construction.

Figure-9: Damage to a building in Mormori.

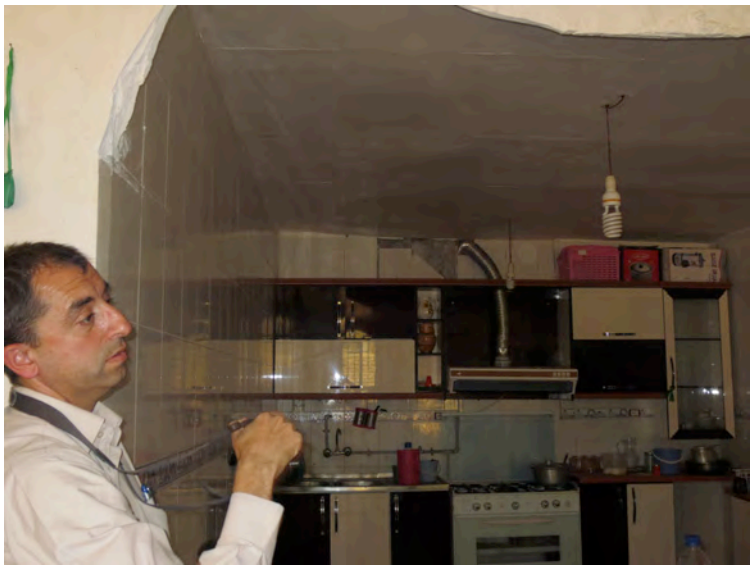


Figure-10: Damage to the buildings in Abanar: collapse of walls, figures and object and plaster fall in the kitchen.

The damages might be explained taking into account these aspects:

1: Based on the level and distribution of damage in the epicentral region, we may assess that the city of Mormori was located about 10km from the epicenter, and Abdanan was located 38km from the epicenter, where no major damage was observed. The exception were the damages observed in the "Mehr" apartments (constructed about 1 year ago) which forced some of the inhabitants to move out. This damage is likely an indication of the poor quality of construction of such apartments (Figure-11).

Figure-11: Cracks created in "Mehr" Appartments (Maskan-e Mehr) in Abdanan (38km from the epicenter); constructed about one year ago and suffering extensive damages due to an intensity VI (EMS98) in the 18 Aug 2014 Mormori earthquake.

2: There are many new buildings in this region which are damaged and it seems that they suffer from poor quality of construction.

3: The Momori earthquake with a magnitude Mw6.2 and about 10km depth occurred in a sparsely populated region; and the epicenter was located in an unpopulated region. This and the foreshocks that led to early evacuations were major reasons for the lack of casualties. The mainshock occurred

at 7:02 am. Most of the people were awake in this early morning because of hot summer temperatures (the conditions might have been more dramatic if the event had occurred during the night, i.e. 2 or 3 am. Moreover the schools were closed for summer holidays, likely avoiding many injuries in the schools.

4: The trend of major damages in the Mormori earthquake was NE-SW to E-W. This is most probably the fault normal direction. The slope of the causal fault was towards the northeast, therefore the occurrence of most damages towards the east and northeast (especially in Abanar and Siahgel villages) might be explained as possibly due to a fling effect.

Strong Motions

The strong motions were recorded in 13 stations of the Iranian Strong Motion Network (ISMN) managed by the Road, Housing and Urban Development Research Center (BHRC) (Figure-12, Table-3). The maximum PGA (216 Gal) was recorded on the horizontal component in the Abdanan Station (15km from the epicenter; Figure-13). The second important record was observed within 45km from the epicenter in Dehloran (98 Gal; Figure-14). The acceleration response spectra for the records obtained in these two stations are presented in figures 15 and 16 respectively.

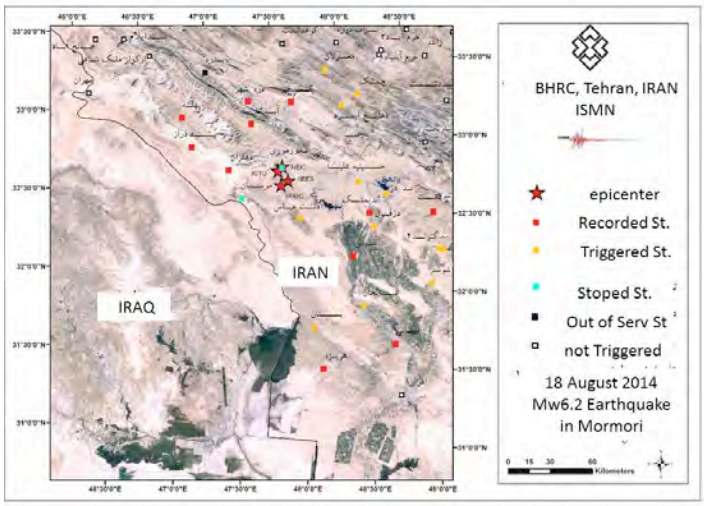


Figure- 12: The location of the Strong Motion stations of BHRC that recorded the Mormori 18 August 2014 earthquake in SW Iran.

Table-3: The specification the records and the stations of BHRC that recorded the Mormori 18 August 2014 earthquake in SW Iran.

NAME-EN	CODE-1	Long.	Lat.	Record No.	Acceleration (cm/s/s)		
					L	V	T

Abdanan	ABN	47.42	33.00	6275	216	96	192
Dehloran	DLR	47.27	32.69	6279-2	67	47	98
Dareh Shahr	DAR	47.38	33.14	6278	77	32	57
Pol Dokhtar	PDK	47.71	33.15	6284	42	29	48
Andimeshk	AND	48.35	32.47	6277	22	10	19
Bisheh-Deraz	BIS	46.98	32.83	6276	19	15	21
Pahle	PHL	46.89	33.01	6285	21	9	15
Shoosh	SUS	48.25	32.19	6287	20	9	21
Hoveyzeh	HVZ	48.07	31.46	6280	19	3	12
Lali	LAL	49.09	32.34	6281	11	5	17
Sar Dasht	SDS	48.83	32.50	6286	15	6	13
Alhaee	ELH	48.60	31.65	6288-1	12	3	12
Abdolkhan	ABK	48.34	31.88	6289-1	12	5	11

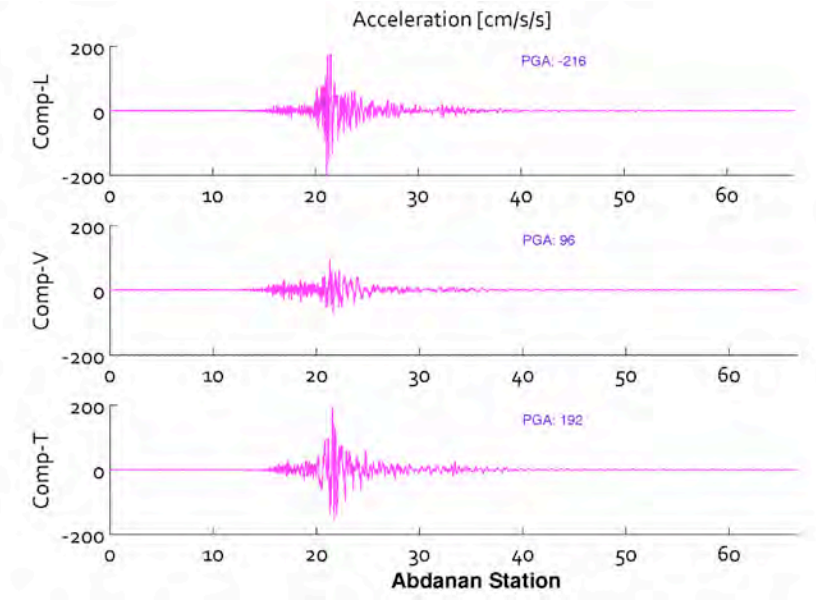


Figure-13: Recorded time histories for Acceleration in Abdanan

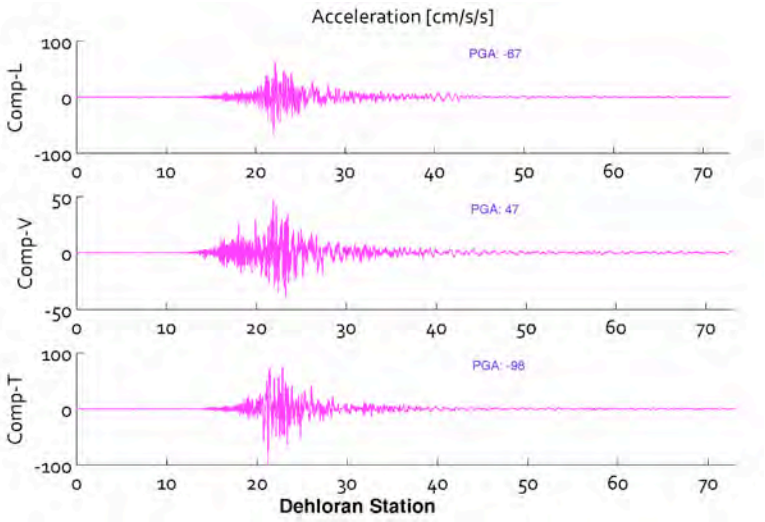


Figure-14: Recorded time histories for Acceleration in Dehloran

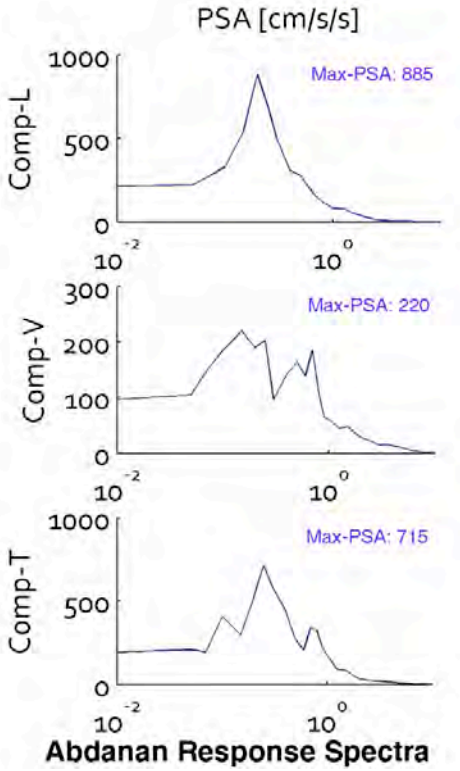


Figure-15: Response Spectra for recorded Acceleration Time history in Abdanan.

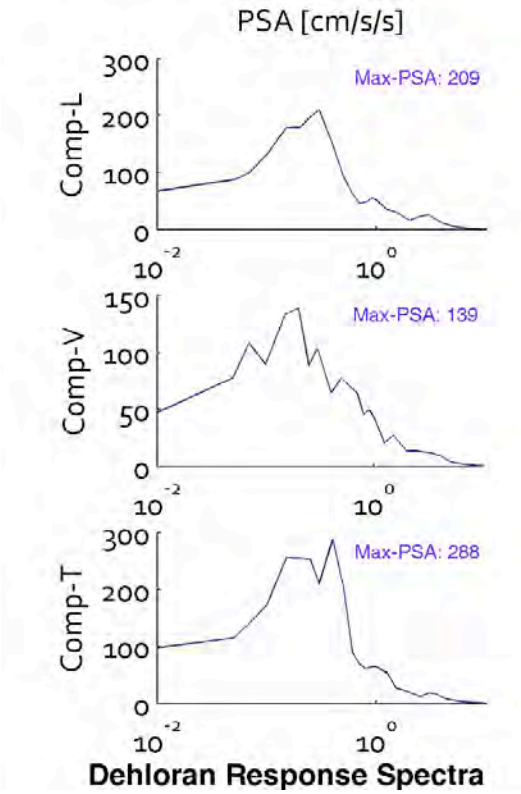
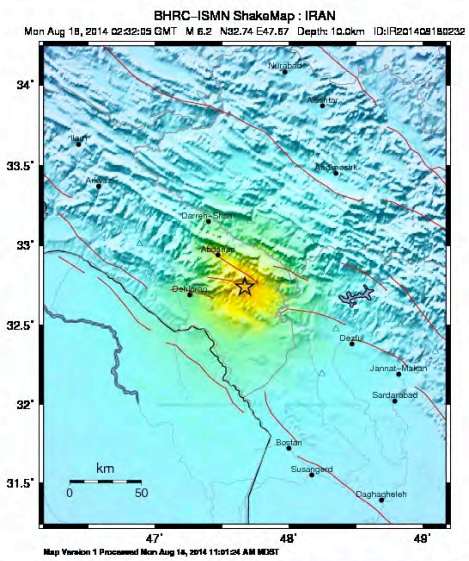


Figure-16: Response Spectra for recorded Acceleration Time history in Dehloran

The shake maps are developed for this event (Figure-17) in which a maximum intensity of VII-VIII (EMS98) are estimated for the epicenter. The Maximum acceleration between 100 to 200 gals are estimated for the epicenter.



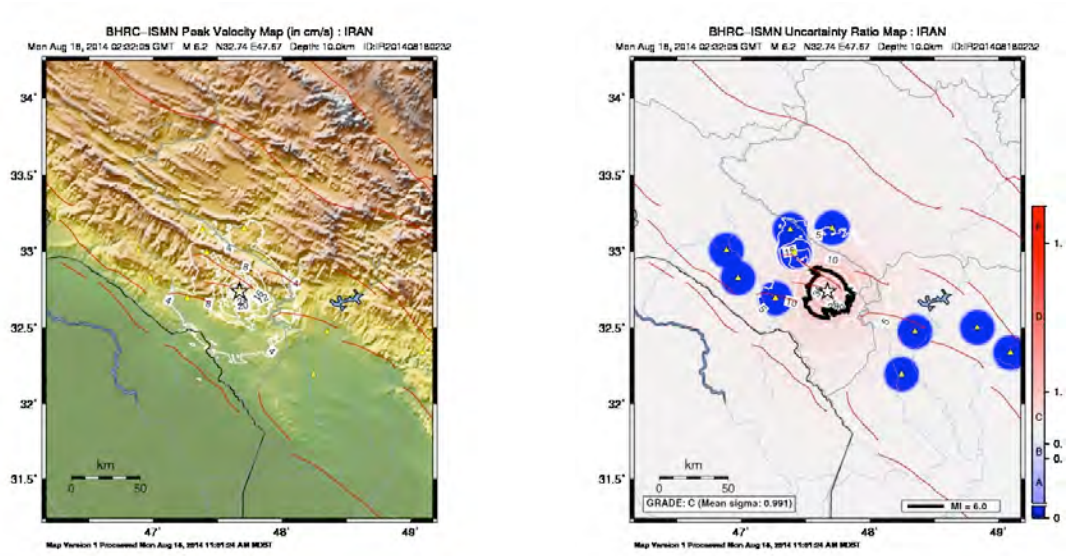


Figure-17: Shake maps developed for the Mormori 18 August 2014 earthquake in SW Iran. Above-left: Instrumental Intensity, Above-right: Acceleration, below left: Velocity; below-right: uncertainties.

Disaster Management

In the Mormori earthquake there was no reports of casualties (in part because of the foreshocks which served as a natural warning), however 250 people were injured (Figure-18). The epicentral region has very hot temperatures in the summer (about 45 to 50 degree celsius during the day and 30 to 35 during the night). In the first 8 hours after the second foreshock (which occurred at 19:17h. local time, Mb4.8) the electricity current was disconnected. Therefore the people were not sleeping indoors (because of very hot temperatures inside their homes). Most of the tents given to displaced people in the affected area (by Iranian Red Crescent) for temporary shelters were not suitable for such hot weather conditions. There were some reported cases of inhabitants exaggerating the extent of damage to official building observers who were examining buildings after the mainshock. This might have resulted in a "100% damage" designation for such buildings. Since loans to be given to affected inhabitants may not cover all of the reconstruction expenses, this may cause a major financial problem for the inhabitants themselves.

One of the sources of follow up casualties of this earthquake was the numerous aftershocks (8 aftershocks with Mb of 5 to 6 in the first 20 days after the mainshock) that was a major cause of panic and post-traumatic stress disorder for the inhabitants of prone area.

The disaster management efforts were coordinated from Abdanan and Dehloran by the Governor General of Ilam and emergency aid and food were distributed in the region by Iranian Red Crescent.

Temporary shelters have been provided in the towns of Mormori and Abdanan (next to the damaged buildings) and in the villages (Figure-19). There were some reports about the appearance of scorpions before and after the mainshock as well as some cases of scorpion stings especially in Abanar village. This problem might have been caused by water level changes (increasing the level of underground water) and has been controlled by spraying by the authorities.

Figure-18: A teenage boy with a broken hand during the mainshock in Mormory.

Figure-19: Temporary shelters provided for the people living in Mormori after the mainshock of 18 August 2014.

Conclusions

The Momori earthquake of 18 August 2014 (Mw6.2, about 10km depth) occurred in a sparsely populated region. The sparse population in the area and the occurrence of 2 foreshocks (the day before) that warned people to evacuate their houses the night before the mainshock were likely the reasons for the low number of casualties. The mainshock occurred at 7:02 a.m. Most of the people were already awake at this early morning hour. Based on the numerous moderate magnitude aftershocks that have been occurring there might be another possible mainshock (M>6.0) in the coming weeks or months. Most of the observed damages can be attributed to poor construction of rural and newly constructed buildings in the affected region.

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References:

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