Preliminary report of M_w7.3 Sarpol-e Zahab, Iran earthquake on November 12, 2017

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Seismic features

On November 12, 2017, at 18:18 UTC (21:48 Iran Standard Time), a major earthquake with the moment magnitude of 7.3 occurred in Kermanshah province of Iran. According to the National Center of Broadband Seismic Network of Iran, the epicenter of this event was located at 34.88°N and 45.84°E near the Iran–Iraq border with a depth of 23 km. The epicenter has a distance of about 5 km to the town of Ezgeleh (Fig 1), 43 km from Sarapul-e Zahab city and 46 km from Qasr-e-Shirin city. The focal mechanism solutions for this earthquake indicate a fault dipping shallowly to the east-northeast, or on a fault dipping steeply to the southwest. Based on the active fault map of Iran, this earthquake can be triggered by the movement of the Zagros Mountain Front Fault (MFF) in Pol-e-Zahab Region. A simple schematic picture for the thrust faulting during the Nov. 12, 2017 Sarpol-e Zahab Iran earthquake as well as the location of main faults of the Zagros mountains in the affected area have been shown in Fig. 2 and Fig. 3, respectively.

This event that continued for 30 seconds, was felt in an extended area in Iran, Mesopotamia, the Caucasus, eastern Turkey, Iraq and Syria. Until November 22, 2017 (8:00 a.m. UTC time), about 490 aftershocks with magnitudes over 2.5 have been recorded by the Iranian Seismological Center (IRSC) (Fig 4). The largest magnitude of this earthquake's aftershock sequence was 4.8, which occurred November 13th.

Fig 1. *Ezgeleh, the nearest town to the epicenter of the 2017 Sarpol-e Zahab, Iran earthquake*

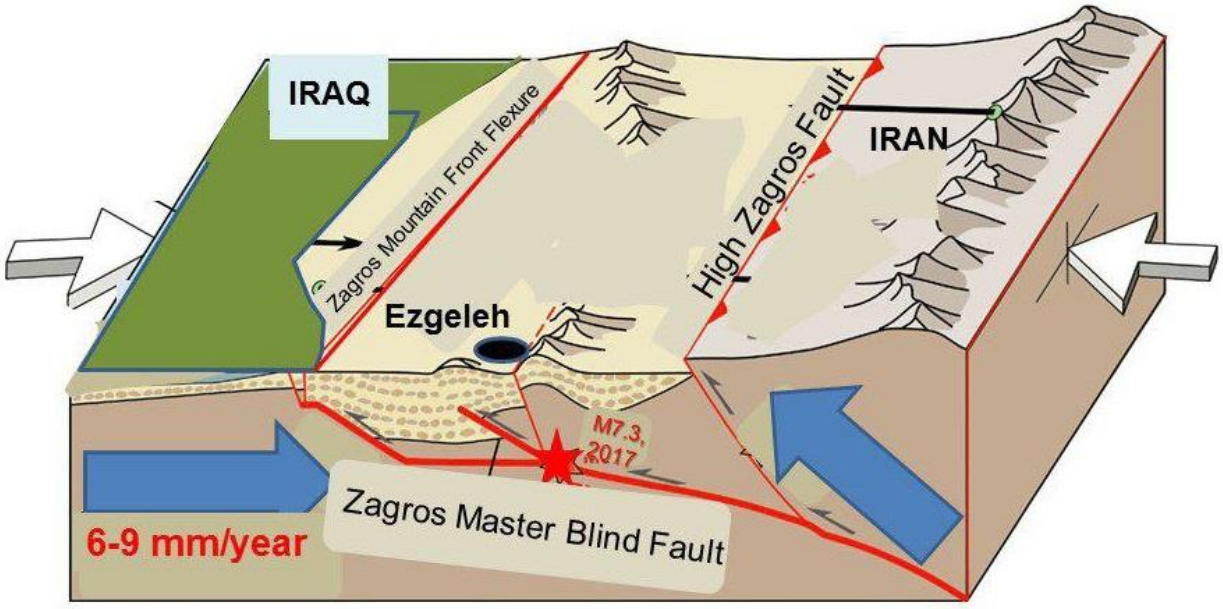


Fig 2. *A simple schematic picture for the thrust faulting during the Nov. 12, 2017 Sarpol-e Zahab Iran earthquake*

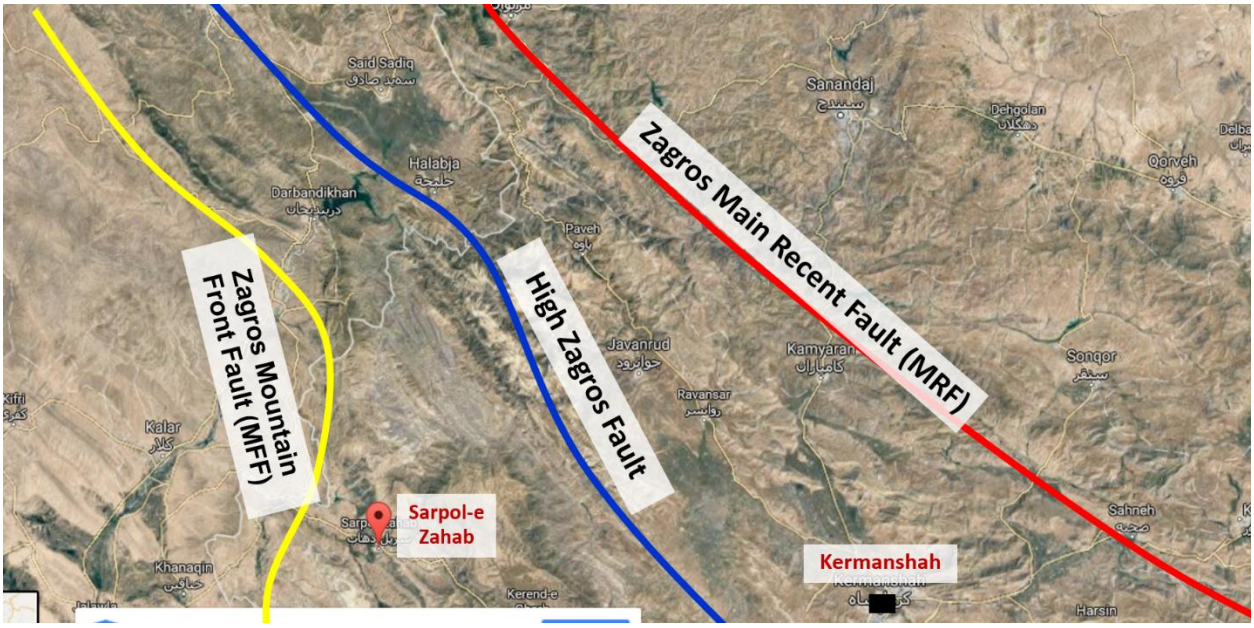


Fig 2. *Location of different faults in the Zagros Mountains near the affected area of the 2017 earthquake*

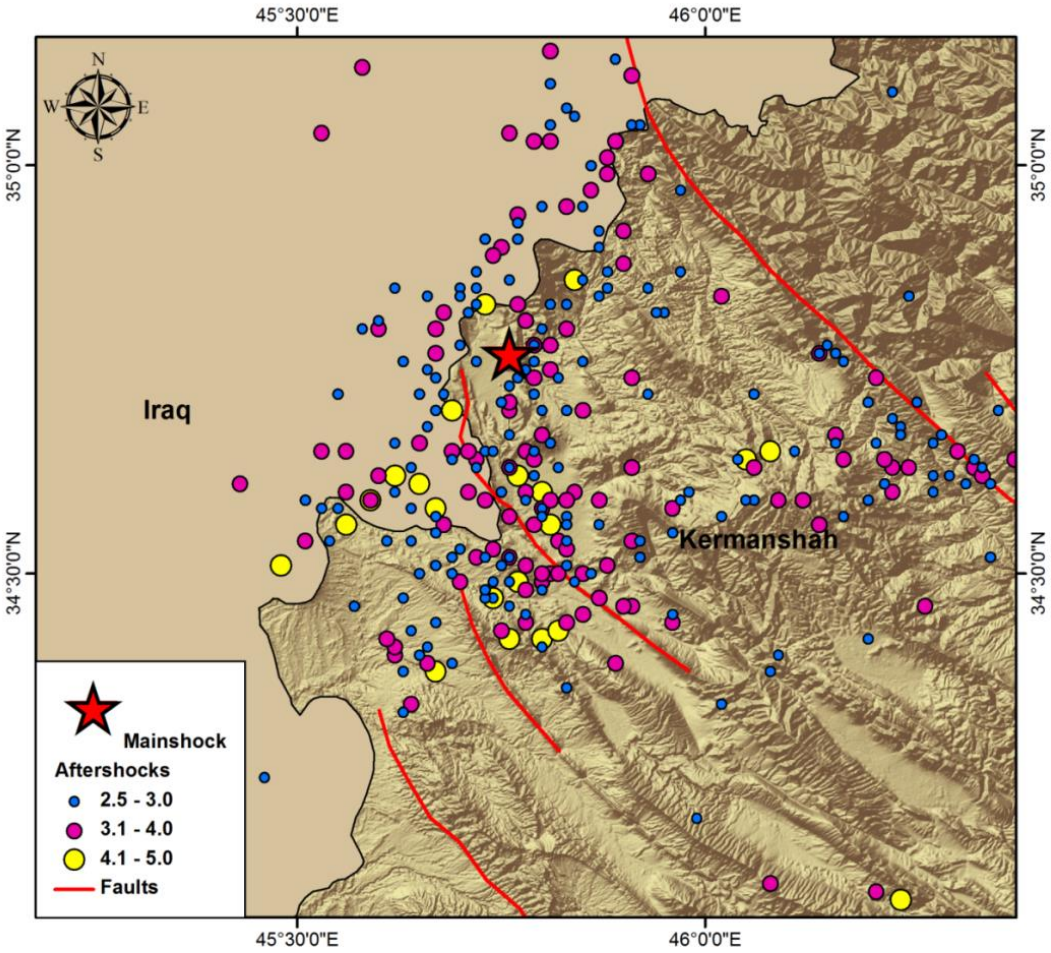


Fig 4. *Aftershocks of the 2017 Sarpol-e Zahab, Iran earthquake.*

Strong Motion and Intensity

The strong motion of the November 12, 2017, M_w7.3 mainshock has been recorded by 98 stations of the Iran Strong Motion Network (ISMN) (Table 1). Among these records, the highest value corresponds to the Sarepol-e Zahab station with an uncorrected PGA of about 684 cm/s^2 (Fig 5). The corrected PGA values of the important records will be soon released in subsequent studies.

Table 1. *Strong motion records of the 2017 Iran-Iraq earthquake*

No	Station Name	Record No	Un. PGA (cm/s^2)	Epicentral Distance	Station Code
1	Sarpolezahab	7384/01	684	39	SPZ
2	Goorsefid	7377/01	309	66	GRS
3	Kerend	7302/01	261	66	KRD
4	Loomar	7385	139	161	LUM
5	Eslamabadqarb	7313	123	96	ELA
6	Ravansar	7296	120	70	RVN
7	Homail	7294	93	125	HML
8	Arkvaz-e-MalekShahi	7378	91	170	AVZ
9	Shoeisheh	7317	88	93	KAT
10	Mahidasht	7295	86	101	MHD
11	Dinevar1	7304	81	143	DIN1
12	Marivan	7287	70	83	MAR
13	Degaga	7310	70	67	DGG
14	Ilam1	7341	69	138	ILA1
15	Badreh	7315	64	197	BDR
16	Soomar	7375	61	106	SUM
17	Kermanshah1	7292	55	120	KRM1
18	Lenjab	7376/01	55	125	LJA
19	Sarv Abad	7290	54	70	SVA
20	Nosood	7297	53	47	NSD
21	Palangan	7279	50	70	PAG
22	Sahne	7303	45	166	SHN
23	SarDasht	7289	40	155	SRS
24	Firoozan	7284	36	208	FRA
25	Kamyaran	7278	35	93	KYN
26	Aran	7301	35	163	ARA
27	Pol Dokhtar	7351	35	248	PDK
28	Naqadeh	7291	33	244	NAG
29	Deh Golan	7311	33	146	DGO
30	Holilan	7320	32	161	HEL
31	Dasht-e-Abbas	7332	32	320	DAS
32	Shahin Dej	7293	30	216	SHJ
33	ChalanChoolan	7350	29	304	CHL
34	Sanandaj1	7280	28	114	SAN1
35	Chaghalvandi	7344	28	275	CLV
36	Piranshahr	7288	26	222	PRS
37	Dezaj	7316	26	189	DZJ
38	DarehShahr	7298	25	230	DAH
39	Pahle	7314	25	220	PHL
40	Noor Abad	7347	24	206	NRA

41	Eyvan	7338	23	116	EYN
42	Armordeh	7277	22	125	ALV
43	Moosiyan	7381	21	289	MOS
44	Saqez	7318	19	162	SAG
45	Divandarreh	7312	18	159	DIV
46	Shoosh	7356	18	363	SUS
47	Ebrahim-Abad	7299	17	154	EBH
48	Saleh Abad	7309	17	151	SLA
49	Bisheh-Deraz	7372	17	242	BIS
50	Khosro Abad	7300	16	175	KSA
51	Sonqor	7307	16	154	SON
52	Famenin	7283	15	282	FMN
53	Darbastaneh	7333	15	294	DRB
54	Giyan	7286	14	225	GYN
55	Sanandaj2	7281	14	113	SAN2
56	Bagh-Malek	7352	14	518	BGM
57	Shool Abad	7349	14	352	SUL
58	Aleshtar	7343	14	240	ALR
59	SarabDoreh	7348	14	239	SRD
60	Andimeshk	7371	14	344	AND
61	Dorood	7345	13	325	DRD
62	Kangaver	7306	12	192	KNG
63	Khoram Abad1	7335	12	269	KRA1
64	Mehran	7340	11	189	MER
65	Haftgel	7346	11	504	HFG
66	Kohnoosh	7285	10	217	KNS
67	Mamolan	7336	10	247	MAL
68	Boroojerd	7331	10	278	BRO
69	Abadan	7342	10	543	AAD
70	Ajin	7282	9	185	AJN
71	Kouhdasht	7334	9	212	KDT
72	Qom2	7321	8	456	QOM2
73	Hersin	7305	5	162	HES
74	Mehtarlo2	7319	3	413	MTL2
75	Chahardangeh2	7324	3	498	TH015
76	Tehran69	7367	3	507	TH008
77	Tehran79	7328	2	509	TH010
78	Garmsar1	7326	2	586	GMS1
79	Tehran74	7358	2	510	TH013
80	Tehran26	7362	2	504	TH009
81	Fasham1	7323	1	525	FSH1
82	Tehran90	7329	1	506	TEH90
83	Eyvanaki1	7327	1	564	EYK1
84	Tehran93	7353	1	489	TH018
85	Tehran91	7354	1	506	TEH91
86	Tehran82	7355	1	506	TH001
87	Tehran78	7368	1	508	TH004
88	Tehran70	7360	1	525	TEH70
89	Tehran76	7359	1	509	TH007
90	Tehran47	7361	1	502	TH005
91	Tehran73	7363	1	507	TH014
92	Tehran84	7364	1	499	TH016

93	Tehran85	7365	1	495	TH017
94	Tehran86	7366	1	495	TH019
95	Firoozkooh2	7369	1	631	FRK2
96	Tehran71	7370	1	510	TH003
97	Mosha2	7325	0.86	567	MOA2
98	Bojnoord1 (University)	7330	0.33	1063	BOJ1

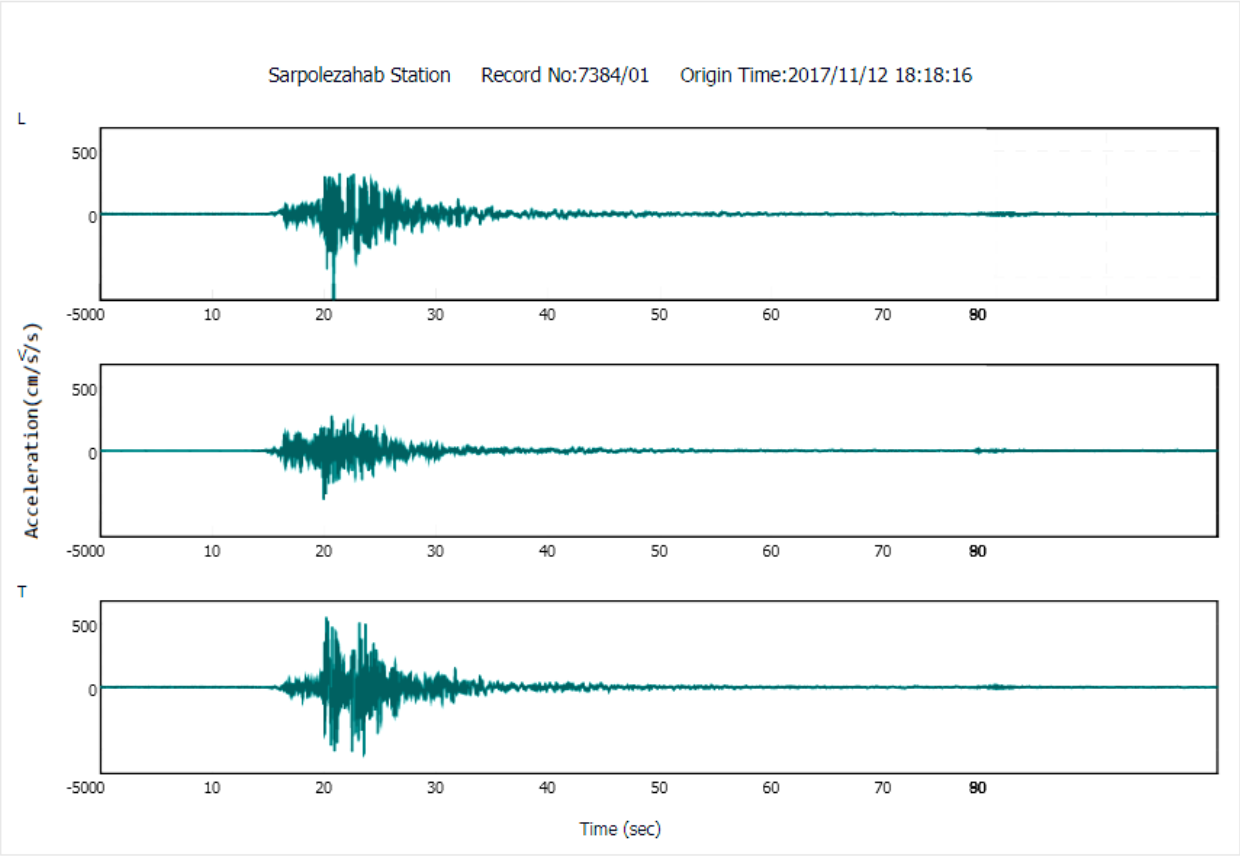


Fig 5. *The maximum PGA of the 2017 Iran-Iraq earthquake recorded at the Sarpolezahab Station. (Record No: 7384/01)*

Based on the preliminary assessments, the maximum intensities and most of the destructions have been reported in the Sare-pole-Zahab (Fig. 6) and Qasr-e- Shirin cities of Kermanshah Province in Iran. An isoseismal map has been also provided (Fig. 7) based on a field investigation by the first author. According to the formal reports by the Iranian legal medicine organization, until this time (Nov. 22, 2017, 8:00 a.m. UTC time), over 438 people died (the number of which will be possibly increased during the coming days) (Table 2), 8,000 injured, 70,000 displaced, and over 12,000 buildings have been damaged due to this earthquake disaster. The unofficial record of fatalities is more than 500, as there were undocumented burials, according to the local communities' confessions.

Fig 6. *Collapsed buildings in Sarpol-e Zahab city*

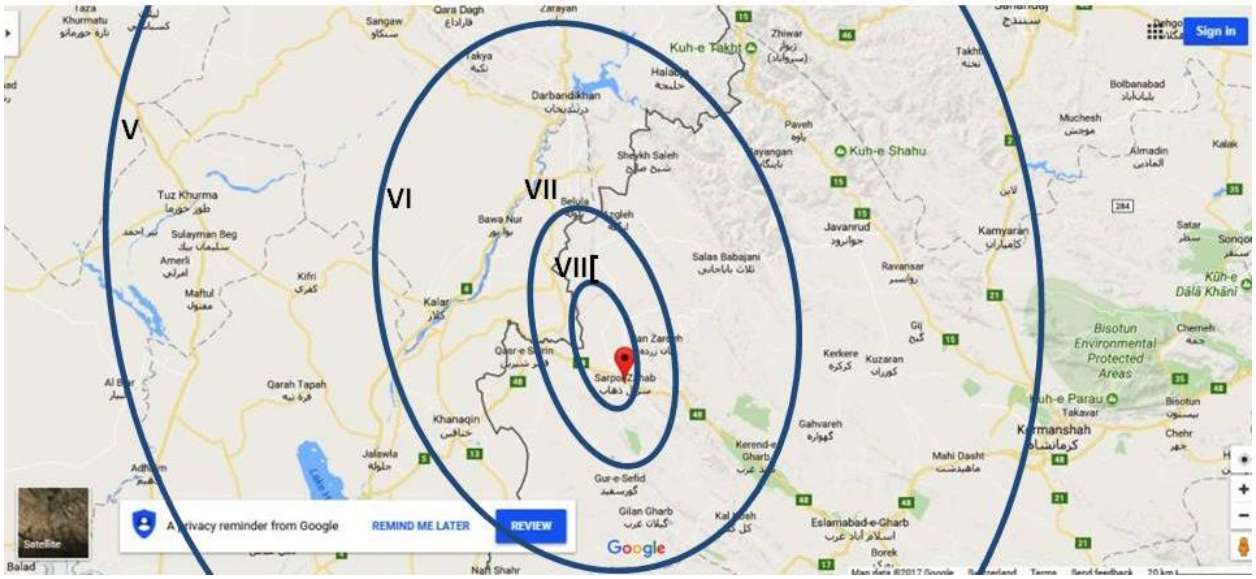


Fig 7. *Iso-seismal map of the M_w7.3 November 12, 2017 Sarepo-e Zahab earthquake in Iran*

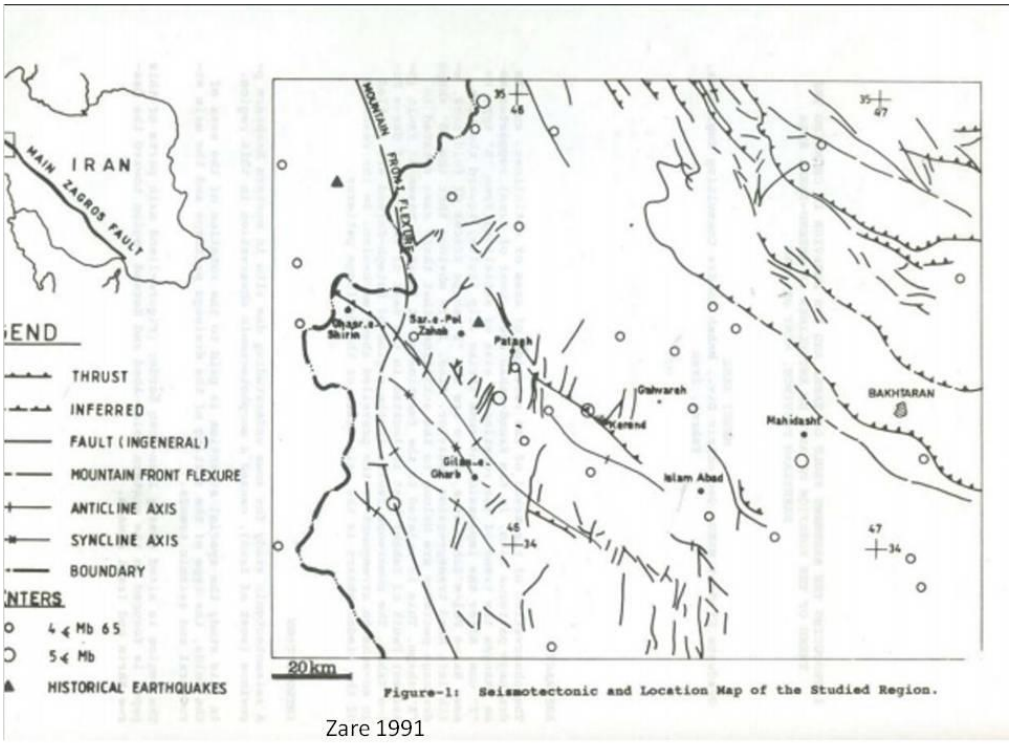
Table 2. *Number of fatalities in different parts of Kermanshah province due to the November 12, 2017 M_w7.3 earthquake (This number will be possibly increased during the coming days). (Data source: Iranian legal medicine organization website)*

District	Number of dead people
Sarpol-e Zahab	387
Kerend	14
Qasr-e-Shirin	16
Thalath Babajani	12
Kermanshah	1
Tazehabad	1
Ezgeleh	6
Eslamabad	1

DNA from the missing dead has been taken for genetic testing.

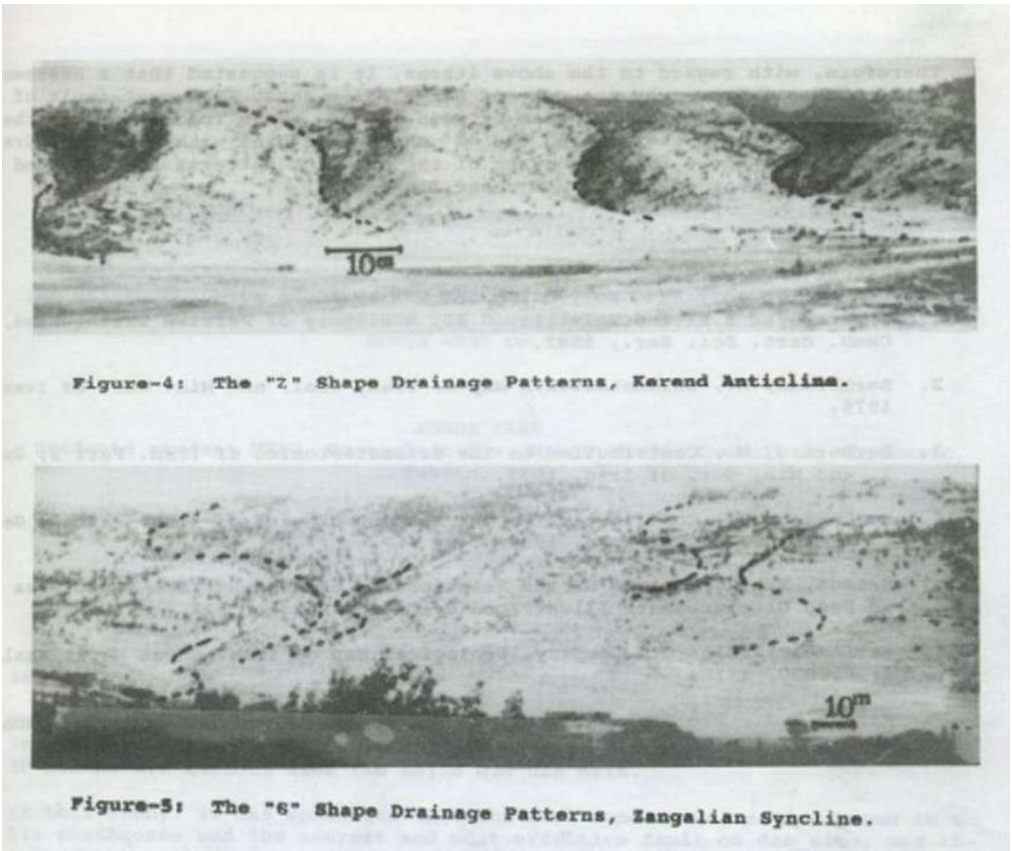
Previous important earthquakes in this area

The seismotectonic of the affected area had been investigated in a previous study by Zare (1991) (Fig 8). Before the 2017 Sarpol-e Zahab earthquake, there has been only one major event with magnitude over 7 in this part of the Zagros Mountains which occurred in the Farsinaj region of Kermanshah province in Iran on Friday Morning, Dec. 13, 1957, at 5:15:00 a.m. local time, (1:45:00 GMT) with magnitude of Ms=7.6 and mb=6.5. The epicenter of the earthquake was located at 34.35°N and 47.67°E with about 35 km depth. A filed investigation carried out 16 years later (Ambraseys et al, 1973) shows that this earthquake caused heavy damages within an area of 2,800 square kilometers in which 1,119 people were killed and left 900 injured and 15,000 homeless. Macroseismic evidence suggests a somewhat more moderate epicentral intensity of VII+ (MMI).With the exception of a single aftershock which preceded the main earthquake by about 26 hours and which was strongly felt at Kangavar, records of the nearest seismological stations show no trace of important seismic activity in this part of the Zagros during the preceding four months. The earthquake and its numerous aftershocks destroyed or damaged beyond repair 5,000 housing units out of a total of about 9,000 (more than 55%). Most of the local type of dwellings were one-storey adobe or rubble masonry houses set in mud and covered with heavy flat roofs of tamped earth. In the larger villages there were a few two-storey adobe houses as well as some one-storey brick masonry buildings covered with Iranian jack-arches or with light roofs of galvanized iron sheets. A reconnaissance survey disclosed a fracture between Karaj Olia and Karkasar, probably of tectonic origin. As a matter of fact, there was linear topographic features in the form of terraces bearing 130°E. These fractures, which are mainly in alluvium, suggested very recent normal faulting and showed no evidences of lateral motion.



Zare 1991

(a)



(b)

Fig 8. *Seismotectonic framework of the affected area in the Zagros Mountains (Zare, 1991).*

SAR Interferometry

Geodetic data, obtained by spaced-based techniques, can be used to infer the distribution of slip on a fault that has ruptured in an earthquake. Satellite images can capture co-seismic and synthetic aperture radar (SAR) interferometry can be used to detect changes in the ground surface, by removing the signal from the topography. In this earthquake event we use Differential SAR Interferometry to capture the movements produced by the 2017/11/12 earthquake in the broader area of the boundary between Iran and Iraq.. We construct interferogram by combining topographic information with SAR images by the Sentinel-1 satellite before and after the earthquake. During the stage of processing, the SAR images which were used, are on the dates 2017/10/30 and 2017/11/17 in ascending orbit. The seismic event took place at 2017/11/12so we had the opportunity to include this date into the intermediate time period between the two images. The differential interferogram produced by the SNAP software.

The map (Fig 9) of wrapped interferograms shows the fringe pattern associated with the event, where each color cycle demonstrates phase difference of [-2π], interpreted as ground deformation equal to 2.8 cm in the LOS (Line Of Sight) direction to the satellite. On the map are depicted clearly 24 to 26fringes which cover the south part of the map. At the north of the map only 4 fringes are detected. Also, we found a potential land motion between the Arabian plate and the Eurasia plate. The results of the differential interferometry show that the Arabian moved by one (1) meter and the Eurasia block moved by 10cm according to the satellite.

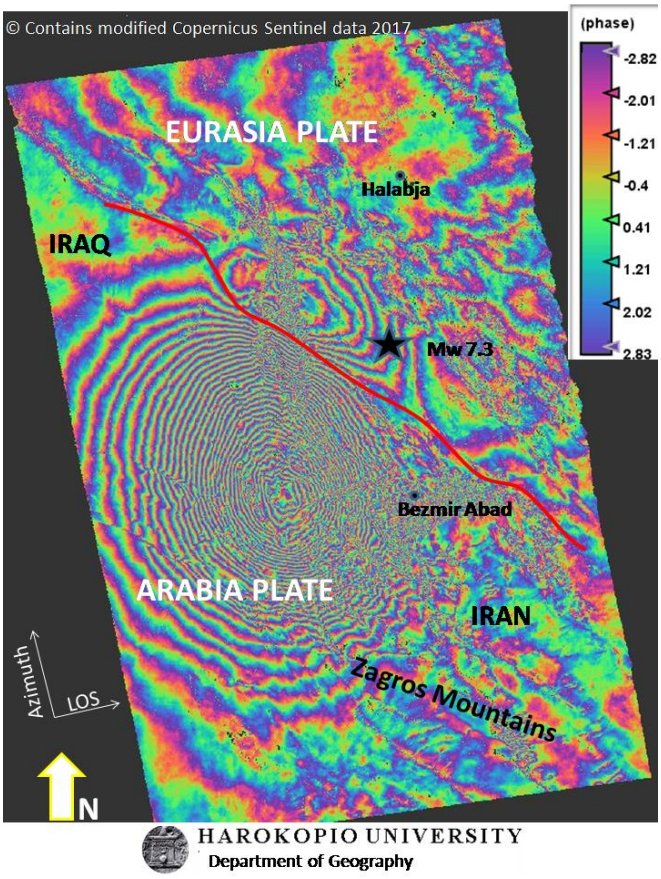


Fig 9. *Ground displacements corresponding to the 2017 Iran earthquake based on SAR data*