**Preliminary report of Mw7.3 Sarpol-e Zahab,**

**Iran earthquake on November 12, 2017**

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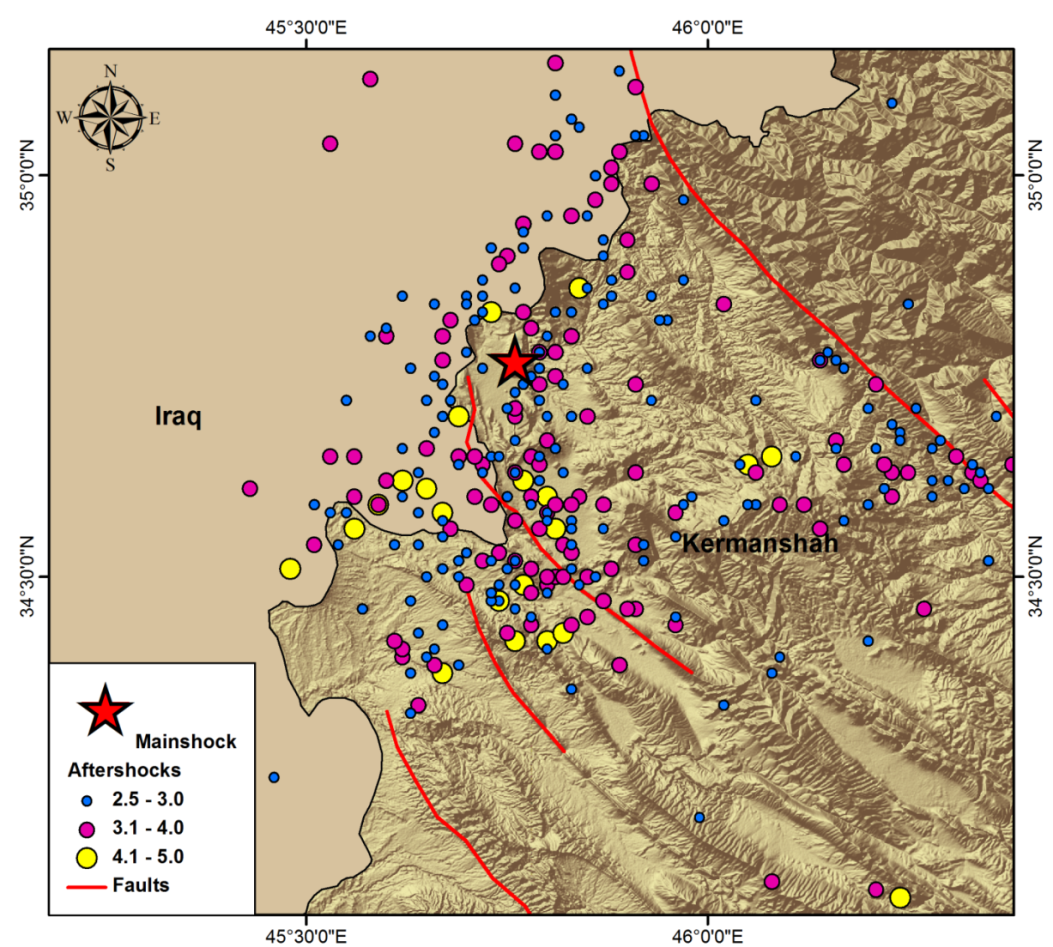
**2017 Sarepol-e Zahab Iran earthquake**

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.

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 20, 2017 (8:00 a.m. UTC time), about 460 aftershocks with magnitudes over 2.5 have been recorded by the Iranian Seismological Center (IRSC) (Fig 2). The largest magnitude of this earthquake's aftershock sequence was 4.7, which occurred November 13th.



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



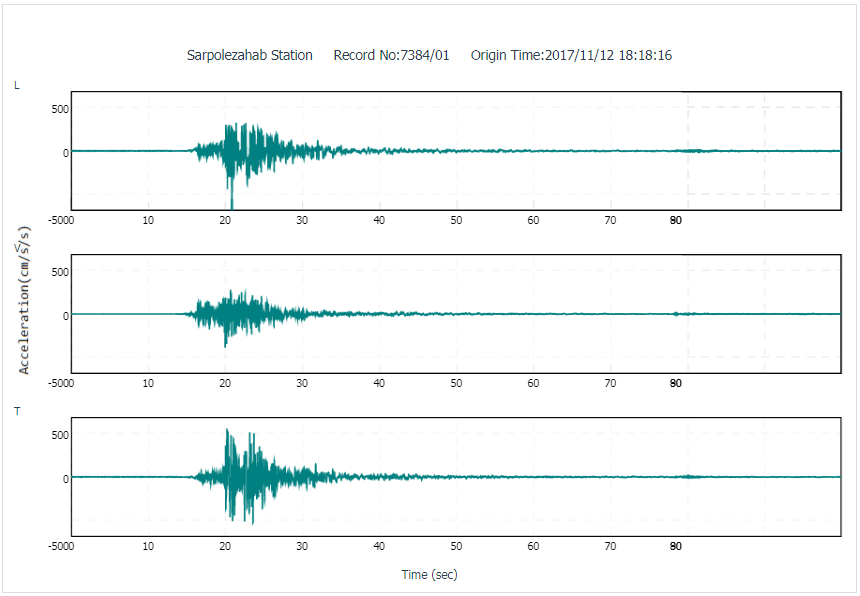
**Fig 2.** Aftershocks of the 2017 2017 Sarpol-e Zahab, Iran earthquake.

**Strong Motion and Intensity**

The strong motion of the November 12, 2017, Mw7.3 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/s2 (Fig 3). 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 earthqauke

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **No** | **Station Name** | **Record No** | **Un. PGA (cm/s2)** | **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 |



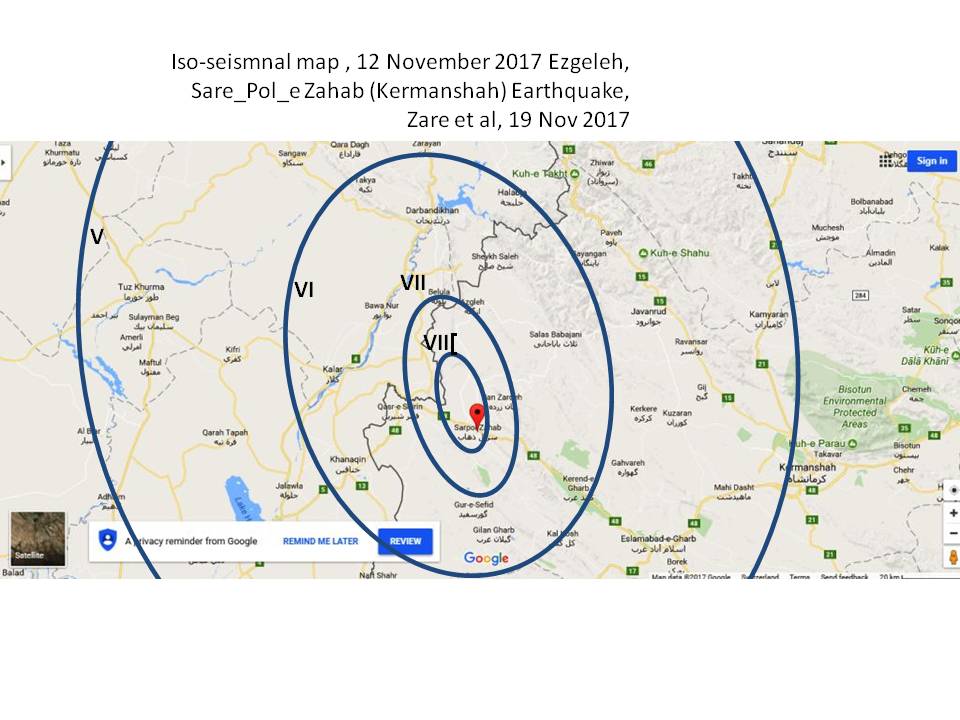
**Fig 3.** The maximum PGA of the 2017 Iran-Iraq earthquakerecorded at the Sarpolezahab Station. (record No:7384/01)

Based on the preliminary assessments, the maximum intensities and most of the destructions have been reported in the Sare-pole-Zahab (Fig 4) and Qasr-e- Shirin cities of Kermanshah Privince in Iran. An isoseismal map has been also provided (Fig 5) based on a field investigation by the first author. Until this day (Nov. 20), 437 people are killed and over 7,500 injured.





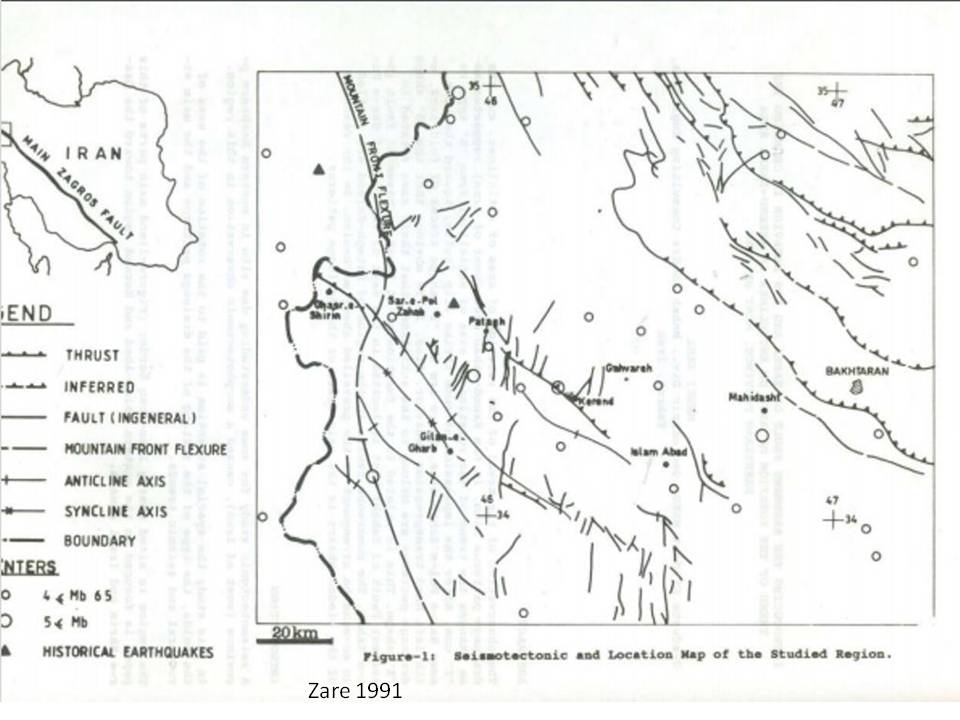
**Fig 4.** Collapsed buildings in Sarpol-e Zahab city



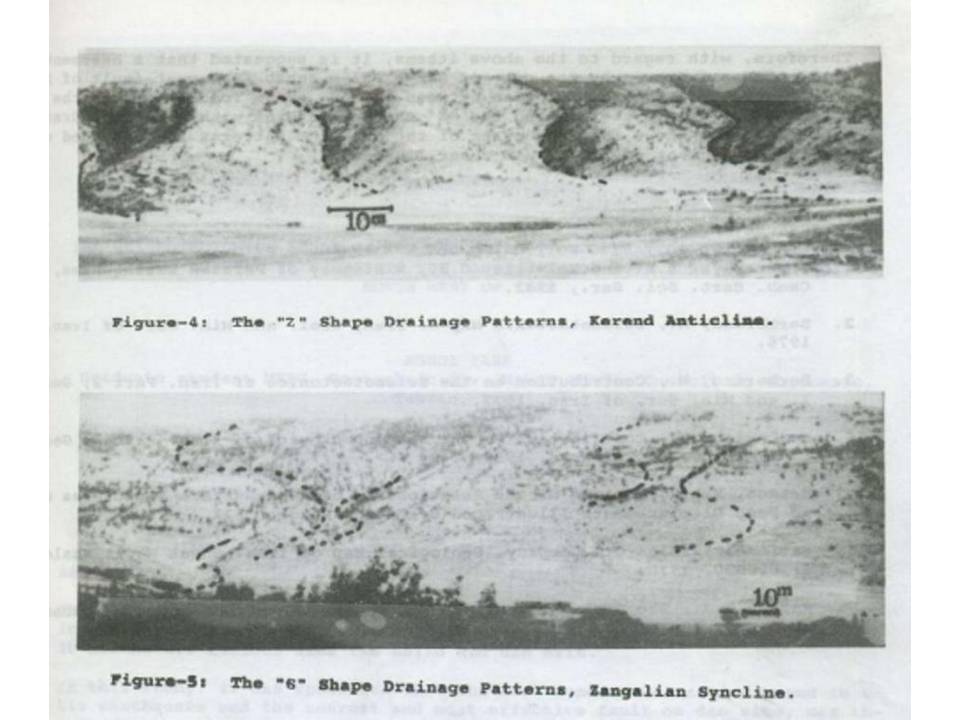
**Fig 5.** Iso-seismal map of the Mw7.3 November 12, 2017 Sarepo-e Zahab earthquake in Iran

**Previous important earthquakes in this area**

The seismotectonic of the affected area had been investigated in a previous study by Zare (1991) (Fig 6).



(a)



(b)

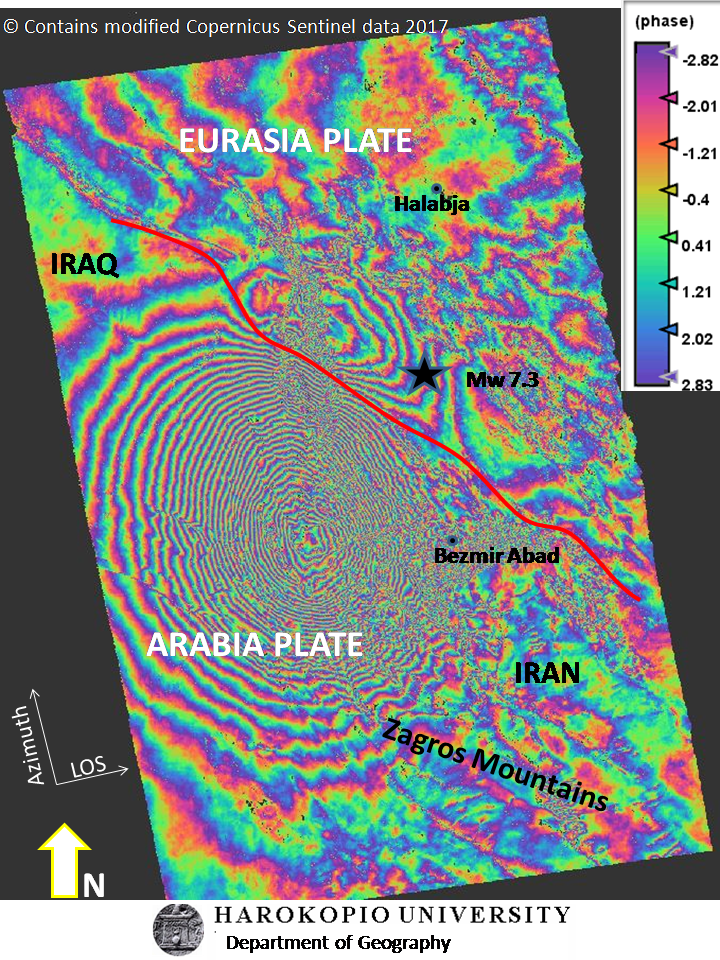
**Fig 6.** Seismotectonic framework of the affected area in the Zagros mountains.

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.

**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 7) 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 7.** Ground displacements corresponding to the 2017 Iran earthquake based on SAR data