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STRONG GROUND MOTION FROM THE NOVEMBER 12, 2017 M_W 7.3 SARPOL-E ZAHAB EARTHQUAKE: ANALYSIS OF SOURCE AND SITE CONDITION

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On November 12, 2017 at 18:18:16 UTC, a strong earthquake with seismic waves felt to a distance of 2000 km caused extensive damage in the western part of Iran. The Iranian Seismological Center reported this event with a moment magnitude (M_w) of 7.3 and depth of 18.1 km with epicentre close to the Iran-Iraq border. This large earthquake devastated cities within the epicentral area with the most damage reported from the cities of Sarpol-e Zahab and Qasr-e Shirin (Zare et al., 2017).

The epicentral area of the M_w 7.3 earthquake lies within the Zagros Fold and Thrust Belt between the High Zagros Fault and the Zagros Mountain Front Fault. Near-field ground motion, moment tensor solution, finite fault inversion, and geological and geodetic source models indicated that the M_w 7.3 earthquake occurred on a blind reverse fault striking northwest-southeast with a relatively large right-lateral component and dipping shallowly northeast (Babaie Mahani and Kazemian, 2018; Utkucu, 2018; Tavani et al., 2018; Kuang et al., 2019).

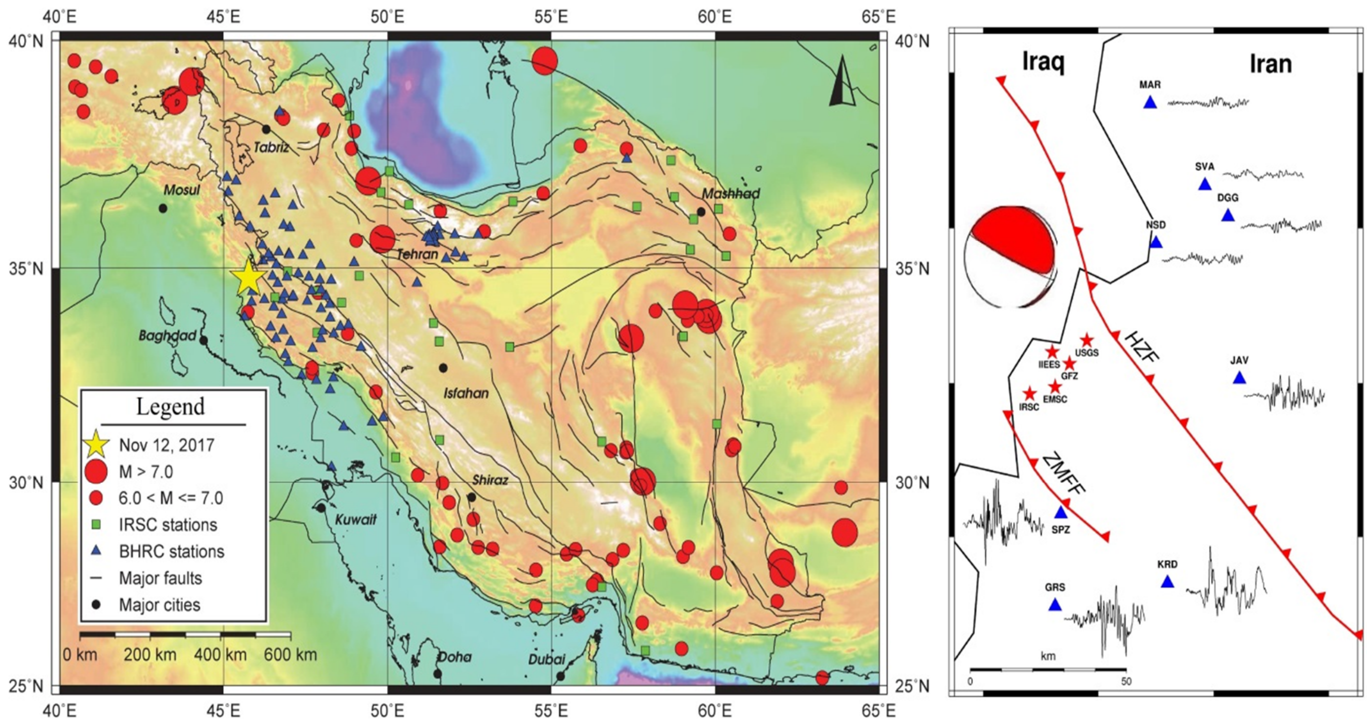

Figure 1. Earthquakes above magnitude 6 in Iran and environs for the period 1960 to 2017 from USGS earthquake catalogue (left). map of stations (labelled triangles) within hypocentral distance of 100 km from the November 12, 2017 Kermanshah earthquake (right). Stars show the location of the mainshock from various seismological catalogues with moment tensor solution from global CMT solutions. Solid lines show the thrust faults in the region with triangles depicting the hanging wall. For each station, the strike-normal component (considering ZMFF as the causative fault) is shown which was filtered using a second-order, band-pass Butterworth filter at corner frequencies of 0.07 and 5 Hz. All waveforms have the same time window (20 sec) with their amplitudes plotted with respect to station SPZ (Babaie Mahani and Kazemian, 2018).

Here, using the available recordings, I provide an overview of the source and site characteristics of this large earthquake along with its strong motion duration. To investigate the local site condition, I use three methods. First, ground motions recorded at similar distance but at sites with different Vs_{30} are compared in both time and frequency. Second, horizontal-to-vertical (H/V) spectral ratios are computed and analysed with regards to distance and Vs_{30}. Finally, I compare the observed motions with the estimated values from ground motion prediction equations to obtain a sense of site amplification. I also investigate the source characteristics of the M_w 7.3 earthquake through analysis of directivity on recorded motions at close distances.

Overall, I used data from 121 accelerometers and seismometers. The largest acceleration, which was recorded at epicentral distance of 36 km in the city of Sarpol-e Zahab, was ~700 cm/sec^2. While linear amplification of ground-motion amplitudes occurred at stations located on softer soil at hypocentral distances above 100 km, at closer distances, lower amplitudes were observed at stations with softer soil compared to those with stiffer soil condition, pointing to the effect of nonlinearity which is notable at higher frequencies (> ~1 Hz). The evidence of forward directivity was observed at stations located to the south and southeast of the fault rupture. The observation of large ground-motion amplitudes dominated with long-period pulses on the strike-normal component of the velocity time series suggests a right-lateral component of movement and propagation of rupture towards southeast. Analysis of the bracketed duration (Db) showed that Db was higher in the velocity domain than in the acceleration domain for the same modified Mercalli intensity (MMI) threshold. For example, Db reached ~30 sec at the maximum peak ground acceleration while it was ~50 sec at the maximum peak ground velocity above the threshold of MMI = 5. Although the standard design spectrum from Iranian Code of Practice for Seismic Resistant Design of Buildings (standard No. 2800) seem to include appropriate values for the design of structures with fundamental period of 1 sec and higher, it is underestimated for near-field ground motions at lower periods which includes the majority of the residential buildings in the country. Therefore, revisions to the Standard No. 2800 to include parameters of the near-field ground motion including the effect of forward directivity must be a priority.

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