Rupture directivity effect of the 07 May 2020 Damavand-Mosha M_w 5.0 earthquake

Milad Kaboli[1], Saeid Rahimzadeh[2], Noorbakhsh Mirzaei[3]

[1] *PhD Student, Institute of Geophysics, University of Tehran, Tehran, Iran, m.kaboli@ut.ac.ir*
[2] *PhD Student, Institute of Geophysics, University of Tehran, Tehran, Iran, saeid.rahimzadeh@ut.ac.ir*
[3] *Professor, Institute of Geophysics, University of Tehran, Tehran, Iran, nmirzaii@ut.ac.ir*

ABSTRACT

Rupture directivity effects that cause spatial variations in ground motion amplitude around faults, is a parameter of seismic source that plays a significant role in generation of ground motions (and damage of structures, if the earthquake is large enough). Damavand-Mosha earthquake of 2020/05/07, Mw 5.0, occurred on the Mosha fault. To investigate rupture directivity of the mainshock we analyzed accelerograms recorded by the BHRC network. Larger amplitudes accelerations recorded in the stations west of the earthquake epicenter suggest mostly westward unilateral rupture propagation along the Mosha fault. This can be important in terms of seismic hazard for the Tehran megacity.

Keywords: Rupture directivity, Mosha fault, Strong ground motion, Damavand-Mosha earthquake, Tehran

INTRODUCTION

Rupture directivity is a parameter of the seismic source that plays an important role in the generation of ground motions and thus in structural damage (Courboulex et al., 2013). It produces azimuthal variation in the seismic radiation. When rupture propagates mostly in a single direction, the resulting ground motion can be subject to azimuthal effects (e.g. Poiata et al., 2017). That's why can be used to infer both the orientation of the fault plane and the rupture velocity; it also controls the peak ground shaking and damage (e.g., Kanamori et al., 1992) (Figure 1).

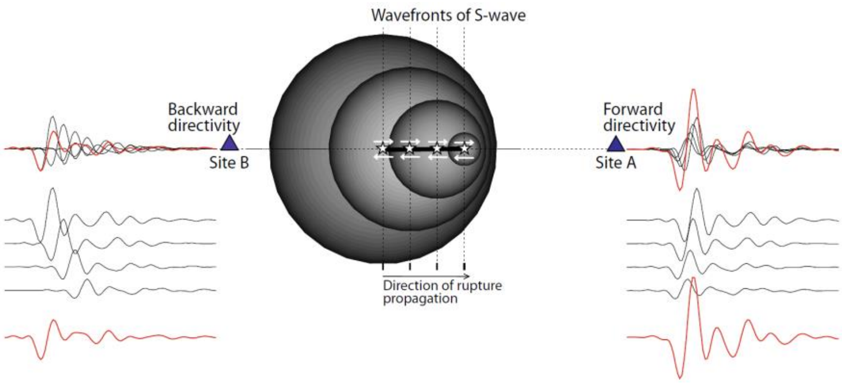

Figure 1. Snapshot of the S-wave fronts, illustrating the rupture directivity effect. Site A is located in the direction of the rupture propagation, while Site B is located in the direction opposite to that of the rupture propagation (Poiata et al., 2017).

This effect is known to cause directional variations in seismic ground motion and damage, and to occur if a strike-slip or dip-slip rupture propagates to a site in the along-strike or up-dip direction, respectively. Distance to the fault is not the only consideration for ground motion amplitude but the direction is also important. When a fault ruptures unilaterally, the radiated waves are stronger in one direction along the fault. Fault rupture directivity results in stronger ground motion along the rupture as compared to other directions concerning the epicenter of the earthquake. Its effect has, therefore, larger damaging potential in that direction (Boatright., 2007) due to the transmission of maximum energy placing serious demands on the design of structures (Srivastava et al., 2018). The rupture directivity effect is observed when the rupture front propagates over the earthquake source fault at high speed, typically slightly less than the shear wave (S-wave) velocity of the media. In this case, if a site is located in the direction of rupture, most seismic energy of the wave front will arrive in a single pulse of ground motion (Poiata et al., 2017) (Figure 1). The relationship between the rupture directivity and the seismic hazard is an important issue. The effect of directivity on seismic hazard depends on style of faulting, dip direction and fault orientation (e.g., Nemati et al., 2020).

TECTONIC SETTING AND SEISMICITY

The Alborz fold and thrust mountain belt, located south of the Caspian sea, results from the Iran–Eurasia collision starting in the Late Triassic (e.g. Jackson and McKenzie, 1984) with a present-day convergence rate of 23 mm/year (Vernant et al., 2004). One of the most important faults in the southern flank of Alborz mountain is Mosha fault that is a large left-lateral strike-slip fault with an approximate length of 200 km. It is part of the partitioning system that accommodates the oblique motion across Central Alborz together with both the reverse Khazar and North Tehran faults (e.g. Jackson et al., 2002). This fault is the largest fault in a complex system of faults located near Tehran.

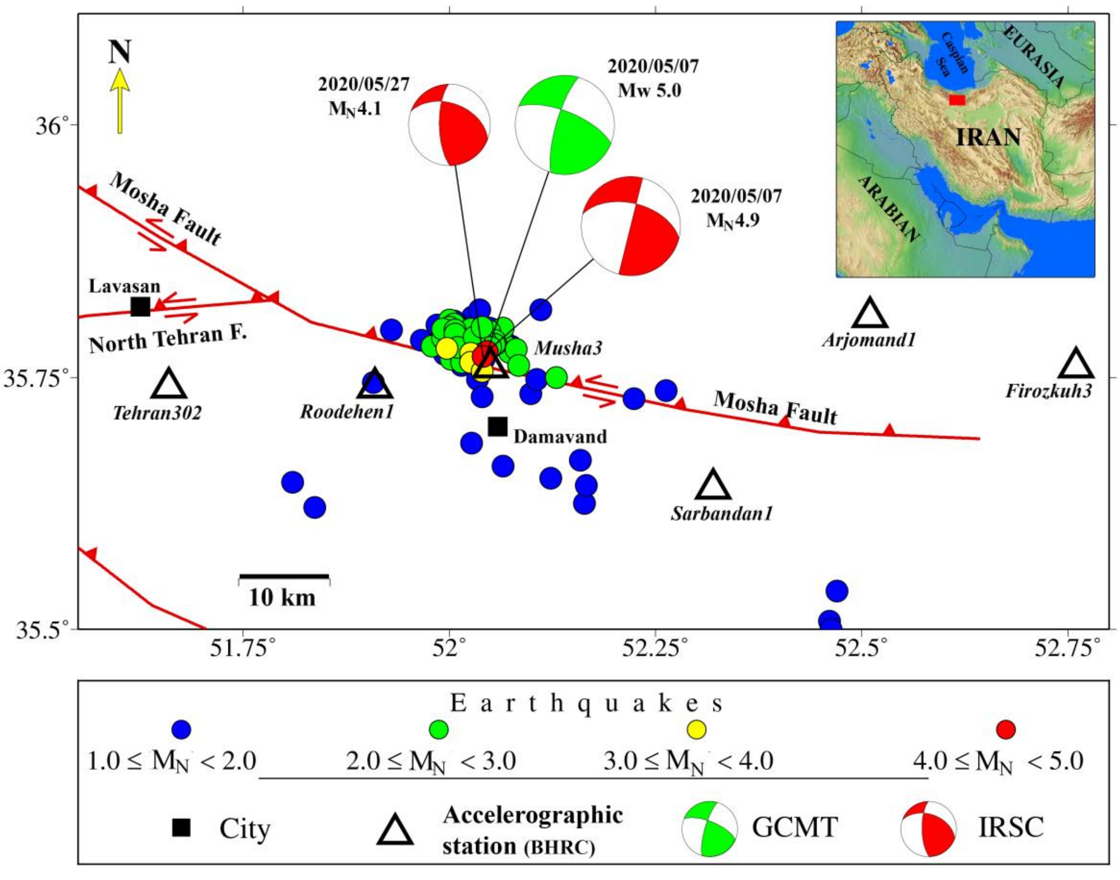

Figure 2. Simplified seismotectonic setting of the May 7, 2020 Damavand-Mosha earthquake.

On May 7, 2020, a M_N 4.9, M_w 5.0 earthquake with several aftershocks of various magnitudes occurred near the Mosha Fault. Figure 2 shows the position of the Mosha fault, accelerographic stations, the epicenter of the May 7, 2020 earthquake, aftershocks, and the focal mechanism solutions reported by GCMT and IRSC.

DAMAVAND - MOSHA EARTHQUAKE DIRECTIVITY

The rupture directivity can be measured from azimuthal variations in the duration of ground-motion, and the amplitude of the accelerograms waveforms recorded at similar distances. To investigate the rupture directivity, we used strong motion data recorded by Building and House Research Center (BHRC) network. Fig. 3 displays longitudinal, vertical, and transversal accelerograms recorded at 6 selected stations around the epicenter of the earthquake. These are the nearest stations in the epicentral area (Figure 1).

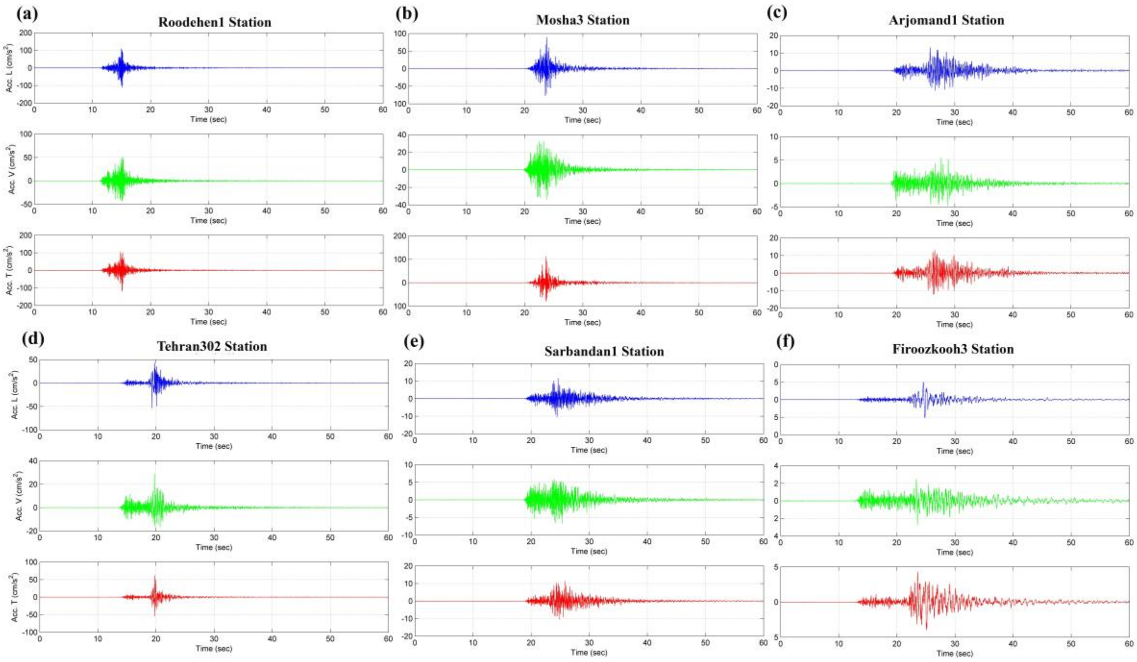

Figure 3. Three component strong motion records for 6 accelerographic stations.

In this event, strong ground motions took longer time at the eastern stations (Firozkuh3, Arjomand1 and Sarbandan1), but were larger in amplitude at western stations (Tehran302, Roodehn1) (Figures 3). This indicates that rupture was probably initiated in the east and propagated unilaterally towards the west (Figure 4).

CONCLUSION

In this study, we used the duration and amplitude of strong ground-motion records to investigate the rupture directivity of the May 7, 2020 Damavand-Mosha earthquake (Mw 5.0). In all cases, the rupture may have generally initiated in the east and propagated to the west, unilaterally. Longitudinal strong motions recorded well at Tehran302 station, ~40 km west of the earthquake, and at Arjomand1 station, ~37 km east of the earthquakes. In this event, strong ground motion took longer at Arjomand1, but was larger in amplitude at Tehran302. This time histories clearly indicate rupture directivity propagation to the west.

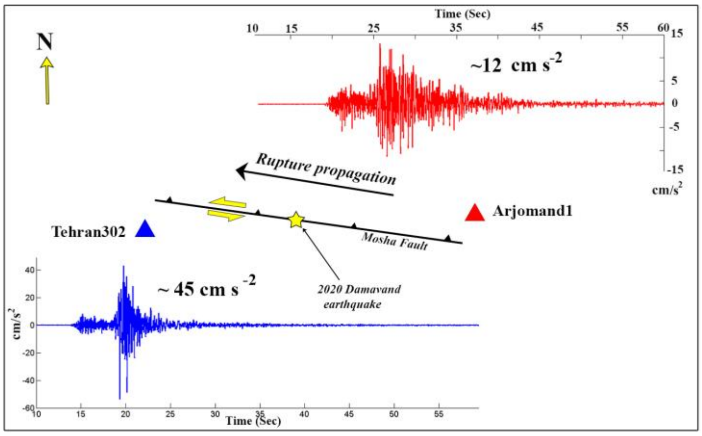

Figure 4. Characteristic waveforms observed in the vicinity of the rupture exhibiting directivity effect. The Tehran302 station is located in the forward-rupture propagation region with a large amplitude pulse on the longitudinal component. The Arjomand1 station is in the backward-rupture propagation region, and waveforms have longer duration without large amplitudes.

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