Strike-variable coseismic and postseismic slips of the 12 December 2017 Mw 6.0 Hojedk (Iran) earthquake revealed by Sentinel-1/2 images: Implications for the local lithospheric structure

Yingwen Zhao, Caijun Xu, and Yangmao Wen
School of Geodesy and Geomatics, Wuhan University, Wuhan, China

On 12 December 2017, a shallow reverse earthquake ruptured an unrecognized fault located in a transpressional relay zone between Lakar Kuh and Gowk faults. Four tracks of Sentinel-1A/B interferometric wide swath SAR images are used to generate coseismic interferograms. The retrieved maximum line-of-sight (LOS) displacement is up to ~1 m toward the satellite for descending data. An offset tracking method within GAMMA software is used to generate range and azimuth offsets based on Sentinel-1 SAR images. Two Sentinel-2 images are processed with the COSI-Corr package to generate horizontal displacements. The calculated three-dimension deformation field shows that the east-west displacements have motions in different directions, the north-south shortening near the fault trace approaches ~2 m and the maximum uplift is over 1 m. Based on the rupture trace in Sentinel-2 image, a strike-variable fault is constructed to explain the LOS displacements. The estimated slip distribution shows that the peak slip is ~2.5 m located at a depth of ~1.5 km and the depth extent of rupture is 0-3 km with the length of rupture on the surface approaching ~7 km. There are both right-lateral and left-lateral slips occurring on the fault, which are consistent with field observations. The one year of postseismic displacements are estimated by a short baseline subset technique based on two tracks (ascending and descending) of Sentinel-1 SAR images. The maximum LOS displacements is up to ~7 cm toward the satellite for the descending data. The forward displacements show that the poro-elastic rebound in the upper crust does not explain the LOS data. The data can be fitted well in terms of afterslip. The estimated postseismic slip on this strike-variable fault is found to occur in portions of the fault where small slips on these patches are obtained in the coseismic slip inversion. Most of patches related to the postseismic slip are located below the main coseismic patches with the depth extent of rupture being 0.5-4 km. The cumulative slip distribution during one year has the peak slip of ~20 cm, releasing ~12% of the moment of coseismic rupture. Taking into account aftershock depths, the shallow postseismic slip is considered to occur aseismically and cause the most of postseismic deformation. The afterslip may result from some response to a stress concentration located at the periphery of main coseismic rupture. After the analysis on Coulomb stress change, it is possible that the former two Mw ~6 earthquakes occurred on 1 and 12 December cause stress perturbations in the seismogenic zone of this earthquake, which further may bring the local prestressed lithosphere to rupture. For this shallow event, a small shear modulus (less than 30 GPa) is needed to make the moment more comparable to seismic results. This earthquake can be
interpreted as the accommodation of the northward motion in the form of oblique-slip reverse fault between right-lateral strike-slip fault systems. The unusually deformation patterns caused by the coseismic and postseismic slips of this earthquake may be indicative of differently local lithosphere structure in this transpressional relay zone.