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Graben formation during the Bárðarbunga rifting event in central Iceland

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On the 16th of August 2014, an intense seismic swarm was detected at the Bárðarbunga caldera (central Iceland), which migrated to the east and then to the northeast during the following days. The swarm, highlighting magma propagation pathway from the caldera, migrated laterally during the following two weeks over 40 km. By the end of August, a volcanic eruption had started along a north-south oriented fissure located ∼45 km from the caldera.

Here we focus on the near-field deformation related to the dike emplacement in the shallow crust, which generated in few days an 8 km long by 0.8 km wide graben (depression) structure. The new graben extends from the northern edge of the Vatnajökull glacier and to the north to the eruptive fissure. We analyze the temporal evolution of the graben by integrating structural mapping using multiple acquisitions of TerraSAR-X amplitude radar images, InSAR and ground-truth data with GPS and structural measurements. Pixel-offset tracking of radar amplitude images shows clearly the graben subsidence, directly above the intrusion pathway, of up to 6 meters in the satellite line-of-sight direction. We installed a GPS profile of 15 points across the graben in October 2014 and measured its depth up to 8 meters, relative to the flanks of the graben. Field structural observations show graben collapse structures that typically accompany dike intrusions, with two tilted blocks dipping toward the graben axis, bordered by two normal faults. Extensive fractures at the center of the graben and at the graben edges show a cumulative extension of ∼8 meters. The formation of the graben was also accompanied by strong seismic activity locally, constraining the time frame period of the main graben formation subsidence.

Our results show a rare case of a graben formation captured from space and from ground observations. Such structures are the dominant features along rift zones, however, their formation remain poorly understood. The results also provide information about transient deformation occurring along rift zones, suggesting that rapid dike intrusions modify the topography permanently in only a few days. This supports that rift morphologies are primarily generated during rifting events rather than by long-term regional tectonic processes.