Basaltic Magma Propagation: Insight from Inversion of InSAR and GNSS data of the May 2016 Piton de la Fournaise eruption

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Abstract

Magma stored beneath basaltic volcanoes is often transported by propagation of planar intrusions, which lead to fissural eruptions when they intersect the Earth's surface. This propagation is an unsteady process controlled by the magma-crust interaction, which generates seismicity and surface deformation before the eruption onset. To gain information into the dynamics of magma propagation we invert complementary ground deformation datasets recorded during the 8 hours preceding the May 2016 eruption onset at Piton de la Fournaise volcano (La Réunion, France). We combine SAR interferograms ensuring good spatial resolution and continuous GNSS data providing high temporal resolution. We use 3-D boundary element models combined with a Monte Carlo inversion method. We first retrieve the final geometry of the intrusion based on four interferograms, both ascending and descending paths, spanning the whole propagation phase. The imaged intrusion consists in a 2700 m long sill located at an elevation of 800 m, connected to the eruptive fissure by a 880m sub-vertical dike. We invert the continuous GNSS data performing a succession of independent inversions with a 5min time step in order to localize the pressurized area of the geometry previously retrieved from InSAR data. We take advantage of one Sentinel–1 image acquired during the propagation phase to compare inversion results from GNSS and InSAR data. We show that the a priori knowledge brought by the InSAR data helps to estimate the intrusion depth otherwise poorly constrained. Our temporal inversion provides insights into the dynamics of the propagation. We evidence that the horizontal part of the intrusion opens a few tens of minutes after the beginning of the crisis. The intrusion is then stalled for 4h, while the pressure increases, until the last part of the intrusion propagates vertically to feed the eruption. These observations might indicate the presence of barriers to propagation.

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