Pressure source estimation of tilt changes associated with small explosions at Stromboli volcano

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Stromboli volcano is characterized by continuous activities of Strombolian explosions (small explosions) at summit craters. A lot of studies have investigated volcanic processes by multi-parameter observations. However, pressure source determination by geodetic measurements, which is indispensable to understand shallow magma reservoir which is a key for understanding magma dynamics, have not yet been well conducted because of insufficient geodetic observation network. In the present study, we analyze tilt records at 3 temporal and 2 permanent stations located closely to the summit craters to determine the locations and size of pressure source by comparing the observed tilt vectors with the theoretical ones that are calculated by using finite element method.
Temporal stations CPL, PZZ, RFR were equipped with Applied Geomechanics 701-2A, and installed at a distance of <500 m from the active craters. Continuous stations LFS, OHO, LSC, operated by University of Florence, were equipped with Pinnacle 5000T. We analyze continuous tilt records of 5 stations during July 1 to July 15 when small explosion activity was high. We extract uplift and subsidence tilt signals associated with each of small explosion and classify them in 4 stages: (A) Gradual uplift prior to small explosions, (B) Rapid uplift just before small explosions, (C) Rapid subsidence after small explosions, (D) Small uplift after (C). Tilt azimuths and amplitudes are almost same for the stages of (A) –(C), although LFS show about 30 degrees difference. We use the tilt vectors averaged for 680 events in the following analyses. We suppose that the pressure source is represented by an ellipsoidal cavity at (1) beneath the summit craters or (2) VLP source (Chouet et al., 2003; 200 m NW from the summit craters). We searched optimal source model which could explain the observed tilt vectors by changing the size and shape of the ellipsoidal cavity. The results show that simple shape sources such as a sphere cannot explain the observed tilts both for the locations of (1) and (2). A spheroidal source that is modeled from the VLP source mechanism do not explain the observed tilts, either. By changing the size and directions of ellipsoidal cavity, we find that the ellipsoidal cavity with a size of 300×150×600 m at 400 m depth beneath the summit craters can well explain the observed tilts. The pressure applied during the episode (A) is estimated to be about 1 kPa.
The size and position of the estimated ellipsoid is basically consistent with the picture of shallow magma reservoir inferred from an analysis of temporal evolution of flank lava effusion in 2007(Ripepe et al., 2015). The mass and volume of magma supplied for conduit during a small explosion that are estimated from the obtained pressure change, appropriate conduit radius and magma density is comparable to the ejected mass and volume of one small explosion estimated from the observations of surface phenomena.

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