Moment tensor inversion of very-long-period seismicity at Stromboli volcano based on a very-near-field observation

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In recent decades, moment tensor inversion of very-long-period (VLP, 2-100 s) earthquakes associated with explosive/non-explosive activities has been applied to estimate the optimal source location and mechanism. Source mechanism of VLP associated with explosions at Stromboli volcano has been interpreted as the pressure source of opening/closing cracks embedded in the volcanic medium (Chouet et al., 2003). However, the nearest temporal station is 300 m away from the craters so that the source mechanism might have not been constrained well to discuss the detail processes of the magma motion in the conduit. In this study, we analyze broadband seismic data observed in the very-near-field condition, only 100-300 m away from the active craters, to obtain a more precise source mechanism solution.

We use the seismic data recorded at eight broadband seismic stations including temporary and permanent networks. Infrasonic array analyses show that the explosive eruptions mostly occurred at the north-east (NE) crater during the observation period in the end of September 2016. We apply a moment tensor inversion method to VLP (0.05-0.2 Hz) signals associated with the largest explosion occurring at the NE crater. The result shows that the optimal centroid is located at 200 m southwest of, 160 m beneath the NE crater. The source mechanism is greatly dominated by the vertical component of the moment tensor (Mzz), although the polarity inverts with other two diagonal components (Mxx, Myy). The squared error between the observed and synthetic waves (Ohminato et al. 1998) is only 11%.

We note that the squared errors less than 20 % are widely distributed around the optimal location: 300 m ×300 m in horizontal distances and 250 m in the vertical direction. For example, the solution obtained at a depth of 160 m beneath the NE crater shows the error of 18 %, which is within the confidence interval 95 % range of the residual at the optimal location. At this location, the inverted source mechanism is dominated by three diagonal components with a same polarity. This is much different from the best solution.

To examine why such different source mechanisms are obtained for nearby source locations, we calculate a model resolution matrix using the Green’ s functions computed from a point source at the optimal location and investigate how well the moment tensors can be resolved. The minimum singular value in the model resolution matrix is assumed to be 2.1 % of the maximum. We replace this value with zero and consider the pseudoinverse. The model resolution matrix for the pseudoinverse shows that the resolution of the diagonal components of moment tensors is lower than deviatoric ones. This suggests that the amplitudes of diagonal components are not well constrained from the moment tensor inversion even using near-by stations in our temporal observations. These results will be indispensable for discussing the spatial distribution of the volumetric change in the conduit or magma chamber accompanying the explosions.

Keywords: moment tensor inversion, source mechanism, VLP, Stromboli volcano, very-near-field, model resolution matrix