Inflations of Magma Reservoir Occurring prior to the Caldera Formation with the 2000 Miyake-jima Volcanic Activity

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Miyake-jima island, which is about 200 km south of Tokyo, is one of the most active volcanoes in Japan. In most historical events, basaltic magma have erupted mainly from the flank of the volcano in a more or less constant interval, but the 2000 activity took place in a different way, namely a formation of caldera after an interval of 2500 years.

The interesting seismic signals that have a very long pulse width of about 20 s, called VLP events hereafter, are observed in the initial stage of the volcanic activity. The VLP events can be clearly identified 4 days before the first subsidence of the summit area leading to a caldera formation on 8 July from 4 July, and are frequently observed 1-2 days prior to the subsidence start. However the events are hardly recognized after the onset of the subsidence. Considering the temporal relation to the caldera formation event, the VLP signals are likely relevant to the preparatory process of the caldera formation. In this study, we investigate the source properties of the VLP events with conducting a waveform inversion procedure and discuss the occurrence in relation to the caldera formation process.

The particle orbits of the VLP events have elliptical shapes at all the stations, and their major axes consistently point to the same region. Each initial motion is oriented outwardly from the region where the elliptical orbits point to, strongly suggesting that a VLP event is excited by a significant volumetric expansion.

To determine the location and the mechanism of the VLP source, we conduct a waveform inversion procedure. In this analysis, synthetic waveforms for trial point sources placed at a grid point in three-dimensional space are computed, and are compared with the observed waveforms. The source point and source time functions that give the best waveform fit are regarded as the optimal estimate of the source. We assume six moment tensor components for the mechanism of VLP event, because it is likely that the VLP signal is produced by some source process significantly involving a volume expansion.

The results of a waveform inversion show that the source location is positioned at the depth of 3.5 km below the 1 km south of the summit, whose position is good agreement with a pressure source inferred from geodetic analyses. The source mechanism can be explained by an inflation of an elliptical cylinder that stretches to NE-SW direction and slightly inclines toward the summit area.

The interesting is that the VLP events have several similar features to ultra very long period (UVLP) events which are intermittently observed with a pulse width of 50 s after the caldera formation on 8 July until the terminal stage of caldera enlargement [Kumagai et al., 2001], suggesting that similar phenomena have already been in progress even before the caldera formation start. We interpret that a fall of a rock block in the volcanic conduit produced an inflation of a magma reservoir due to an internal pressure increase at each injection, and resultantly facilitated a gravitational instability of the crustal rock leading to the caldera formation.