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Kinematic GPS Analysis Gives New Insights on the Origin of the Very-Long-Period Seismic Signal at Miyake-jima Volcano during the Caldera Formation

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1. VLP signals at 2000 Miyake-jima eruption

The 2000 eruption of the Miyake-jima volcano, located 200 km south of Tokyo (Fig. 1) is characterized by the formation of gigantic summit caldera (Fig. 2). During the caldera forming period (8 July to 18 August, 2000), very long period (VLP) seismic signals were repeatedly recorded on the broadband seismograms (Kumagai et al., 2001).

In this study, we aim to construct a source model for the VLP signals by use of the associated crustal deformatinos as observed in the kinematic GPS time series.

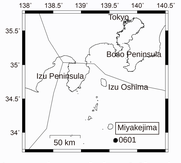

Fig. 1 Location of the Miyake-jima

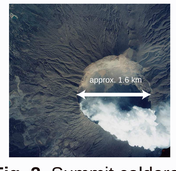

Fig. 2 Summit caldera

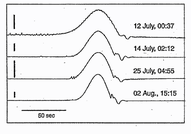

Fig. 3 Example of VLP signals (from Kumagai et al., 2001)

2. Insights from broadband seismograms

The VLP signals has been investigated using broadband seismograms and tiltmeter. They occured repeatedly approximately 40 times during 40 days with similar waveforms, suggesting repetitive and nondestructive source process. The ``piston model'' is proposed in which a vertical piston of solid materials in the conduit is intermittently sucked into the magma chamber by lateral magma outflow (Kumagai et al., 2001).

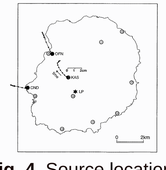

Fig. 4 Source location (from Kikuchi et al., 2001)

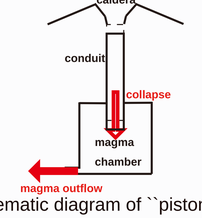

Fig. 5 Schematic diagram of ``piston model'' (after Kumagai et al., 2001)

Abstracts

During the 2000 eruption of Miyakejima in Japan, very long period (VLP) seismic signals were repeatedly observed. Corresponding kinematic GPS time series can be interpreted as the superposition of 1) inflation of the VLP source at the onset of VLP signal, 2) Continuous deflation of the same source, and 3) exponential volume decrease of the same source following the onset of VLP signal with a decay constant of approximately half a day.These features basically support the piston model for the VLP signals in which a vertical piston of solid materials in the conduit is intermittently sucked into the magma chamber by lateral magma outflow.

3. Kinematic GPS analysis

We obtained the kinematic GPS time series for 15 GPS stations on the Miyakejima island with 30 sec interval. To enhance the signal-to-noise ratio, we stacked the kinematic GPS time series for all VLP events and used the resulting stacked kinematic GPS time series for further analyses (Fig. 7).

In Fig. 8, we present the stacked kinematic GPS time series at Site 3060 as an example. For every component, one can see that the time series can be decomposed into:

1) offsets at the onset of VLP signals (which corresponds to an elapsed time of 0)
2) linear trends
3) gradual decay following the offset

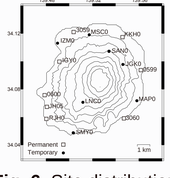

Fig. 6 Site distribution

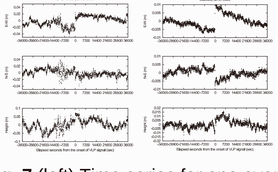

Fig. 7 (left) Time series for one event (right) Stacked time series

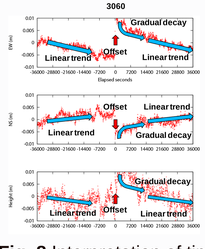

Fig. 8 Interpretation of time series

4. Modeling

4-1. Offsets

Inflation of the source composed of a spherical source under the southern flank of the edifice at a depth of 3.6 km and a nearby tensile dike with approximately northeast-southwest strike whose top is at a depth of 0.5 km successfully explains the data (Fig. 9).

4-2. Linear trends

The estimated source location match that of the offsets within a reasonable margin of error. The source was continuously deflating. These fasts support the ``piston model'' a vertical piston of solid materials in the conduit is intermittentlysucked into the magma chamber by lateral magma outflow.

4-3. Gradual decay following the offset

We constructed the stacked kinematic GPS time series by considering polarity of the offsets, Dp, which will represent the volume (pressure) change at the source. Dp can be modeled by the exponential decay with decay time of half a day, along with the offsets and linear trends. This exponential decay may reflect the temporal increase of the magma outflux at the source in response to the overpressure associated with the collapse of the conduit materials, that resulted in VLP signal (Fig. 10).

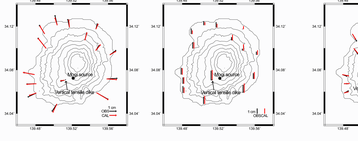

Fig. 9 Displacements associated with the VLP signals and the optimal source model

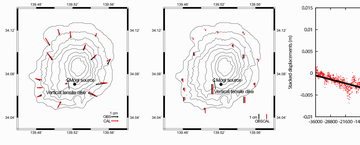

Fig. 10 Displacements associated with the linear trends and the optimal source model

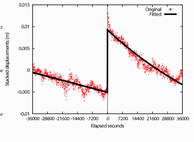

Fig. 11 Stacked kinematic GPS time series by considering offset polarity

Acknowledgements

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