Moment tensor analysis of low-frequency earthquakes at Kuchinoerabujima volcano

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1. Introduction

Kuchinoerabujima, located at south off Kyushu, is andesitic volcano. Recently, inflation around the summit crater (Shindake crater) from GPS observation and increases of seismic and geothermal activities were observed. Activities of volcanic earthquakes increased in 1996, 1999 and every year after 2001 at shallow part beneath the Shindake crater. Most of volcanic earthquakes observed at the volcano were high-frequency events with the dominant frequencies of higher than 8 Hz. However, low-frequency, monochromatic, and hybrid-type (high-frequency earthquake including a low-frequency component at the first part) earthquakes were observed during increase in seismicity of high-frequency earthquakes. In this study, moment tensors for low-frequency components (1-2 Hz) of the hybrid-type earthquakes were estimated by a waveform inversion method. And, the mechanism of source of the low-frequency components was discussed from obtained moment tensors and seismic and fumarolic activities around the Shindake crater before and after the occurrence of the hybrid-type earthquakes.

2. Seismic observation

A three-component short-period seismometer (natural period of 1 Hz) was installed at 0.4 km apart from the Shindake crater of Kuchinoerabujima volcano operated by Sakurajima Volcano Research Center (SVRC), since 1992. And, three broadband seismometers were installed around the Shindake crater since May, 2002. Seismic signals from the stations are transmitted to SVRC via radio and telephone line and recorded as velocity waveform with a sampling rate of 200 Hz by data logger (LS-7000XT). In this study, the records from a short-period and three broadband seismometers at four stations were used for the evaluation of the moment tensor.

3. Moment tensor analysis

Hypocenter of the hybrid-type earthquake using arrival time of high-frequency component at the first part is the depth of 0.3 km beneath the Shindake crater, whereas hypocenter of source of the low-frequency component could not be determined because the first motion was not clear. Particle motions of the low-frequency components at all the stations were linearized in the direction to the Shindake crater. So, epicenter of the source of the low-frequency components was assumed at the Shindake crater. The depths (increment of 0.05 km beneath the crater) were tested to minimize the residual between synthetic waveform and observed one in order to obtain moment tensor of the source of the low-frequency components.

The moment tensors were dominated by negative diagonal components. The ratio of horizontal dipoles and vertical dipole was approximated by 2:1. Non-diagonal components were less than 15% of horizontal dipoles. The depth of the source as minimizing the residual between synthetic waveform and observed one was 0.30 km. The hypocenter of the source of the low-frequency components was the same location as one of high-frequency component. From moment tensor analysis, the source of the low-frequency component of the hybrid-type earthquake is excited by a cylindrical contraction at the depth of 0.30 km beneath the Shindake crater.

4. Discussion

High-frequency earthquakes occurred beneath the Shindake crater with the depth of 0-600m. Geothermal and fumarolic activities exist in and around the Shindake crater. The fumarolic activity increases and area of activity spreads during increase in seismic activity. So, it is considered that hydrothermal fluid rises up through the hypocentral distribution of high-frequency earthquakes, and reaches at the ground surface, forming geothermal anomaly (Iguchi et al., 2002). It is inferred that a cylindrical contraction may be generated by movement of hydrothermal fluids from hypocenter to surface, considering occurrence of the hybrid-type earthquakes and increase of fumarolic gases in and around the crater during increase in high-frequency earthquakes.