

Hypocenter determination of B-type earthquakes at Miyakejima volcano using waveform cross correlation technique

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The 2000 eruptive activity of Miyakejima volcano is characterized by dike intrusions, episodic large summit eruption, summit caldera formation and successive emission of volcanic gases. No noticeable eruption has occurred since September 2000, but Miyakejima still continues to emit a large amount of volcanic gases. During this long gas emission stage, many volcanic earthquakes also occurred, but most of them are so called B type earthquakes whose hypocenters are not determined because of unclear P and S phases. To better understand the activity of B type earthquakes, we classify the B-type earthquakes into several earthquake families based on waveform similarity, and determine their hypocenters.

We analyze seismograms of about 1,020 B-type earthquakes at Miyakejima volcano, which are observed by JMA and NIED for the period from August 2010 to April 2011. The seismic network consists of about 10 stations, each of which is equipped with a short period, three-component seismometer. All stations are located within 4 km from the summit crater. In order to find earthquake families, we first band-pass filter the seismograms at 2-4 Hz that is the dominant frequency of B-types. Then, we calculate cross-correlation coefficients for all of the pair of two earthquakes that are selected from 1,020 events. We select the pairs with a cross correlation coefficient larger than 0.7, and find 4 groups of the B type earthquake families, each of which consists of more than 20 earthquakes.

Assuming that all the B-type earthquakes belonging to a same group of earthquake family are closely distributed in space and their source mechanisms are same, we stack the observed seismograms at each station for the same group. As a result, P and S phases on the stacked seismograms become clearer, which enables us to precisely measure their arrival times. Under a homogeneous half space with a P-wave velocity of 2 km/s, we determine the hypocenters of 4 groups of the earthquake family from the arrival times. Their hypocenters are located at the southern part inside the summit caldera, at depth of about 1 km.

We further investigate low frequency component of these earthquake families. The individual seismograms at each station are band-pass filtered at 0.25-0.5 Hz, and are stacked for the same group. As a result, significant low frequency signals appear for one group of the earthquake families. Particle orbits of the low-frequency waves are characterized by linear trajectories in the horizontal plane. The major axes of the trajectories at all of the stations intersect at the southern part of the summit, which is almost the same location with the epicenters determined from P-wave arrival times.

We have succeeded in determining the hypocenters of about 18 % of the total B-type events by using waveform cross correlation techniques. Also, we found an interesting low-frequency phases that may represent an existence of volumetric seismic source beneath the active crater of Miyakejima.

Keywords: Miyakejima volcano, earthquake family, hypocenter determination, B-type earthquake