

Hypocenter determination of B-type earthquakes at Miyakejima volcano using the envelope correlation method

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After the 2000 eruptions, Miyakejima volcano still continues to emit large amount of volcanic gases. Meanwhile, B-type earthquakes have also been continuously and frequently observed after the eruptions, and often show emergent onsets of P- and S-phases, which makes the application of conventional phase-picking hypocenter determination rather difficult. Recently, Uchida et al. (2012) analyzed B-type events at Miyakejima volcano, which are observed by Japan Meteorological Agency from August 2010 to April 2011, and succeeded in determining 18 % of the observed 1,049 B-type events by stacking the waveforms of earthquake families to read the P- and S-wave onset times. However, the hypocenters of the rest of B-type events still remain unknown.

In this study, aiming to locate all of the B-type earthquakes at Miyakejima, we apply the method of Obara (2002), which was used for non-volcanic deep tremors on the subducting Philippine Sea Plate in south west Japan, to the seismograms observed at nine stations located within 4 km of the summit. At each station, we compute a RMS envelope from 4 - 8 Hz band-pass-filtered three-component seismograms, and measure the differential travel times between stations by taking cross-correlations of the envelopes. We assume that the envelope is composed of S-wave traveling with the velocity of 1250 m/s, as in Uchida et al. (2012).

To assess the applicability of the method to B-type earthquakes, we determine the hypocenters of individual events in each of the four earthquake families by applying the envelope correlation method, and compare the resultant hypocenters with those obtained from phase picking of the stacked waveforms. As a result, we found that the epicenters located by the envelope correlation almost coincide with those determined by the phase picking. On the other hand, the method sometimes yields large error in depth. That is probably due to the difficulties in measuring the S-wave travel times from the envelopes. To improve the accuracy, we need to consider the envelope broadening by scattered waves, surface waves and/or reflection phases.

We then apply the envelope correlation method to all of the observed 1,049 B-type earthquakes, of which about 80 % had never been located, and successfully locate them in an automated way. As a result, we found that 97 % of them are located within a 1.5 km diameter centered on the southern part of the summit caldera, where continuous fumarolic gas emission occurs. It strongly suggests that the occurrence of B-type earthquakes is related to the gas emission activity at Miyakejima. Those hypocenters are distributed at the depths shallower than 3 km. Our study shows the usefulness of the method as a tool to monitor volcanic earthquakes which are difficult to locate by conventional phase picking.

Keywords: Miyakejima volcano, B-type earthquake, hypocenter determination, envelope correlation method