Hypocenter determination of seismic activity at Tokachi-dake volcano by using ASL method

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Tokachi-dake volcano in the central part of Hokkaido continues active fumarolic discharge from 62-II crater and Taisho crater. In these craters, the effusion of hot muddy water and the expansion of the fumarolic area have been sometimes reported. Recently, ground inflation and increase in thermal activities in the vicinity of the active craters have been observed and some observation stations were newly installed to reinforce the volcano monitoring.

Seismicity at Tokachi-dake is also active especially at the shallow part around the active craters. Thanks to the installation of seismic stations near the craters in these years, it has been revealed that there is a clear temporal change in amplitude of background seismic signal. In the meantime, volcanic earthquake at Tokachi-dake contains many events with the obscure arrival of P and S phases and tremor-like signals though they have large signal amplitude. Such events are left unexamined because of the difficulty of manual picking in routine hypocenter determination analysis. For the better evaluation of seismic activities at Tokachi-dake, it is necessary to determine the hypocenter and magnitude of the unexamined events. In this study, we introduced Amplitude Source Location method (ASL method), an alternative hypocenter determination approach free from phase picking, to the volcanic earthquakes at Tokachi-dake and examined the precision of results and dependency on the seismic station distribution.

ASL method is a hypocenter searching technique using the spatial distribution of observed seismic amplitudes and has been applied to determine the source location of volcanic tremor and volcano lahars (e.g., Battaglia and Aki, 2003; Kumagai et al., 2010; Ogiso and Yomogida, 2015). This method assumes the isotropic radiation of S wave regardless of the source mechanism. Here we assumed that the observed seismogram of volcanic earthquake mainly composed of the isotropically radiated S wave and analyzed the signal in the frequency band of 5 –10 Hz in which the seismic signal has enough power.

To evaluate the precision of hypocenter determination by ASL method, we compared the result of ASL method using seismic amplitudes at 7 stations with that of the traditional analysis using phase picking and "*hypomh*" algorithm. The data used here were the 66 earthquakes with clear P and S phases occurred in May 2017. Hypocenters determined by the phase picking are mostly distributed at a shallow part under the summit crater and are partly located at around 1000 m below sea level. We tried several Q values in the range of 50 –200 and Q = 50 gave the best coincidence between the traditional analysis and the ASL method. Then we relocated the 913 seismic events of Tokachi-dake observed in 2017. Almost half of them (446/913) were the undetermined event. The undetermined events are also distributed at a shallow part under the crater area.

Because of the severe weather condition in winter, seismic data transmission sometimes interrupts. So, as the next step, we reduced the number of the station used in ASL method by one and tested the different combination of the seismic station. When one of the summit 3 stations around the craters is eliminated, hypocenter distribution is distorted towards the eliminated station. Since the number and spatial distribution of seismic station are limited at Tokachi-dake, the precision of hypocenter largely decreases if the summit station stops.

Finally, we tried to determine the source location of background seismic signal with large amplitude fluctuation in time. In 2017, a rapid increase in seismic amplitude was observed at around the crater area. The determined source locations by ASL method concentrate at the shallow part under the crater area. Therefore, we fixed the epicenter at the 62-II crater and searched only source depth. The amplitude increase in background seismic signal in 2017 can be explained by a little rise and strengthening of the seismic source.

Keywords: Tokachi-dake volcano, volcanic earthquake, hypocenter determination

