Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

SVC55-P33 Room:Poster Time:May 1 18:15-19:30

Waveform analysis on initial phases of explosion earthquakes at Lokon-Empung volcano, Indonesia

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Excitation mechanism of explosion earthquake that often accompanies explosive Vulcanian eruptions is understood to be macroscopically explained by a downward single force acting in the vent. In the meantime, it is revealed that the excitation of initial phases of explosion earthquake occurs earlier than the explosion at the crater [e.g. Tameguri et al., 2002]. So the excitation of the initial phases of explosion earthquake can be regarded as one of the most important processes to understand the initiation of Vulcanian eruption. However, the researches focusing on the initial phases are not so common in spite of their scientific importance. In this study, we implemented temporary observation of Vulcanian eruption at Lokon-Empung volcano in Indonesia and estimated source parameters of the initial phases of explosion earthquakes to compare them to the previous works at Sakurajima volcano and Suwanosejima volcano.

Lokon-Empung volcano located in the northern part of Sulawesi island is known as one of the very active volcanoes in Indonesia. We deployed seismic and infrasound observation network around Lokon-Empung in September 2012. During about one-year-long observation, 46 events of explosion earthquakes associated with Vulcanian eruptions had been recorded. Seismograms of explosion earthquakes have common features in the initial phases at all stations; the compressional P phase arrives first, and a larger dilatational phase follows it. Comparison between seismic and infrasound record shows that the excitation of the P phase occurs about 1 second earlier than that of infrasound which is thought to be excited by the explosion at the crater. Particle motion analysis reveals that these initial phases consist of P wave and propagate from the direction of the active crater. Since signal to noise ratio of the first compressional wave (P phase) is not good at some distant stations, we focus on the second dilatational phase (D phase). We performed waveform fitting on the D phase using synthetic seismogram to estimate source depth, shape of source time function, contraction mechanism and seismic moment.

For most events, we obtained the best fitting solution with cylindrical contraction source located at 1 km below the crater. We compared the estimated seismic moment of D phase and the amplitude of seismogram and infrasound with those reported in the previous works, and found that the strength of the explosion of Lokon-Empung ranks between those of Sakurajima and Suwanosejima. At Sakurajima volcano, Tameguri et al. (2002) showed that the amplitude of infrasound is independent from the moment of D phase. On the other hand, Hirai (2013) reported a positive correlation between them at Suwanosejima volcano. Estimated focal depths of D phase at these two volcanoes are 2 km and 100 - 400 m, respectively. At Lokon-Empung volcano, we recognized a weak positive correlation between the amplitude of infrasound and the moment of D phase. The comparison suggests that the shallower focal depth of D phase becomes, the stronger the correlation between moment of D phase and strength of infrasound appears. This result we obtained here will provide a new insight into the unrevealed process between the excitation of D phase and the surface explosion.

Keywords: Vulcanian eruption, Explosion earthquake