Source depth of Strombolian eruptions at Aso volcano in April 2015

*Kyoka Ishii¹, Akihiko Yokoo¹, Tsuneomi Kagiyama¹, Takahiro Ohkura¹, Shin Yoshikawa¹, Hiroyuki Inoue¹

¹Graduate School of Science, Kyoto University

At the Nakadake 1st crater of Aso volcano, magmatic eruptions had started in November 2014 after 22 years dormancy. This eruption activity lasted until May 2015. It was a first time for us to observe the eruptions using a network of seismo-acoustic sensors deployed around the crater. We have stations equipped with a low-frequency microphone (ACM) and a short-period seismometer (KAF) on the crater rim. They are situated at 260 m SW and 230 m SSW from the active vent, respectively. On the NNW flank of the volcano (830 m distance), a broadband seismometer (UMAB) is installed. In this study, we analyze seismo-acoustic data acquired at these three stations in the 19:00-20:00 JST (GMT+9:00) on 24 April 2015 to estimate source depths of Strombolian eruptions.

At each Strombolian eruption, characteristic seismo-acoustic signals were observed. They were typically started by a downward phase of low-frequency (<0.1 Hz) seismic velocity to the UMAB station. This wave corresponded to a long period tremor (LPT; Yamamoto et al., 1999, GRL). A couple of seconds later (1.7-5.4 s), higher frequency (5-10 Hz) seismic velocity arrived to the KAF station. Infrasound wave was detected at ACM about 1 s after the seismic arrival to KAF. The infrasound wave (peak frequency is ~0.5 Hz) was started by a compression phase, however in 0.1 s later a high-frequency content (>10 Hz) was added on it. We can recognize a strong positive correlation (R=0.92) between Root-Mean-Squared (RMS) amplitude of the seismic velocity at KAF and that of 10 Hz high-passed infrasound wave at ACM. The time delay between the arrivals of these two signals was 0.93-1.56 s (mean 1.2 s).

To estimate source depth of each Strombolian eruption, we assumed that a space in the conduit through which infrasound wave propagates was occupied with hot volcanic gases. On the basis of a composition (H₂O:SO₂:CO₂ =90:4:4; Shinohara, Pers. Comm., 2016) and a temperature data (330-360 K at the vent), the sound velocity inside the conduit was estimated to be 410-430 m/s. We also considered that seismic signals observed at KAF are composed of the P wave (Vₚ=3.3 km/s; Tsutsui et al., 2003, BVSJ). It resulted in the source depth of each Strombolian eruption to be 70-380 m. This depth is consisted with a shallow region above an upper edge of the crack-like conduit (300 m; Yamamoto et al., 1999, GRL).

We intended that signals of LPT arrived to UMAB was 1.7-5.4 s earlier from the arrival time of high-frequency seismic wave to KAF. Because LPT is resulted from a resonant oscillation of the fluid-filled crack-like conduit beneath the active crater (Yamamoto et al., 1999, GRL), Strombolian seems to relate the source of LPT as well. According to a near-field effect, the phase velocity of the LPT has a value between those of the P and S waves (3.3 and 1.9 km/s; Sudo and Kong, 2001, BV). It indicates that ascending speed from the source location of the LPT, at the center of the crack-like conduit (1.6-1.8 km; Yamamoto et al., 1999, GRL), to the depth of Strombolian eruption we could estimate (70-380 m) is 300-700 m/s. It is too fast to consider that the volcanic fluids (magma and gases) migrate upward with this velocity. At the present, we interpret it as a pressure wave; it is radiated from the LPT source at the same time of the LPT occurrence and propagates inside the crack-like conduit to the depth of Strombolian eruption. Estimated speed of the pressure wave (300-700 m/s) is accountable either when andesite molten magma (sound velocity is 2.3-2.5 km/s; Murase and McBirny, 1973, BGSA) includes bubbles at a few vol.% (Morrissey and Chouet, 2001, JVGR), or when H₂O vapor steam contains small amount of ash particles (< 10 vol.%).
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