

Conduit opening process toward ash eruptions estimated from continuous tremor at Aso volcano: ash eruptions in May 2011 and in January 2014

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Continuous volcanic tremor at Aso volcano, has a feature to vary in amplitude with volcanic activity. Takagi et al. (2009) revealed that the source location of the continuous tremors was different between a calm and an active period. However, it has not yet been clarified about path and timing of the source migration, and relationship between the source location and occurrence of eruptions.

Ash eruptions occurred on May 15, 2011 and January 13, 2014 at Aso volcano (Japan Meteorological Agency 2011, 2014). Preceding both the eruptions, vents opened in the center of the crater bottom, 5 and 11 days before the 2011 and 2014 eruptions. Amplitude of continuous tremor increased before the opening of the vents and then decreased after the opening. While no significant change in the tremor amplitude was observed before the 2011 eruption, the amplitude gradually increased before both opening another vent and an eruption on January 13, 2014.

In this study, we estimated source location of the continuous tremor in these two eruption event periods. Then, we infer processes in a conduit system toward the eruptions. We use the vertical seismic records at five permanent stations around the active crater. The source location was estimated by a grid search technique using spatial distribution of the observed tremor amplitude (e.g. Battaglia & Aki, 2003). In this calculation, 1-D seismic velocity structure (Sudo & Kong, 2001; Tsutsui et al., 2003) and $Q=40$ were used. The quality factor was determined by an inversion method using t^* value (De Gori et al., 2005).

As a result of our estimation, in both the 2011 and 2014 event periods, the source locations of the continuous tremor are distributed in a cylindrical space beneath the crater. They are ranging between a depth of 400 m and the crater bottom. The distribution of the tremor source locations should indicate the shallowest pathway in the conduit system at Aso volcano. This pathway connects the crack-like conduit (Yamamoto et al., 1999) and the crater bottom distribute, through the hydrothermal fluid reservoir at a depth of 50-300 m (Kanda et al., 2008).

Another finding of the estimation is that the source location varies with changes of the activity. Before the significant increases of amplitude in 2011 and in 2014, the tremor is radiated at a 200 m depth. The source depths of the tremor with increasing amplitude before the opening the vents are different between these events, 100 m in 2011 and 200 m in 2014. This is thought to indicate processes of establishing the fluid pathway at <200 m depths, which finishes when the vent has opened with drop of amplitude. The source location has migrated to 200 m shallower region until <10 days before the ash eruptions in the both events. This source migration may be caused by processes leading the eruptions, without change of amplitude.

Based on the temporal variation in the observed amplitude and the estimated source depth of continuous tremors, we specular processes in the shallowest part of the conduit system in the 2011 and the 2014 events. Fluid supply into the pathway had increased from March 2011 and then fluid pressure in the

pathway increased. This led the pathway at a 100 m depth was widened with significant increase in tremor amplitude. Due to opening the vents, the amplitude decreased sharply on May 10. After that, the tremor source ascended. When the source reached at the crater bottom, on May 15, the ash eruption occurred. After that, the activity was once ceased by rainfall. From December 2013, the fluid supply had increased again. Then, the pathway was expanded at a 200 m depth. After the opening of the vent on January 2, 2014, the tremor source ascended to a 200 m depth. At this time, the small-scale pathway expansion also proceeded. As the shallower pathway than the depth 200 m had already been established, the source depth may jump to the near of the crater bottom. On January 13, the other vent was opened and the ash eruption occurred.

Keywords: Aso volcano, volcanic tremor, ash eruption, conduit system