A study of the temporal change in oscillatory characteristics of Long-period tremor at Aso Volcano, Japan

*Mare Yamamoto[1], Takahiro Ohkura[2], Satoshi Kaneshima[3], Hitoshi Kawakatsu[4]

1. Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University, 2. Aso Volcanological Laboratory, Institute for Geothermal Sciences, Graduate Shcool of Science, Kyoto University, 3. Department of Earth and Planetary Sciences, Kyusyu University, 4. Earthquake Research Institute, University of Tokyo

Low-frequency earthquakes and long-period events observed at active volcanoes are considered to be generated by the motion of volcanic fluid like magma and volcanic gases, and the elucidation of these signals and their temporal change are one of the critical keys to understand the dynamics of the volcanic system. At Aso volcano, various kinds of volcanic signals with broad frequency contents have been observed since the pioneering work by Sassa in 1930s. One of these signals is long-period tremor (LPT) with a dominant period of around 15 s, which are intermittently emitted from the volcano regardless of the surface activity. The characteristics of the LPTs are fairly short duration of only a few cycles and multiple spectral peaks at 15 s, 7 s, and so on. Our observations using broadband seismometers so far have revealed that LPTs are a kind of resonance oscillation of a crack-like conduit beneath the crater. Because the resonance characteristics of a fluid-filled crack are strongly controlled by the physical properties of the fluid inside the conduit and the geometry of the conduit, in this study, we analyze the temporal variation of oscillatory characteristics of Long-period tremor from 1994 to the present.

In this study, we first examine the temporal variation of dominant periods of LPTs (fundamental mode of around 15 s and first overtone of around 7 s) using the continuous data recorded at broadband seismic stations close to the active crater. The result shows clear temporal change in the dominant periods of LPTs in 2003-2005 and 2014-2015. These two time periods corresponds to the periods in which small phreatic and phereatic/magmatic-hydrothermal eruptions occurred. As to the temporal variation in 2003-2005, as already reported by Ikeda (2005) and Yamamoto (2013), the periods of the fundamental mode and the first overtone show correlated temporal change, and it can be interpreted as compositional and/or thermal change of hydrothermal fluids. On the other hand, in 2014-2015, the period of first overtone is almost constant at around 8 s, while that of the fundamental mode shows relatively large temporal fluctuations between 16 s and 12 s. Such a trend is rather difficult to explain, if we consider the resonance oscillation of a flat fluid-filled crack.

In this study, we therefore examine the oscillatory characteristics of a fluid-filled crack having linearly varying thickness. As a result, it becomes clear that the dispersion of the boundary wave along the fluid-filled crack becomes weaker and thus the ratio between resonance periods of the fundamental mode and the first overtone becomes smaller than the case of a flat crack having constant thickness. This behavior can be understood by considering that the effective thickness of the crack depends on the wavelength of each resonant mode. Based on these results, the different temporal variation of dominant periods of the two resonant modes can be interpreted by depth-dependent thickness of the crack-like conduit which caused by pressurization and/or intrusion of magma at deeper portion of the conduit. Our result suggests that the long-term trend in the state of volcanic fluid systems beneath active volcanoes may be monitored by seismological means.

Keywords: Volcanic earthquake, Hydrothermal system, Boundary wave

