Crack resonances at an LP source beneath Kusatsu-Shirane volcano triggered by volume changes with vapor condensation

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Long-period (LP) events observed at active volcanoes have been considered to be generated by the change of the fluid pressure in a fluid-filled resonator. The frequencies and *Q* factors for decaying oscillations of observed LP waveforms depend on the resonator geometry and fluid properties at the source, and their spectra change with the excitation defined by the area where the fluid pressure change applied. Taguchi et al. (*J. Geophys. Res.*, 2018; AGU Fall Meeting, 2019) developed the method to estimate the resonator geometry and fluid properties simultaneously based on the crack model (Chouet, *J. Geophys. Res.*, 1986), and analyzed LP events at Kusatsu-Shirane volcano, Japan, in 1992 and 1993. From their estimates and dilatational initial motions of the observed waveforms, they interpreted that the LP events were generated by the resonance of an existing crack containing water vapor and mist which was produced by condensation of the vapor within a constant length from the crack edge. However, this triggering process was not discussed quantitatively.

To resolve this problem, we estimated the excitation area where the fluid pressure changed and the fluid volume change for an LP event on 2 November 1992. We first numerically simulated far-field seismograms generated by the crack resonances with various excitation areas, then compared their spectra with those of the observed LP waveforms. In our simulations, we used the values of the crack geometry and fluid properties estimated by Taguchi et al. (2018). The observed spectra showed dominant spectral peaks with the estimated wavelengths of $2L/3$ and $2L/5$, where L is crack length. These peaks were dominantly appeared when we applied the fluid pressure change over a narrow strip located at one edge of the crack length and across the entire width of the crack. This excitation is consistent with that proposed by Taguchi et al. (2018), which suggested that the condensation of water vapor within a constant length from the crack edge triggered the observed event. Next, we estimated the fluid volume change associated with the occurrence of the LP event. The values for crack geometry and fluid properties shown by Taguchi et al. (2018; 2019) were estimated from the decaying parts of the observed waveforms, which were generated by the crack resonances after the condensation and mist generation. Their estimates of crack length, width, and aperture were 160 m, 87 m, and 92 mm, respectively, and the crack volume was estimated to be 1300 m^3, in which the mist occupied 46 m^3. Assuming that all the mists in the crack were vapor, the vapor volume before the occurrence of the LP event was estimated to be 3500 m^3. If we consider that the volume decrease occurred at one edge of the crack length as shown by the estimated excitation area, the crack length was shortened by 280 m due to the condensation. Considering the fact that the decaying oscillations of the observed waveforms started after several seconds from the initial motion, our interpretation of the source process of this LP event is given as follows. First, the existing crack was opened by the supply of water vapor exsolved from magma. Condensation at the edge of the crack was observed as the initial dilatational motions of the observed waveforms and triggered the crack resonances. A part of the vapor became mist by the pressure change in association with the resonances, then the crack was closed from the edge where the first condensation occurred. After the mist generation, the resonances of the remaining part of the crack was observed as the decaying oscillations of the LP waveforms.