Triggering process of long-period events at volcanoes inferred from resonance frequency analysis using a crack model

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Long-period (LP) seismic events have been considered to be generated by the oscillations of a fluid-filled crack. Geometries and fluid properties of the crack have been estimated by the comparison of the resonance frequencies of the crack model with observed ones using numerical simulations, which took extensive computational time. Recently, an analytical formula for the crack resonance frequencies was proposed by Maeda and Kumagai (*Geophys. J. Int.*, 2017), which makes the comparison simple and systematic. Taguchi et al. (IAVCEI meeting, 2017) analyzed LP events at Kusatsu-Shirane (Japan) and Galeras (Colombia) volcanoes with the method based on this formula, and showed that the parameters of fluid property and crack geometry can be estimated simultaneously. We further analyzed these LP events assuming misty and dusty gases as the fluids in the cracks at Kusatsu-Shirane and Galeras, respectively, and found the following common features: (1) The crack volume increased with increasing gas-weight fraction and water vapor supplied to the crack. (2) Mist and dust volumes were proportional to the product of crack aperture and length or width. Assuming that the water vapor was degassed from magma, the feature (1) suggests that the crack volume increased with increasing magma volume. The feature (2) implies that mist or dust occupied a constant length or width in the crack. From these results we inferred the triggering process of LP events at each volcano as follows. At Kusatsu-Shirane, water vapor degassed from magma was supplied to an existing subhorizontal crack and opened it. Then, cooling of the water vapor from the crack edge to a constant length produced mist by condensation. At Galeras, there was a vertical crack near the ground surface, which consisted of the upper part of the magma conduit. Vesiculated magma intruded into the crack to a constant height and opened it. Magma fragmentation occurred due to a pressure decrease by crack opening and generated dust in the crack. Condensation of water vapor and magma fragmentation triggered the crack resonances, which were observed as LP events at Kusatsu-Shirane and Galeras, respectively. Volume decreases by condensation of water vapor are consistent with dilatational initial motions of the observed LP waveforms at Kusatsu-Shirane. Volume increases by magma fragmentation reasonably explain compressional initial motions of the observed LP waveforms and ash emissions from a fissure across the summit after LP events at Galeras. These results demonstrate that our method using the analytical formula for the crack resonance frequencies enables us to estimate the geometries and fluid properties of the crack source of LP events, which may contribute to monitor the state of fluids beneath volcanoes and to understand the triggering process of LP events.

