Fluid properties estimated from frequencies of LP events using the analytical formula for crack resonance frequencies

*Kimiko Taguchi[1], Hiroyuki Kumagai[1], Yuta Maeda[1]

1.Nagoya University Environmental Studies

The crack model has been considered as a model of the resonator at the source of long-period (LP) events, and fluid types and sizes of resonators are estimated by comparison between peak frequencies of the observed LP events and resonance frequencies of the crack model by numerical simulations. However, numerical simulations required an extensive computational time, which prevented the systematic comparison to identify the oscillation modes of observed peak frequencies. Therefore, it was difficult to constrain all parameters of the crack model. Recently, Maeda and Kumagai (GRL, 2013) proposed an analytical formula for the resonance frequencies of the crack model, and this formula enables the comparison in a simple and systematic way. In this study, we investigated the resonance modes of peak frequencies of the observed LP events based on the analytical formula to estimate the crack model parameters. We analyzed observed LP events with the method described below. (1) First, we take the ratio of the resonance frequencies calculated by the analytical formula. We vary the assumed mode in the denominator of the ratio from the lowest mode to higher mode. Then, this ratio is expressed by three parameters of the crack model, *m* (the oscillation mode in the numerator of the ratio), *W/L* (the ratio of crack width to length), and *C* (crack stiffness). Here, *C* is expressed as $C = 3(a/\alpha)^2(\rho_f/\rho_s)(L/d)$, where *a* is the sound speed of the fluid in the crack, $\alpha$is the *P* wave velocity of the solid, ρ_f and ρ_s are the densities of the fluid and solid, respectively, and *d* is the aperture of the crack. Next, we take the ratio of observed peak frequencies to the lowest one. By comparison of the frequency ratio between the analytical and observed ones varying the assumed mode in the denominator and *W/L* systematically, we estimate *W/L* and *C* that best explain the observed peak frequencies successively from the lowest one. (2) It is known that Q factor of the crack model strongly depends on α/a (Kumagai and Chouet, JGR, 2000). So we estimate α/a by comparison between synthetic and observed waveforms based on numerical simulations of the crack model. We analyzed two LP events based on the step (1) (2). These LP events were observed at Kusatsu-Shirane volcano on 11 August and 2 November 1992. Here we refer to the events on 11 August and 2 November as the events 1 and 2, respectively. We first analyzed the event 1, and four observed peak frequencies were explained. Then we found that the fluid in the crack was explained by a misty gas, and all parameters of the crack model were estimated. We analyzed the event 2 in the same way, and we found that the fluid in the crack was also a misty gas but the crack size was larger than that of the event 1. These results suggest that water vapor was supplied to the crack in an aquifer system by outgassing from magma, then water vapor was cooled to saturation temperature, so the crack was filled with a misty gas. The difference of the crack size between the event 1 and the event 2 suggests that the amount of water vapor supplied to the crack in the event 2 was larger than that in the event 1. In the previous study of Kumagai et al. (JGR, 2002), it was difficult to compare observed peak frequencies to resonance frequencies of the crack model, so crack parameters (*W/L*, *L/d*) and oscillation modes were assumed. But the method used in this study enables simple and systematic identification of the modes of observed peak frequencies, and all parameters of the crack model can be constrained.

