Excitation mechanisms of volcanic long-period events

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The volcanic Long-Period events (LP) are characterized by harmonic waveforms with frequency of few hertz. The excitation mechanism of LPE is superficial. We have, so far, developed a method to quantify the apparent excitation of LPE at each station based on the normal mode theory and an inhomogeneous autoregressive(AR) method. In this work, waveform inversion of the excitation is applied and investigate the physical mechanism of the excitation of LP observed at Kusatsu-Shirane volcano.

We have obtained the source mechanism of the excitation as vertical single force with volumetric contraction. One possible explanation of the excitation is that the fluid is pushed out of the resonator by contraction of the resonator.

Introduction: The volcanic Long-Period events (LPE) are characterized by harmonic waveforms with frequency of few hertz. The excitation mechanism of LPE is superficial so far. In general, the observed waveforms of LPE reaches their maximum amplitude few seconds after their onset and decay exponentially with their eigen frequency and decay rate. This feature implicates the LPE may be an eigen oscillation of some types of a resonator under a summit crater. Most LPE are superposition of some modes, and one of them, especially the lowest frequency mode, dominates. We have, so far, developed a method to quantify the apparent excitation of LPE at each station based on the normal mode theory and an inhomogeneous autoregressive(AR) method (Nakano et al., JGR, 103, pp.10031, 1998). In this work, waveform inversion of moment tensor and/or single force (Ohminato et al., JGR, 103, pp.23839, 1998) is applied to the apparent excitation assuming point source, and investigate the source mechanism of the excitation of LPE observed at Kusatsu-Shirane volcano.

Data: We use LPE observed at Kusatsu-Shirane volcano, that observation network is maintained by ERI of Tokyo Univ. In the network, seven stations are deployed surrounding the source region of LPE and four stations have three component observation. We analyse about 10 LPE data observed during September to November, 1992.

Features of LPE and temporal variation: LPE observed in this term are categorized into two groups by their eigen frequency (f) and decay constant (Q). They are categorized into two groups as (a) occurred in September, of which f is about 1 Hz and Q is about 100, and (b) occurred in October and November, of which f changes from about 1.5 Hz to 2 Hz and Q changes from about 30 to 10.

Excitation function: To estimate excitation functions of LPE, we first low-pass filtered the original waveform to keep only the dominant mode. Second, eigen frequency of the mode is estimated by the Sompi method (Kumazawa et al., GJI, 101, pp.613, 1990) from the part of exponential decay. Next we create an AR filter that removes the characteristic oscillation and operate it on the whole seismogram to obtain excitation function. The excitation functions are also categorized into to groups similarly according to the occurrence time. Those of the group (a) have duration of about few seconds, while those of the group (b) have duration about 1 sec. These feature are independent on both f and Q.

Waveform inversion: We apply the technique of waveform inversion to the excitation function to investigate the source mechanism of it. We assume three models for the source excitation: single force (SF model), moment tensor (MT model), and combination of them (MT+SF model). To evaluate the superiority among the models, AIC are calculated.

Results and discussion: Based on AIC, the MT+SF model is the most plausible model for the excitation of LPE. For the group (a), the source excitation is dominated by pulsive volumetric contraction with pulsive downward force. For the group (b), that is dominated by pulsive volumetric contraction with simultaneous pulsive upward force. The deviatoric components in moment tensor is not dominated for both groups. The duration of the pulses is about 0.3 sec.

We have obtained the source mechanism of the excitation as vertical single force with volumetric contraction. One possible explanation of the excitation is that the fluid is pushed out of the resonator by contraction of the resonator. In the present analysis, the excitation function is limited for only one mode. Moreover, the number of the stations and frequency band of the observation are not enough to resolve whole picture. In order to investigate whole picture of the excitation, dense and broad band observation and a new method to obtain excitation of multi mode are required.