Temporal variation of complex frequencies of volcanic long-period events

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The waveform of a volcanic long-period (LP) event is characterized by a superposition of decaying sinusoids. It has been recognized that the complex frequencies (frequency, f and the quality factor, Q) of decaying sinusoids show temporal variations. In this paper, we present a detailed description of temporal evolution of f and Q of LP events at Kusatsu-Shirane volcano to investigate the relation between LP and magmatic activities. We use waveform data from the Kusatsu-Shirane permanent seismic network of Earthquake Research Institute starting from 1988, which we recovered from magnetic tapes.

The occurrence of LP events shows a correlation with that of volcano-tectonic earthquakes. Also, it seems to exist a seasonal variation that LP events tend to occur on autumn more frequently during one year.

We identify 45 LP events occurred in the period of 30 days from October to November in 1989. We determine f and Q of LP events occurred in this period by the Sompi method. The frequency decreases from about 3.2 Hz to 1.7 Hz at the middle of the period, and then increases up to about 4 Hz. The Q factor increases from about 30 to 100, and then decreases down to about 20 at the middle of the period. After that, the Q factor again increases up to about 100 and then decreases down to about 30 at the end of the period.

This observed temporal evolution of f and Q may be explained by oscillations of a crack filled with a water-gas mixture. The frequency and Q factor of oscillations of such a crack depend on gas volume fraction (GVF). The frequency of oscillations of a crack filled with a water-gas mixture increases with increasing GVF. On the other hand, the Q factor is around few tens at GVF of 0 and 1, and reaches a maximum value of about 100 in the vicinity of GVF of 0.5. Therefore, the temporal evolution of f and Q can be explained by a change of GVF in a water-gas mixture: In the first half of this period, GVF changes from 1 to 0, and then changes from 0 to 1 in the second half of this period. This change may be interpreted that the crack first gets wet by a seepage of hydrothermal water, and then gets dry by a heat supply from deeper magma, suggesting that the LP activity is affected by an interaction between magmatic heat supply and seasonal change in a hydrothermal system.