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Step-wise temporal change in the frequency-amplitude distribution of volcanic long period tremors at Aso volcano

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Introduction

Aso volcano located in Kyushu Island is one of the most active volcanoes in Japan. At the volcano, different seismic phenomena related to the volcanic activity have been observed, including characteristic long period tremors (LPTs) with a period of 15 sec. The origin of LPTs is found to be the tensile crack almost parallel to the chain of the craters. In this study, we monitored LPTs from Aso volcano for around three years of 2011-2014 and found that the activity has changed with time before and after a Strombolian eruption on November in 2014, .

The monitoring of LPTs

We detected and located the LPTs by means of waveform correlations. Seven stations in Kyushu Island have been chosen from F-net broadband seismograph network operated by NIED for the period starting from October 5, 2011 to December 28, 2014. First, we picked up candidates of LPT signal by amplitude threshold at vertical-component band-pass filtered (10-20s) velocity seismogram at the Tomochi (N.TMCF) station, where is located nearby the volcano and provides high-quality data. Next, the delay times between 13 pairs of stations were measured by taking waveform cross correlation. All candidates were located by the grid search by assuming the propagation velocity of 3.5 km/s, which is typical to the Rayleigh wave. Finally, if the source of the candidate is located near the crater, we adopted it as a volcanic LPT.

We found that the LPT activity was separated into several stages particularly before and after the eruption in 2014. From October 2011 to August 2014, the LPT activity had been generally infrequent, except for small bursts with short-term period. After the late August 2014, LPTs began to occur more actively and frequently. The amplitude level also was getting higher with repeating stages composed of a temporary tremor stop and a sudden increase of tremor amplitude. This high amplitude level of LPTs abruptly dropped around 3 hours before the Strombolian eruption on November 25. Just after the eruption, LPTs with a large amplitude occurred frequently again. However, the amplitude level decreased distinctively within 5 or 6 days after the eruption. In total, we detected 65,942 LPTs, while 98.2% of them were occurred within 123 days around the eruption.

Changes in frequency-amplitude distribution

We investigated the frequency-amplitude distribution and its temporal changes. Based on the amplitude level and the Stromboli eruption on November 25, the LPT activity from the late August to the end of December 2014 was divided into five stages and the frequency-amplitude distributions was estimated. The result shows the following sequent transits of the LPTs activity. (1) In the first three stages before the eruption, the distributions were well fitted to the exponential-type distribution. However, the characteristic amplitudes of the distribution increased at stages with increasing time towards the eruption. (2) Just after the eruption, the distribution at the 4th stage obeys preferably to the power law rather than the exponential, which implies the characteristic amplitude had been lost within this stage. (3) In the last stage, the distribution again obeys the exponential law as similar to before the eruption.

Previous studies suggested that the frequency-amplitude distribution at volcanoes is well explained by the exponential distribution rather than the power-law, which implies that the characteristic amplitudes are related to the sizes of the tremor sources at volcanoes. Our results show that the characteristic scale of LPTs at Aso volcano has changed in stages and the scale had been lost in association with the Stromboli-type eruption. It implies the possibility of forecasting eruptions by investigating a transition of the frequency-amplitude of LPTs, which is considered related to the change of the generating system, such as the crack and the hydrothermal system between magma and groundwater.

Keywords: Frequency-amplitude distribution, Volcanic tremor, Long period tremor, Strombolian eruption