Earthquakes series preceding very long period pulses, observed during the 2000 Miyakejima volcanic activity - part II -.

Tomokazu Kobayashi[1], Takao Ohminato[2], Yoshiaki Ida[3]

[1] ERI, Univ.Tokyo, [2] ERI, [3] School of Sci., himeji Inst. of Technology

1. Introduction

The summit eruption of Miyakejima that started on 8 July 2000 was accompanied by depression of the summit crater, or caldera formation, which was going on stepwise till 18 August. During this period, very long period (VLP) seismic signals, whose period is about 50 seconds, were observed once or twice a day. The mechanism of VLP pulses are explained by a volumetric expansion of magma reservoir that may be associated with a slip of a vertical piston in the conduit. Unusual earthquakes series were observed one to two hours before VLP pulses. We will report characteristics of these earthquakes series, which is called hereafter pre-swarm.

2. Characteristics of pre-swarms

The 4 series on July 11 and 12 have particularly a clear feature. We obtained the following features. Firstly, the time intervals of the earthquakes in the series decrease at a constant rate in the manner of geometric progression. Secondary, the maximum amplitude of each earthquake is initially almost constant (zone I), but linearly decreases with time from few minutes before the occurrence of a VLP pulse (zone II). Thirdly, each individual earthquake has almost identical waveforms although amplitudes of them are not the same.

3. Hypocenters

Hypocenters are at a southwest region of the crater, the depth is about sea level. There is no systematic difference in hypocenter distribution among the 4 swarms. We found that the hypocenters locate above the source region of VLP pulses.

4. Discussion

As has been noted, these pre-swarms have the following four main features.

(1)Time intervals of occurrences of earthquakes gradually decrease in the manner of geometric progression.

(2)Maximum amplitudes are almost constant initially, but decrease linearly with time starting a few minutes before the occurrence of the VLP pulse.

(3)Hypocenters of pre-swarms are below the south-western region of the crater and near the sea level in depth, being located above the source region of VLP pulses

(4)Individual earthquakes in the pre-swarms have almost similar waveforms.

In order to interpret above features, we propose a model as follows. We assume that the maximum amplitudes represent the amount of stress drops. In the process leading to a VLP pulse, the stress tends to increase with time gradually, and a pre-swarm earthquake occurs when the stress reaches a critical stress value. The stress is released to a certain minimum stress level by the earthquake, and then the stress starts increasing again.

The stress recovery rates, which are proportional to the ratios between stress drops and the time intervals of earthquakes, increase with time in zone I, while are constant in zone II.

Based on the model described above and on the framework of the falling piston in the conduit, the entire sequence from a pre-swarm to a VLP pulse can be interpreted as follows. Initially, the piston is coupled with the conduit wall, some parts strongly and other weakly. Hereafter, we call the strongly coupled parts as asperities. In zone I, asperities have almost constant strength. Failures of the asperities, which correspond to the earthquakes in zone I, occur one by one. As the number of broken asperities increases, the stress recovery rates increase with time because the same amount of frictional force has to be shared with the smaller number of asperities.

When the asperities cannot hold the piston against the downward force any longer, the piston starts moving down at a nearly constant velocity determined by the dynamic friction. This stage corresponds to zone II in the pre-swarms. In this stage, occurrences of pre-swarms are controlled by a constant stress recovery rate corresponding to a velocity of sliding piston. Finally, a downward free slip of the piston is made possible by the smoothed wall of the conduit, and leads to a rapid increase of pressure in the magma reservoir and a VLP pulse.