Monitoring System of a Large Rockslide in Heisei-Shinzan Lava Dome, Mt. Unzen, Japan

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INTRODUCTION

A lava dome called "Heisei-Shinzan" was formed by eruptions during 1990-1995 at Mt. Unzen, southern Japan. It is concerned that a huge rockslide is possible to occur because east-side slope of the lava dome has moved about 1.2-m downslope during last 20 years. A severe damage is expected to be suffered if huge collapse event occurred. Kyushu Regional Development Bureau of the Ministry of Land, Infrastructure, Transport and Tourism has been providing both the structural measurements and non-structural ones against the possible lava dome collapse. This report shows the integrated monitoring system and establishment of thresholds for collapse.

SETTING MONITORING INSTRUMENTS

Predicted collapse block is located at southeastern slope of the lava dome (shown in **Fig.1**). Outline of the collapse block was determined based on geological structure which consists of several lava flows and pyroclastic-flow deposits, distribution of underground water estimated by electromagnetic survey, and distribution of fractures at the surface of lava. Its volume is estimated to be in the order of 10^7 m^3. 6 kinds of monitoring instruments have been set on and around the block. Displacement of the block has been measured using 2 total stations with 12 mirrors. A ground-based Synthetic Aperture Radar (SAR) with 4 corner reflectors has been also applied to the displacement measurement. 6 seismometers has been set to detect seismic waveforms that are possibly caused by rockfall or collapse. Number of the instruments has been increased gradually since 1994, when the oldest of them was set.

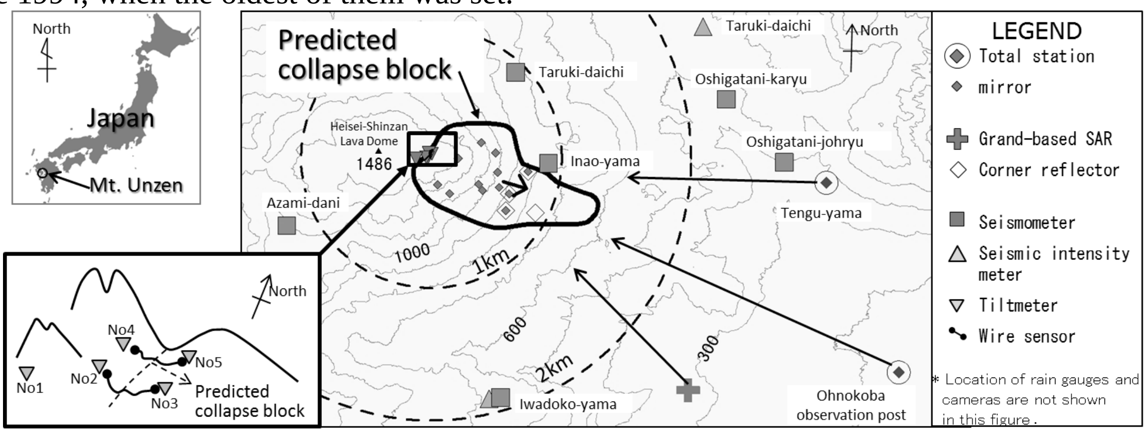

Fig. 1 Arrangement of monitoring instruments

5 tiltmeters and 2 wire sensors were set on the top of the block. It was a very hard mission to set the instruments because of heavy weather conditions, inaccessible rock cliffs, and farness from electric power supply and telecommunications infrastructure. However, since grasping the behavior of the upper area of the block is essential for the monitoring of whole rockslide, we overcame the hardness and completed the setting of instruments. The mission was made possible by making system configuration which includes new power-saved tiltmeters, solar batteries and wireless installations, and taking 3 flights of helicopter for 700 kg material handling and 8 times field work. Observation by the tiltmeters started at December 8th, 2016. Because seasonal deviations are expected, at least a year measurement will be needed for initial calibration, before using newly installed instrument data.

ESTABLISHING THRESHOLDS FOR EMERGENCY MANAGEMENT

Thresholds were established for each of monitoring instruments except tiltmeters based on the analysis of data set from observation during last few years to few decades. We established three thresholds (i.e. Immediate, short-term, and long-term) according to length of lead time for final collapse. "Immediate" values were set to detect inducement, premonitory phenomena (e.g. rapid increase of rockfall) or large scale collapse. "Short-term" and "long-term" values were set to find accelerate of creep curve. Among the thresholds, the "immediate" value is most important because it might be applied to evacuation order for residence.

Among them, the threshold for seismometer is taken up here. We focused on a new index-value, "Integrated value of Square of Seismic Velocity in 30 minutes (hereafter ISSV)", which indicates the increase of rockfall leading to final collapse. At the pyroclastic-flow eruptions in the order of $10^5 – 10^6$ m^3, June 3rd and 8th, 1991, some parts of lava dome collapsed as a trigger of pyroclastic flow. The results of calculations of the data from seismometer at these eruptions show that the ISSV increased rapidly just before pyroclastic flows (shown in **Fig. 2**). So ISSV was adopted as one of "immediate" value.

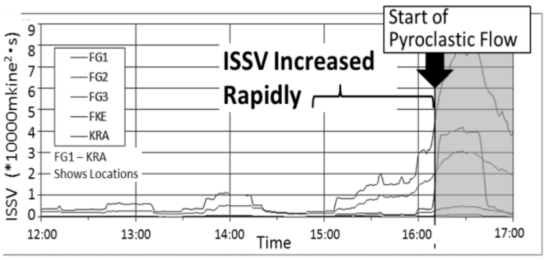

Fig. 2 Increase of ISSV before a Pyroclastic Flow at June 3rd, 1991

We set two steps of evaluation because of wide variety of monitoring instruments. In the first step, measurement by each instrument is compared with the thresholds. And in the second step, results of the comparison are put into a flowchart to judge whether emergency measures should be executed. In the flowchart, we paid attention to mitigate either overestimation or underestimation. To avoid overestimation, necessary condition was set to cases in which measurement records exess the thresholds for more than two kinds of monitoring instruments. To avoid underestimation, we regarded missing data of multiple instruments as indicator of occurrence of premonitory phenomena or final collapse.

CONCLUSIONS

As non-structural measurement against a large rockslide of a lava dome, a number of monitoring instruments were set and thresholds for each of them was established. Future issues will be maintenance of instruments, to verify the thresholds based on accumulated data and to discuss definite action when thresholds will be exceeded.

Keywords: Rockslide, Monitoring system, Monitoring instrument, Threshold, Seismometer