DEFORMATION CHARACTERISTICS OF UNZEN LAVA DOME BASED ON LONG RANGE DISPALCEMENT MONITORING

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INTRODUCTION

Unzen volcano erupted in 1990, causing the recurrent formation and collapse of lava domes. Although these hazardous failures of the domes have almost ceased in 1996, the large remaining lavas (100 million m^3) that exist along the steep slope, is posing threat to the public. Unzen Restoration Work Office, Ministry of Land, Infrastructure, Transport and Tourism (MILT) has been monitoring the lava dome, by surveillance cameras, vibration sensors, and electronic distance measurements (EDMs), in order to ensure the safety of the public. The main objective of this paper is to describe the results of the long range displacement monitoring and to discuss the characteristics of the movements of the lava.

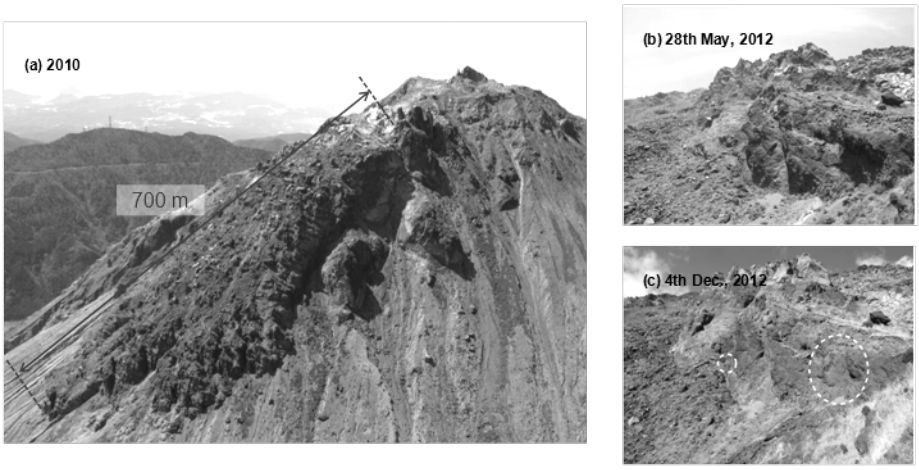

Fig. 1 Bird's-eye view of the lava dome and local failures near the toe of the lava

OUTLINE OF THE LOMG RANGE MONITORING

One of the ongoing main monitoring methods for detecting the movements of lava dome is the automatic long distance EDM, using the eight reflecting prisms installed near the end of the lava dome. The change in the distances (displacements) are obtained with the two EDM stations set at 2.7 km and 3.5 km from the lava dome, since 2007 (Fig. 2). Although a periodic fluctuation, due to the atmospheric variation, can be seen in the time variation of the displacement, long term monitoring over 6 years indicates that the eight prisms are continuously moving at rates between 38 mm to 69 mm per year. An example of displacement of prism 3 is shown in Fig. 3.

In addition to EDM, Ground Based Synthetic Aperture Radar (GBSAR) has been monitoring the movements of the lave dome since October of 2011. The distance between the

radar and the lava dome is approximately 3.5 km. One of the main differences between the EDM and the GBSAR is that the radar wave covers wide area of the lava dome, such that surficial distribution of displacement can be obtained, allowing differentiation of areas with large movements from the areas with small movements. It was also found that the noise of GBSAR, due to the atmospheric variation, is smaller than that of the EDM and enabled detection of change in the displacement velocity which may be correlated with the rainfall in 2012 (Fig. 4). However, it is noted that the displacements are relative to the area which is assumed to be stable: the reflected wave from the stable area is used for the compensation of the atmospheric effects, using the method similar to the Persistent Scatterer (PS) technique.

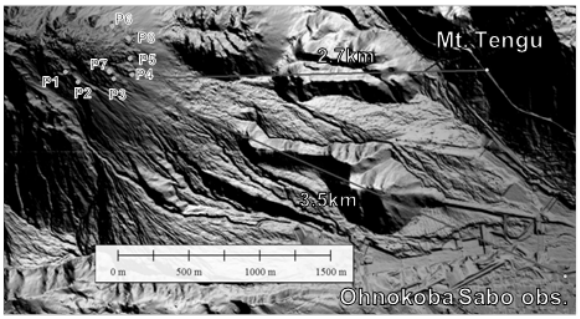

Fig. 2 Location of two EDMs and the eight prisms

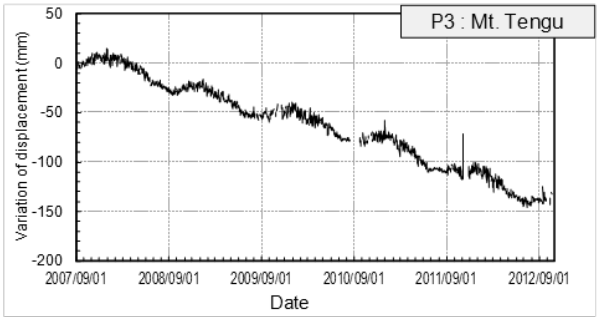

Fig. 3 Time variation of displacement (Example of prism 3 monitored from the station at Mt. Tengu)

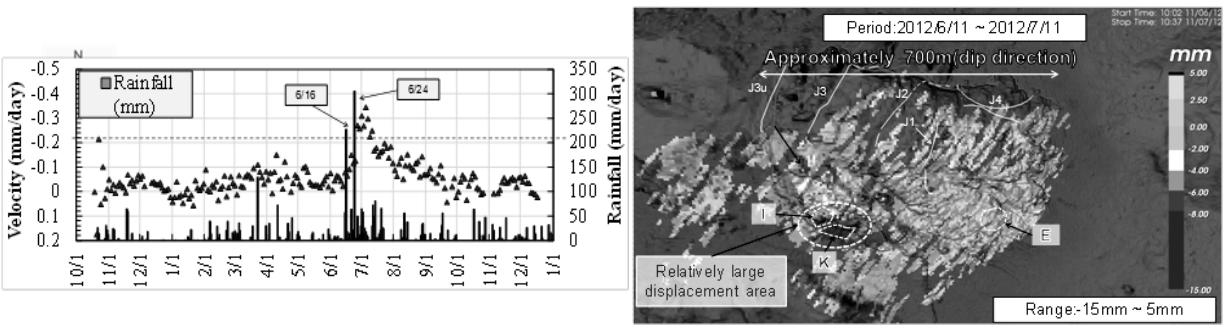

Fig. 4 Example of the time variation of the relative displacements obtained by the GBSAR from June 11, 2012 to July 11, 2012. The velocity of the areas I and K clearly increased in response to the rainfall over 200 mm/day on June 16th and June 24th.

ASSESSMENT OF MOVING MECHANISM

Mechanism of the main trends of the movements was assessed, using the data obtained by EDM and GBSAR together with the geological structure of the lava dome. The area of the main lobe, which was found to show relatively large displacements by the GBSAR, may be related to the structure of overlapping lobes and the underlying deposits of collapsed materials. The area with relatively small displacement is overlying the other overlapping lobes, whereas the area with relatively large displacement is overlying the deposit of the collapsed materials which may be undergoing gradual deformation.

Further monitoring and analyses of the mechanisms of the movements will be performed in order to evaluate the stability of the lava dome and to develop methodologies to assess the precursor of the instability.

Keywords: Lava dome, Unzen volcano, electronic distance measurement, ground based synthetic aperture radar