Evaluation of Potential Hazards from Lava Dome Collapse on Mt. Unzen-Fugen-dake

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Introduction

Due to the eruption activities in the period between 1990 and 1995, a large amount of ejecta (about 170 million m^3 of pyroclastic flows deposit and about 100 million m^3 of lava dome) has been produced and remains around the summit of Mt. Unzen-Fugen-dake. As pyroclastic flow deposit may cause debris flows, the Unzen Restoration Work Office, Ministry of Land, Infrastructure, Transport and Tourism has promoted measures based on erosion control. To prevent accidents due to rock falls at the construction site, the lava dome is being observed on a continuous basis. Currently, a continual displacement accompanied by creep due to gravity or to the cooling and resultant contraction of the lava dome has been observed.

Sector collapse in a volcanic body formed mainly by ejecta may cause a large-scale, high-speed debris avalanche as seen in the collapse of Mt. Bandai in Japan in July 1888 and Mount St. Helens in USA in May 1980, and may cause a hazard(Inokuchi, 2006). As methods for assessing the impact of a debris avalanche, various models such as the energy cone model, the dry particle flow continuum model(Takahashi et al., 1995), and the distinct element model(Yamada et al., 2011) have been studied, but there are few studies that quantitatively reproduce the characteristics of blocks falling while being crushed into finer particulars.

In this study, the authors examined a method for quantitatively assessing the impact of the collapse of the lava dome to obtain data used for risk management.

Observation of lava dome on Mt. Unzen-Fugen-dake

By taking optical geomorphic measurements it was shown that blocks of the lava dome have moved approximately 1 meter in a south-eastern direction in fourteen years(as shown **Fig.1**). Steady secular fluctuation is also suggested by this measurement. Moreover, relative movement in the lower part(maximum of sixty millimeter in a south-eastern direction in fourteen months) was shown by observing the ground based synthetic aperture radar(GB-SAR). An observation spanning the whole year had also suggested the possibility of a seasonal variation existing. As a result of these observations, it is thought that the lava domes are moving downward.

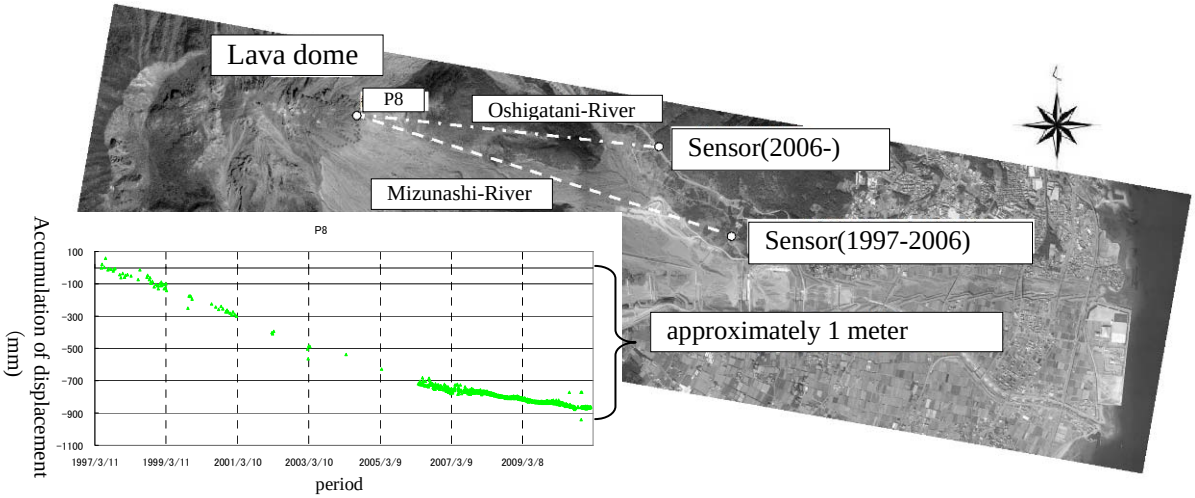

Fig.1 Position of sensor and movement

The authers assumed five patterns of lava dome collapse(as shown **Fig.2,Table.1**). The bases of classification are cracks on the surface of a dome, the position of an area where stress is concentrated, which is found in stress analysis,the boundary part of a lava lobe,and the boundary part with the natural ground before an eruption, and so on. Since making observations of the GB-SAR and the fragileness of lava dome lower layer, it has been suggested that the possibility of occurrence of case 1 to 3 is higher than case 4 to 5. The result of an airborne electromagnetic survey carried out separately also suggests that this assumption is appropriate.

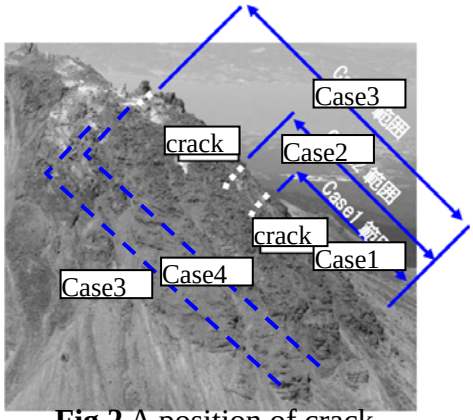

Fig.2 A position of crack

Table.1 Collapse cases

Case	Collapse form	Basis for estimating collapse location	collapsing volume (10^6 m^3)
1	Collapse from the crack in the lower part of lobe 11	Visual confirmation of the crack	7.68
2	Collapse below the crack in the mid-slope of lobe 11	Result of stress analysis	10.24
3	Collapse above the boundary between lobe 11 and lobe 4	Boundary between lava lobes	17.92
4	Collapse above the boundary between sediments from collapse and lobe 4	Boundary between lava lobes	32.00
5	Collapse in the boundary with the natural ground before the eruption	Boundary with the natural ground before the eruption	53.76

Assumption of dangerous range in numerical simulations

It is assumed that when the lava dome collapses, large-size blocks become fine particulars as particulars collide with each other or the ground while they flow down the slope. Currently, there is no model available that can accurately reproduce such a phenomenon. Thus, it was decided to use Takahashi's pyroclastic flow equation (Takahashi, 2006), which takes into account the fact that particulars become finer and the law of resistance is changed accordingly. It was shown in a simulation that a inundation of sediment occurs in the downstream alluvial fan which encompass a city area there is sediment volume of Case3 or greater as shown **Fig.3**.

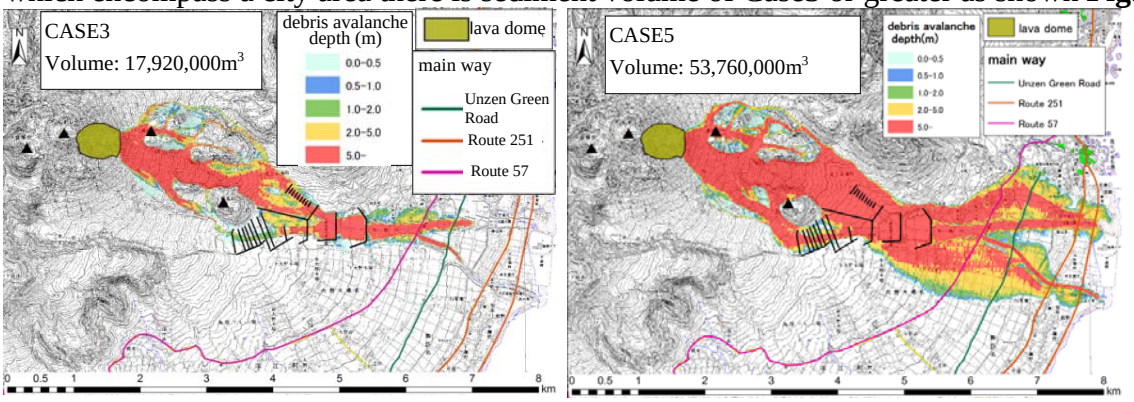

Fig.3 Simulation result

Conclusion

By examination, the authors were able to obtain knowledge about the potential hazards of lava dome collapse to some extent. As a result of simulation, in case 3, which is the most likely to occur among five assumed cases, there is a possibility that the collapse of the lava dome will cause damage to the settlement, and this suggests the need to take countermeasures. In cases 4 and 5, which are less likely to occur than case 3, there is a possibility that the collapse of the lava dome will cause damage to a wide range. The range of impact obtained in this study should be used as a basis for developing a hazard map to help evacuate residents.

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Keywords: sector collapse, debris avalanche, monitoring, lava dome