Dome building processes of Mt. Usu revealed by the comparison of precise DEM

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1. Introduction

Mt. Usu has many characteristic topographies and geological structures, such as lava domes, crypto-domes, large deformation faults, a somma caldera and some craterlets at the summit area. We have yet to understand the local deformation patterns at the summit. Not only for understanding shallow intrusion process of Mt. Usu, but also basic understanding for dacite volcanism, it is very important to examine how each portion of the summit was deformed at every eruption and also evaluate the changes during inter-eruption dormancy. However, until recently, this had not been done because of lack of geodetic data sets in both time and space (excepting 1977-1982 Usu-Shinzan formation). In this study, to investigate detailed deformation patterns of the summit, topographic analysis using precise DEMs are done.

2. High precision DEMs

Precise DEMs (1-2 m mesh) are newly generated from large scale topographic maps of 1/5,000 and 1/2,500 by STRIPE method (Noumi et al., 2002). The original DEMs have the 1.7-2.5m resolution in height. Ground deformation associated with dome building activities of Mt. Usu is usually more than several m scales, in such a case, several m of height change can be reliably detected by comparing DEMs. Precise DEMs were created for the periods; 1976.10, 1977.11, 1983.10, 1993.8 and 2000.4, which include last two dome building eruptions in 1977-1982 and 2000.

3. Results

Several m of significant deformations both for vertical and horizontal are recognizable at the summit in the periods of 1993 and 2000 DEMs, which is mostly due to the shallow intrusion associated with the 2000 eruption. Spatial deformation pattern indicate the existence of shallower dike intrusion beneath the NW summit along weak fault zones, the orientation of which correspond to those pre-studied by Okazaki et al. (2002). Great subsidence of Ko-Usu lava dome, which is more than 60 m, is most remarkable in the period 1976-1977. This subsidence is closely related to the graben structure accompanied by Usu-Shinzan crypto-dome growth because eastern part of Ko-Usu, which is just located in the graben, is clearly cut along the main fault. The loss volume of the dome is estimated as about 3E06 m3. Result of the 1977-1983 DEMs suggests that the subsidence had still continued but happened step by step dividing the dome edifice as several parts. Highest peak of the lava dome corresponds to the most subsidence part. This indicates the existence of characteristic internal structures such as spines or solidified magma blocks.

4. Future prospective

From the case study of Mt. Usu, it is confirmed that the precise DEM analysis could be very useful tool for the investigation of dome building process with a few m scale large topographic changes. Available supplementary maps in different periods are needed to be examined for further understanding of the dome building process, especially mutual relations between deformation and doming seismicity. It is also expected to apply the same approach to another dacite volcanoes, such as Mt. Unzen, Mt. St. Helens and Soufriere Hills Volcano, hopefully using more precise DEMs generated from recent modern surveys (e.g. SAR, Air-born lidar survey etc...)