Emplacement process of the 1991-1995 lava dome at Unzen volcano, Japan

Miyuki Nonaka[1]; Setsuya Nakada[2]; Yoshihiko Goto[3]

[1] ERI, U-Tokyo; [2] ERI, Univ. Tokyo; [3] Civil Engineering, Muroran Inst. Tec.

Lava domes are the products formed by effusive eruption of volcanoes. Morphology of lava domes is controlled by viscosity, effusion rate, the rate of time required to form solid crust during flowing and so on(Fink and Griffiths, 1998). During emplacement, mass of lava received strains and changed its form under various strain rates. Structures indicating ductile or brittle (or both) deformation are often observed in lava domes. Preferred orientations, deformed shapes of crystal or bubble in solidified lavas are good indicators of flow direction, strain history, strain magnitude and deformation direction.

Castro et al. (2002) analyzed crystal preferred orientation (CPO) of microlites in Obsidian Dome (USA), and found two flow regimes in the dome. Near the vent, axes of microlites are parallel to the dome surface, reflecting pure shear resulted from injection of lava from beneath. In the flow margins, microlites are oriented according to local flow direction of lava, reflecting simple shear resulted from gravity of lava itself due to lateral expansions. This study aims to analyze CPO within porphyritic and high crystallinity lava dome, in order to reconstruct strain histories,and emplacement processes, referring to the observed textures of lava domes.

During the 1990-1995 eruption of Unzen Volcano, a complex lava dome was formed at the summit. Although most of lava lobes were collapsed and the surfaces were brecciated, their initial structures remain in several locations.

Petal lobe: 4 lava lobes like large petals extruded from a linear vent (axis of creese structure). Lava extruded was separated into 4 pieces, turned sideway and flowed to downstream. They grew in November 1993.

Platy lobe: Imbricated lava plates protruded from the endogenous dome to above the talus. They are considered to be a part of ramp structure formed during lateral spreading of lava in the endogenous dome in 1994.

Spine: A large intrusion mass at the center of the endogenous dome. It had extruded in the solid state and grown for several months in late 1994.

Long axes of phenocrysts in the carapace of Petal lobe are normal to the flow direction and the surface. Long axes of phenocrysts in Platy lobe are inclined 40 to 70 degrees from their surface toward the center of the endogenous dome. Long axes of phenocrysts in Spine are roughly parallel to the intrusion direction at the margin but random as a whole in the interior. Foliation of Petal lobe may record the injection force of lava from beneath. Foliation observed in Spine may record simple shear only along the conduit wall.

For quantification of solidification depth of lava types, water contents in glass was calculated by water content measured by Karl-Fisher method and crystallinities of the groundmass estimated by chemical mass balance calculation. It is 0.9 wt. % for the carapace of Petal lobe and 1.9 wt. % for the center of the Spine. Based on the solubility curve of rhyolite melt, the equilibrium pressure is about 12 MPa (about 370 m) for platy lobes and about 34 MPa (about 1000 m) for the center of Spine. The estimated depth for Spine is in harmony with the geologic monitoring where Spine was extruded in nearly solid state.

Manga (1998) theoretically predicted dependency of behavior of elongated particles under different strains and flow regimes in the Newtonian fluid. They applied their model to the Obsidian Dome and estimated strain rate, using the standard deviation of microlite orientation, strain regimes and emplacement time. In the lava dome at Unzen Volcano, the calculated strain rates are 1x10-6 to 3x10-5 s-1 (0.6 to 1.2, 1day) in Petal lobe and 2x10-8 s-1 (1.5 to 1.7, 3 months) in the edge of Spine. The strain rate in Petal lobe is 2 orders larger than that in the edge of Spine.