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Muon Radiography Expected from Volcanology

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Muon radiography was first applied to the pyramid Giza in 1968 while volcanology has long history since the 0079 eruption of Vesuvius. Some traditional conception of volcanology for many centuries sometimes disturbed its progress. It has been difficult for volcanologists to correctly explore subsurface structure of volcanoes by conventional means even though some of them were formed under their eyes. Volcanologists would complain that they could not see through the earth beneath their feet. Very recently muon radiography gives us a clue for visualization of the interior of volcanoes though its detection ranges are limited at present.

In 2007, Tanaka et al. [1], [2] succeeded in visualization of the explosion deposits inside the crater of Asama, and of the subsurface structure of the 1944 lava dome of Usu. Tanaka et al. [1] carried out muon radiography of the summit part of Asama after its 2004 eruption, and found the deposits of the 2004 eruption inside the summit crater. By such radiography, we can visualize the internal structure inside the erupting crater and vent. Then we can judge whether the vent is plugged with lava or is drained of magma to the deeper parts. This is useful for prediction of the coming consequences in volcanic eruption.

Lava domes are one of the conspicuous topographic features in volcanic fields and afford us important data to discuss magma risings through conduits and resultant deformations of the ground. The knowledge of subsurface structure of lava domes is indispensable to discuss their formation mechanisms. The 1944 eruption of Usu produced a lava dome at its eastern foot. The activity began first with earthquakes and the ground began to uplift forming a mound. After 6 months, explosion took place and another 4 months later, a lava spine extruded at the top of the mound. Finally a lava dome was completed in 22 months after the first earthquake. The height of the mound is roughly 200 m and the relative height of the lava dome reaches approx. 100 m above the mound. In 1952-1955, Hayakawa et al. [3] applied various methods to explore the underground structure of the lava dome and succeeded in finding the distribution of seismic velocities inside the dome, but could not detect the shape of the deeper part. Later Yokoyama [4] analyzed the results of precise levels carried out during the 1944 eruption by Minakami et al. [5] and obtained “pseudo growth curves”

of the lava dome, and necessarily presented its growth model. The model assumes that the true uplifts are parallel to those of the leveling route and the conduit has the uniform section. Yokoyama has been eager to prove his model. In 2007, Tanaka et al. [2] applied muon radiography to the lava dome and this model proved approx. correct. If we further know configuration of the magma conduit connected to the lava dome, we can proceed to discussion of magma rising through the conduit from reservoirs.
Volcanologists expect that muon radiography should extend its detection ranges to deeper parts beneath volcanoes and visualize the real-time movements of magma inside volcanoes.

References

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