Mapping lava tubes by Ground Penetrating Radar: a cavity detection using the velocity analysis and its validation from survey data

Hideaki Miyamoto[1]; Jun'ichi Haruyama[2]; Takao Kobayashi[3]; Katsurou Mogi[4]; Toshiyuki Nishibori[5]; Keiichi Suzuki[6]; Kazuhiko Masumoto[7]; Tatsuaki Okada[2]; Shuichi Rokugawa[8]; Tomochika Tokunaga[8]

[1] Geosystem Engineering, Univ. Tokyo; [2] ISAS/JAXA; [3] JST; [4] Geosystem Engineering,Tokyo Univ; [5] JAXA; [6] KGE; [7] Kajima Technical Research Institute; [8] Dept. Geosystem Eng., Univ. Tokyo

The emplacement of a long-lived lava flow is often largely influenced by the formation of a lava tube, since it insulates the inner hot part of the flow from the cooling. A lava tube might be a major structure of a pahoehoe flow: a large number of lava tubes have been found in terrestrial and extraterrestrial volcanoes. Since the detection of a lava tube is usually more or less accidental (i.e., a lava tube is usually found only when a part of the tube is collapsed and connected to the surface), there might be even larger numbers of unknown lava-tube systems remaining in volcanic structures. As such, detecting and mapping the structure of a lava tube would help understand the evolution of volcanic structures. In this talk, we will present the preliminary results of our recent field measurements using ground penetrating radar method and show that this method is significantly useful to map the structure of a lava tube inside a lava flow.

We realize that there are different views in the formation of lava tubes, including the process of roofing over active lava channels (e.g., Greeley, 1971) and the movement of lava within an inflated sheet flow (e.g., Hon et al., 1994). However, in this talk, we do not further discuss in this aspect. Rather, we here focus only on the detection of a lava tube with a cavity, knowing that a lava tube is not necessary accompanied by a cavity.

The propagation of electro-magnetic (EM) wave is controlled by the dielectric property of the media. Thus, the contrast in the dielectric property between a massive lava flow and a cavity inside would provide an ideal situation to be detected by the ground penetrating radar method. On this ground, we are applying and testing this method to map the structure of a lava tube. In this work, we selected Aokigahara lava flow as a test site, since it has a large lava-tube system, whose structure had been mapped in detail by survey measurement. In order to detect a part of this lava tube, we performed more than 100 measurements using both a step-frequency radar, whose frequency range is 50 to 500MHz, and a pulse radar, whose central frequency is 200MHz.

Preliminary results of profile measurements have been reported (Miyamoto et al., 2003), which shows that the GPR profiling is a useful method to determine the potential locations of hidden lava flows. In this work, we newly performed common mid-point (CMP) measurements and confirmed that the CMP measurements enable us to estimate the propagation velocity as well as the vertical possible variations in dielectricity. New findings of our CMP measurements include that a lava tube is associated with a characteristic pattern of reflections, which indicates the propagation velocity at depth is as large as the velocity of light. This strongly suggests that the pattern would be solid evidence of the existence of a subsurface cavity. In other words, once the possible location of a lava tube is mapped by a profiling measurement, the following CMP measurement can clearly confirm if the cavity really exists or not. We will further explore the possibility of mapping the lava structure using the GPR method by expanding the above idea into a more general case.