Ground Penetrating Radar to detect lava tubes: preliminary results of a GPR application to Fuji volcano, Japan. Hideaki Miyamoto\textsuperscript{1}, Jun'ichi Haruyama\textsuperscript{2}, Shuichi Rokugawa\textsuperscript{1}, Kyosuke Onishi\textsuperscript{1}, and Alexis Palmero\textsuperscript{3}, \textsuperscript{1}Department of Geosystem Engineering, Univ. Tokyo, Tokyo 113-8656, Japan (miyamoto@geosys.t.u-tokyo.ac.jp), \textsuperscript{2}Lunar Mission Research Center, NASDA, Ibaraki 305-8505, Japan, \textsuperscript{3}Department of Earth and Planetary Science, Univ. Tokyo, Tokyo 113-0033, Japan

**Introduction:** Lunar base is one of the most important infrastructures for future lunar explorations and utilizations. Selecting a potential site of the future lunar base, some previous workers suggest taking advantages of lava tubes [e.g., 1]. Lava tubes are quite adequate for the development of an early-stage lunar base because they probably serve as natural shelters to prevent from dangerous or hazardous agents such as cosmic ray, micrometeoroids, and severe changes in temperature. On these grounds, searching lunar lava tubes is extremely important from a lunar-exploration viewpoint.

**Lava tubes:** Although lunar lava tube has not been found very clearly, there are some evidences strongly suggesting their existence. One of the most important evidence is the existence of a large number of sinuous rills. Sinuous rills are sometimes interpreted to be formed by successive collapses of roofs of ancient lava tubes. Some uncollapsed sinuous rills are proposed as lava tube sites (Fig. 1). However, no one has ever closely examined the existence of a lava tube or the survival of a subsurface room on the Moon.

Lava tubes on the Earth have recently been focused especially because they enhance lava flow advancements very effectively by preventing significant cooling [e.g., 2-5]. Nevertheless, geophysical surveys of lava tubes are not commonly carried out even on the Earth [e.g., 6-7].

**Ground Penetrating Radar to detect lava tubes:** The difficulty in searching uncollapsed lunar lava tubes is very clear: they are only formed deep subsurface and are difficult to find by surface image. To find a subsurface structure, a method allowing deep penetration through the surface crust should be invoked. For this purpose, we propose a new method of detecting lava tubes using a Ground Penetrating Radar (GPR) system, which is known as a powerful tool for detecting subsurface structures. Propagation of the radar wave of GPR is strongly controlled by the water content on the Earth, and therefore, a considerably deeper penetration will be allowed on the Moon compared with the case of the Earth because of the no-water condition prevailing on the Moon.

**Study area:** To assess the feasibility of a detection of a lunar lava tube by a GPR system, we have been applying a GPR system to detect a lava tube of a terrestrial basaltic lava flow. The target area is the Komori-ana cave in the Aokigahara lava flow, Fuji volcano in Japan. This tube is an ideal site where a well-paved road crosses over a well-known underground lava tube (Fig. 2-4).

**Acquisition of data:** We adopted the Subsurface Interface Radar (SIR) 2 system with a 200MHz antenna developed by Geophysical Survey Systems, Inc. (GSSI) and maintained by OYO corporation. A 200V transmitter is triggered by pulses from the SIR System and radiates electromagnetic energy into the media subsurface. We have attempted the survey subsurface features in a profiling mode with a fixed offset between transmitter and receiver antenna.
Radar antennas were moved on the ground, along the road and two-dimensional profiles of a large number of periodic reflections were created, producing a profile of the subsurface structure with a fixed gain. The dotted line in Fig. 4 was obtained by dragging the GPR antenna.

**Results and summary:** Fig. 5 shows a raw data profile. Although we took profiles for more than several hundred meters, the total distance of the profile shown in this figure is 17m. This image is a raw data without removal of background noise, but two clear structures are found at around white arrows. They are interpreted as the roof and the bottom of the lava tube, and are confirmed by the locational check through careful survey measurements of Komoriana cave lava tube. See details for the caption of Fig. 5.

This successful first trial strongly ensures that GPR is a very effective and convenient tool to discover unknown lava tubes hidden deeply inside lava flows and will be a quite effective method to detect lunar lava tubes as potential sites of future lunar bases.

References