EXISTENCE OF A LUNAR LAVA TUBE AT WEST OF RIMA MAIRAN SUGGESTED BY SELENE LRS.

T. Kaku[1,2], J. Haruyama[2], W. Miyake[1], A. Kumamoto[3], K. Ishiyama[2], T. Nishibori[2], K. Yamamoto[4], T. Iwata[2], S.T. Crites[2], T. Michikami[5], Y. Yokota[2,6], R. Sood[7], H. J. Melosh[8,9], L. Chappaz[10], and K.C. Howell[8]. [1]Department of Mechanical Engineering, Graduate School of Engineering, Tokai University (4-1-1 Kitakaname, Hiratsuka, Kanagawa 259-1292, Japan), 7bemm027_at_mail.u-tokai.ac.jp (change "_at_" to @), [2]Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, [3]Department of Geophysics, Graduate School of Science, Tohoku University, [4]National Astronomical Observatory of Japan, [5]Faculty of Engineering, Kindai University, [6]Faculty of Science, Kochi University, [7]Department of Aerospace Engineering and Mechanics, College of Engineering, The University of Alabama, Tuscaloosa, AL, USA, [8]School of Aeronautics and Astronautics, Purdue University, West Lafayette, IN, USA, [9]Department of Earth, Atmospheric, and Planetary Science, Purdue University, West Lafayette, IN, USA, [10]AstroLabs, Pasadena, CA, USA.

Introduction: Lunar lava tubes are important from various science perspectives and provide potential sites for future lunar base construction.[1-4] Since the insides of lava tubes are shielded from meteorite bombardment, cosmic radiation, or particle implantation, they are expected to be in pristine condition, an environment with preserved lava composition, textures, and even volatiles. Careful examination of the interior can add insight concerning the evolutionary history of the Moon. The radiation and meteorite bombardment which disturb the geologic record at the surface of the Moon also make it a harsh place for humans and instruments; thus, the inside of an intact lava tube would be the safest place on the Moon from an exploration perspective. Developing methods of gradiometry and cross correlation to isolate the target signal of mass deficits from the twin GRAIL gravity data, Chappaz et al. (2017)[5] detected several locations of horizontally extended mass deficits. Some of them could be caused by intact lava tubes. One of the mass deficits is an area containing the rille A at Marius Hills in which a skylight hole had been discovered.[6] Kaku et al. (2017)[7] investigated radar data from Lunar Radar Sounder (LRS) onboard SELENE (Kaguya) for the mass deficit area and found echo patterns of two peaks suggesting the existence of an intact lava tube.

The Lunar Radar Sounder (LRS), an active radar sounder, was installed on SELENE. The operation frequency of the LRS is 4–6 MHz (around 60 m wavelength), and transmission power is 800 W. Subsurface structures at depths of a few hundred meters to a few kilometers have been investigated using LRS data.[7-10]

In this paper, we examine the LRS echo data reflected from a few tens of meters to a few hundred meters depth for an area containing south of Rima Sharp and west of Rima Mairan (35.00–37.00°N, 312.50–314.50°E) where mass deficits suggesting the existence of intact lava tubes were found.[5]

Result: Figure 1 shows the results that mark locations corresponding to the characteristic features of two peaks echo patterns same as those found in the vicinity of the Marius Hills Hole.[7] The background of the figure is an image from the Terrain Camera (TC) onboard SELENE. The gray lines in the figure correspond to the LRS observation tracks. The colors of the circular points marked on these lines denote the power difference between the two echo peaks (ΔPrb): the first echo peak is from the nadir surface and the second echo peak is from a ceiling or floor of a subsurface cave such as a lava tube. Some candidate sites for the presence of a cave exhibit strong second echo peaks; the lower the ΔPrb value (for instance, at circle points with orange to red and purple colors in Figure 1), the more likely the presence of a subsurface cave.

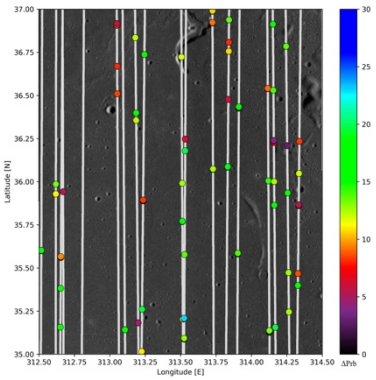

Figure 1: Locations presenting the characteristic features of two peaks echo patterns which suggest the existence of caves or lava tubes, for an area containing south of Rima Sharp and west of Rima Mairan.

For the same search region (35.00–37.00°N, 312.50–314.50°E south of Rima Sharp and west of Rima Mairan), we compared the result of Chappaz et al. (2017)[5] based on the GRAIL data. Figure 2 indicates the cave or lava tube candidate sites as suggested by the LRS data overlaid on a cross-correlation Bouguer gravity map Chappaz et al. (2017)[5] developed. The cold colors on the map are consistent with mass surplus, whereas the hot colors correspond to mass deficits (i.e.,

low-density space or voids such as caves). Most cave or lava tube candidate sites suggested by LRS data are also apparent as LRS data correlate with the area of mass deficits (red to yellow regions) in the cross-correlation Bouguer gravity map.

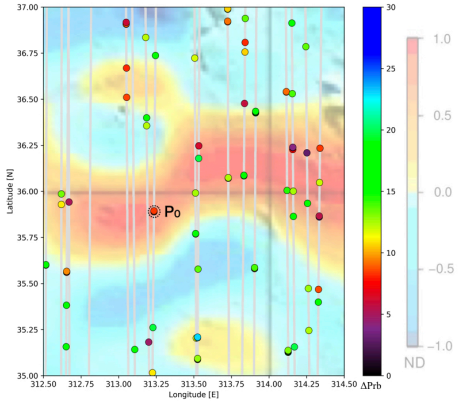

Figure 2: Locations presenting the characteristic features of two peaks echo patterns in Fig.1. The background image is a cross-correlation Bouguer gravity map referred from Chappaz et al. (2017)[5].

Location P_0 in figure 2 presents typical characteristic features of echo with two peaks same as those found in the vicinity of the Marius Hills Hole. Figure 3 plots the LRS echo powers as observed at location P_0 and four locations around P_0 along the observation track (P_1 and P_2 are in north of P_0, and P_{-1} and P_{-2} are in south of P_0) versus the subsurface depth from where the LRS radar power was reflected. Here we set the dielectric constant (ε) to that of vacuum, which is 1, to calculate an upper limit for the depth. The first echo peak (red point; normalized to 0 dB) is from the surface, and the second peak (blue square) must be from the subsurface boundary. At P_{-2}, P_{-1}, P_0, P_1 and P_2, sequential locations along the observation track, second echo peaks are observed (see Fig.3) which suggest the existence of a subsurface layer or a wide cave.

Conclusions: We investigated the LRS data to detect subsurface intact lava tubes in an area (35.00–37.00°N, 312.50–314.50°E) containing south of Rima Sharp and west of Rima Mairan. Several locations exhibit the characteristic features of two peaks echo patterns same as those found in the vicinity of the Marius Hills Hole. These locations are candidate sites for the presence of underground lava tubes or cavernous voids. We note that most of these candidate sites are at locations consistent with a mass deficit on the cross-correlation Bouguer anomaly map based on GRAIL data. At ones of the candidate sites which are along 313.235°E (35.897°N to 35.887°N), it may be suggested that there exists a wide cave.

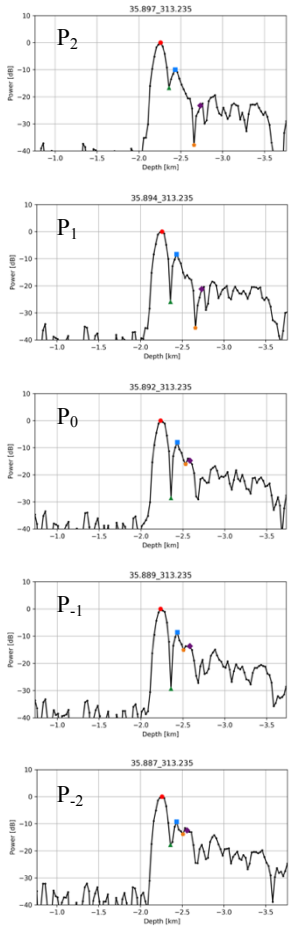

Figure 3: The LRS echo power versus the subsurface depth of a location P_0 (35.892°N, 313.235°E) and its vicinity locations where echo features with two peaks was observed. The tendency that the echo powers of suggesting the existence of a subsurface layer or a wide cave.

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