COMPARISON OF KNOWN LUNAR PITS USING THE LROC QUICKMAP TOOL

Jaelin Hensley, Asher Molzer, Holly Bensel (Mentor), Dr. Viranga Perera (Advisor),
Logos Public Charter School
1203 N Ross Ln, Medford, Oregon, 97501

Specific Question and Relationship

Lunar pits would be beneficial for human exploration of the Moon, therefore the ability to locate additional pits would greatly aid in the search for a permanent habitat on the Moon. Pits can provide shelter from extreme temperature variations, radiation, and micro-meteorites [2]. Additionally, water ice, a vital resource for exploration, may also be present within these pits. The goal of our research is to determine if the LROC Quickmap data shows any correlations that could help identify potential pit sites [3].

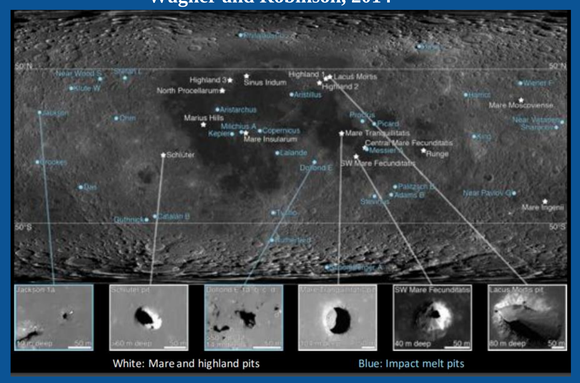
Table 1 - Pit Types and Their Characteristics [3]

Types	Flow Melt	Highland	Mare
Diameter	5-40 m	5-40 m	>=100
General Shape	Elliptical	Oval	Circular

General Topic

Lava tubes and pits were recently discovered using lunar orbiter images. In 2009, the first pit was confirmed through images by the Kaguya spacecraft [4]. Since then, more than 300 lunar pits have been cataloged using a computer algorithm that scanned thousands of high-resolution images of the lunar surface from the LRO Narrow Angle Camera (NAC) [5]. The majority of these pits were located in the lunar maria or large craters with impact melt ponds.

Fig. 1 Examples of Lunar Pits, created by Wagner and Robinson, 2014



There are several mechanisms for lunar pit formation. The large majority are skylights (i.e., holes that lead into lava tubes). Some pits formed as fractures in cooling melt ponds, or due to the collapse of a void under a dome. Collapses could be the result of vibrations generated by meteorite impacts [6].

Methods

- **Study lunar pits using Quickmap Tool**
- **Study and compare known surface features**
- **Collect data and organize into spreadsheets**
- **Data collected includes:**
  geologic location, age, topographic profile, chemical and mineral abundance, pit diameter, and flow melt pond diameters.

Findings

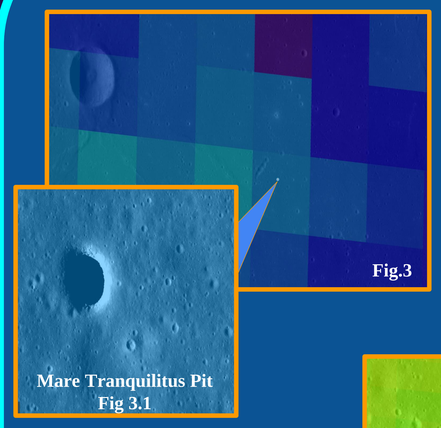
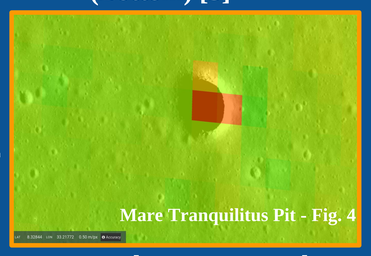
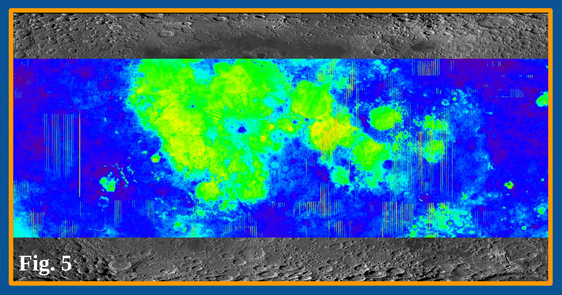


Fig. 3 and 3.1 Lunar Prospector resolution for Iron Abundance 15 km/px (Left) [3]

Fig. 4 Kaguya Resolution for Iron-Oxide Abundance 60 m/px (Bottom) [3]



Due to the limitations of the Kaguya and Lunar Prospector Data, it is difficult to see the abundance of certain elements in the pits. In Figures 3 and 4 you can see the area covered by each pixel of the overlay is too large to get an accurate enough reading. In Figure 5 you can see that the mineral data does not extend past +50 degrees or -50 degrees latitude. This makes it more difficult to gauge what minerals the pits contain, especially in the polar regions.



LROC Kaguya Iron-Oxide Abundance, max lat. 50 degrees, minimum lat. 50 degrees. [3]

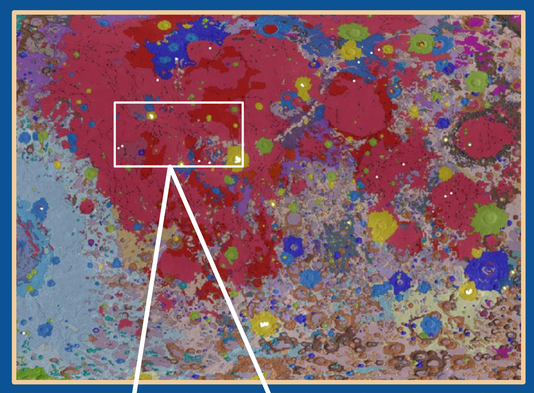


Figure 6 - LROC Quickmap Geologic Overlay - Pits are white dots

The known pits are located in younger geologic areas. The youngest being Copernican and the oldest being Late Imbrian

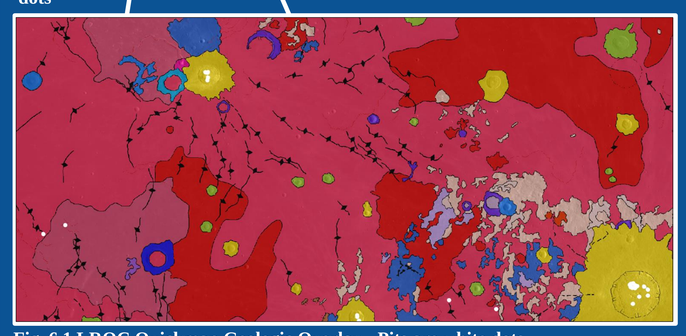
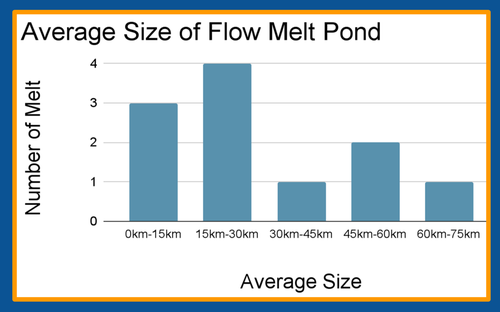


Fig. 6.1 LROC Quickmap Geologic Overlay - Pits are white dots
The yellow shaded regions are the Copernican regions. The dark red and blue regions are Late Imbrian and the dark red regions are the Eratosthenian Periods [3].

Findings (Cont.)

Fig. 7
There is not a correlation between pit locations and the size of flow melt ponds [3].



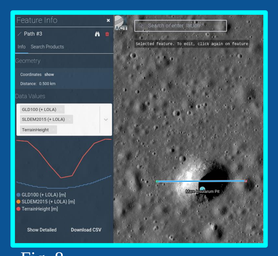


Fig. 8

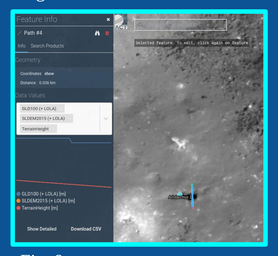


Fig. 9

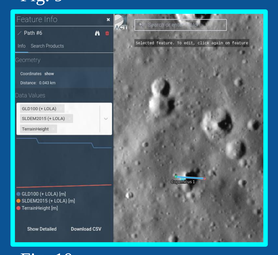


Fig. 10

When attempting to get profiles of the pits, there were unexpected result from the LOLA data. The expectation was to have the profiles look like a pit, as seen in Fig. 8. However, the majority of the pits' profiles looked like Figures 9 and 10, flat with no indication of elevation dip. This made it extremely difficult to analyze pit depths and determine a trend. We hypothesize that the reason we did not get a pit-looking profile is because the majority of the pits were too small for the resolution of the LOLA data, which is probing every 100 meters. Our pit diameters were much smaller than this meaning the profiles did not look as expected.

Conclusion

There are likely many undiscovered pits. Lighting and distortion of the lunar map near the poles, and accuracy of the various tools when dealing with small features, makes finding additional pits difficult. According to Wagner et al. [6], the LRO mission has only imaged about 40 percent of the Moon with appropriate lighting for the successful automated pit searching program.

Going Further

Based on our collected data, areas of interest as well as potential new pits were found. The target areas are fractured flow melt ponds found in young geologic terrain. The only way know the exact size, shape, and habitability of a pit is to conduct a physical study using technology such as free-flying spacecrafts and robots, designed to study subterranean features on the Moon. These could be sent ahead of humans to scout the nature of these voids.

Sources

[1] Wagner, R.V., et al. (2015) Update: The Search for 01Lunar Pits, *2nd International Planetary Caves Conference*, 9021.pdf [2] Leonard, D. (2019) Living Underground on the Moon: How Lava Tubes Can Aid Lunar Colonization, *JGR-Planets, Space.com* [3] LROC Quickmap, shorturl.at/bigrF [4] Possible Lunar Haruyama, J., et. al., (2019), Lava Tube Skylight Observed by SELENE Cameras, *GRL, Vol.36,* shorturl.at/bgCSX. [5] Earth's Moon (2014) Lunar Pits Could Shelter Astronauts, Reveal Details of How 'Man in the Moon' Formed (2014) *NASA .gov* [6] Wagner, R.V., et al. (2021) Occurrence and Origin of Lunar Pits: Observations from a new Catalog, *52nd Lunar and Planetary Science Conference 2021 (LPI Contrib. No. 2548)*, 2530.pdf