Lunar Lava Tube Mapping and Exploration: Resource Prospector Options

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Solar particle radiation and galactic cosmic radiation pose a direct threat to crew safety on extended lunar and interplanetary missions. A few meters of rock is sufficient to reduce background radiation to a safe level. Rather than bringing heavy shielding material from Earth, or excavating material from the Moon's surface to cover habitats, the quick way to shield habitats from radiation would be to place the habitat in an existing cave or other naturally protected structure. Such natural structures exist on the Moon and Mars. Lunar and Martian Lava Tubes were formed as a result of volcanism during Late Heavy Bombardment (LHB) evolution period of our solar system some 300 million years ago. Lunar lava tubes can be several hundred meters wide and tall, and many kilometers long.

One of the difficulties posed for lava tube exploration is ease of access. Until recently it was thought that the only way to access such structures was to drill into them. Recent high resolution images of both the Moon and Mars show breaches in lava tubes called "skylights" that are large enough for entry. Data obtained by the GRAIL and LRO missions show that lava tubes exist on the Moon in relative abundance. There are likely many more that could not be detected or surveyed by the coarse sensors on these missions.

In order to map and catalogue the size and locations of these lava tubes, this proposal calls for a two-phase dedicated discovery class mission to search for and survey lava tubes and subsurface caverns, while also prospecting for water ice and volatile deposits. Similar technology can be used to search for both lava tubes and volatiles. The first phase would be to use a satellite with Ground Penetrating Radar (GPR), allowing for high resolution data penetrating several kilometers below the surface. After gathering data by satellite, the second high-resolution phase will be surface operations; using rovers to perform additional ground based GPR measurements on promising locations found from phase one, and follow this up by robotic exploration of the lava tubes themselves.

Once optimal candidates in terms of accessibility, stability, and radiation protection are identified, long term crewed missions to the lunar surface can commence, knowing that astronauts will be protected from adverse radiation exposure while in their long duration tours of duty in lunar habitat modules.

Once this method is used and refined on the Moon, it can also be used to search for and identify habitat locations on Mars, a crucial first step to establishing a permanent human settlement on the planet.

Slides of this project may be found in Section 03 under the 2016 SeleneOption team project at : https://sites.google.com/a/usc.edu/aste527/home/2016---seleneoption-high-fidelity-simulations-and-analogs-on-the-moon

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