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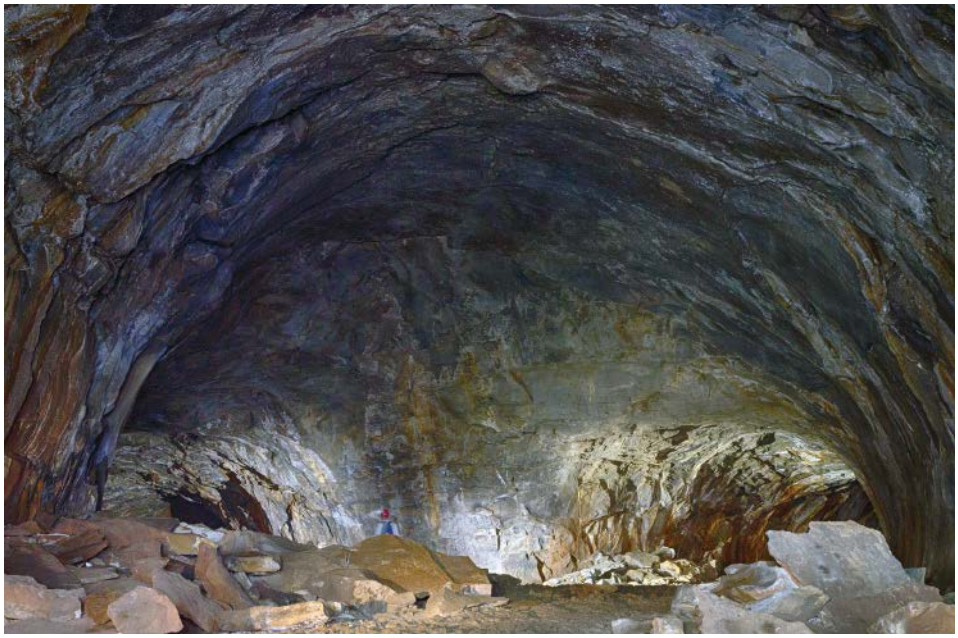
Planetary Caves' Role in Astronaut Bases and the Search for Life

2nd International Planetary Caves Conference
Flagstaff, Arizona, 20–23 October 2015



Thomas Prettyman

During the conference, attendees explored a 1.6-kilometer-long lava tube cave, northwest of Flagstaff, Ariz. This cave, which is more than 700,000 years old, provided an ideal setting for discussions on formation processes, robotics requirements, and astrobiological potential within Martian caves.

Planetary caves are practically everywhere. Scientists have identified more than 200 lunar and more than 2000 Martian cave-related features. They've also found vents and fissures associated with water ice plumes on Saturnian, Jovian, and Neptunian moons. Recently, primary vents of two possible cryovolcanoes were identified on Pluto.

Caves on other planetary bodies and vents associated with plumes on icy moons offer high-priority targets for future habitability studies and robotic and human missions. Martian and lunar caves are ready-made sheltered environments for astronaut habitation or storage facilities. Additionally, Martian caves provide access to the subsurface without the need for Mars landers to bring a costly drilling payload. Such access facilitates the search for evidence of life and could reveal significant water ice deposits for human consumption and fuel.

To advance our understanding of planetary caves, an interdisciplinary group of about 40 researchers convened at the Lowell Observatory (see http://bit.ly/PlanetCaves2). Attendees discussed current research and pathways for future human and robotic missions to planetary caves. Scientists and engineers had the opportunity to discuss how to expand robotic planetary cave exploration capabilities. A local educational outreach component included a primary school "space caves" art contest and a presentation from the Coconino High School robotics team.

In addition to processes associated with volcanism and tidal forces, we discussed the potential for dissolution caves. On Titan, scientists used radar imaging to identify regions on the landscape indicative of dissolution. The study of how caves form on other planetary bodies will likely become an active area of research as higher-resolution imagery becomes available.

We also discussed new techniques for detecting planetary caves. For reliable remote cave detection, an approach that combines data from gravimetry, visible imaging, and thermal-infrared spectra shows considerable promise. Modeling cave entrance structure and genesis requires multiple images acquired from various viewing geometries and spectral wavelengths. Presently, researchers are limited by slightly off-nadir imaging and a limited ability to obtain multiple thermal and visible spectrum images of a given feature. For example, determining if a Martian pit crater wall is simply an overhanging rim or a possible cave entrance requires sideways-looking imagery with appropriate solar illumination.

Engineers reported on advances in cave explorer robotic technologies and prototype development. Any successful planetary cave robotic mission should include three-dimensional computer vision analysis of the entrance passageway and associated surface area to determine the cave access route, a data link from a rover deep within a cave to a surface rover or relay station, and a power supply for long-duration underground operations.

Astrobiologists discussed robotic payload requirements for detecting evidence of life in caves and techniques for detecting biosignatures, as well as Earth-analogue biosignatures of rock-consuming microorganisms. We suggested that such a payload should include mass spectroscopy, laser-induced breakdown spectroscopy, energy dispersive spectroscopy, and a visible spectrum camera. Cellular automation algorithms of visible spectrum imagery of the cave interior could assist in recognizing potential biosignatures.

NASA and private space companies have made recent statements concerning sending humans to Mars sometime in the 2030s. However, reaching technical readiness levels sufficient to support a crewed mission to Mars will require considerable work and substantial funding. The participants of this conference have helped elevate the importance of caves in this effort and will likely influence the direction we will take toward making robotic exploration and human habitation of planetary caves a reality.

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