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PERISCOPE: PERIAPSIS SUBSURFACE CAVE OPTICAL EXPLORER; LUNAR CAVE CHARACTERIZATION FROM ORBIT

Abstract

Although their presence was hypothesized over 130 years ago [Nasmyth & Carpenter, 1874], the discovery of putative lava tubes (caves) on the Moon and Mars is only a recent phenomenon, and even then the interpretation as lava tubes is not 100% certain. At inception of the PERISCOPE project, observations of skylights above putative caves on other worlds had only happened a few years prior, with Martian skylights reported first on the basis of Mars Odyssey's THEMIS (thermal emission spectrometer), in 2007 [Cushing et al., 2007], followed in 2009 by similar and larger skylights on the Moon by the SELENE (Kaguya) camera system [Haruyama et al., 2009]. Following their discovery and initial analysis, 100s more skylights, "putative caves" and "atypical pit craters" were found, in both reassessment of existing data and some additional planned observations. Arguments for underlying caves were initially circumstantial, being typically found within basaltic lava flows in contexts similar to lava tubes on Earth. However, follow-up imaging using oblique viewing angles and coordinated lighting geometries confirmed subsurface voids up to 20 meters beneath overhanging rock [Robinson et al., 2012].

While martian voids may have an astrobiological component to their attraction [Boston et al., 2001], lunar speleology is motivated more by what subsurface voids represent to 1) basic lunar science, and 2) lunar engineering. Planetary science will benefit significantly from direct exposure to crustal rocks from deep within lunar volcanic and impact melt deposits. Significantly for long-term human exploration or habitation, protection from many surface hazards (vacuum conditions, micrometeorites, dust, solar wind, extreme temperature cycling, and radiation) is achieved only a few meters beneath the surface. To simplify base construction and reduce engineering costs, such structures may require only a minimum of "retrofitting" to become useful as habitations or caching supply depots. This paradigm is not new; homo sapiens has used caves for protection from weather throughout its history.

Funded by the NASA Innovative Advanced Concepts program, PERISCOPE (PERIapsis Subsurface Cave OPtical Explorer) intends to show a method of systematically mapping the interior structure of dozens to hundreds of these lunar skylights, from orbit, with a single mission. This is possible with a beyond-line of sight, time-of-flight photon detection system. We recently showed simulations of cave reconstructions using realistic cave geometries, noise, and illumination, and have built several tabletop systems that demonstrate the method.