EXPLORE AND STUDY A MARTIAN LAVA TUBE OR CAVE. Stephen J. Edberg[1], [1]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, M/S 183-301, Pasadena, CA 91109; Stephen.J.Edberg@jpl.nasa.gov.

Introduction: A rover capable of entering Martian lava tubes or caves would provide crucial data across geological, exobiological, and human exploration disciplines. The Mars rovers Sojourner, Spirit, and Opportunity have all inspired the public with their rolling exploration of the surface of Mars. Subsurface exploration would engage the public with drama while providing highly valuable data.

High quality imagery from orbit (Fig. 1) has revealed the presence of "skylights" opening the ceilings of major lava tubes. A mission combining these aspects of the exploration of Mars should land a vehicle capable of navigating and studying nearby lava flows and then accessing lava tubes and igneous caves. Orbiter data suggest a vertical entry system through "skylights" will be necessary.

Discussion: Once inserted in the lava tube or cave (Figs. 2 & 3), the vehicle would be capable of exploring the floor, walls, and ceiling of the underground chamber and performing a variety of scientific investigations. It would be investigating an environment similar to Mars' surface but much more protected from solar and cosmic radiation and atmospheric weather.

The scientific return from such exploration could address the following questions:

- How different is the chemistry of Martian lavas from Earth lava flows? (geology)
- What does this reveal about Mars' interior? (geology)
- Are the mechanics of the lava flow different in the lower gravity, thinner atmosphere, and slower cooling lava in Mars' environment? (geology)
- What are the ages of the surrounding surface lava flows and the interior of the lava tube? (geology)
- How do these ages compare to ages determined by the cratering record? (geology)
- How does the weathering of exposed lava flows compare to the protected area within a lava tube? (geology)

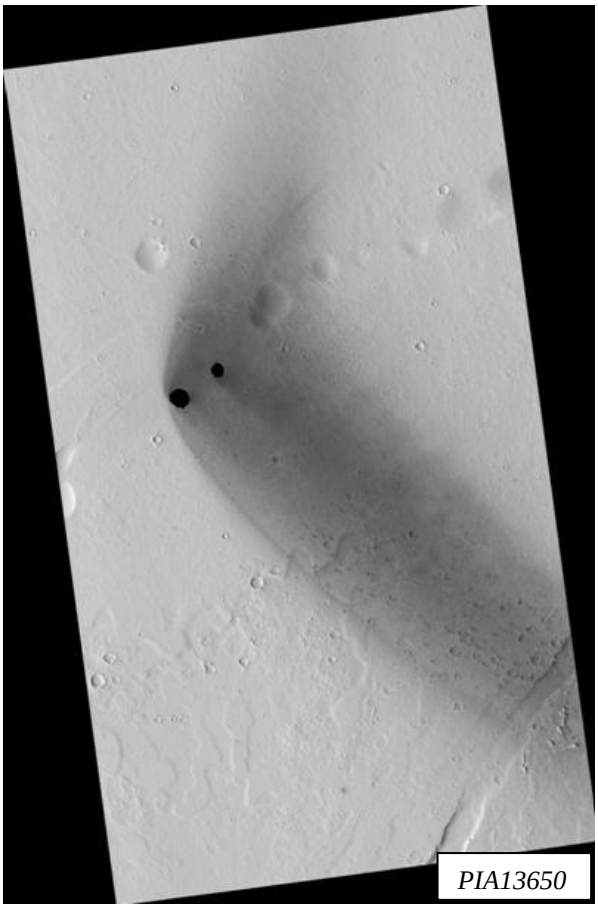

Fig. 1. Two dark, rimless pits are located to the northwest of Ascraeus Mons in the Tharsis volcanic region of Mars. These pits are approximately 180 meters and 310 meters in diameter. They are situated in the midst of a wispy, dark, boomerang-shaped deposit. The pits are aligned with what appear to be larger, degraded depressions.

- What materials have been blown into and trapped in the lava tube/cavern? (geology, exobiology)
- What does this sedimentary record tell us about past conditions on Mars? (geology)
- Was water ever trapped in the lava tube? If so, what minerals were dissolved in it? (geology, exobiology)

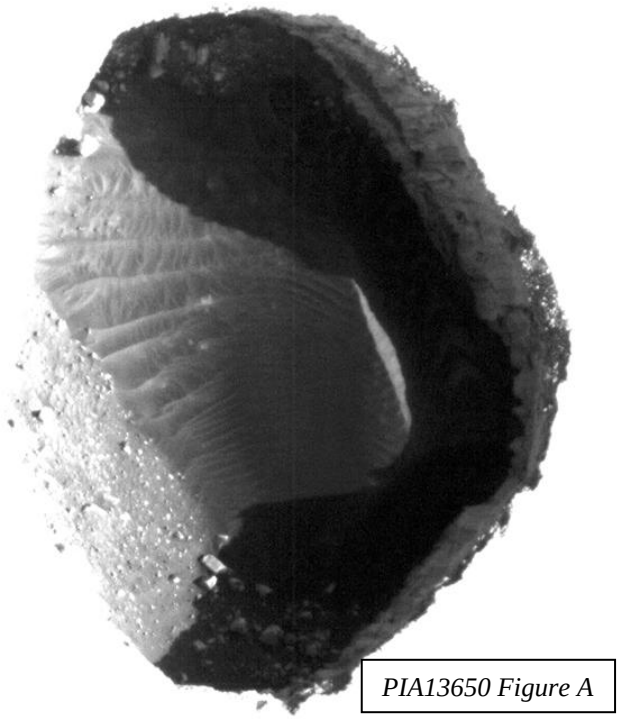

Fig. 2. Sunlight illuminating the floor of the larger skylight shows rock and sand debris on the floor of the lava tube.

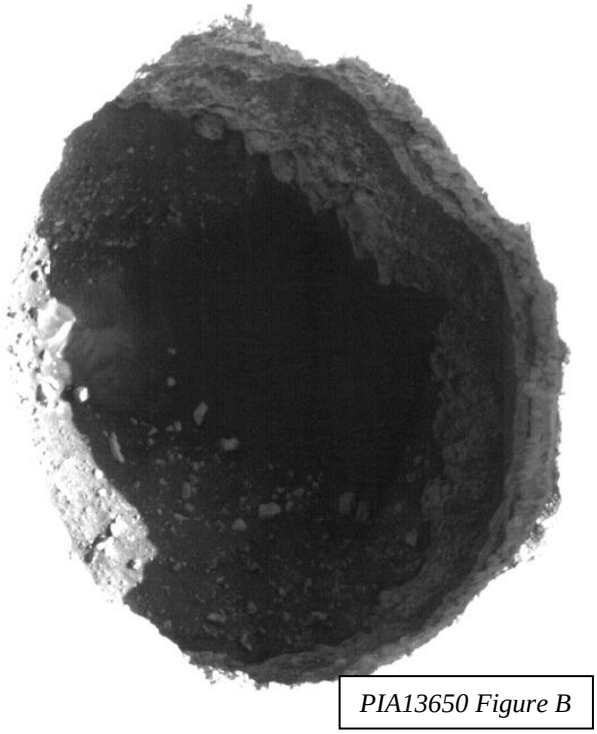

Fig. 3. Sunlight illuminating the floor of the smaller skylight shows a different distribution of rock and sand debris on the floor of the lava tube.

- Are there organic and/or biological materials in the lava tube or in the sediment on the floor that have accumulated over time? (exobiology)

- Is the lava tube (or similar subsurface environment) a potential site for a human habitat, protected from weather and radiation? (human exploration)

Schedule & Approach: This mission could be built for the near-term 2018-2024 period and fulfills the goal of interrogating the shallow subsurface of Mars. The investigation is novel and instrumentation to answer some of the research questions would be new. The DuAxel rover design[1] has many of the necessary qualities required for this investigation: In ground tests it has demonstrated mobility over rough terrain and has demonstrated access down near-vertical cliffsides for exploration. Modifications would permit it to deliver the rolling exploration segment to the floor of a lava tube while the stationary segment pays out an umbilical providing power and communications while also serving as the ground station for uplink/downlink.

Conclusion: Moving *in* to Mars is a logical step in the exploration of the planet. It would return valuable geological and physical data, explore potential, protected habitats for Martian and human life, and demonstrate new capabilities for exploration in extreme terrain on Mars and elsewhere.

Reference: [1] Nesnas, Issa A.D. et al, Journal of Field RoboticsEarly View; article first published online: 3 FEB 2012 at http://onlinelibrary.wiley.com/doi/10.1002/rob.21407/pdf and also available at http://robotics.caltech.edu/wiki/images/b/b7/AxelJOFR.pdf.