

Exploration of Planetary Pits and Caves

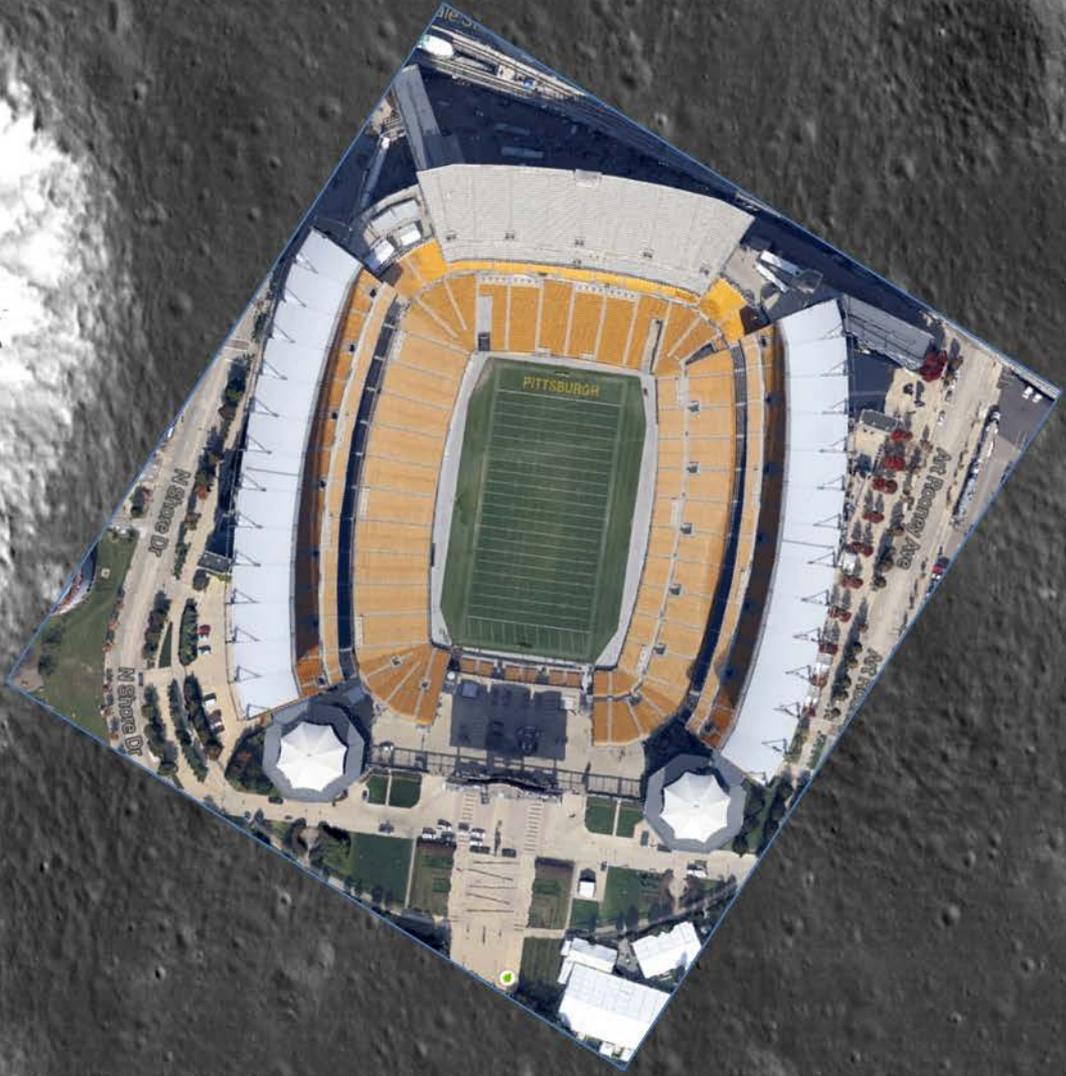
Dr. Red Whittaker

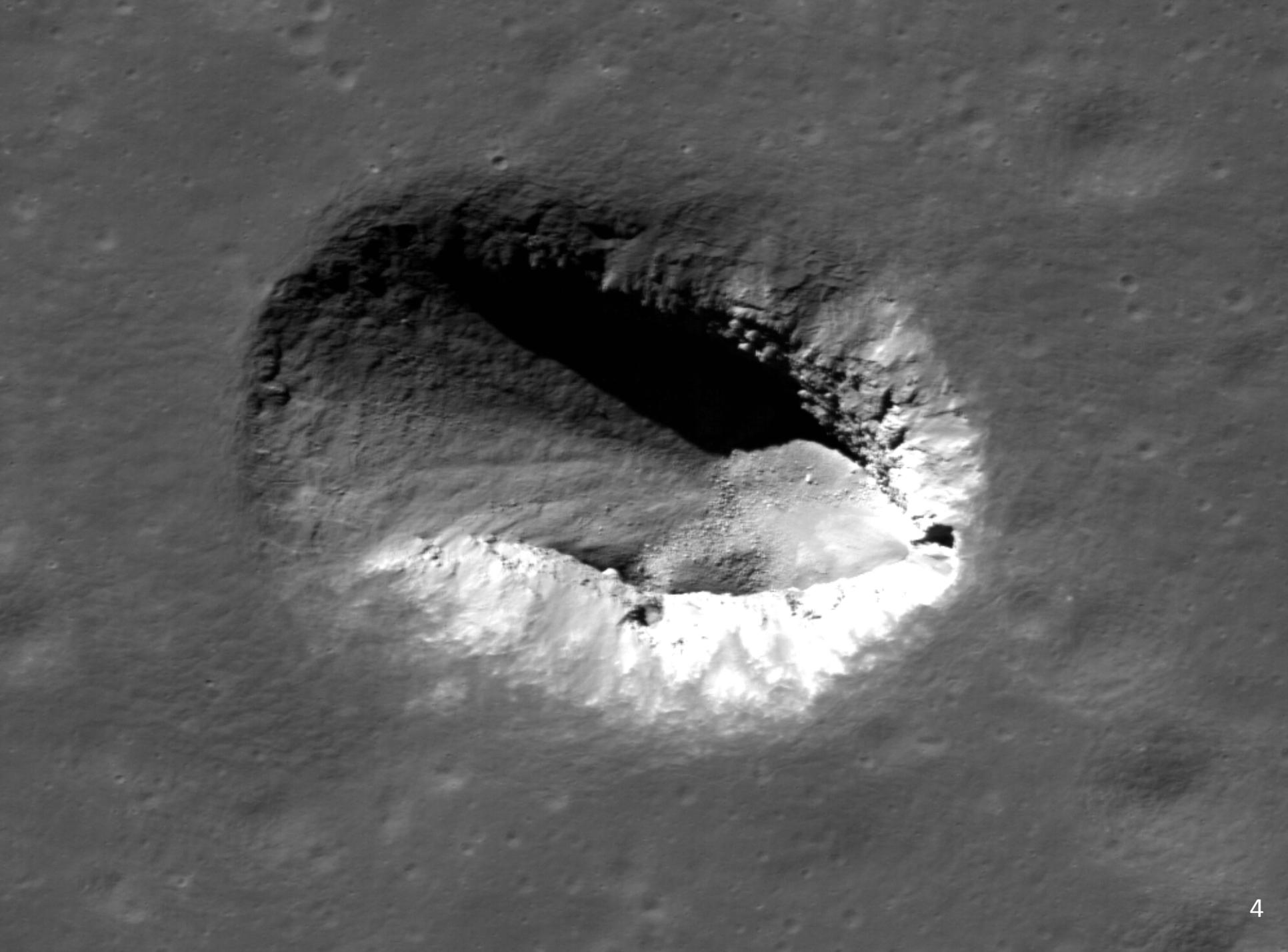
Dr. Uland Wong

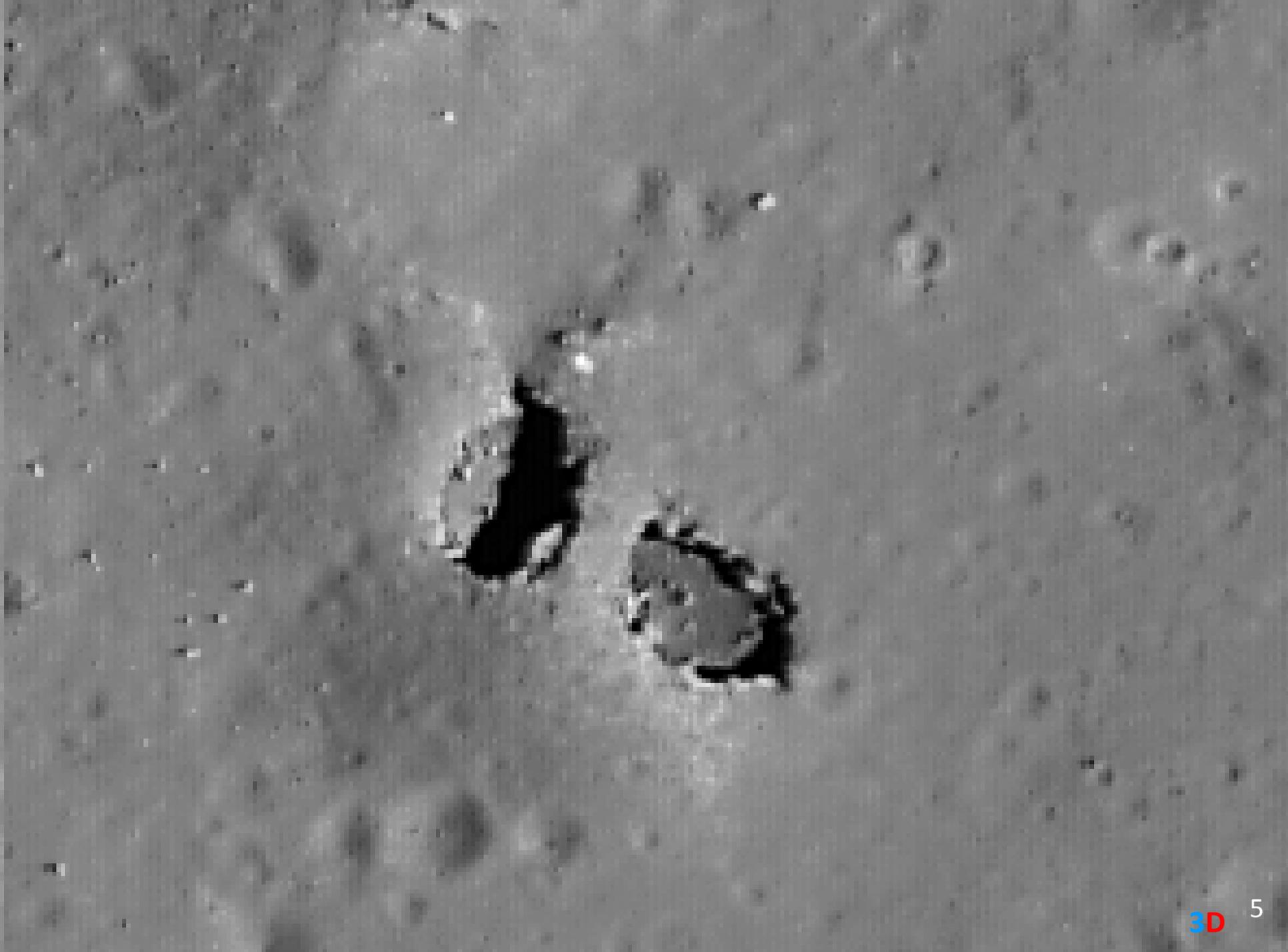
NIAC NNX12AQ55G



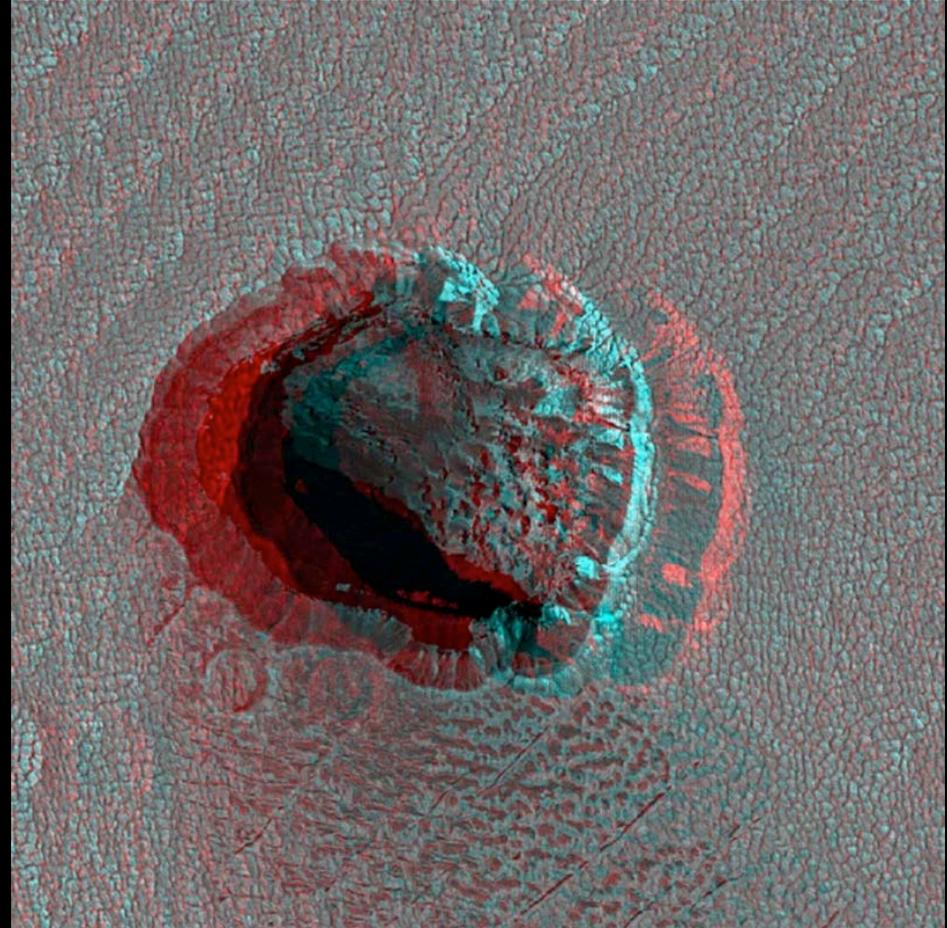
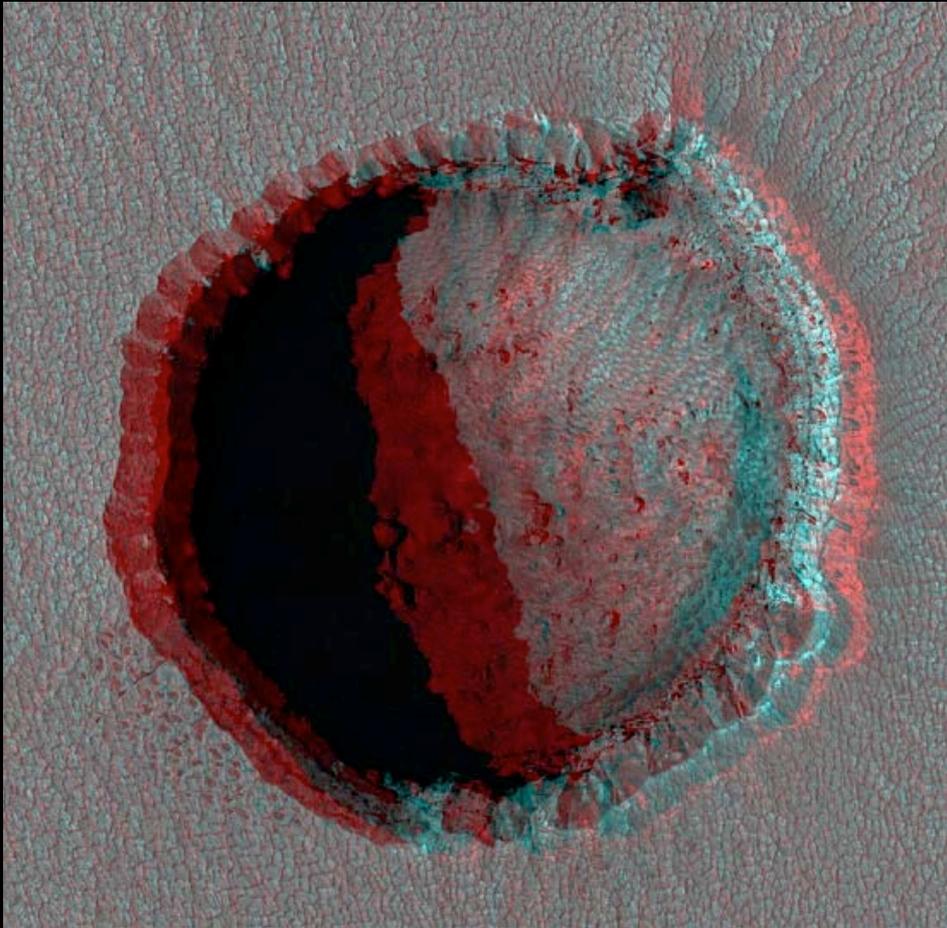




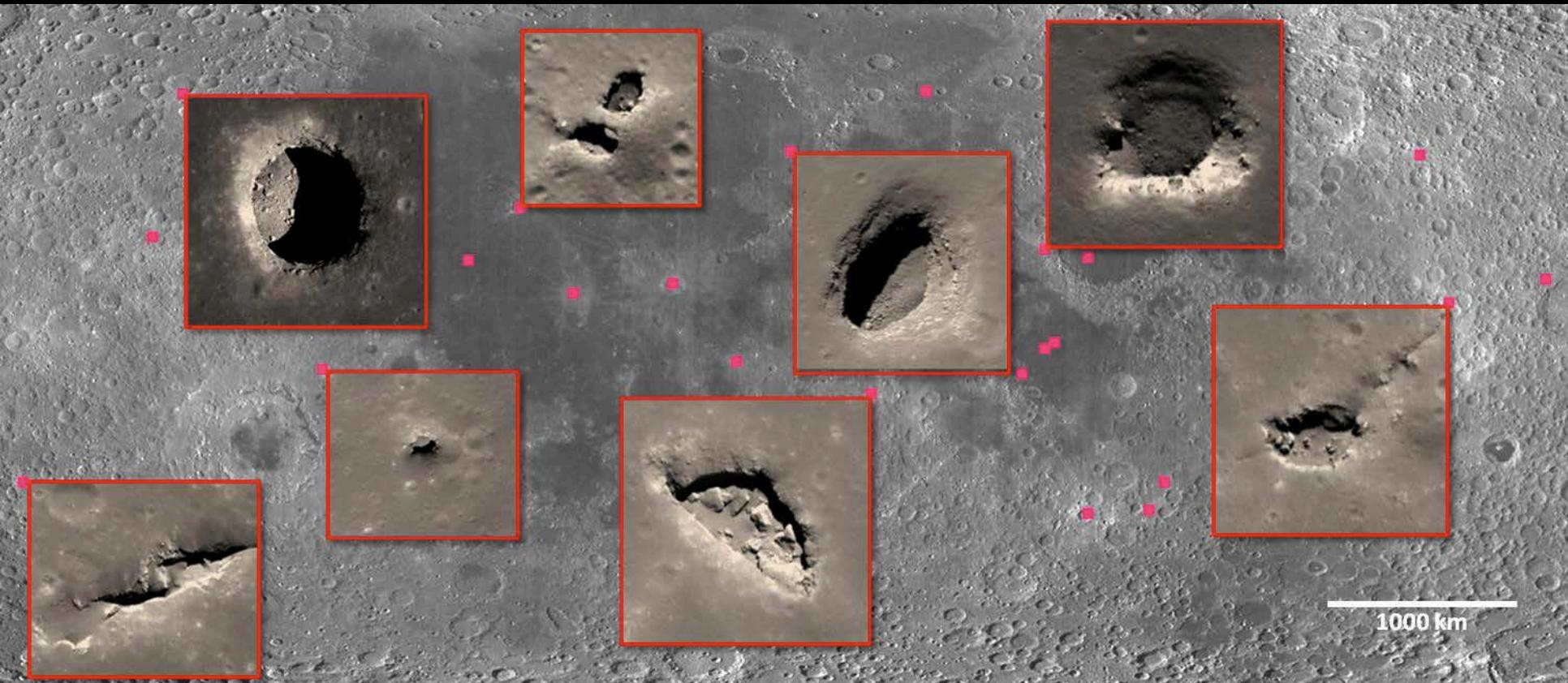




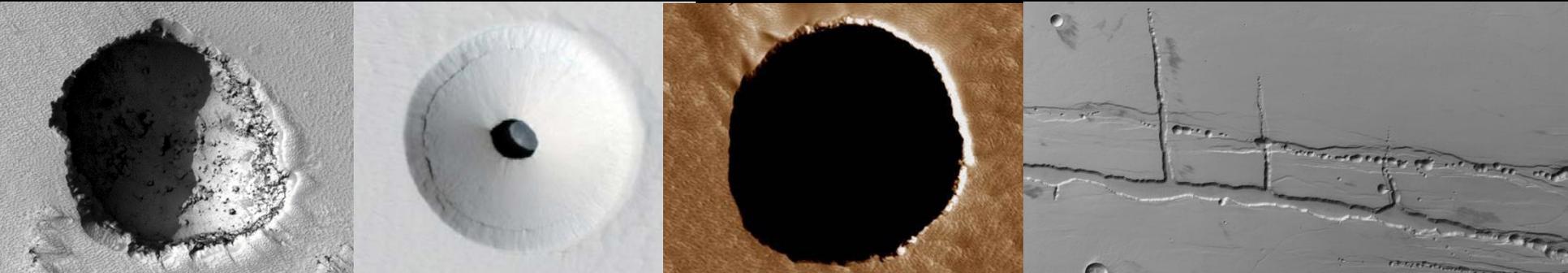
Mars Pits in 3D



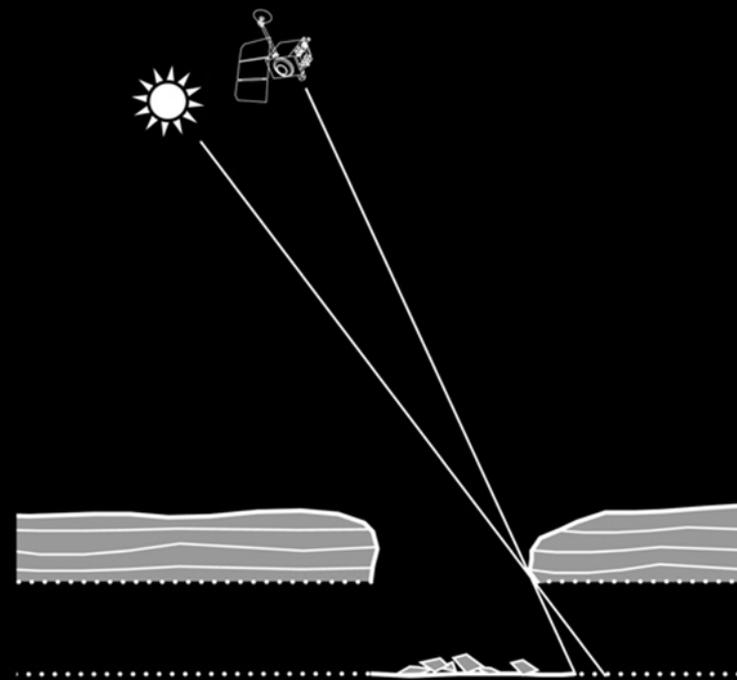
150+ Lunar Pits



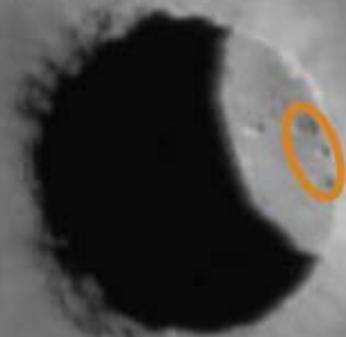
Hundreds on Mars & Mercury; Other Bodies



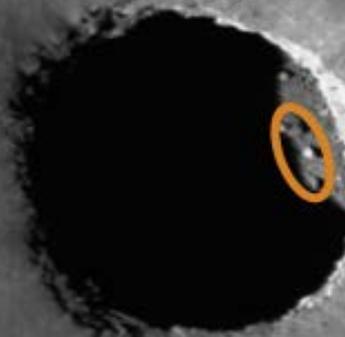
Discovering cave entrances by looking under a rim



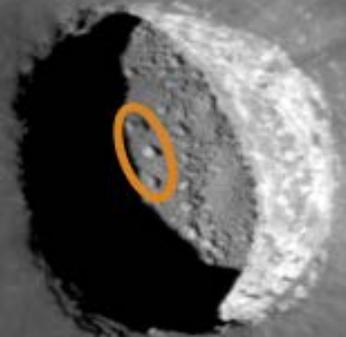
Emission angle: 1.4°



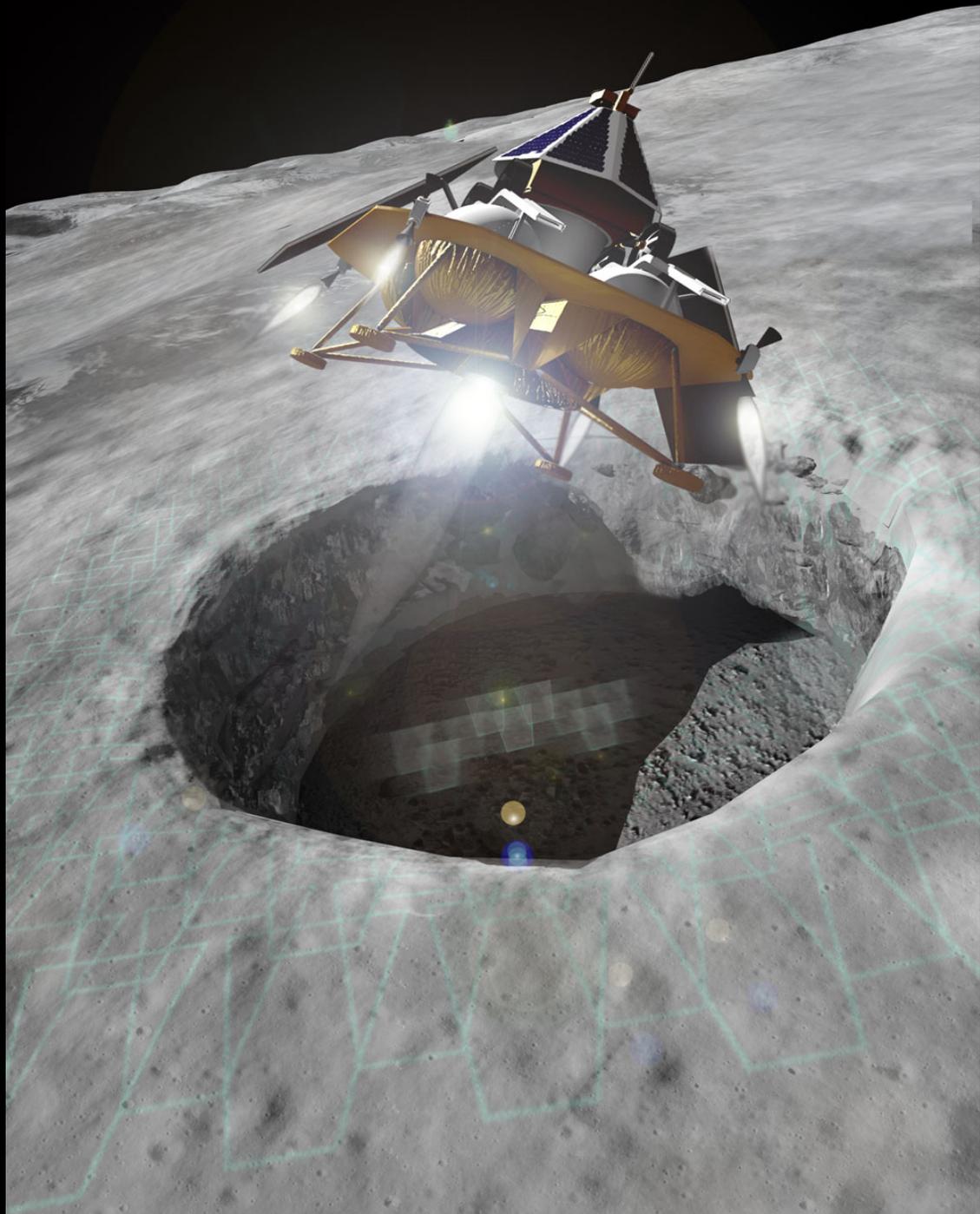
Emission angle: 7.2°

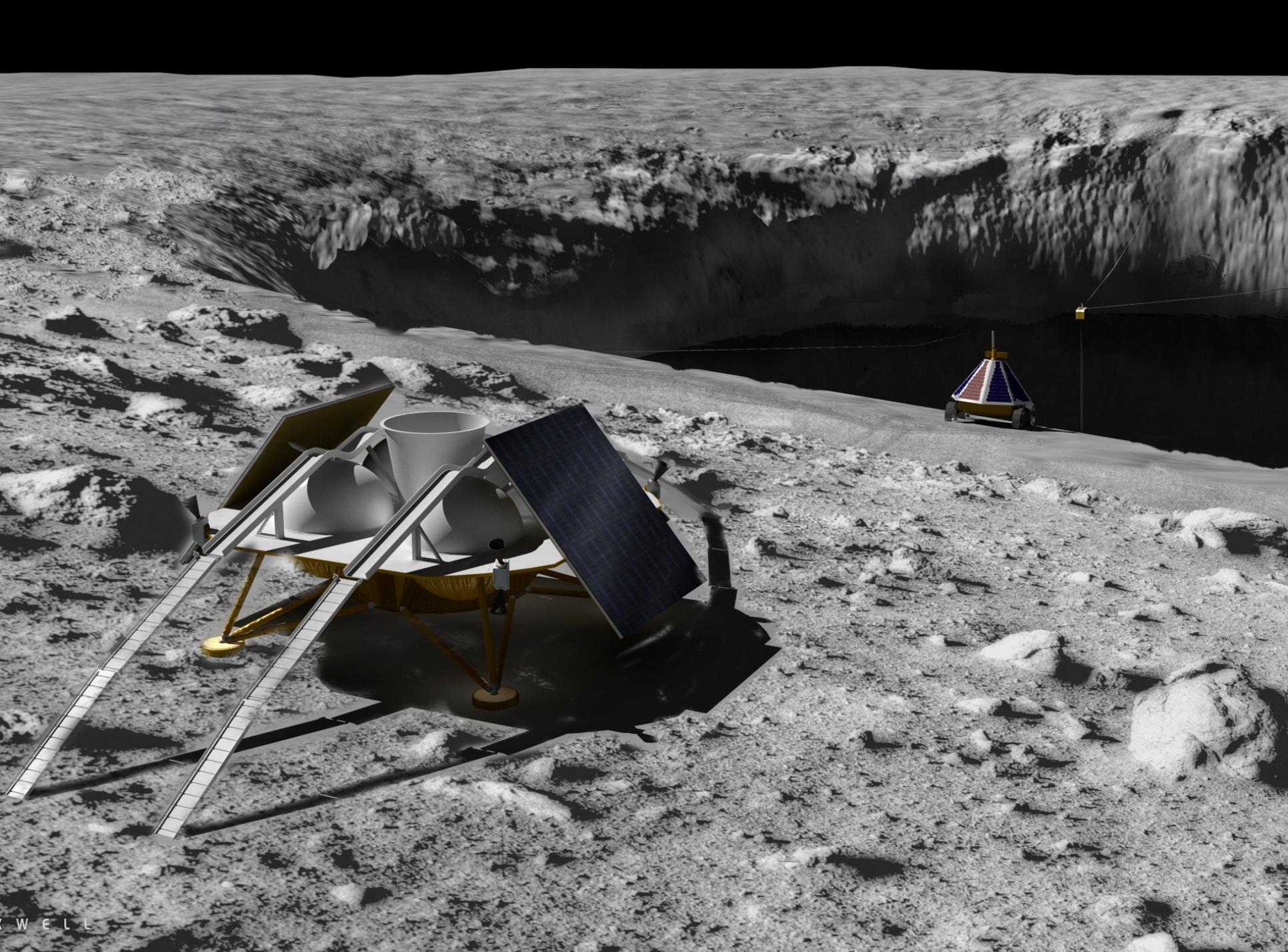


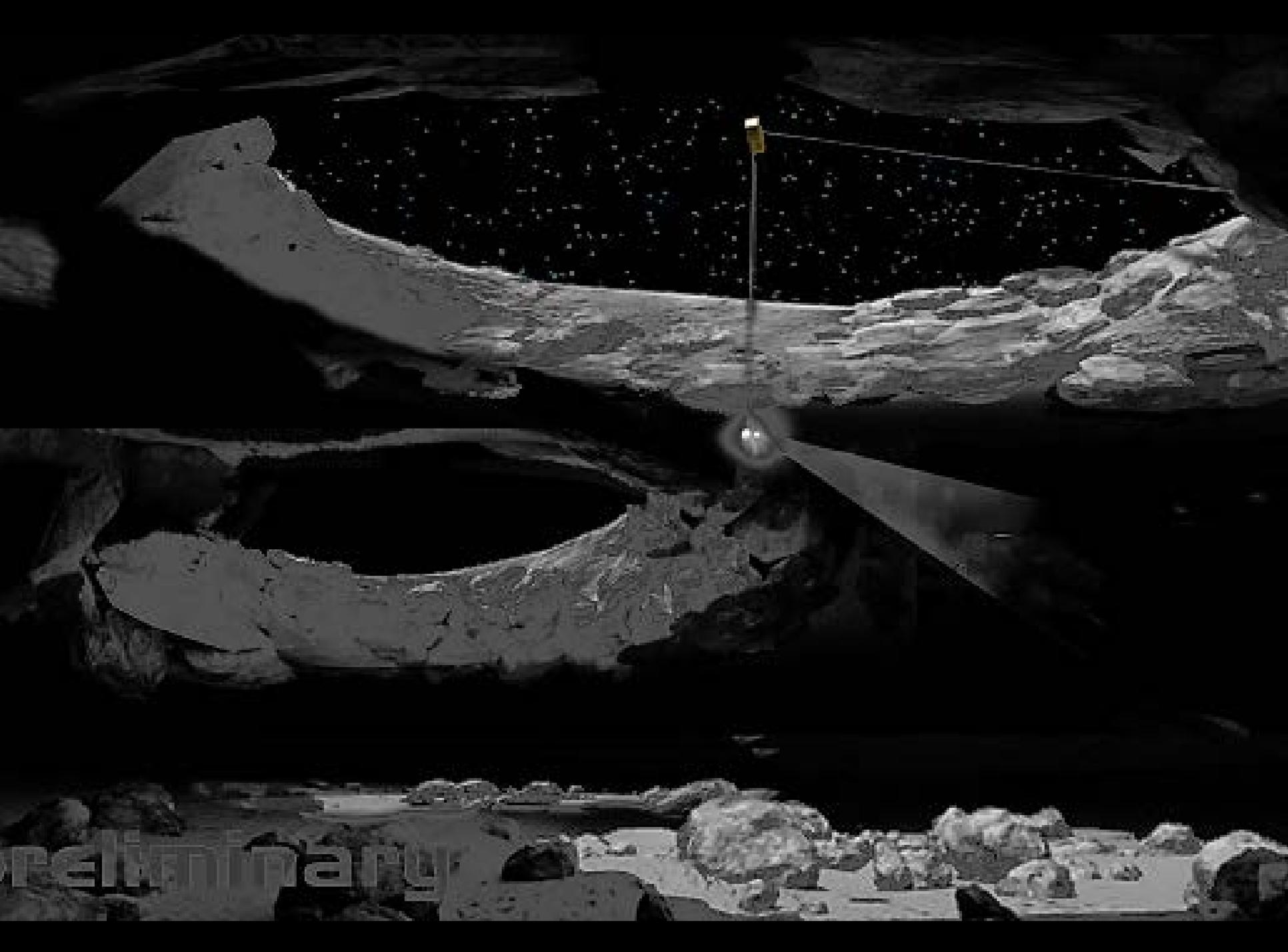
Emission angle: 25.8°



- Compelling destinations
- Science, Exploration, Resources & Safe Havens
- Inaccessible from orbit
- Too risky for humans-first
- Inevitable destinations
- Economical, near-term missions
- Long-term storage





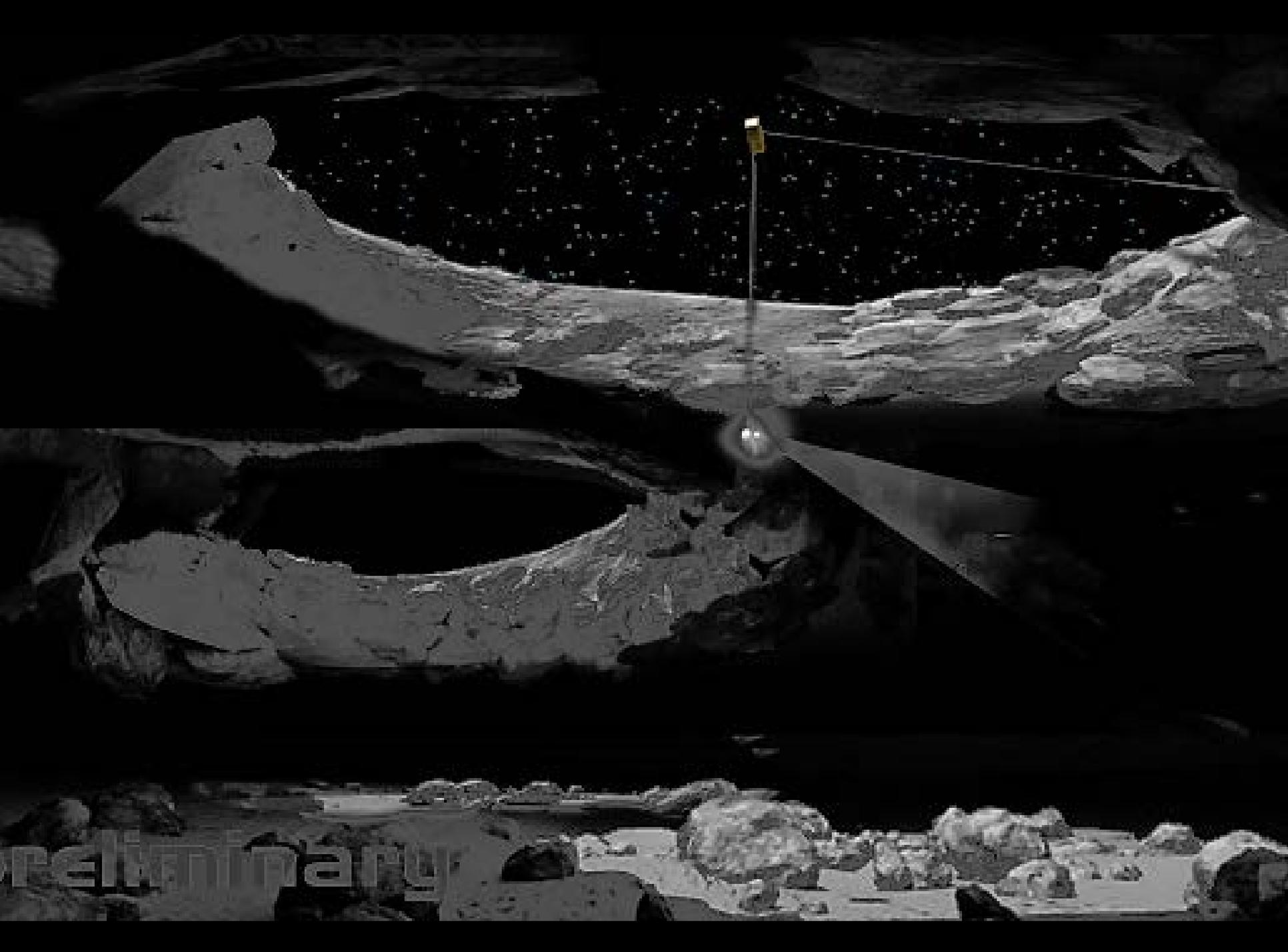


preliminary



- Precision apron landing
- Descent into voids and access to caves
- Mobility over Skylight floors and through caves
- Communication & Power
- Sensing, Lighting, & Scanning
- Scientifically-Significant Modeling
- Autonomous Ops & Coordination

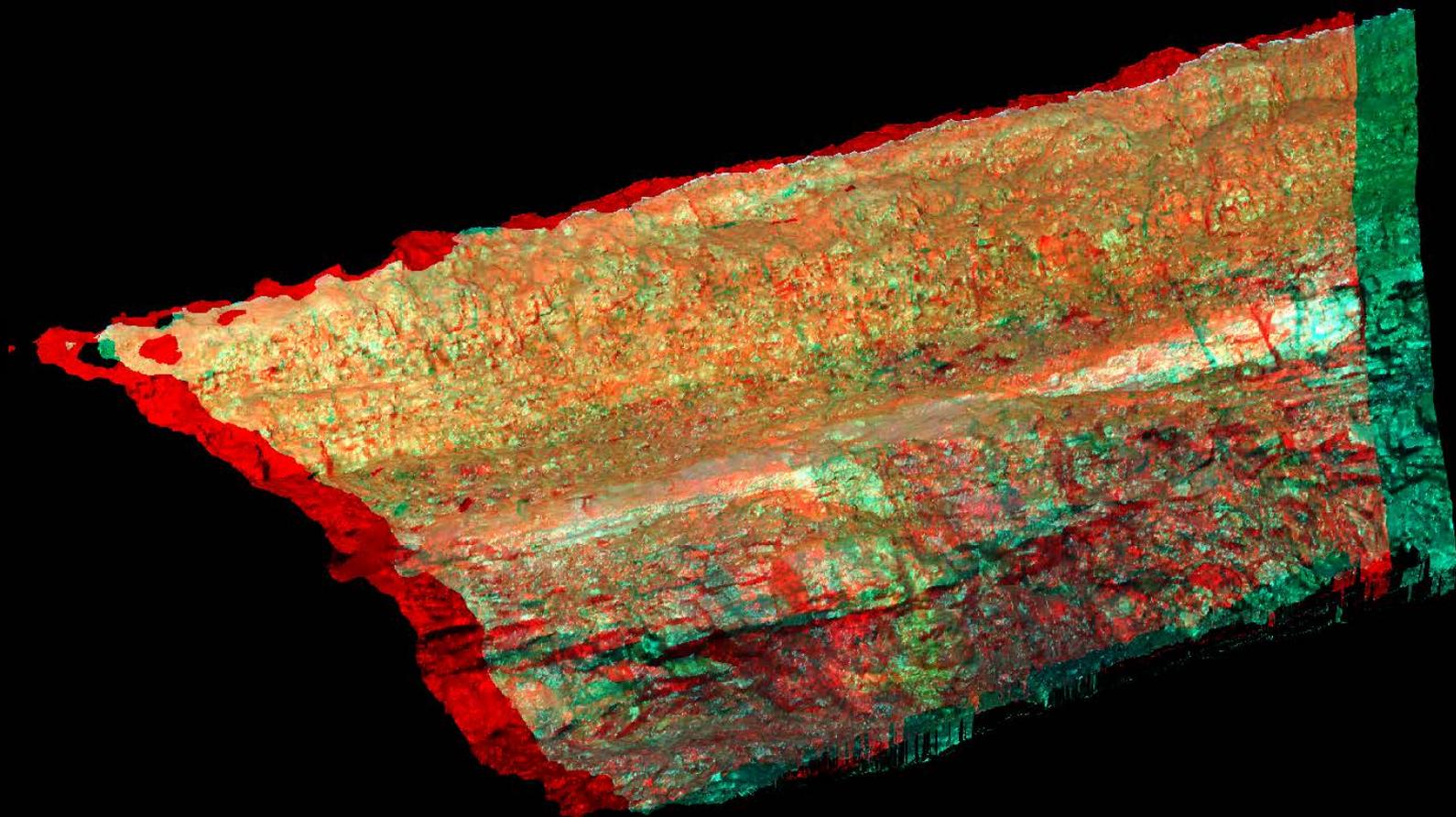
- Developed new robotic methods for skylight access and modeling
- Developed new algorithms for high-fidelity science modeling of pits
- Conducted rigorous analog testing campaign
- Created immersive visualizations of pit and tube analogs
- Created first downloadable 3D-print of pit walls
- Developed mission concepts and roadmap to flight



preliminary



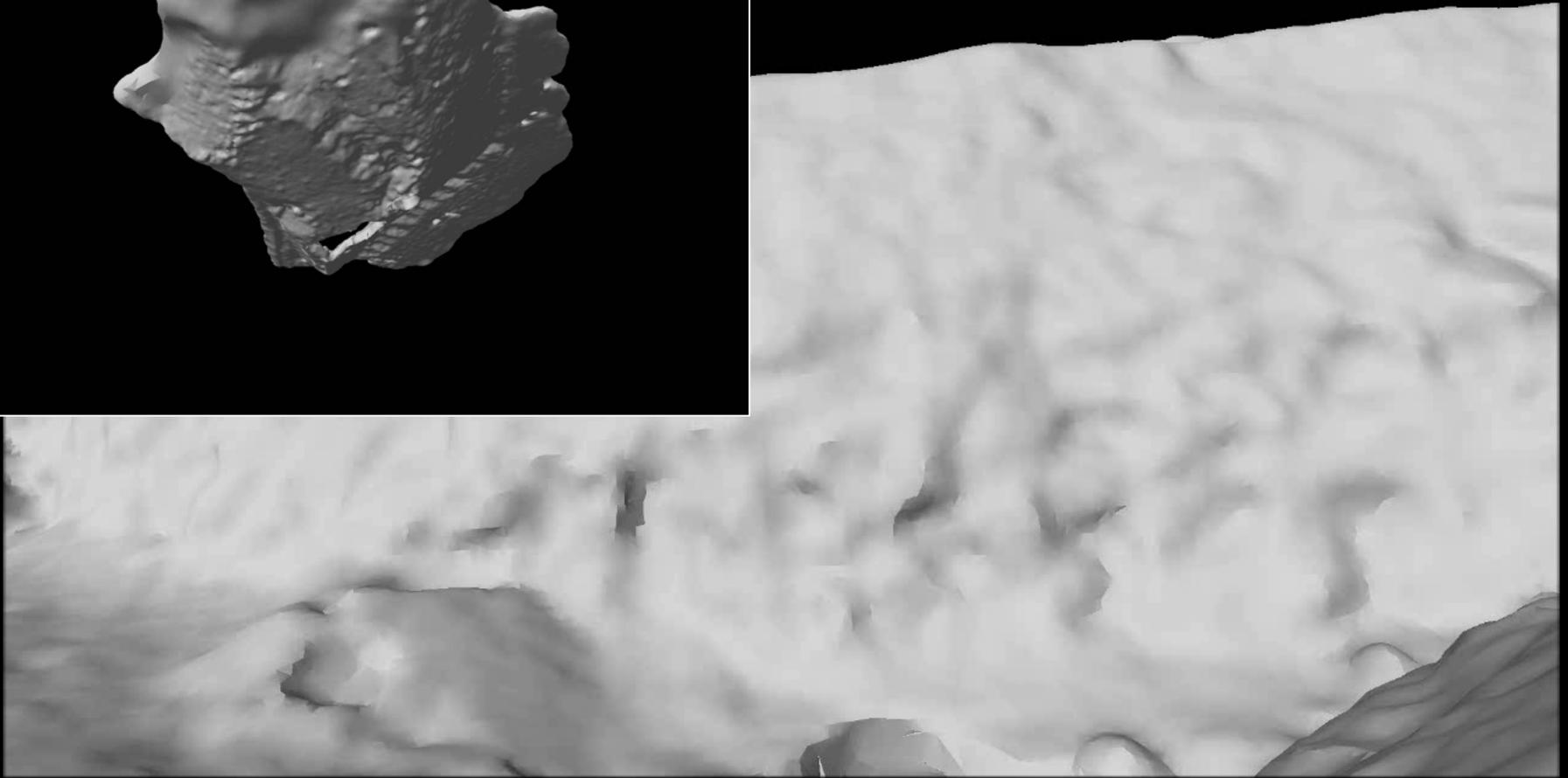
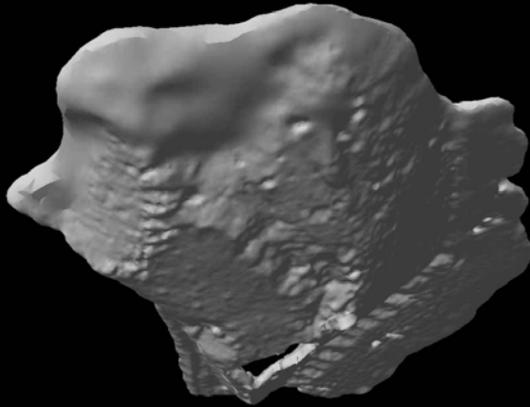
Skylight and Pit Modeling



Fusion with Lumenhancement



Pit Shell Models





Rock Crawling in 3D



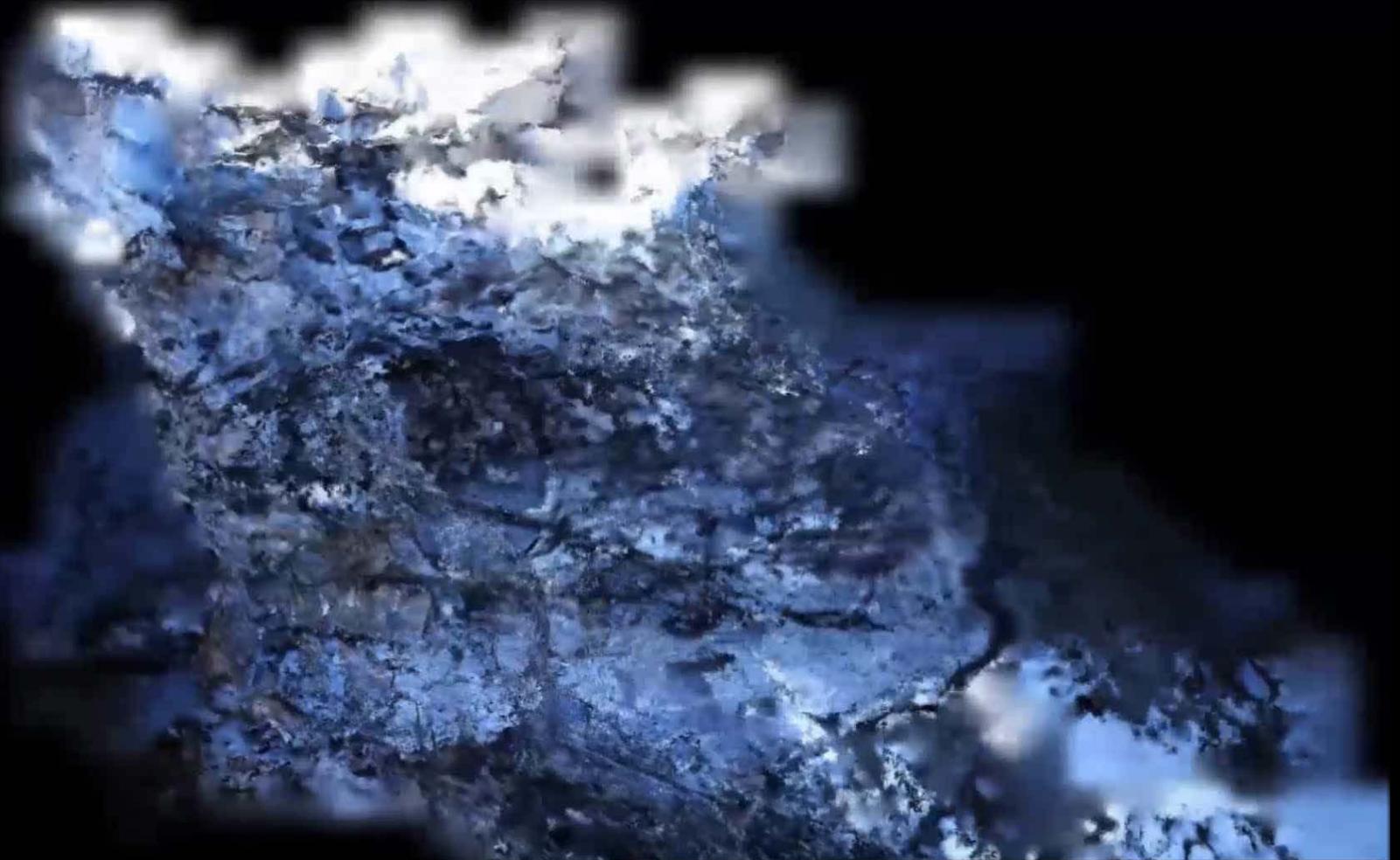




3D Cave Exploration



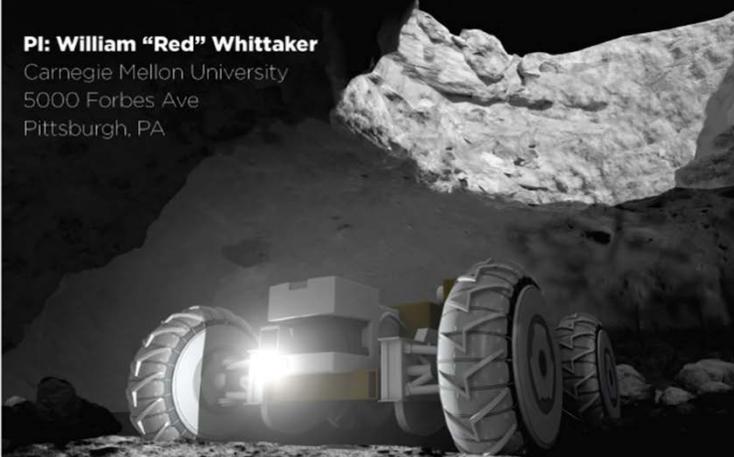
Subsurface Modeling



CAVES

Cave And Void Exploration Science

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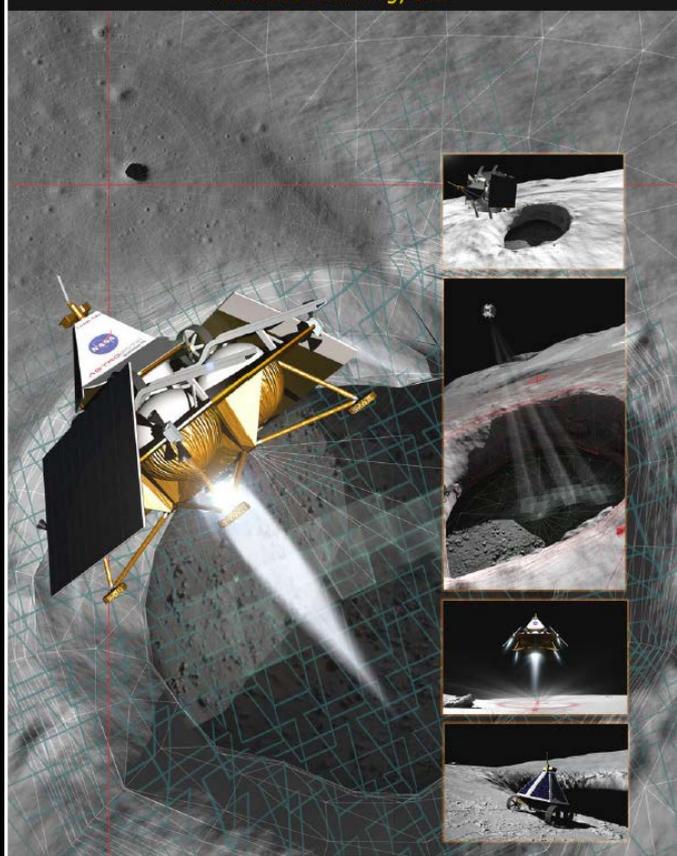
Carnegie Mellon University



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Skylight: Pinpointing Planetary Destinations

BAA NNM11ZDA001K / June 24, 2011
 Astrobotic Technology Inc.



- OUTSTANDING work by an impressive team with far-reaching connections to the kinds of new science that the AGENCY needs to be doing.
- Progress to date is “beyond impressive” with a tapestry of practical field demonstrations tied to real questions with direct relevancy to science at the frontier (and well connected to several Mars priorities)
- The demonstration [of data fusion] is particularly attractive as it presents a pragmatic demonstration of what could be possible (and affordable) for NASA in the 2020’s and beyond.
- If we are to pursue new environments with science potential that was unrecognized only a few years ago (such as in Pits, Caves, lava tubes), then this is the right step at the right time.

-James Garvin

- Modeling from apron
- Terrestrial skylight experiment
- Terrestrial lava tube experiment
- Terrestrial pit flyover
- Publication
- Mission Roadmap
- Evangelism & Infusion



