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Highlights of Science and Exploration Activities at the SSERVI CLASS Node.

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Abstract

The Center for Lunar and Asteroid Surface Science (CLASS) includes several initiatives to support science and exploration activities of the world-wide space science community. Two major initiatives are the CLASS Planetary Landing Team that brings together leading expertise on plume dynamics and the Exolith Lab which develops and produces high-mineralogical fidelity regolith simulants for science and engineering applications.

1. CLASS Planetary Landing Team

When exploration missions interact with the surfaces of moons, planets, and asteroids, the rocket exhaust will produce dramatically different effects depending on the gravity and size of the object, the mechanical strength and porosity of the soil, and the density (or lack thereof) of the atmosphere. In lunar landings, a spacecraft the size of the Apollo Lunar Module will blow away more than a ton of soil, dust, and rocks at high velocity. For human-class landers on Mars, the supersonic jet will dig a deep, narrow crater that redirects a jet of gas carrying rocks and sand back up at the landing spacecraft at high velocity.

We need to understand the physics of these effects, so we can predict and control them. The Apollo 12 Lunar Module landed on the Moon just 160 m away from the Surveyor 3 spacecraft, and the spray of sand and dust from the Lunar Module thoroughly scoured and pitted the Surveyor's surface. This kind of sandblasting can ruin optics and thermal control surfaces. The impact of rocks can destroy hardware. The chemicals in the rocket exhaust can disturb scientific measurements in the landing zone. Strategies to mitigate these effects include building landing pads and berms on the Moon or Mars.

The CLASS Planetary Landing Team includes world-leading experts in these topic areas. We have already made significant progress developing the science and technology to enable safe, effective landings on other planets, and we are ready to support the lunar and Martian landings of the future.

If you have interests in plume effects and the Landing Team please contact Phil Metzger (Philip.Metzger@ucf.edu) or Dan Britt (dbritt@ucf.edu). The Landing Team web pages can be accessed at https://sciences.ucf.edu/class/landing-team/.

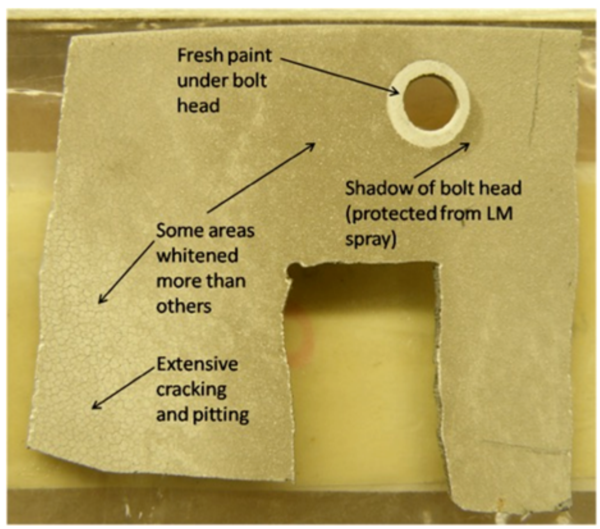

Figure 1: Piece of Surveyor 3, cut from the spacecraft by Apollo 12 astronauts and returned to Earth. It shows evidence of the sandblasting by the Apollo 12 Lunar Module landing.

2. CLASS Exolith Lab

The Exolith Lab is a not for profit extension of CLASS, dedicated to regolith simulant production and applied research. Simulant costs cover materials, facilities, and labor. We design our asteroid and planetary simulants starting with individual raw minerals because minerals are the basic building blocks of planetary materials. Simulants designed to replicate the mineralogy of a reference material will tend to compare well on many different metrics, because the secondary properties (spectra, strength, etc.) are a result of the specific combination of minerals present in the regolith. Simulants made from natural terrestrial materials will never be perfect copies of extraterrestrial regoliths, but the process of manufacturing high-fidelity simulants is one of constrained maximization. The primary constraints are cost and safety, with the goal to provide inexpensive, safe simulants that to the greatest extent reasonable mimic many of the key properties of science, exploration, ISRU, and engineering interest. These include:

- Mineralogy: Our simulants are high-fidelity materials that accurately capture the major modal mineralogy of the reference materials, including both crystalline and amorphous phases.
- Bulk chemistry: The bulk major element chemistry of our simulants is generally accurate, except for excesses in Mg, Na and K, and deficiencies in Fe and Ca due to the crystal chemistry of terrestrial minerals.
- Particle size distribution: For lunar simulants there are good controls from returned samples and we target these distributions. For martian and asteroid simulants we use a natural power law distribution from crushing.
- Volatile release: We have measured the evolved gases from the simulants during heating, and the martian and asteroid simulants accurately capture the total amount of water released compared to the reference materials.
- Derivative properties: Many properties such as reflectance spectra and magnetic susceptibility are mainly a product of the modal mineralogy. Our simulants should perform well in these properties, although we do not specifically target them.

What we specifically do not simulate are potentially hazardous materials which are part of the mineralogy of many planetary materials. These hazards include carcinogenic polycyclic aromatic hydrocarbons (PAHs) and asbestiform serpentines in volatile-rich carbonaceous chondrites and perchlorates in martian materials.

Simulants Available: The following simulants (Fig. 1) are currently available for order on the Exolith Lab website. https://sciences.ucf.edu/class/exolithlab/.

- LMS-1 Lunar Mare Simulant: Moderate-Ti mare soil with a particle size distribution based on Apollo samples.
- LHS-1 Lunar Highlands Simulant: Generic highlands soil with a particle size distribution based on Apollo 16 samples.
- FROST-Y Lunar Volatile-Rich Simulant: A frozen, contaminated ice-bearing lunar simulant. Replicates highlands regolith in the permanently shadowed regions of the Moon and is appropriate for testing ISRU extraction and purification processes.
- DUST-Y Silicate Dust Simulant: Physical dust simulant dominated by particles in the 1-10 micron range, appropriate for dust mitigation applications.
- CI, CM, and CR Asteroid Simulants: Represent the mineralogy of the volatile-rich carbonaceous chondrites that are high-priority ISRU targets.
- Mars Simulant: Based on the mineralogy of the Rocknest target at Gale crater, with customized sulfate and clay-rich varieties for ISRU applications.

For More Information: To order simulants and for more information see the simulant web page https://sciences.ucf.edu/class/exolithlab/ and the Planetary Simulant Database https://sciences.ucf.edu/class/planetary-simulant-database/.

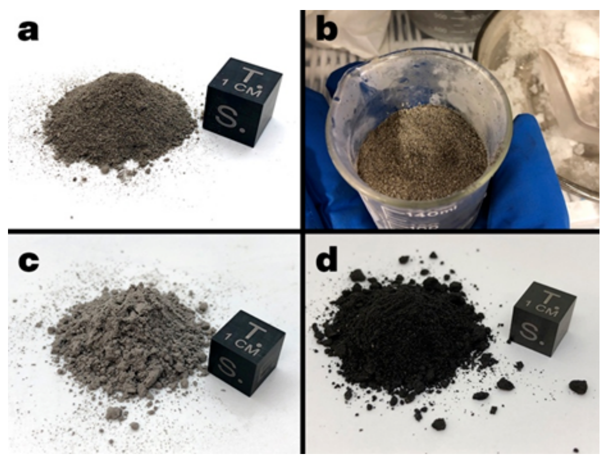

Figure 2: Photographs of our simulants. a) LMS-1 b) FROST-Y, c) DUST-Y, d) CI Asteroid Simulant.