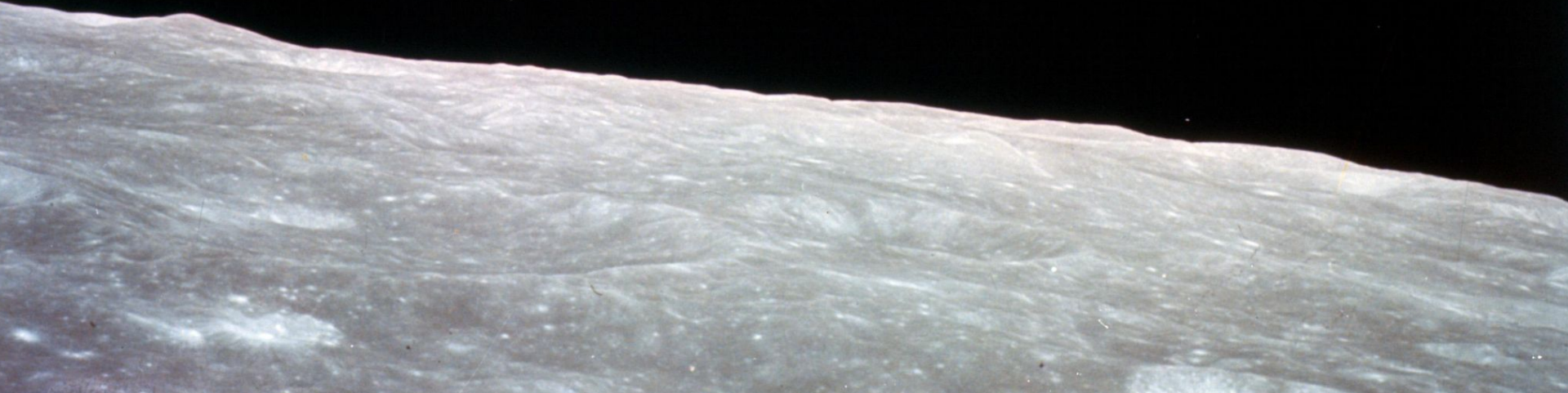




Exolith Lab Lunar Simulants



What is Exolith Lab?

- Exolith provides the space industry with Lunar, Martian, and Asteroid surface analogs
 - Also called “regolith simulants”
 - Working with companies like SpaceX, Blue Origin, NASA, ESA, and JAXA
- Part of the Florida Space Institute and CLASS
 - Under the University of Central Florida



The Moon

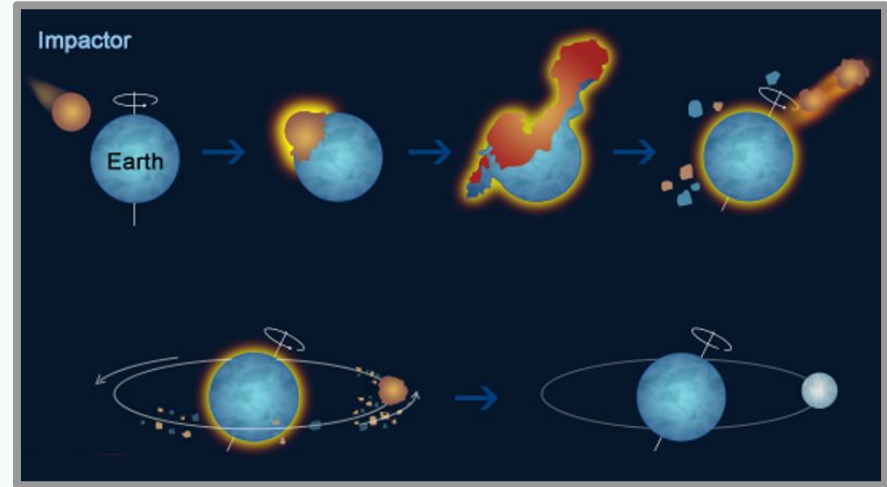
- The Earth's only natural satellite
 - 5th largest Moon in solar system
- Gravity is 1/6th G
 - 2nd highest gravity of any Moon!
- 38 million km² surface area
 - Roughly the size of Asia



The Moon

The Earth-Moon System

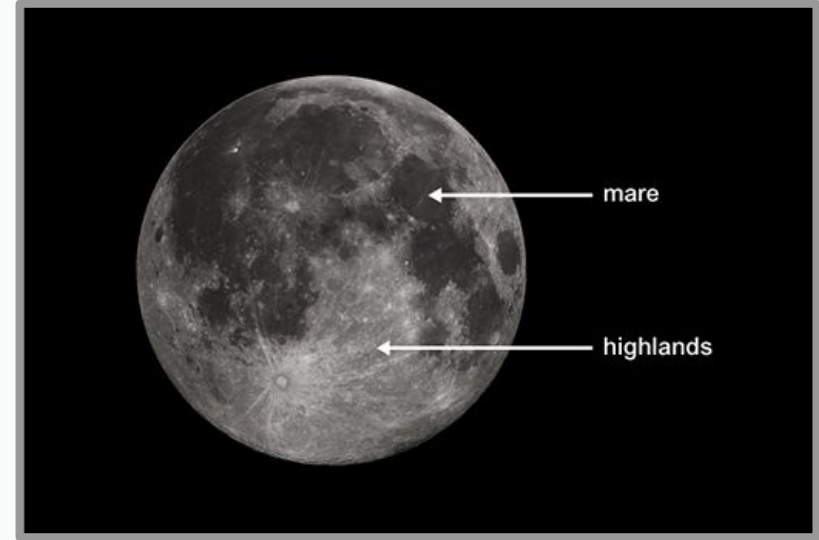
- Formed roughly 4.5 billion years ago
 - It is thought that a large impact ejected the Moon from Earth
- Became tidally locked with Earth
 - We always see the same side of the Moon
 - Tides on earth caused by Moon's gravity



Formation of the Moon

Geology Of The Moon

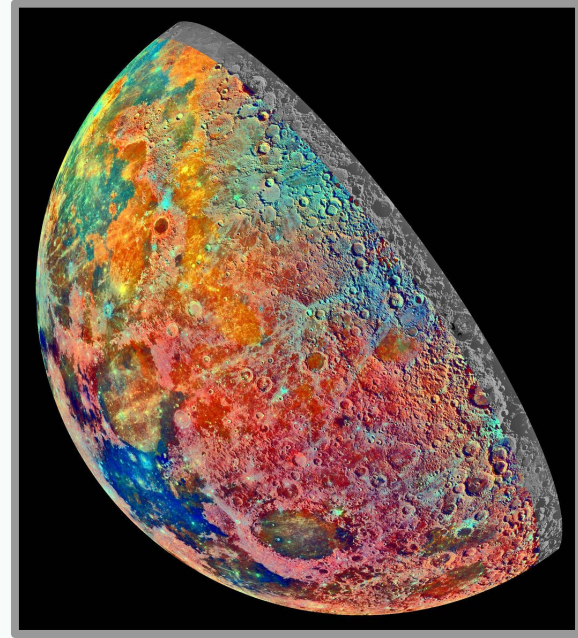
- Moon began as magma ocean
- As magma cooled, Plagioclase (anorthosite) crystalized and floated to the top
 - This is the Lunar Highlands
- Magma later began seeping up through the crust
 - Intense bombardment occurred and revealed the Lunar Mare below



Geological Regions of the Moon

Mineralogy Of The Moon

- Silicates
 - Plagioclase (Anorthosite)
 - Olivine
 - Pyroxene
- Oxides
 - Ilmenite
 - Basalts
- Highlands is mostly Plagioclase
- Mare is a mix of Silicates and Oxides



Mineral Map of the Moon.

Lunar Regolith

- Regolith is a blanket of unconsolidated, loose, heterogeneous superficial deposits covering solid rock
 - Problematic for Human health
 - Useful for many ISRU applications
 - Water extraction
 - Mineral extraction
 - Radiation shielding
 - Construction processes



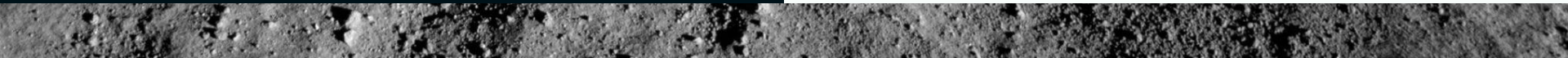
Boot Print in Lunar Regolith

Exolith Lab Lunar Simulants

- Regolith Simulant is used to test hardware and processes on Earth, before we go back to the Moon
 - Structural applications
 - Plant growth
 - Human health
 - Mineral extraction
 - Hardware deterioration
- High fidelity mixture of minerals found on The Moon
- We do not simulate dangerous compounds (perchlorates, asbestos, etc.)



Bucket of LHS-1 Simulant



Simulant Creation

- Appropriate minerals are sourced
 - Come to us crushed or we crush them
 - XRD and XRF used to verify minerals
- Minerals are measured out using recipe sheet
- Mixture is put into cement mixer and mixed until homogenous
 - Oxidizes minerals and assures consistency



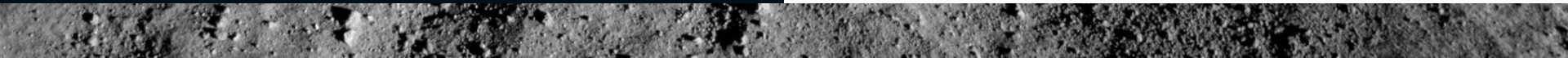
Outdoor Processing Area

Simulant Creation

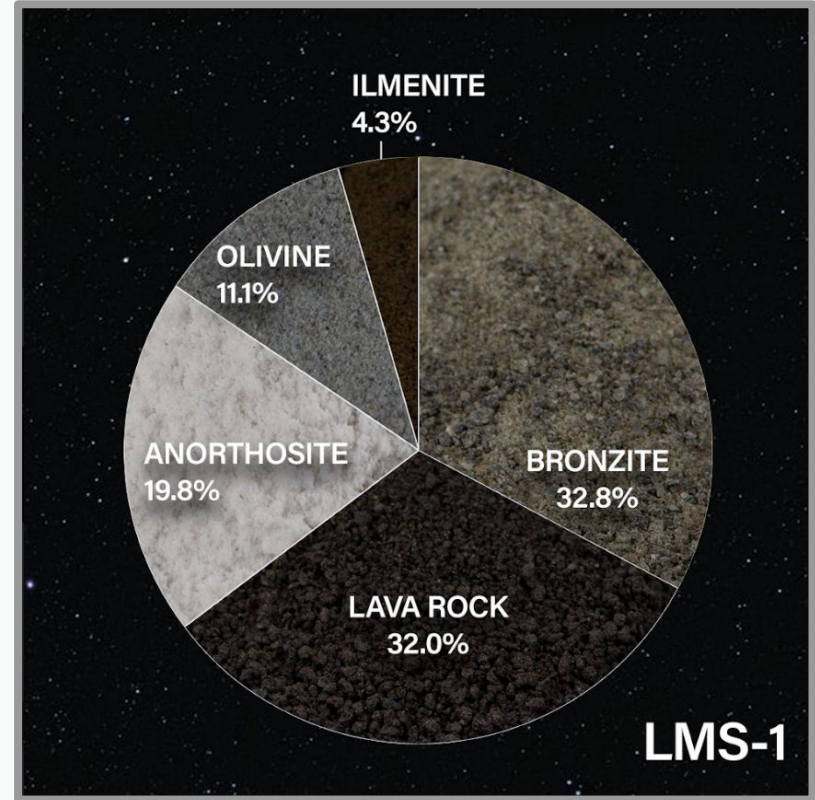
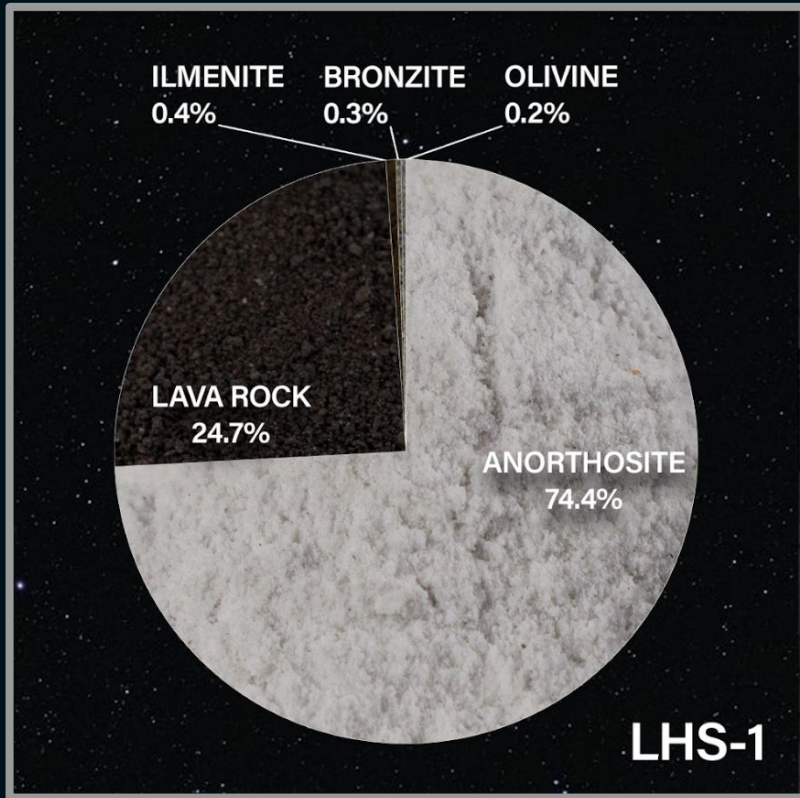
- Data on the mineralogy of The Moon was gathered during the Apollo missions
 - Samples were returned to Earth and analyzed
- Goals of simulant
 - Accurate Mineralogy
 - Particle size range
 - Particle shape
 - Oxidation



Adding Mineral Mixture



Simulant Composition



Lunar Highlands Simulant (LHS-1)

- Simulates the Lunar Highlands
 - Based on Apollo 16 returned samples
- Particle Size Range: .04-1000 microns
- Mean Particle Size: 88 Microns
- Bulk Density: 1.30 g/cm³
- Used for many upcoming missions going to the Highlands



Component	Wt.%
Anorthosite	74.4
Glass-rich basalt	24.7
Ilmenite	0.4
Pyroxene	0.3
Olivine	0.2

Lunar Mare Simulant (LMS-1)

- Simulates the Lunar Mare
 - Based on the other Apollo missions
- Particle size range: .04-1000 microns
- Mean particle size: 91 microns
- Bulk Density: 1.30 g/cm³
- Much more pyroxene, basalt, and olivine



Component	Wt.%
Pyroxene	32.8
Glass-rich basalt	32.0
Anorthosite	19.8
Olivine	11.1
Ilmenite	4.3

Dust Simulants

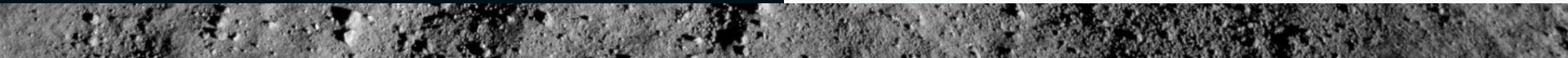
(LHS-1D and LMS-1D)

- Dust variant of each simulant
 - Less than 35 microns
- Particle size range: 0-35 microns
- Mean particle size: 7 microns
- Bulk Density: 0.7 g/cm^3
- Used to test systems that may be sensitive to dust



Lunar Highlands Agglutinates (LHS-1-25A)

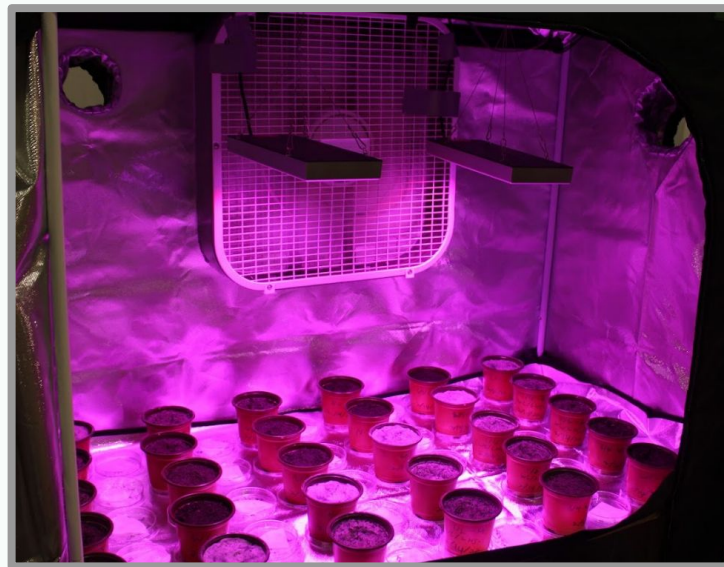
- Higher fidelity variation of LHS-1
 - Includes glassy Anorthosite that we produce through a high temperature
- The Lunar surface has a large amount of glass, formed through meteor impacts



Uses of Simulant



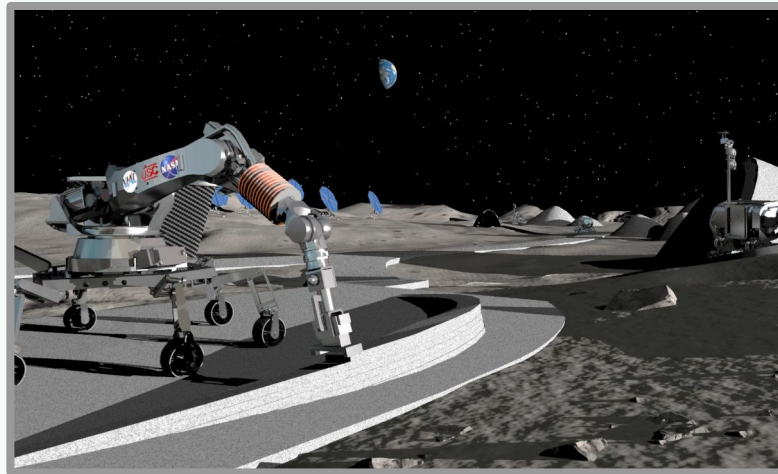
- In Situ Resource Utilization
 - water extraction
 - construction processes
- Hardware testing
 - Rover wheels
 - Sampling equipment
- Mechanical properties testing
- Plant growth
- Outreach



Exolith Plant Growth Studies

In Situ Resource Utilization

- Water extraction
 - Testing methods to extract water ice from regolith
- Construction processes
 - Manufacturing using the lunar regolith
 - Used for landing pads, parts, habitats. etc



Lunar ISRU Concept

Plant Growth



- Plant growth is one of the most common uses of Lunar Simulants
 - Food production is essential on a lunar base
- Plant The Moon challenge
 - Students all over world participate
 - Various methodologies and level of success



LHS-1 Plant Growth Experiment

Summary

- A good simulant will replicate:
 - Mineralogy
 - Physical Properties
 - Driven by mineralogy
- Exolith Lab creates mineralogically accurate simulants that mimic the expected chemical and physical properties of planetary regolith
 - Can create custom simulants
 - Free scientific consultations
 - <https://www.exolithsimulants.com>
 - exolithlab@ucf.edu

