National Aeronautics and Space Administration

FY23 Strategic Initiatives Research and Technology Development (SRTD)

Lunar Science

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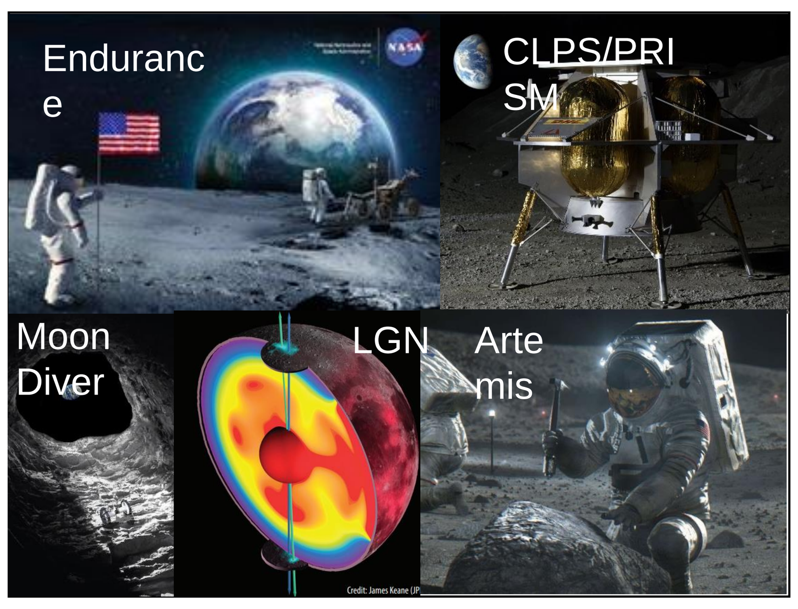
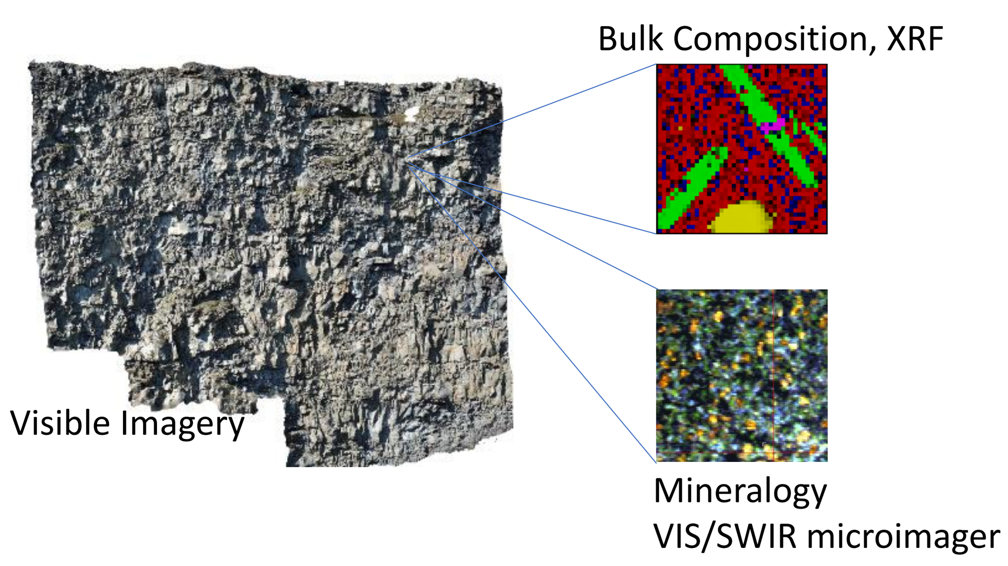
Strategic Focus Area: Lunar Science/ Moon and Mars Extreme Cold, Steep Terrain Rover **| Strategic Initiative Leader:** John D Baker

Significance/Benefits to JPL and NASA

At the current time, opportunities for JPL to participate in lunar science and exploration are growing rapidly. The next few years represent a critical time during which JPL can establish a reputation in the lunar science literature, and conduct analyses that will be critical for future lunar mission proposals. This strategic initiative aligns with JPL's desire to keep a diverse portfolio of missions by building needed scientific expertise in the emerging lunar mission environment. It helps JPL "Understand how the Solar System formed and how it is evolving" by researching and refining our knowledge of the measurements required to make advances in lunar science. The initiative also helps JPL infuse technology into new missions by providing a strong scientific foundation for those infusions. JPL has extensive experience with robotic systems and operations on other planets. By bringing this expertise to the new lunar mission ecosystem, JPL can help NASA in its goal to "develop and transfer revolutionary space technologies to enable exploration capabilities for NASA and the nation". The Lunar Science SRTD addresses three tasks focused on volcanism, volatiles, and seismology, each in support of advancing lunar science to support Decadal, lunar program, and strategic 4X directorate goals.



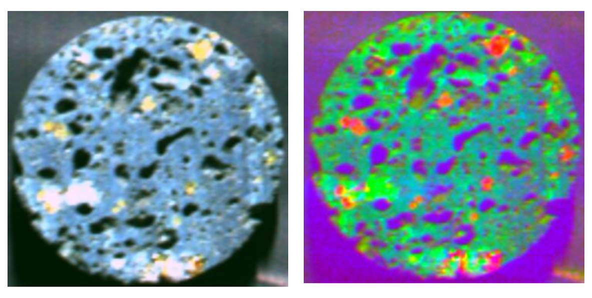
Lunar Volcanism

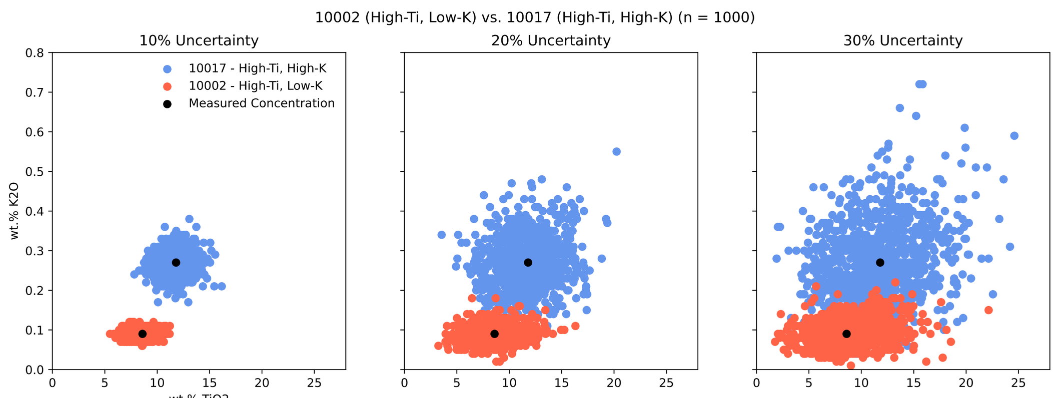


Objective: To collect images and hand samples from analog lava sites representing morphological end-member cases for lunar volcanism. The samples are examined via traditional laboratory techniques and the results are compared to those taken from common in-situ instruments.

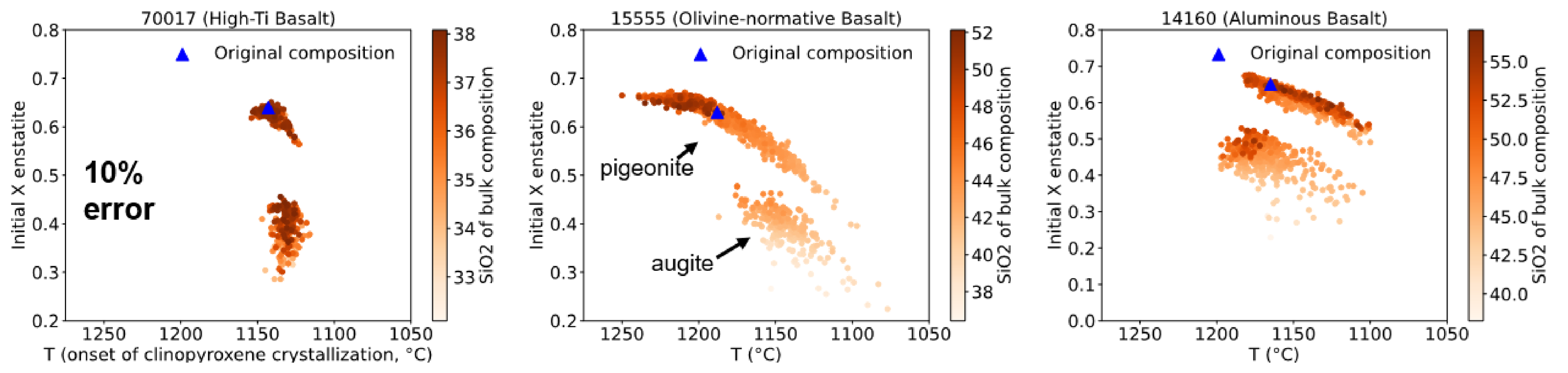
A mock rover, instrumented with GoPro cameras, was used to collect information on lava morphologies in cross-section. From images, we may distinguish between small, complex pahoehoe fields, inflated pahoehoe sheets, a'a flows, and giant continental-style flood basalts. Complex flow fields constructed from thin pahoehoe lavas tend to eventually form shield volcanoes, and require a shallow magma reservoir, while large flood basalts are expected to be from deeper reservoirs under high amounts of pressure.

Multispectral and hyperspectral instruments were used to image the analog basalts and extract information about their mineralogies.





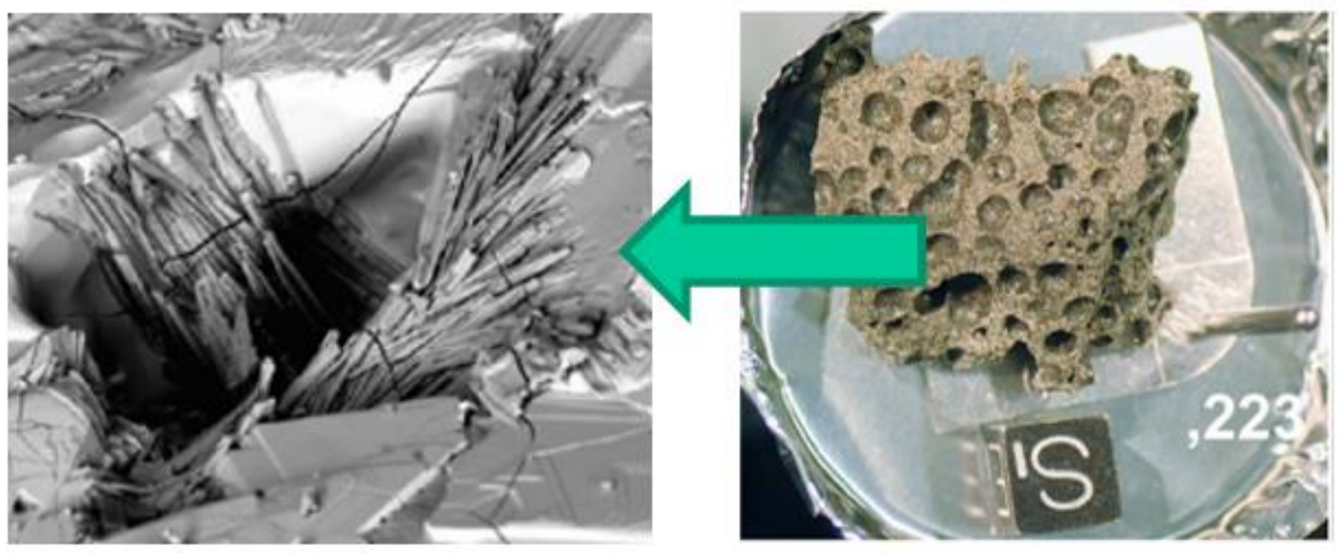
The bulk composition of a rock can be taken though several different means. The consequences of measurement error was explored by making a Monte Carlo simulation of the major oxides. Increased error causes some distinct Apollo sample subgroups to become indistinguishable.



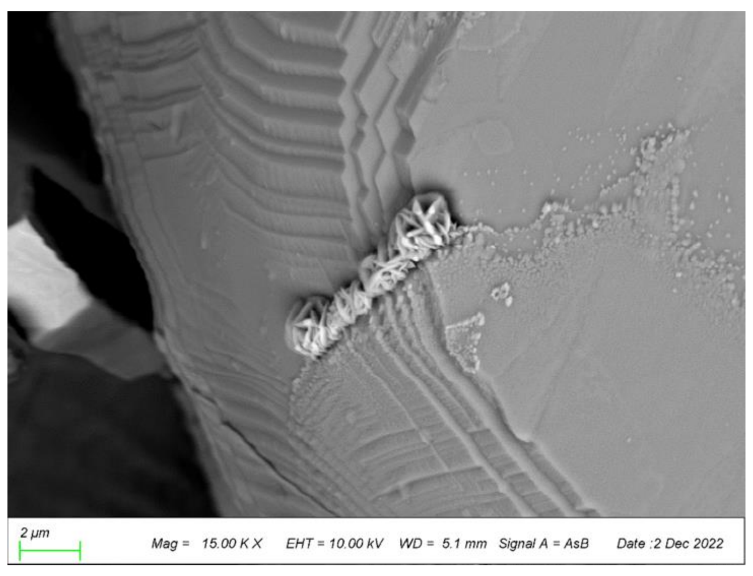
It was found that errors in the bulk composition of the rock could lead to confusion about which phenocrysts are native to the rock and which were acquired during its journey. This information is important because modeling the composition of minerals that should crystallize from that bulk composition is one way to determine if the magma is "primary", that is, representative of mantle processes.

Lunar Water

Lunar Water is a task that links into Artemis SDT *Goal 2b. Determine the source(s) for lunar polar volatile deposits, and 2e. Learn how water vapor and other volatiles are released from the lunar surface and migrate to the poles where they are absorbed in polar cold traps*. Following water is a major new focus of the lunar exploration program. Upcoming missions to the poles will be focused on where the ice comes from: delivery by comets, delivery by asteroids, solar wind processes, or volcanic outgassing. This task undertakes fundamental research to understand the production and chemical fingerprint of volcanically-sourced water. Co-I Hosseini and Davidsson's work addresses how water moves on the surface.

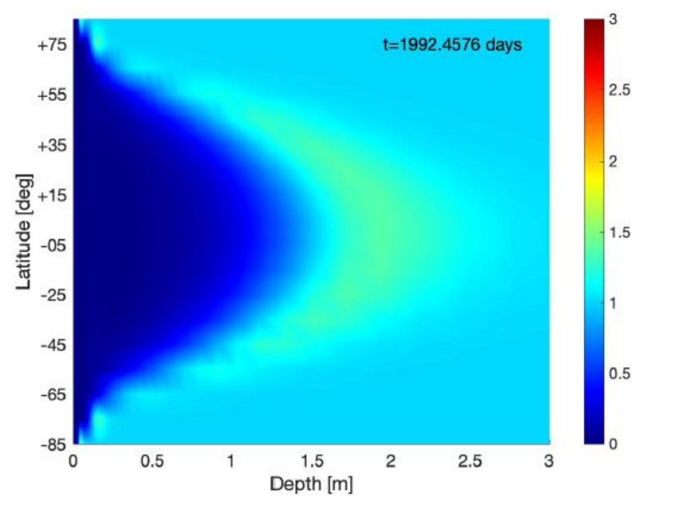


Vesicular Apollo basalts were studied Unusual minerals such as copper sulfate and apatite were found on the inside walls of the rock's ancient vesicles.



Copper sulfate was discovered on the vesicle walls. In addition to making "desert rose" formations, there was clear evidence of their having been an aqueous phase on the Moon.

Co-Is Davidsson and Hosseini developed a model of lunar water transfer, starting with a model originally developed for comets.



Applying a state-of-the-art comet nucleus thermo-physical numerical simulator to the Moon: water ice abundance (x 400 ppm) after 5.5 years of evolution (solar illumination, heat conduction, first-order water ice sublimation, vapor diffusion, recondensation).

Publications: **Baraka, S.M.**, Hosseini, S., Gronoff, G., Ben-Jaffel, L., Rankin, R., 2023a. The Sun-Earth-Moon connection: I-3D Global kinetic simulation. Journal of Geophysical Research (submitted)

Baraka, S.M., Hosseini, S., Gronoff, G., Ben-Jaffel, L., Rankin, R., 2023b. The Sun-Earth-Moon connection: II-Solar wind and lunar surface interaction. Journal of Geophysical Research (submitted)

Ma, C., Liu, Y., 2023. Nanomineralogy of Lunar Beads: Discovery of a Zinc-Sulfide (ZnS) Nanocrystals on a Yellow Bead Fragment, 54th Lunar and Planetary Science Conference, p. 1420.

Liu, Y., Ma, C., Eckley S.A. 2023. Copper sulfide in a vesicular basalt reveals aqueous liquid on the Moon. Nature Geoscience (in review). https://www.researchsquare.com/article/rs-2649595/v1

Kerber, L. 2023. An Update on the Moon Diver Mission: Field Tests and Instrument Requirements. 4th International Planetary Caves Conference 2023 (LPI Contrib. No. 2697) 1083.pdf

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