Moon and Mars Analogue Missions Activities
Abstracts of selected proposals.
(NNH07ZDA001N-MMAMA)

Below are the abstracts of proposals selected for funding for the Moon and Mars Analogue Missions Activities program. Principal Investigator (PI) name, institution, and proposal title are also included. 20 proposals were received in response to this opportunity, and 11 were selected for funding.

David Blake/NASA Ames Research Center
In Situ Mineralogical analysis with CheMin during the Scarab/RESOLVE field expedition

We have developed a field-portable miniaturized version of the CheMin XRD/XRF instrument that can be adapted for either human or robotic use. Funding is requested in this proposal for deployment of the instrument during the Scarab/RESOLVE field test in Nov., 2008. The objective of the deployment is to understand how near-real-time in situ mineralogical analyses will benefit robotic field campaigns such as Scarab/RESOLVE: To identify synergisms between CheMin and the other components of the robotic instrument suite, and to learn how to best use mineralogical and other data for hypothesis generation, science understanding and knowledge-based guidance of rover deployment and operations.

A knowledge of the mineralogy of the lunar regolith is important for developing an understanding of the geological history of the moon (and the early evolution of the rocky planets) and for evaluating the potential of lunar materials as in situ resources or health hazards during human exploration activities. Further development of instruments such as CheMin, already underway as flight-qualified hardware, will enable lunar science, lunar resource development and human exploration in and beyond the next decade.

Mary Chapman/U. S. Geological Survey
Reactivation of Apollo Astronaut Training Sites in Northern Arizona for Moon and Mars Analogue Missions

The central objective is to assist the NASA Johnson Space Center Desert RATS group during field trials at several sites in northern Arizona originally used to train the Apollo Astronauts (Cinder Lakes, Hopi Buttes, Meteor Crater), and new locales at Camp Navajo, Babbitt Ranch properties, and near Johnson City, AZ. There are 3 task objectives at these sites: (1) to revamp original 1960s-70s Apollo Astronaut Flagstaff-area training studies for the year 2008+, and to provide similar surface scenarios at the new locales, (2) to test the collection of high resolution field-support traverse images using a remote-controlled miniature helicopter with camera-mount at the 2008 task 1 training site; and (3) field test restructuring in-situ materials at Cinder Lakes site to create a “habitat” in order to begin testing the safe construction of a low-cost simulated lunar shelter and monitor the time required by EVA personnel to set up shelter and control the construction process. This proposal will benefit from an interfacing of personnel from the USGS, NASA, US Army...
Corps of Engineers (USACE), and independent contractors at Kepler Academy. The study meets the relevant NASA programs goals of enhancing human and robotic performance to maximize scientific return while integrating surface images, and developing requirements for in-situ analysis of surface materials and material resource utilization.

**Jack Farmer/Arizona State University**  
**Multispectral Hand Lens and Field Microscope**

The Multispectral Microscopic Imager (MMI) provides mineralogical and microtextural color observations essential for advancing capabilities for in situ evaluations of the origin, composition and diagenesis of rocks and soils on other planetary surfaces. With a TRL of 4-5, the MMI has been developed through prior funding by SMD's ASTID and ASTEP programs and JPL Director's Research and Development Fund (DRDF). We propose to complete field trials of the Multispectral Microscopic Imager (MMI) through participation in the ESMD's Desert Research and Technology Studies (Desert RATS) program in 2008. The instrument is proposed as a basic tool for traverse characterization and for documenting and mapping the distributions of a broad variety of geological materials. Such observations are basic to an evaluation of the geology, physical properties, health risks and in situ resource evaluations for human exploration of the Moon and Mars.

We propose the following specific activities for the Desert RATS field trials in 2008:

- Characterize the microtextures and mineralogy of rocks along traverses (both weathered surfaces and unweathered interiors), as required to determine their origin.
- Identify basic diagenetic (post-depositional) histories of rocks, including their interactions with liquid water.
- Detect the presence of selected volatile-bearing species, including water-bearing minerals, complex organics, and clathrates.
- Characterize the physical properties of soils/regolith along rover traverses, including grain size, shape and sorting and cementation to form soil crusts.
- Improve our understanding of how to optimize human and robotic interactions for maximizing scientific return.
- Define specific science requirements for early lunar missions involving human-robotic interactions and clarify the role of autonomous activities in implementing traverse science and/or carrying out in situ analysis (e.g. sample selection and acquisition, delivery to onboard laboratory, sample documentation, sample archiving).

**William Garry/Smithsonian Institution Center for Earth and Planetary Studies**  
**Computer-Assisted Surface Science Scenarios to Develop Operational Procedures for Manned Lunar and Martian Missions Using the Individual Mobile Agents System (iMAS)**

We will develop operation concepts for surface science scenarios relevant to the preparation of planned human missions to the Moon and Mars through geologic field studies of lava flows, fluvial valleys, and impact related deposits. Our main question:
"How can we use simulated Extra-Vehicular Activities (EVAs) on Earth to develop efficient EVA plans for the Moon and Mars?" We propose a 1 year project to collect science data related to our geologic research on lunar and Martian lava analog flows and establish training scenarios using technology to assist Astronauts on an EVA. We will simulate EVAs at three different field sites using the 'individual Mobile Agents System' (iMAS), an advanced, voice-activated, computer system that assists the user (i.e. Geologist-Astronaut) with EVA tasks, timeline, and data collection. Our three field sites are: (1) McCarty's lava flow, New Mexico, (2) NASA Haughton Mars Project (HMP) and (3) NASA Extreme Environment Mission Operations Project (NEEMO). Three overarching questions we will explore are: How can geology be documented efficiently and effectively using technology? What science-based field exercises can be developed to train Constellation Astronauts? How do simulated EVAs at three analog field sites compare to actual Lunar EVAs? The objectives of this proposal are to: (I) Conduct simulated EVAs at the McCarty's lava flow in New Mexico using iMAS to collect data related to our analog studies of lunar and Martian lava flows. (II) Develop concepts of operations and surface science scenarios for future missions and field test the integration of technology in EVA systems at HMP and NEEMO. (III) Compare the work efficiency and productivity of performing EVAs in different analog environments to the performance of Apollo Astronauts on lunar EVAs. Our investigation will provide empirical requirements analysis for Moon and Mars surface operations.

Brian Glass/NASA Ames Research Center
Drilling for Regolith-Analog Permafrost Stratigraphy (DRAPEs)

Future planned lunar in-situ resource utilization (ISRU), as well as lunar science, will require the ability to obtain samples and cores in lunar subsurface rocks. Looking for volatiles and accessing subsurface ices will require the ability to drill 1-3m without getting stuck. Searching for ices, or for rocks from which water and oxygen may be manufactured, can be accomplished with lightweight planetary drills capable of penetrating a few tens of meters in depth. These lightweight exploration drills have a direct counterpart in terrestrial prospecting and ore-body location, and will be designed to operate either as autonomous robotic missions or be human-tended. Whether into into Martian or lunar polar permafrost, an automated exploration drill must be able to penetrate ice and ice-consolidated soils, as well as hard rock and dust, to gain cores and explore the stratigraphy below.

In 2004-06 drill automation was developed under the Mars Instrument Development Program (MIDP) and was tested by the proposers at the Haughton-Mars Project (HMP) analogue site. In the summer of 2007 an ISRU and Human-Robotic Systems ETDP effort brought ground-penetrating radar and LIDAR instruments and surveyed the "Drill Hill" fallback breccia area with these mounted on NASA K-10 rovers.

This proposal will leverage the existing HMP ISRU survey results and the MIDP drill and automation software to study the "ground truth" of ice layers and volatiles in areas identified from the K-10 surveys. A nearby former hydrothermal area will also be drilled, both as a Mars-habitat-analogue and in support of current studies of Haughton Crater.
These will be the first-ever subsurface samples and cores from the a Haughton Crater archaeohydrothermal site. The drill used has been developed by the proposers under the DAME project (MIDP) as an automated drilling testbed. Drilling will be into frozen impact fallback breccia.

Brian Glass/NASA Ames Research Center
Expedition Traverse Science: HMP Gravity Stations

Human exploration of the Moon, and later Mars, has led to interest in studying the operational issues involved in long-range science traverses. ESMD plans to conduct several 50-80km traverses at Haughton Crater in the summer of 2008, based around the use of a modified Humvee as a simulated pressurized-rover vehicle. As in Apollo, geophysical measurements, including gravity stations, would be expected to be part of the science performed on future lunar exploration traverses by humans.

This task proposes to take approximately 25-40 new gravity stations as part of one or more of the planned ESMD long-range traverses. This has two benefits: (a) it adds to ongoing studies of the structure of Haughton Crater, a large impact structure; (b) it adds realistic science tasks and operations to the long-range simulated human traverses, thereby improving their fidelity.

David Kring/Universities Space Research Association
Chariot-GPR Integration and Field Tests Involving Signal Ops to a Simulated Mission Control and Science Backroom

We propose to integrate the LPI Ground Penetrating Radar system with the front or rear instrument pod on Chariot. This system is a new-generation, multi-frequency, and field-tested GPR system that is superior to older GPR systems. Integration and on-site tests at the outdoor test facility at JSC (adjacent to our institution) will be accomplished in time for a June 2008 field test and for the more complex October 2008 field test. Data will be streamed to a field science crew and to a distant science backroom to test the interfaces between the mobility system, science instrumentation, and operational staff. In addition, we will integrate a multi-frequency (albeit single channel) GPR system with the robotic K-10 Black Rover and run the instrument during the June 2008 field test.

Jake Maule/BAE Systems Technology Solutions & Services Inc.
Monitoring Forward Contamination of the ISS in Preparation for Human Exploration of the Moon and Mars

The International Space Station (ISS) is itself a high fidelity and mission-critical space-based analogue for exploration missions. NASA Administrator Michael Griffin has called for higher priority to be given to ISS research that addresses exploration objectives (Griffin, 2005). The proposed ISS investigation shall address the issue of forward contamination associated with human spaceflight; an issue that has been identified as a
key challenge for the human exploration of the Moon and Mars (Horneck et al., 2003; 2001).

The investigation consists of two phases: Phase 1 and Phase 2. Phase 1 shall be performed at the Space Station Processing Facility (SSPF) at NASA Kennedy Space Center (KSC); Phase 2 shall be performed on the ISS with support from Dr Maule and collaborator Dan Gunter at the Payload Operations and Integration Center (POIC) at NASA Marshall Space Flight Center (MSFC) as part of an existing funded ISS flight project (called LOCAD-PTS) for which Dr Maule is Project Scientist. This proposal requests funds for Phase 1 only.

There are three main objectives of this proposed investigation:

1. Monitor three types of common microbial molecule (endotoxin, beta-glucan and lipoteichoic acid) within the SSPF at NASA KSC; to determine the typical type and level of microbial environment to expect for pre-flight processing of exploration missions.

2. Monitor these same molecules on external handrails of ISS elements before launch in the SSPF; to determine the typical type and level of forward contamination to expect for exploration missions.

3. Monitor the same external handrails in space onboard the ISS, by swabbing the palm of a spacesuit glove before and after extra-vehicular activity (EVA); to test an in-space method to determine the “forward contamination” of external surfaces and to evaluate forward contamination introduced in the time interval between the SSPF processing and ISS docking.

---

**Heather Morris/NASA Marshall Space Flight Center**

**Testing a Portable Microarray Device in an Arctic Mars Analogue Environment**

As future exploration missions to the Moon and Mars approach, science goals based on expert recommendations describe the detailed analysis of a variety of samples. The Martian surface holds significant appeal for the field of astrobiology, particularly exploring for signs of life, as well as beginning to determine how best to recognize any biosignatures that may be present. Not only is the development of specific technologies to address these goals imperative, but also the development of exact protocols for sample collection and analysis to prevent possible forward contamination. Lunar and Mars analogue sites provide an ideal setting for testing instruments and sample collection/analysis protocols in a field environment. Therefore, we propose testing a portable micro array device as part of the Arctic Mars Analogue Svalbard Expedition (AMASE) in the fall of 2008. Our study objectives will be to design sample collection protocols that minimize potential forward contamination, but maximize sample analysis. We will test these protocols for both forward contamination prevention and life detection in a relevant field environment using a multi-purpose, handheld micro array device. The proposed work is relevant to multiple Agency goals, more specifically SMD’s planetary protection program, and ESMD’s goals of defining science requirements for early lunar
missions with humans, and developing surface science scenarios for architecture planning.

Horton Newsom/University of New Mexico
Slow motion field test of Laser-Induced Breakdown Spectroscopy (LIBS) and other instruments for geological mapping of rocks and surficial materials at the Haughton impact structure, Devon Island, Canada

The Haughton impact structure provides a unique setting for demonstrating remote analysis of complex outcrops produced by impact processes. Laser-Induced Breakdown Spectroscopy (LIBS) is a new technology for both geological and geochemical exploration of the Moon and Mars. An exciting development for LIBS is the ability to distinguish mineralogy along with chemistry (Lanza et al., 2008, LPSC #2299). We propose to simulate a remote investigation of one or more outcrops at Haughton. The successful Slow Motion Field Test (SMFT) accomplished by the Mars Science Laboratory instrument teams, especially the ChemCam LIBS instrument and CheMin XRD, provides a framework for this follow-on project (Wiens et al., 2008, LPSC, #1500). For this proposal, Drs. Newsom, Osinski and Lee (the field science team) will select target outcrops and send previously collected samples to the remote team (consisting of Drs. Newsom, Wiens, Clegg, Vaniman, and King and their students). At Haughton, the field science team will acquire the required images of the outcrop and any new samples needed for later analysis. The remote team will select sites to investigate and iteration of the process to simulate up to approximately 10 days of rover operation will allow a good test of the remote team’s ability to understand the chemistry and geology of an outcrop that has been extensively studied by traditional methods, and will allow feedback from the field team on how the remote investigation could have been improved. This program will also allow new procedures and instrumentation to be tested, such as depth profiling with LIBS. Following the simulated field test, the opportunity to study the previously collected generic samples and additional samples collected in the field during the test, will provide an important component of the project based on the experience from the MSL SMFT.

James Rice/Mars Space Flight Facility / Arizona State University
Human-Robotic Geologic Traverse Planning Strategies for the Moon and Mars

I propose to use human and robotic subjects, working together and independently in the field, to plan and conduct geological traverses in order to develop various mission scenarios and strategies that will optimize performance and maximize scientific return for future Moon/Mars missions. Activities performed during these scientific traverses will include detailed geologic observations of landforms, outcrops, stratigraphy, surface materials (rocks and soil/regolith), photo documentation, and collection of representative samples. All of this information can then be used to construct geologic maps which will then feed forward into determining the geologic history and evolution of the region. Detailed operational timelines will also be kept to assist in planning future NASA Moon/Mars surface science scenarios and to aid in the definition for surface systems and operations requirements. This will be achieved by keeping timelines for amount of time
spent driving to stations, time spent at stations, time spent 'geologizing' (observation and photo documentation, sample identification and collection). This proposed work will aid in the development of a more efficient astronaut-robotic field exploration capability for the Moon and Mars. This proposal is relevant to NASA's Vision for Space Exploration. Specifically, the return of U.S. astronauts to the Moon by 2020 followed by manned missions to the surface of Mars.