Moon and Mars Analog Mission Activities

Rover-based Scientific Investigations During the 2012 Analog Field Test on Mauna Kea Volcano, Hawaii

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INTRODUCTION

The 2012 Moon and Mars Analog Mission Activities (MMAMA) were recently completed on Mauna Kea Volcano, Hawaii. Rover-based scientific investigations, scientific input, and science operations constraints were tested in the context of existing project and protocols for the field activities designed to help NASA achieve the Vision for Space Exploration.

Science Investigation: Several different investigations were done to determine key geophysical, geochemical properties and the geological context of the basaltic material and the samples gathered. The instruments used included a combined miniaturized-Mossbauer/XRF spectrometer (MIMOS IIA), a ground penetrating radar, a 360 degree panoramic video camera, a magnetic susceptibility sensor, a GPS location sensor and a 3-axis accelerometer.

Science Input: Initial traverse planning was completed based on the desired science and the expected outcomes. However, real-time constraints of rover mobility capability, probability of science instrumentation damage and available time resulted in significant changes to the initial plan.

Science Operations: Initial science operations were planned based on a model similar to the operations control of the Mars Exploration Rovers (MER). However, evolution of the operations process occurred as the analog mission progressed.

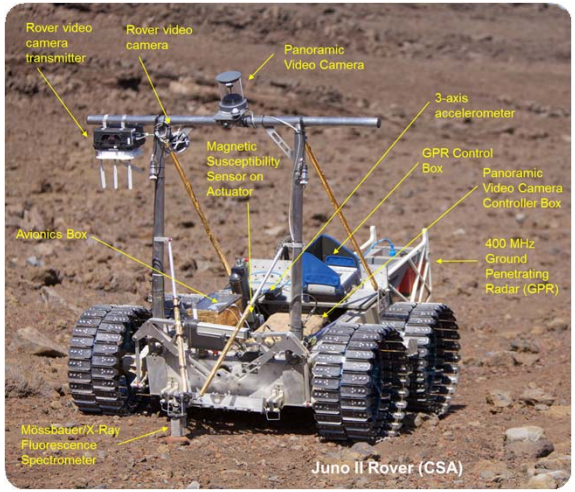
LOCATION

The 2012 Moon and Mars Analog Mission Activities (MMAMA) were conducted on the SE flank of the Mauna Kea Volcano (Hawaii) at an elevation of ~11,500 feet. This area is known as "Apollo Valley". The rover traversed and explored a region largely comprised of outwash material and the surrounding terrain.

Location of 2012 MMAMA analog test on the slopes of Mauna Kea (Hawaii).

Perspective view of the rover traverse map looking up slope. Colored icons represent locations of data collection from the various MMAMA instruments.

INSTRUMENTATION



Mossbauer/X-Ray Fluorescence Spectrometer: The MIMOS IIA (MIniaturized MOSsbauer Spectrometer) instrument is a combined backscatter Mössbauer and XRF instrument, specifically designed and developed for space exploration. The innovative backscatter design allows for the instrument to be placed in contact with a rock or soil sample, providing in-situ analysis with no sample preparation. The MIMOS II instruments on board MER have collected valuable scientific data of the martian surface for more than seven years. The advanced MIMOS IIA prototype uses new detector technologies and electronic components to significantly increase the sensitivity and performance of the instrument. [see Klingelhöfer G.]

Ground Penetrating Radar: The GPR system used during this field test was a commercially available Geophysical Survey Systems, Inc. monostatic radar unit. A 400 MHz and 200 MHz antenna were both deployed in Apollo Valley during this test, however only the 400 MHz was attached to the rover. The 400 MHz antenna has a mass of 5 kg and measures 30cm x 30cm x 17cm with a signal penetration up to a max of 4 meters in depth (the radiated peak power of the antenna is 1.7 watts). The 200 MHz has a mass of 20.5 kg and measures 60cm x 60cm x 30cm with a signal penetration up to 9 meters in depth (the radiated peak power of 3 watts).

Panoramic Video Camera: The Lucy-S is a professional-level panoramic capture system for collecting seamless 360° video. The camera head was mounted on the JUNO cross bar and is approximately 13 cm in diameter, 20 cm tall, and has an approximate mass of 2.5 kg.

Magnetic Susceptibility Meter: The magnetic susceptibility meter system operates by generating a low frequency, low intensity AC magnetic field around the contact sensor head. Sample material placed near the sensor causes a change in this field. This change is sensed by the system and converted to magnetic susceptibility readings. The reading and sensor operation are non-destructive so the sample retains it's original magnetic characteristics. The system used for the 2012 test consisted of a Bartington MS3 magnetic susceptibility meter with a MS2K magnetic contact head that was attached to a linear actuator enabling it to remotely make contact with the ground.

RESULTS AND DISCUSSION

Analog Science

- CSA Juno II rover performed well traversing ~5 km over extremely rough terrain; flexible design and capabilities were integral to rapid integration and instrument deployment.
- Analysis and subsequent re-planning was executed well. A robust "plan-operate-evaluate-replan" operation was carried out. Pre-mission traverse plans using the kind of images available prior to "landing" was developed. Although there were many legs of the planned traverse that were not executable (given the trafficability of the surface), the planned traverse provided a framework to vary from, and maximized our efficiency in the field when rapid re-planning was required.
- Initial evaluation of the geologic context and history of landing site were continually refined during the analog test; hypotheses will continue to be evaluated post-test.
- The data load a strategic team has to analyze is enormous (exceeded data acquisition plan by 2-3x), this puts significant demands on the team members to understand what happened at a level sufficient to make informed tactical decisions.
- The MMAMA Science activity allowed for a small team to perform significant science over the 3 main days of testing. Tremendous 'Bang for Buck' for the test activity. All personnel meshed and worked well even though each instrument started out as a separate proposal.

Mössbauer/X-Ray Fluorescence

- Performed numerous MIMOS IIA integrations in the field. Integration times varied from 30 to 90 mins.
- Collected primary scientific data on the variety of rocks exposed in Apollo Valley and reduced data to report on the tactical timeline.
- Comparable data was collected from the MIMOS II for direct comparison with the data collected from the advanced MIMOS IIA.
- Unique rover design allowed for rapid deployment of instrument without the use of a complicated robotic arm.

Ground Penetrating Radar (GPR)

- Conducted first known GPR science investigation of Apollo Valley, collecting approximately 4 km of data lines.
- GPR data showed the valley has a complex geologic history.
- Data was collected with the 400 and 200 MHz antenna for direct comparison and evaluation of the resolution required for detailed interpretation of subsurface structure.
- Numerous lessons learned from deployment of a GPR system from a robotic platform such as the CSA rover.

Panoramic Video Camera:

- Acquired numerous video pans for site characterization and planning.
- Integration of video into the strategic process for rover operations was unique to this test and requires further evaluation.

Magnetic Susceptibility Meter:

- Acquired numerous reading from the various valley materials.
- Reduced data to report on the tactical timeline, strategies for use of magnetic susceptibility information require further evaluation.

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