GEOLAB 2011: NEW INSTRUMENTS AND OPERATIONS TESTED AT DESERT RATS.

C.A. Evans[1], M. J. Calaway[2], M.S. Bell[2] , [1]Astromaterials Acquisition and Curation Office, Mail Code KT, NASA Johnson Space Center, 2101 NASA Pkway, Houston TX 77058, cindy.evans-1@nasa.gov, [2]Jacobs Technology (ESCG), NASA Johnson Space Center, Houston TX

Introduction: GeoLab is a geological laboratory and testbed designed for supporting geoscience activities during NASA's analog demonstrations. Scientists at NASA's Johnson Space Center built GeoLab as part of a technology project to aid the development of science operational concepts for future planetary surface missions [1, 2, 3]. It is integrated into NASA's Habitat Demonstration Unit, a first generation exploration habitat test article. As a prototype workstation, GeoLab provides a high fidelity working space for analog mission crewmembers to perform in-situ characterization of geologic samples and communicate their findings with supporting scientists. GeoLab analog operations can provide valuable data for assessing the operational and scientific considerations of surface-based geologic analyses such as preliminary examination of samples collected by astronaut crews [4, 5]. Our analog tests also feed into sample handling and advanced curation operational concepts and procedures that will, ultimately, help ensure that the most critical samples are collected during future exploration on a planetary surface, and aid decisions about sample prioritization, sample handling and return. Data from GeoLab operations also supports science planning during a mission by providing additional detailed geologic information to supporting scientists, helping them make informed decisions about strategies for subsequent sample collection opportunities.

Figure 1. GeoLab inside the DSH. Microscope and computer displays are above the glovebox, XRF is on the left. The MMI is inside the glovebox (see Fig. 2).

In 2010, the HDU was configured as a Pressurized Excursion Module that would accompany rovers (Space Exploration Vehicles or SEVs) during traverses on a planetary surface. In 2011, the basic HDU configuration was augmented to include living space; the HDU became a Deep-Space Habitat (DSH). The basic GeoLab glovebox configuration remained the same, (See Figure 1) but we included new instrumentation and updated crew interfaces and data displays.

Desert RATS Test Plan: The 9-day Desert RATS (Research and Technology Studies) analog mission conducted in August-September 2011 simulated certain operations that might be used for exploring a small body like an asteroid. The series of single-day tests involved different combinations of rovers, crew members, and mechanisms for crew mobility, as well as a communications time delay equal to 50 seconds of one-way travel time. Mission operations were staged at two locations near Black Point Lava Flow north of Flagstaff, Arizona [6]. Each of these areas presented a relatively small geologic field area that could be reasonably explored within an 8-hour day. The DSH subsytems, including GeoLab, were tested in parallel to the rover operations. Two separate crews (A and B) alternated between testing SEV and spacewalk scenarios, and testing DSH systems including GeoLab. Two science teams (A and B), located in Houston, followed the science operations of the respective crew - either the rover activities, including spacewalks and sampling, or the sample examination in the GeoLab.

GeoLab Test Operations: Each day, a subset of samples collected during the rover "spacewalks" were examined in the GeoLab by crew members and supported by their science team. The samples were selected at the conclusion of the previous day's rover operations, after the associated science team considered the day's geologic activities and samples collected, and created a prioritized list of samples for more detailed examination in the GeoLab. When the science team (and the crew) rotated from rover operations to DSH/GeoLab operations on a subsequent day, they examined the set of samples they had previously selected from the rover traverses. In this way, both the crew members and the science team had first-hand knowledge of the samples that were examined in the GeoLab.

GeoLab's 2011 Innovations. Building from basic operations that we tested in 2010 [1,2,3] that included comprehensive imaging of samples, microscopic examination, and geochemical fingerprinting using a handheld XRF spectrometer, we expanded GeoLab's capabilities to include collaborative operations with a new instrument (multispectral microscopic imager or MMI, [7]), built new integrated software for crew and backroom displays, including the initial integration of RFID (radio frequency identification) sample tracking; and tested new mechanisms of communications with the science and mission operations teams (combined voice and texting). Over the 9 days of GeoLab tests, we also evaluated operating GeoLab with only 1 crewmember as well as with a team of 2 crew members. Finally, we coordinated sample analysis of certain samples with the VAPoR (evolved gas analyzer) instrument team [8].

GeoLab 2011 Accomplishments and Results:

- Nine continuous days of GeoLab operations during the 2011 Desert RATS for the rapid end-to-end preliminary sample assessment of 36 samples (from collection to science team review to GeoLab analysis) from two distinct locations; full results are still in work with participating scientists.
- Multispectral imaging of samples at microscopic scales for GeoLab samples (Fig.2) enabled mineral identification that could be combined with fine-scale textural data from natural light microscopic images [7].

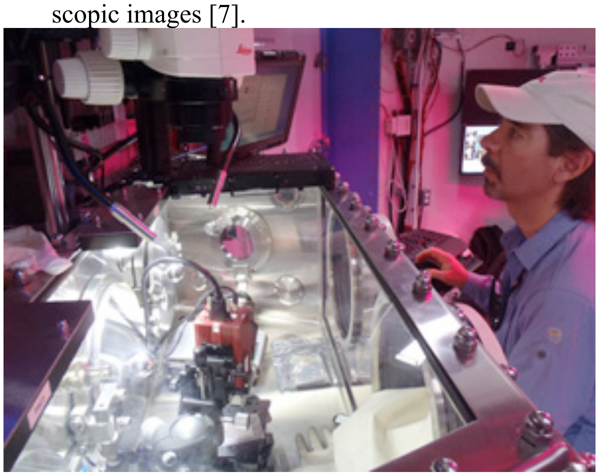

Figure 2. MMI instrument operations in GeoLab

- Successful testing of custom and interactive crew display software that allowed for both instrument control and sample-based data collection. Although the test revealed software bugs and areas for improvements, the new software consolidated data for each sample for later review by crew or science team.
- Successful testing of new web-based and mobile-device displays of sample data and crew inputs about samples. These displays were viewable by science team and represent a successful advance at recording and integrating both operational data (e.g. glovebox environmental parameters) and preliminary examination data on samples.
- Successful operations demonstrating both the efficiencies and drawbacks of 1-person and 2-person operations. This included working with crew members who had only minimal training in the lab and instrument operations.

The 2011 GeoLab configuration at Desert RATS fit the test constraints and habitat configurations, but was not realistic for operations associated with asteroid exploration. Designing appropriate configurations for different exploration destinations will require continued dialog and planning between the science community, and the engineering and mission operation teams.

Future Applications of GeoLab's Analog Tests: NASA is developing a suite of Design Reference Missions that target a variety of exploration destinations, including near-Earth asteroids, the Moon, and ultimately Mars. There is much forward work; curation techniques are complicated, and dependent on exploration destination, mission design, sampling strategies and types of samples. We plan tests of future hardware designs and operational concepts that focus on more sophisticated mechanisms for sample handling in a micro-gravity environment, including robotic sample handling within an isolation chamber like the GeoLab glovebox. Progressive tests using GeoLab in different configurations and combinations of human and robotic elements will help us develop the appropriate requirements, instruments and protocols for preliminary examination of geological samples and sample curation procedures for both deep space habitat and planetary surface missions.

Finally, an important objective for GeoLab is to educate and build a constituency of engineers and mission operations staff that understand the critical operational details related to geological sample collection, handling, preliminary examination, documentation, and containment. Our 2011 test allowed us to collaborate with engineering and mission operation teams and our mission success was tied to their understanding and support of our science requirements.

References:

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