GEOLAB – A HABITAT-BASED GEOSCIENCE LABORATORY FOR HUMAN EXPLORATION MISSIONS. 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 (Figure 1) is a geological laboratory and test bed designed for conducting geoscience activities during NASA's analog missions. Scientists at NASA's Johnson Space Center built GeoLab as part of a technology project to aid the development of science operational concepts and to test a variety of analytical tools that could be developed for future planetary surface missions [1, 2, 3]. It is integrated into NASA's Deep Space Habitat (DSH), an exploration habitat test article (Figure 2). As a prototype workstation, GeoLab provides a high fidelity facility for analog mission crewmembers to perform preliminary examination and characterization of geologic samples and communicate their findings to supporting scientists.

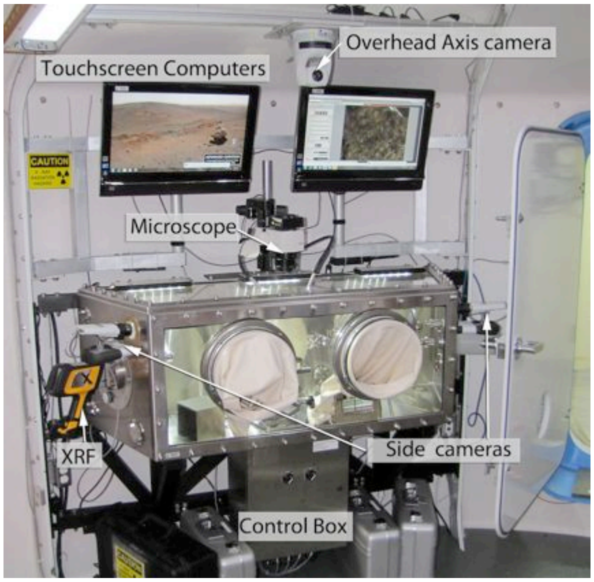

Figure 1. GeoLab inside the DSH. Microscope and computer displays are above the glovebox, XRF is on the left, cameras provide overhead and side viewing.

Hardware Description: GeoLab's configuration provides a safe, contained working space for crewmembers to perform preliminary characterization of geologic samples (Figure 3). The GeoLab concept builds from the hardware and clean room protocols used in JSC's Astromaterials Sample Curation laboratories. The main hardware component is a custom-built glovebox, constructed from stainless steel and polycarbonate, and built to support a positive pressure nitrogen environment. The glovebox is mounted onto the habitat's structural ribs; the unique shape (trapezoidal prism) fits within a pie-shaped section of the cylindrical habitat. A key innovation of GeoLab is the mechanism for transferring samples into the glovebox: three antechambers (airlocks) that pass through the shell of the habitat. These antechambers allow geologic samples to enter and exit the main glovebox chamber directly from (and to) the outside, minimizing potential contamination from inside the habitat. The glovebox also incorporates an environmental monitoring system. The main chamber of the glovebox is equipped with sensors that monitor O_2 (ppm), pressure (mbar), humidity, and temperature, and each antechamber contains pressure sensors. Four video surveillance cameras provide real-time displays of operations inside the GeoLab workstation and the area around the antechamber doors on the outside the habitat.

Figure 2. The Deep Space Habitat. The GeoLab antechambers are the 3 circular ports just left of center and the "Segment G" letters.

Configurability: GeoLab hardware and operational concepts are also derived, in part, from experiment facilities aboard the International Space Station (ISS). ISS payload racks emphasize experiment flexibility and autonomous operations by a trained crew, and support "plug and play" instrument integration for different payloads or data collection campaigns. The GeoLab design includes a suite of ports in the glovebox for rapid reconfiguration with new instruments. The initial instrumentation included a Leica stereoscopic microscope and an Innov-X handheld Delta DP6000 X-ray Fluorescence (XRF) spectrometer. This basic configuration allows for comprehensive imaging of samples, microscopic examination, and geochemical fingerprinting of specified sample surfaces. In 2011, we demonstrated the glovebox's configurability through collaboration with scientists from Arizona State University and JPL. We integrated the Multispectral Microscopic Imager inside the GeoLab to acquire multispectral data [4], in addition to the visible light microscopy and XRF spot analyses.

All instrumentation and cameras are controlled at the workstation with two touchscreen computers (HP Touchsmart 600xt, see Fig. 1) that are integrated into the DSH avionics system. Data from the cameras, sensors, microscope and XRF can be viewed remotely using a web interface, enabling collaboration between the astronaut crew and a supporting science backroom.

Figure 3. Crew performing preliminary examination of samples collected during geological traverses.

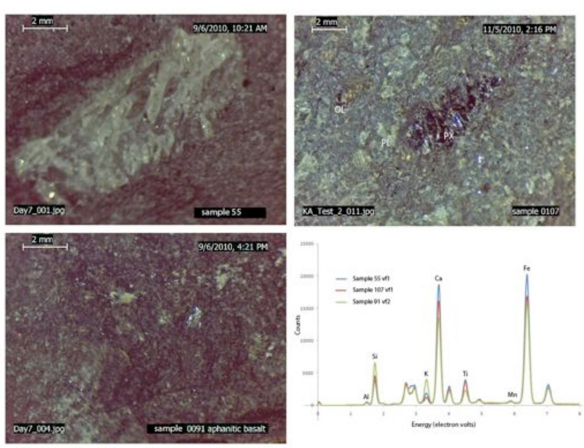

Figure 4. Example GeoLab data: microscopic imagery and XRF spectra collected from 3 distinct basalt flows.

2012 tests include new instrument controls and data displays, voice commanding sequences, and a robotic sample manipulator inside the glovebox (Figure 5). The robotic arm will be used for grabbing and holding samples in a micro-gravity environment, and for translating and positioning the sample for data collection from the different GeoLab instruments (camera, microscope, XRF). Development of this technology will increase crew efficiency, broaden the options for GeoLab location (for example, on the outside of a habitat bulkhead), and potentially enable remote operations of the preliminary examination of samples.

Figure 5. GeoLab sample manipulator (CAD model).

Results from GeoLab Operations: We have tested the GeoLab operations with astronaut crews during two analog field deployments (Desert RATS) in 2010 and 2011. Our initial results suggest that 1) the GeoLab glovebox is a high fidelity field laboratory. A trained crew can operate autonomously, and easily provide a variety of data for consideration by the science team. These data can aid decisions regarding additional data collection, sample handling and prioritization. 2) The detailed data collected in the GeoLab adds to the body of evidence used for understanding the regional geology that is being explored, and can be used for future traverse planning.

There are many additional configurations and instrument operations that can be integrated into the glovebox. Progressive tests using GeoLab in different 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 by humans. Our team aims to apply this work to enable efficient field campaigns and support initial curation efforts that control contamination and preserve pristine samples collected during exploration missions. Assessment of the laboratory operations will drive the definition of requirements and support the advancement of new technologies for handling and examining extraterrestrial samples, and transporting them back to Earth.

References: [1] Evans, C.A.; Calaway, M.J.; Bell, M.S.; Young, K. (2012) *Acta Astronautica,* doi: 10.1016/j.actaastro.2011.12.008***;*** [2] C. A. Evans, M. J. Calaway, M. S. Bell, (2012), *LPS XLIII*, Abstract #1186***;*** [3] Calaway, M.J., Evans, C.A.; Bell, M.S. and Graff, T. (2011) *LPS XLII*, Abstract #1473; [4] J. I. Nuñez, J. D. Farmer, R. G. Sellar, and P. B. Gardner (2009), LPSC XL, Abstract #1830.