GeoLab – A Habitat-based Geoscience Laboratory for Human Exploration Missions

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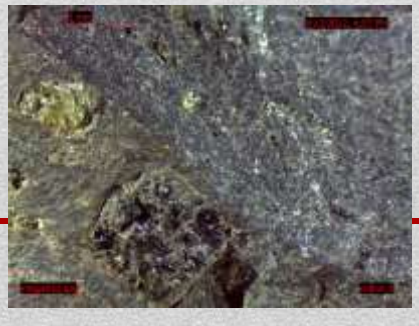
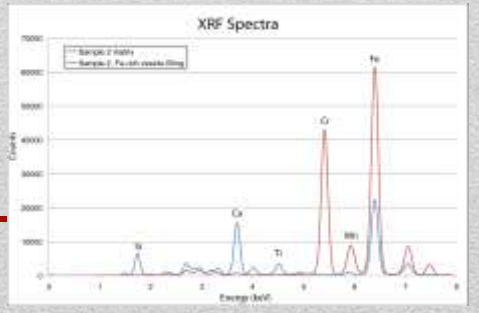
GeoLab Description

- **GeoLab is a glovebox** that is fully integrated (structure, power, network, avionics, software) into NASA's Deep Space Habitat Analog Testbed.
  - A prototype geoscience facility inside a pressurized laboratory, allowing for contained sample examination during an exploration mission.
- **GeoLab is a configurable test article** that provides a high-fidelity workspace for crew members and PIs to test instruments and collect sample characterization data in a simulated mission environment.





GeoLab as Testbed: Conceptual Roots

GeoLab concept grew from

- Ongoing spaceflight research and approaches used on International Space Station
  - Microgravity Science Glovebox
- Terrestrial Analog studies and missions
  - Desert RATS and NEEMO
- Current Astromaterials Curation Laboratory hardware and clean room procedures
- Lunar (former Constellation Program) mission scenarios

GeoLab Hardware Overview

- Custom Stainless Steel and Lexan Glovebox
  - Provides a clean environment for sample handling
  - Built for positive pressure N_2 atmosphere; equipped with O_2, humidity, T and P sensors
- Three antechambers (airlocks) through bulkhead
  - Direct sample transfer into glovebox
- Configurable instrument ports for instruments
  - Supports "plug & play" instrument integration
  - Rapid-transfer port for internal transfer of tools
- Initial Instrumentation
  - Innov-X Delta Hand-held XRF
  - Leica M80 Stereomicroscope with IC HD camera
  - Three internal network cameras around glovebox, including controllable P-T-Z camera
- Two HP Touchsmart 600xt All-in-one computers for instrument control and data display
- RFID reader for sample tracking
- Robotic sample manipulator (U. of Bridgeport engineering project) for precise sample handling

Why we need a GeoLab testbed

Our goal is to enhance the critical interface between mission operations and scientific inquiry. GeoLab fosters the development of both instrument technology and operational concepts for sample handling and examination during exploration missions.

Our tests build from the following needs:

- We need to define mission requirements based on realistic concepts for geological operations on other planetary surfaces (analytical instrumentation, sampling, sample handling and prioritization strategies).
- Samples may require special handling and curation
- We need to address operational and technical questions
  - What activities are best done by humans? By robots?
  - What activities are best done during EVA ? Inside a lab?
  - What type of in-situ sample characterization enhances science returns?

GeoLab Objectives

- Test facilities with crew members and samples on simulated long-duration missions
- Assess what instruments and tools provide efficient and meaningful data in advance of sample return
- Evaluate the scientific contribution of selective in-situ sample characterization
  - Can we boost mission science and and facilitate real-time planning?
  - Can we identify best curation scenarios for returned samples?
  - Can we provide data for informed decisions about prioritization of samples for return?
- Frame science operations that leverage human presence with robotic tools

GeoLab Operational Concept

Science Support

Science Team monitors field operations and sample collection

Science Team distills data and selects samples for GeoLab examination

Earth

Communications

Communications

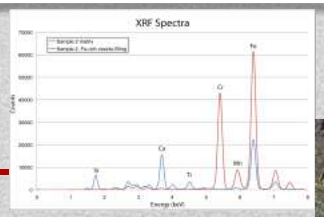
GeoLab data guides return sample priority, future exploration planning

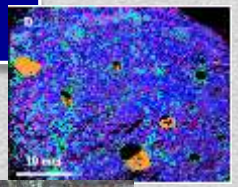
EVA Crew explores small field area of geological interest

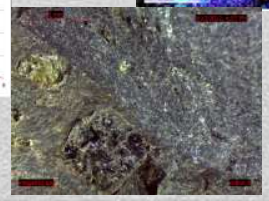
Crew examines samples in GeoLab

Planet surface

Collection



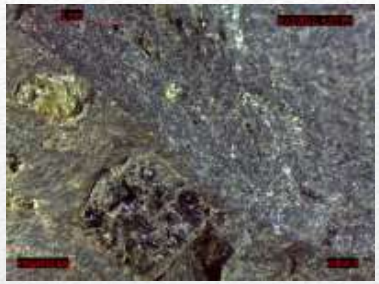
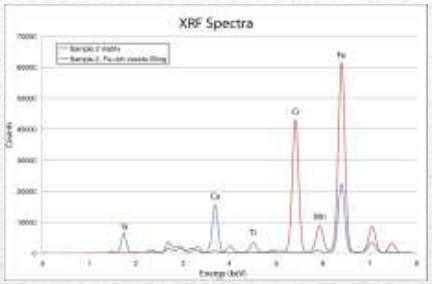




Results: Three years of GeoLab Development and Tests

2010: Test basic operations with crew and science team. Test efficacy of basic sample characterization (descriptions, microscopic imagery, XRF analyses) and feedback to science team

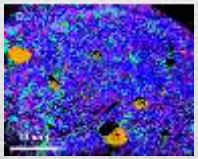
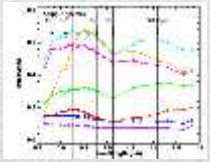


2011: Test enhanced crew software and interfaces for crew and science team; demonstrate lab configurability with new diagnostic instruments (JPL/ASU Multispectral Microscopic Imager)





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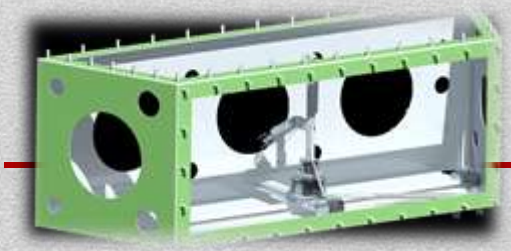

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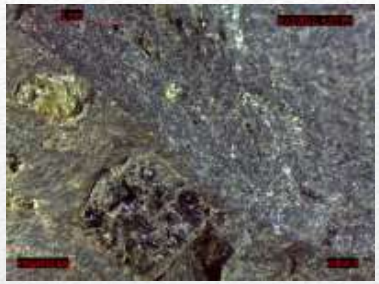

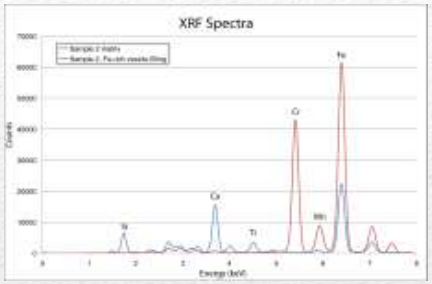

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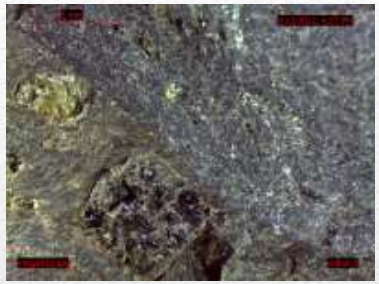
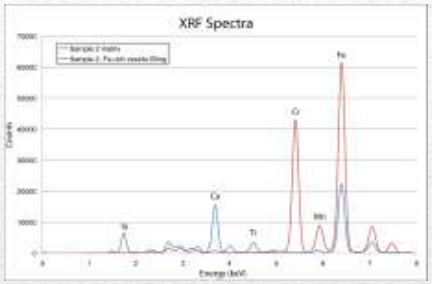

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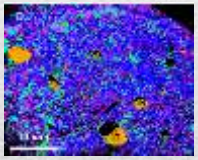
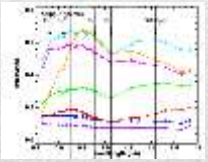

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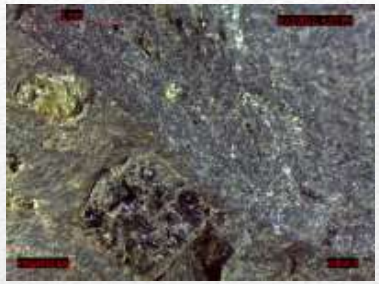
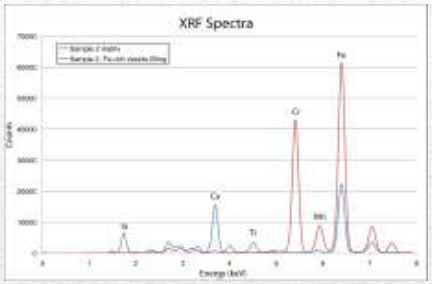

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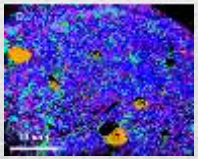
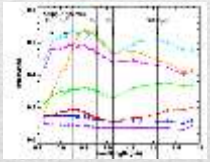

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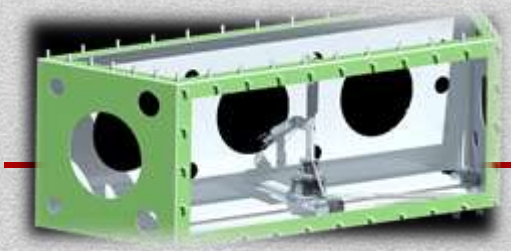

What have we learned?

- **Crew can operate relatively autonomously**– science can leverage smart, well-trained crew. This is not news:
  - We have >12 years of crew-tended science on ISS, including a wide range of PI involvement.
  - Crew observations and initiative have been a solid part of ISS experiment successes, including discoveries
  - Crew lends value by providing real time (especially important with time delay) and spontaneous observations
- **Good imagery is key** for context, and forms the basis for additional characterization.
- **Preliminary sample characterization provides data that supports smart decisions** for sample handling and prioritization, enables a better understanding the regional geology being explored, and is useful for future exploration plans.

What have we learned?

Robotic tools inside GeoLab facilitate automated and repeatable data collection.

- **Robotic assists are critical** in microgravity. Robotics aid crew and enable precision sample handling for operations and data collection.
- **A combination of imaging tools and robotic tools provides significant flexibility** for designing facilities and operations related to sample characterization and sample handling.
  - Progressive tests using robotic interfaces will help develop requirements, instruments and procedures for different exploration scenarios.

GeoLab – Future Goals

- **Engage engineers and mission operations staff** to build advocacy for science operations surrounding geological traverses and sampling.
- **Build and test additional robotic tools for geologic sample handling** within an isolation chamber, commanded by crew (e.g., automated antechamber doors, new sample containers, more automated robotic sample manipulators and instrumentation).
- **Determine best suite of instruments and data** that sufficiently characterizes geological samples that may—or may not—be returned to Earth.
- **Mature hardware for preliminary examination and curation** of geologic samples for both deep space habitat and planetary surface configurations that feed-forward to future human spaceflight missions.

Robonaut demonstration: Sample transfer into GeoLab antechamber