BRAILLE FIELD CAMPAIGN I: ASTROBIOLOGY INSTRUMENT TESTING AND SCIENCE SAMPLING AT LAVA BEDS NATIONAL MONUMENT (N. CA, USA), A PLANETARY CAVES ANALOG SITE.

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Introduction: Planetary caves provide protection from cosmic radiation, small-scale impact events, and have relatively stable thermal environments. These characteristics may enhance preservation of biosignatures over long periods of time and make them an attractive astrobiology target in the search for signs of life beyond Earth [1-3]. The BRAILLE team is conducting mission operations scenarios that involve autonomous deployment of a rover, loaded with a scientific payload, to map and identify potential biosignatures in terrestrial lava caves.

BRAILLE (Biologic and Resource Analog Investigations in Low Light Environments) is a 3-year project sponsored by the NASA Planetary Science and Technology through Astrobiology Research (PSTAR) program. We are coordinating a conceptual and technical demonstration of near-surface (subsurface) mission science operations using the NASA Ames CaveR rover to deploy a suite of scientific instruments (cameras and spectrometers) in low- or no-light settings to conduct astrobiology science and mapping in lava caves. In tandem, we are integrating astrobiology field research at the same locales to characterize the microbial life and associated chemical and morphological signatures of lava tube cave microbial ecosystems and the resources (water, nutrients, energy sources) that limit and/or sustain life.

The Field Site

Lava Beds National Monument. Lava Beds, situated on the northern flank of Medicine Lake Volcano in Northern California, has the highest concentration of lava caves in the Continental U.S., with >780 identified and >50 km of total length [4]. The caves within the Monument are relatively shallow, extending ~20-45 m below the surface and typically well above the water table. The majority of the caves are in the Mammoth Basalt unit, 30-35 Ka (Donnelly-Nolan, 2006); additional caves are found in younger basalts, circa 11-12 Ka [5].

Caves selected for initial study. We selected 3 caves for our initial phase of work: Valentine (VAL), Hopkins-Chocolate (HOP), and L300. These caves vary in length from 400-1700m and depth below surface of 20-65m. Entrance into HOP and L300 is via steep ladder or rope, while there are broad steps down into VAL. The first two of these caves is open to the public year-round. L300 has restricted human visitation and is similar in age and flow history to HOP. Our criteria for selecting caves for rover operations were basic; we are limited by the rover's ability to move and maneuver inside a cave and our ability, as a team, to port the rover from the surface to the interior. Driving the rover in directly into any cave at Lava Beds prohibited by rough and steep terrain. We concluded that VAL would be the cave best suited for CaveR activities and then selected the other 2 caves for additional study and sample collection, to investigate the influence of differences in human visitation and lava flow age.

Field Campaign I: We obtained the necessary permits from the National Parks Service to conduct field work at Lava Beds and completed our first field excursion in November 2017. We accomplished these primary goals during our initial team trip to the field site: (1) assessment of ingress for the rover into Valentine Cave, our primary target for rover deployment, (2) collection of mapping and spectral data for integration with mission operation software (xGDS, created at NASA Ames) to be used in mission operation activities, (3) conducting tests and collecting spectral data related to the NIRVSS instrument suite [6] in preparation for its deployment on the rover in subsequent years, and (4) collection of a suite of water, biological, and mineralogical samples for post-field, laboratory analysis.

Lidar mapping, localization, and cave access assessment. Major portions of the 3 caves were mapped using a FARO 3D laser scanner. The entrance of VAL was mapped using FARO in preparation for future rover ingress. Kinnect laser scanner data and paired DLSR camera images were collected while mounted on a mobile cart to test mapping efficacy; these instruments will be integreated with CaveR in future field campaigns.

Preparation for Scientific Instrument deployment at Lava Beds. A portable version of the NIVSS system, InField [7], was used in VAL (see photo next page, by K. Ingham). Tests with Onsight included measurement of signal attenuation with distance from cave wall and response to lamp intensity and wavelength.

Astrobiology science sample suite collection. We collected a comprehensive suite of materials from the 3 caves. Samples were co-located and each sample site was photographed at different scales to best illustrate the vicinity of the sample origin. Sample sites were photographed before and after sample acquisition to monitor change or whether it we had altered the location noticeably.

Samples for microbiology (sequencing for archaea, bacteria, eucharyota), scanning electron microscopy (high-magnification morphology analysis), organic geochemistry (lipids, TOC), stable isotope (C,O,H) geochemistry of waters from dripping lavacicle tips, and geochemistry and mineralogy of basalt and crusty secondary alteration mineralogy and microbial mat materials from cave walls and floors. (B. Bieler collects water droplets from golden microbial film on cave wall; photo by K. Ingham.)

Results: We will present initial results from our first season at Lava Beds and describe how they feed in to our Years 2 and 3 planning for BRAILLE mission simulations.

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