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SCIENCE AND AUTONOMOUS EXPLORATION OF A TERRESTRIAL LAVA TUBE: A STRUCTURED PLANETARY CAVE MISSION SIMULATION

Abstract

Volcanic caves are compelling targets in the search for extant and past life on Mars. A recent survey using data from the Mars Reconnaissance Orbiter's Context and High Resolution Imaging Cameras has identified more than 1,000 candidate cave entrances on the surface of Mars (Cushing et al., 2017).

BRAILLE (Biologic and Resource Analog Investigations in Low Light Environments) is a NASA-funded analog Martian cave mission project centered around field research at Lava Beds National Monument (Northern California, USA). The BRAILLE Team's objectives are to (1) characterize microbial life and microbial community structure in terrestrial lava caves and the nutrients in rock and water that sustain them; (2) distinguish secondary minerals associated with microbes in the caves – macroscopic, putative signatures of life and a geochemical record of life that could persist long after any life died away; and (3) practice robotic life-detection and mapping mission operations in one of the caves, Valentine Cave, and develop and evaluate performance metrics. The first two of these objectives are independent of the mission simulation but provide valuable ground truth information that aided in the development of a cave life detection algorithm deployed on the robot as well as in the subsequent interpretation, by remote scientists, of observations collected by the robot. Here, we will focus on the mission simulation and its relevance to future planetary cave mission efforts.

The cave environment presents several challenges for robotic investigation that need to be overcome through mission design or the use of novel technologies. BRAILLE partnered with JPL's CoSTAR team and deployed two of the Boston Dynamics legged Spot robots to conduct the field exercises at Lava Beds using that team's NeBula AI. NeBula (Networked Belief-aware Perceptual Autonomy) is optimized to respond to uncertainty in operational capacities including sensing, environment, motion, system health, and communications. The robots were deployed successfully in semi- and full-autonomous mode during two scout campaigns in 2020. We will report the results of our 2021 planetary cave mission simulation activities, focusing on a comparison of operational modes using one robot moving through the cave and two legged robots working in tandem.

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