LUNAR AND MARTIAN LAVA TUBE RESEARCH SIMULATION AT HI-SEAS. M. Musilova[1,2,3], A. C. McAdam[4], J. A. Richardson[4,5], K. Young[4], J. E. Bleacher[4], C. Achilles[4], D. M. Bower[4,5], C. Fishman[6], S. Johnson[6], M. Millan[4,6], M. Napoleoni[6], C. A. Knudson[4,5], N. Y. Wagner[6], N. C. Schmerr[5], B. Shiro[7] & H. Rogers[1]
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Introduction: Lava tubes on the Moon and Mars are considered sites of great interest for exploration by both humans and robots. On Mars, lava tubes may contain biosignatures, while the lunar lava tubes may serve as sheltered environments for the construction of human settlements [1]. However, lava tubes can also be difficult environments for robotic operations and they can pose a safety hazard to humans as well. It will thus be extremely important to prepare for lava tube exploration by humans and robots in analog environments on Earth [2].

Figure 1: Lava tube exploration near HI-SEAS while on EVA (extravehicular activity) in analog spacesuits.

The Hawaii Space Exploration Analog and Simulation (HI-SEAS) habitat is a lunar and Martian analog research station located on the volcano Mauna Loa in Hawaii [3]. The International MoonBase Alliance (IMA) organises missions at HI-SEAS, during which crews of six analog astronauts perform research and technology testing relevant to the exploration of the Moon and Mars [4]. During an analog space mission, crews live for weeks, sometimes months in the HI-SEAS habitat with limited amounts of water, food, electricity and other necessary equipment for survival on the Moon or Mars. Crewmembers can only exit the habitat with the approval of the Mission Control Center on "Earth" and while wearing analog EVA (extravehicular activity) suits [5].

Geology and astrobiology research performed during analog space missions at HI-SEAS: The HI-SEAS habitat is located on lava flows of the volcano Mauna Loa. Its surroundings thus provide valuable access to performing high-fidelity planetary science fieldwork with very little plant or animal life present, and a wide variety of volcanic features to explore, such as lava tubes, channels, and tumuli [2]. This terrain is also ideal for rover and in situ resource utilization (ISRU) testing because of its great similarity to the basaltic terrains on the Moon and Mars [6]. HI-SEAS crews have performed a number of biochemical and geophysical research projects in the lava tubes accessible to them near the habitat. They explored and collected research samples while wearing EVA analog spacesuits and following strict EVA protocols [5].

Figure 2: A HI-SEAS crewmember taking a biological sample in a lava tube during an analog space mission.

Challenges for the human exploration of the Moon and Mars: Performing scientific research as an analog astronaut is very challenging due to the bulky EVA suit gloves and EVA equipment [7]. Precise sampling and measurements sensitive to contamination can be very difficult to do, such as for biochemical research

[8]. While the suits are made to be as flexible and comfortable as possible, they still restrict movement and the field of view of the analog astronaut. Crewmembers usually have to work in very bent and uncomfortable positions in order to perform sampling and different types of measurements.

Figure 3: A scientist taking a biochemical sample in a lava tube while not on mission for comparison.

The crews also have to take into consideration their safety and their limited life support systems during EVAs, as well as a number of other factors relevant to space exploration missions [2]. This includes communication and emergency protocols for both the EVA and the mission.

Figure 4: Performing LIDAR measurements in a lava tube while on an analog space mission.

Future plans: Currently, HI-SEAS has an ongoing collaboration with the co-authors on this study with a focus on collecting astrobiology-relevant analog samples during analog missions at HI-SEAS. Sample collection takes on average three times as long as without EVA gear. Sampling also has to be spread out throughout two or more EVAs, as the life support systems would not last long enough to perform more than three hours of sampling on one EVA.

Further studies will be needed to assess how to best combine scientific goals with human exploration goals during future human missions, which may use lava tubes as a resource as well as a key science site.

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