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LESSONS LEARNT FROM HUMAN LAVA TUBE EXPLORATION AND RESEARCH DURING SIMULATED LUNAR AND MARTIAN MISSIONS AT THE HI-SEAS SPACE RESEARCH STATION

Abstract

Lava tube systems are of great interest for the future exploration of the Moon and Mars. On both celestial bodies, lava tubes could serve as sheltered environments for the construction of human settlements. Furthermore, Martian lava tubes may contain biosignatures and existing lifeforms. Accessing lava tubes, however, remains a challenge for both robotic and human operations, from a scientific, logistical and safety perspective. For these reasons, preparations for the lava tube exploration by humans and robots in analog environments on Earth will be vital for the success of studying lava tube systems elsewhere in the Solar System. Such studies have been performed on a regular basis during simulated lunar and Martian missions at the Hawaii Space Exploration Analog and Simulation (HI-SEAS) space research station in Hawaii. The International MoonBase Alliance 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. Since the HI-SEAS habitat is located on lava flows on the volcano Mauna Loa, there is very little plant or animal life present and a wide variety of volcanic features can be explored for high-fidelity planetary science fieldwork, such as lava tubes, channels and tumuli. This terrain is also ideal for rover and in situ resource utilization testing because of its great similarity to the basaltic terrains on the Moon and Mars. HI-SEAS crews have performed a number of biochemical and geophysical research projects in the lava tubes accessible to them. They explored and collected research samples while wearing Extra-vehicular Activity (EVA) analog spacesuits and following strict EVA protocols. These activities are very challenging for the crew, due to the bulky gloves and EVA equipment they have to wear, while performing precise biochemical research that is sensitive to contamination. The crews also have to take into consideration their safety, their limited life support systems during EVAs and a number of other factors relevant to space exploration missions. Currently, we have an ongoing collaboration with groups

from the NASA Goddard Space Flight Center, University of Maryland, Georgetown University, Honeybee Robotics and other institutions and companies interested in developing better methods and technologies for human spaceflight missions. Further studies will be needed to assess how best to combine scientific goals with human exploration goals during such future missions, which may use lava tubes as a resource as well as a key site for scientific research.