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BENEATH THE LUNAR SURFACE: A MULTI-TIERED ATMOSPHERIC PRESSURE HABITAT DRIVEN BY BIOREGENERATIVE LIFE SUPPORT, HABITABILITY, AND MODULARITY

Abstract

Establishing sustainable habitats on the Moon requires innovative solutions that address the extreme characteristics of its environment and technological limitations, while also prioritizing the holistic well-being of astronauts. This project explores the utilization of a Lunar impact melt tube as a potential solution to mitigate these challenges, thereby fostering the development of lunar architecture suitable for long-term habitation. Underground structures present a unique and clever opportunity for sheltering lunar habitats. They offer natural protection from extreme lunar environmental features such as radiation and micrometeorite impacts along with a decrease in the extreme amplitude of temperature variations. The main challenge remains the lack of a lunar atmosphere and the consequent need to pressurize habitats, which creates extreme pressure differentials between the inside and outside. The present research proposes a bioregenerative life support-driven habitat within an impact melt tube. To decrease the high stress on the pressurized buildings, to create the possibility of using more transparent materials, and to generate an environment that displays a change in light and materials, the habitat is designed with three levels of atmospheric pressure associated with different levels of habitability. It consists of an innermost volume of high pressure for primary astronaut habitation and a greenhouse zone for food production, a middle habitable cultivation space that acts as an intermediary pressure zone and supports astronaut psychological health, and an outermost volume of low pressure with an integrated water wall to support the bioprocessing and recycling of resources. Each zone aims to emphasize functionality and astronaut health and well-being, creating a more livable architecture suitable for long-term habitation. The proposed concept enhances functionality, astronaut welfare, and environmental sustainability by integrating in-situ resources with prefabricated components and innovative materials. High levels of redundancy, modularity, and reusability further enhance the habitat's resilience. Importantly, this approach not only aims to address immediate challenges posed by lunar exploration, but also lays a foundational framework for future habitat construction endeavors, emphasizing adaptability, sustainability, and the well-being of astronauts on future long-term missions.