23rd IAA SYMPOSIUM ON BUILDING BLOCKS FOR FUTURE SPACE EXPLORATION AND DEVELOPMENT (D3)
Interactive Presentations - 23rd IAA SYMPOSIUM ON BUILDING BLOCKS FOR FUTURE SPACE EXPLORATION AND DEVELOPMENT (IP)

Author: Ms. Christine Chamberlain
United States

Mr. Adam Escobar
United States

ECOMINE - A BIOREGENERATIVE APPROACH TO LUNAR REGOLITH MINING

Abstract

NASA's plans to establish a sustained Lunar presence for scientific research, Mars mission preparation, and a thriving commercial Lunar economy will require significant surface infrastructure. The use of in situ resources provides an alternative source of rare Earth minerals for terrestrial use as well as minerals for Lunar use enabling a more economical and sustainable approach to constructing this infrastructure. Lunar regolith contains an abundance of Si and Al in anorthite, Fe and Ti in ilmenite, magnesium [1], and REEs (La, Nd, Sc, Ce) in mare regolith and KREEP rock [2]. However, traditional Earth mining processes are not economically feasible on the moon, due to high energy demands, labor needs, high mass transport costs for consumable reagents (like acids and alkalis), lower ore grade, and potential environmental and safety impacts. EcoMine^{TM} is a bioregenerative mining facility designed for use on the Lunar surface and adaptable for asteroid, Mars, or Earth utilization. It combines a closed-loop biomining process that continuously regenerates consumables (e.g., acids, nutrients, O2, water) with an autonomous, self-powered, bioprocessing facility for commercial operations. The use of biological organisms for mineral leaching is environmentally safer with lower energy demands than chemical mineral mining and it generally has improved extraction efficiency for low-grade ores, like lunar regolith. The Space Lab® EcoMine^{TM} facility can integrate with other infrastructure (like regolith excavation) and is mobile, which minimizes the distance (and time) between excavation, processing, and disposal of regolith. EcoMine^{TM} processes include: i) the production of oxygen and organic carbon sources (e.g. glucose and/or sucrose) by a reactor of photoautotrophic organisms (photobioreactor) harvesting energy from light and carbon dioxide through photosynthesis, ii) the consumption of oxygen and carbon sources by a reactor of aerobic heterotroph organisms (aerobic fermentation reactor) producing organic acids and carbon dioxide as part of their metabolism byproducts, iii) the use of the acidified media (with or without heterotrophs) to be in contact with the lunar regolith for bioleaching the minerals of interest, and iv) the return of carbon dioxide and other inorganic nutrients recovered from the aerobic fermentation reactor and the bioleaching reactor to the photobioreactor where they will be used again. Space Lab® presents an overview and concept of operations of the EcoMine^{TM} bioregenerative mining process, preliminary design of the facility, and preliminary results of the closed-loop bioleaching efforts. EcoMine^{TM} is a major step towards a viable, sustainable Lunar economy with several innovative features transferable to Earth applications.