Paper ID: 46164
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IAF SPACE EXPLORATION SYMPOSIUM (A3)
Interactive Presentations - IAF SPACE EXPLORATION SYMPOSIUM (IP)

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SEPARATION BEFORE EXTRACTION – A LOW-TECH APPROACH TO INCREASING THE YIELD OF LUNAR ISRU EXTRACTION PROCESSES

Abstract

The actual "payload-to-lunar-surface" that has been flown by the Apollo missions can be derived to about 6 metric tons. Future lunar exploration as for example ESA's vision of a "moon village", will therefore still be constrained by mass transportation logistics. Further, also the future exploration missions outlined in the International Space Exploration Coordination Group's Global Exploration Roadmap, will have increasingly demanding payload requirements. Hence, to prepare for such sustainable long-term space exploration missions, means have to be found to lessen the mass constraints. This is where the use of local resources or "In-Situ Resource Utilization" (ISRU) can make a signicant contribution and open-up new approaches to mission design. Extraction of water, aluminum, titanium, iron, magnesium, and oxygen from extraterrestrial sources might be possible and exploitation of these on the moon may be viable via modications to conventional terrestrial extraction techniques. Most often these extraction techniques are proposed as standalone solutions, but their yield could be increased by applying low-tech separation methods to the regolith before beneficiation. Hence, a complementary combination of separation processes, and extraction processes on the lunar surface is proposed with the aim of maximizing the yield and feasibility of in-situ extraction. Amongst the revised technologies are extraction methods for oxygen, water, and metals, such as molten regolith electrolysis, vapor phase pyrolysis, or carbothermal reduction. All these methods can benefit from prior separation, which is regarded as; treatment to the regolith by means of simple mechanical processes and under only little consumption of energy as well as no or only little use of consumables. Processes considered are; shaker tables, froth otation, (hydro)-cyclones (centrifugation), heavy liquids, and electromagnetic separation. These methods are low-tech approaches, capable of handling a wide range of different input materials and are well understood, simple, small and light. Analysis of current terrestrial equipment has shown that it is possible to utilize conventional extraction and separation methods to produce resources on the moon's surface. The European Space Agency is aiming at establishing a permanent outpost on the lunar surface. Therefore, new technologies and equipment need to be developed to enable and augment such a mission, as well as to make long-term planetary missions possible. The proposed systems can help to support these missions by utilising lunar in-situ resources to augment missions with locally extracted resources like oxygen or metals.