On the Exploitation of Lunar Material Resources

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There is a strong need to improve our understanding of the possible role of space resources for maintaining and improving living conditions on Earth and in space. Future robotic and manned space missions could profit, for example, from the utilization of material resources outside the Earth's gravity well. One of the most attractive options appears to be the production of propellants and life support consumables on other planetary bodies, especially the Moon. The lunar surface is extremely dry and an atmosphere is practically absent. Important lunar resources which could be exploited are the oxygen bound in silicate/oxide minerals and solar wind implanted volatiles in the lunar regolith (e.g. hydrogen, likely with an abundance significantly enhanced towards the poles). Due to the fact that the regolith has a typical oxygen content between 40 and 45 wt.%, oxygen production appears to be most promising for an initial phase of lunar resources utilisation, while the exploitation of other materials is considered to be much more complex (e.g. requiring handling and processing of large quantities of regolith) or speculative (e.g. lunar water-ice). It should be remembered, however, that further valuable materials like silicon and other metals as by-products of oxygen production as well as in-situ materials for advanced fuel compounds (e.g. silane, aluminum) could also be exploited. Numerous processes for the extraction of oxygen from the lunar regolith have been proposed and several of these have been experimentally tested or are under evaluation. At DLR the oxidation with fluorine was investigated experimentally in cooperation with the University of Cologne and the feasibility of a closed cycle for oxygen production has been demonstrated. Furtheron, preparations for vapour phase pyrolysis experiments within the solar furnace of DLR in Cologne are under way. In 1998/99 an assessment of the most promising processing concepts has been performed by DLR in the "System Concepts, Architectures and Technologies for Space Exploration and Utilisation (SE&U)" study on behalf of ESA. This evaluation was based on a scenario in which propellants are required to establish and run a permanent lunar base. The results - including technical feasibility and economic benefits - are reviewed together with a detailed discussion of corresponding past and current DLR experiments. Emphasis is also put on possible spin-offs/-ons for these processing methods with respect to related terrestrial processes. Most important are the aspects of closed cycle technology and environmentally benign methods.