# Exploration of Lunar Resources for In-Situ Utilization

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The establishment of a permanent lunar outpost is very much constrained by the utilization of in-situ resources. In this sense, resource-oriented exploration (prospecting) is the first logical step in preparing for lunar development. New materials and innovative processing methods will be required for this purpose; however, some resources can be clearly identified. First of all, it is necessary to specify the nature of and prioritize activities to be carried out at precursor lunar outposts. Due to high transportation costs from Earth, it becomes evident that the possibility of refueling from lunar materials is a first-order requirement. Here, hydrogen and oxygen (among other possible propulsion systems) play a prominent role. We know of the existence of solar wind-implanted hydrogen in the lunar regolith, although abundance estimates are subject to large uncertainties. While it is not clear whether hydrogen can be efficiently exploited from regolith materials, oxygen is certainly one of the most important lunar resources, not only for propulsion but also in life support systems. Oxygen is in high concentration bound in the structure of silicate materials, and a great variety of methods have been proposed for its extraction from lunar materials. Therefore, oxygen utilization constrains the identification and application of other potential lunar resources. First-order determination of oxygen contents can be carried out from orbit (e.g. gamma-ray spectrometer in Lunar Prospector; x-ray fluorescence spectrometer in SMART-1). Optimization of oxygen exploitation will require a careful evaluation of the potential utilization of byproducts of oxygen extraction. For instance, residues of thermal and/or chemical processing of regolith materials used for oxygen extraction can have a wide variety of applications, including construction materials for the development of early lunar infrastructures (e.g. metallic iron and titanium from ilmenite in high-Ti basalts; silicon from lunar glasses; magnesium from dunites; calcium from anorthosites). Following orbital studies, robotic analysis and engineering tests should be carried out on potentially interesting targets, including in-situ determination of chemical (e.g. APXS, XRF) and mineralogical (X-ray diffractometry) compositions. A common strategy should be implemented in view of exploration and exploitation of lunar resources.