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The ESA Lunar Lander and the search for Lunar Volatiles

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Following the Apollo era the moon was considered a volatile poor body. Samples collected from the Apollo missions contained only ppm levels of water formed by the interaction of the solar wind with the lunar regolith [1]. However more recent orbiter observations have indicated that water may exist as water ice in cold polar regions buried within craters at concentrations of a few wt. % [2]. Infrared images from M3 on Chandrayaan-1 have been interpreted as showing the presence of hydrated surface minerals with the ongoing hydroxyl/water process feeding cold polar traps. This has been supported by observation of ephemeral features termed "space dew" [3]. Meanwhile laboratory studies indicate that water could be present in appreciable quantities in lunar rocks [4] and could also have a cometary source [5]. The presence of sufficient quantities of volatiles could provide a resource which would simplify logistics for long term lunar missions.

The European Space Agency (ESA's Directorate of Human Spaceflight and Operations) have provisionally scheduled a robotic mission to demonstrate key technologies to enable later human exploration. Planned for launch in 2018, the primary aim is for precise automated landing, with hazard avoidance, in zones which are almost constantly illuminated (e.g. at the edge of the Shackleton crater at the lunar south pole). These regions would enable the solar powered Lander to survive for long periods > 6 months, but require accurate navigation to within 200m. Although landing in an illuminated area, these regions are close to permanently shadowed volatile rich regions and the analysis of volatiles is a major science objective of the mission. The straw man payload includes provision for a Lunar Volatile and Resources Analysis Package (L-VRAP).

The authors have been commissioned by ESA to conduct an evaluation of possible technologies to be included in L-VRAP which can be included within the Lander payload. Scientific aims are to demonstrate the extraction of volatiles and determine the volatile inventory of the moon with a view for future In-Situ Resource Utilization (ISRU). Surface samples will be collected by a robotic arm with the possibility of a rover to collect more distant samples. The concentration, chemical and accurate isotopic ratios (D/H, $^{12}C/^{13}C$, $^{15}N/^{14}N$, $^{18}O/^{16}O$ and noble gases) of liberated volatiles will be determined, possibly using similar technology to the Philae comet lander of the Rosetta mission [6]. An additional aim is the monitoring of the chemical and isotopic composition of the tenuous lunar atmosphere [7] which will become contaminated by active human exploration. The lunar atmosphere will provide information on the processes involved in forming lunar volatiles and their concentration mechanisms. Modelling the effects of contamination from the Lander is an essential part of this study so that these can be recognized and minimized.

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