LUNAR ROBOTIC EXLORATION OBJECTIVES IN THE NEXT DECADE.

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Introduction: Robotic missions to the Moon can provide a wealth of data for both scientific and exploration objectives. Some objectives require large complex systems, but others can be addressed by simple, short-lived stationary systems. The current fiscal climate suggests that NASA will be constrained to relatively small (Discovery and New Frontiers class) mission for the foreseeable future. While such missions may not be capable of sample return or discovering that water has existed on Mars, they can provide important steps in understanding the Moon.

Scientific Goals: Several reports (e.g., LEAG Roadmap; NRC Scientific Context for Exploration of the Moon; Vision and Voyages for Planetary Science in the Decade 2013-2022) have outlined key lunar science questions and the results of recent lunar missions (e.g., LRO, Chandrayaan, Kaguya, Selene) have provided data that have answered some questions and opened up many more.

Volatiles: Perhaps the most intriguing of the questions that has received recent attention is lunar water - its form, source and distribution. The Apollo view was that the Moon was largely devoid of water; however Lunar Prospector neutron data suggested that significant hydrogen was present in the polar regions, interpreted to be water. Data from the LRO neutron spectrometer suggest that the distribution might be quite complex. Spectral data from the Chandrayaan M^3 instrument indicate that H_2O or OH occurs on the surface across the polar regions. Chandrayaan and LRO radar data have been interpreted to indicate that several shadowed craters hold significant water ice. Analysis of lunar samples has also suggested that water was/is present in the mantle.

Exploration Approach: While the neutron, spectral and radar data can be interpreted to indicate the presence of H and H_2O at the lunar poles (inside and outside of permanent shadow) its form, origin, and distribution are unknown. The most direct way to assess this is to explore a permanently shadowed area having an appropriate neutron and radar signature. Such missions were studied as part of the RLEP and LPRP programs.

Rovers: A rover outfitted with sample acquisition and analysis instrumentation and powered by nuclear (RTG/ASRG), fuel cells or even primary batteries would have the capability to explore a permanently shadowed area to determine the nature of the H-bearing species. Using a neutron spectrometer, an appropriate site could be located and sampled using a drill to obtain subsurface samples. The recovered samples would be analyzed to determine the nature of the H-bearing species. Further traverses would mapping the spatial distribution. Assuming that the complete volatile inventory could be examined and its isotopic composition measured, the origin of the volatiles could be determined as well.

Landers: A static lander placed in an illuminated area of high H (as indicated by orbital neutron data) could address the distribution of H, although in a less direct manner. The assumption has been that most of the H is cold-trapped in permanent shadow. A lander in a non-permanently shadowed region would measure the regolith H abundance. If the H concentration were high (100s ppm) it would suggest that the H was broadly distributed across the poles; if the content was low, then the case that the “missing” H was sequestered in permanent shadow would be stronger. Such a mission could also measure the surface H_2O/OH (indicated by spectral data) and assess the amount and any temporal variation.

Cratering and Volcanism Chronology: The objectives of the lunar cratering chronology and mare volcanism could also be addressed with a simple lander. Crater counts suggest that some mare areas may be as young as 1 Ga. A mission to such a young area could acquire a basalt sample and determine an absolute age *in situ* using the K/Ar or Rb/Sr methodology. While not as precise as a laboratory measurement, it would indicate whether such surfaces are really only 1 Ga. Such a measurement would provide important <3 Ga constraints on the absolute cratering chronology and it will have important implications for models of the lunar thermal history.

Discussion: These examples serve only to illustrate how robotic missions can address important scientific questions. While some objectives (e.g., sample return) require large complex (i.e., expensive) systems, other objectives can be addressed with smaller low-cost systems. In some cases the precision may not be what is ultimately desired, but an actual good measurement maybe be more useful than great measurement that is never obtained.

Mobility is always an important aspect of a mission. While a small mission might only have mobility of the order 100s of meters, such mobility allows collection and analysis of multiple samples to avoid a single unrepresentative measurement.