SEAL: SURFACE AND EXOSPHERE ALTERATIONS BY LANDERS.

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Introduction: The Surface and Exosphere Alteration by Landers (SEAL) instrument aims to investigate the interaction of lunar regolith with volatiles from the lander's rocket exhaust, constraining the adsorptive properties of the regolith and yielding insight into perturbations of past and future surface samples from the Moon and other bodies. The SEAL instrument can be delivered to the lunar surface by one of NASA's already-selected Commercial Lunar Payload Services (CLPS).

Science Objectives: Like all airless bodies in the solar system, the Moon has been subjected to meteoroid bombardment, direct plasma exposure, and solar irradiation for billions of years. This incessant weathering has resulted in the fine, loosely packed, and highly adsorbent regolith that blankets the surface. The adsorptive properties of this regolith play a large role in governing how the surface of the Moon exchanges volatiles with the exosphere, and how volatile species are sourced, transported, recycled or lost in the lunar environment (e.g. [1-4]).

The Surface and Exosphere Alteration by Landers (SEAL) investigation targets three objectives that can be performed readily from a static platform, with far-reaching consequences for archival and future measurements as well as the interpretation of samples:

Objective 1: SEAL will constrain the chemical response of the regolith to the thermal, physical, and chemical disturbances generated by a lander. Volatile release as a function of temperature will yield activation energies that bind volatile gases to the regolith, the mobility of these molecules, and how they compete for adsorption sites. The information that can be garnered from these observations is beyond what can be traditionally achieved by Temperature Programmed Desorption (TPD) experiments conducted in laboratory settings.

Objective 2: SEAL will evaluate the nature and amount of exogenous contaminants from propulsion exhaust and platform outgassing that are injected into the soil by the landing, which will enable interpreting contamination noted in the Apollo missions [5]. Understanding the decay of volatile gas abundance is critical to mitigate the effect of site contamination in samples collected from stationary platforms where only altered soils are accessible.

Objective 3: SEAL will characterize the lunar exosphere directly at the surface, bridging the observation gap left by LADEE/NMS and Apollo/LACE. Maximum number density near the surface in conjunction with extended integration time will enhance detection limits of all major exospheric species on the lunar dayside (He, CH_4, Ne, and Ar [1,6]). These species will be discernible by the instrument with no confusion due to exhaust gases released from the regolith.

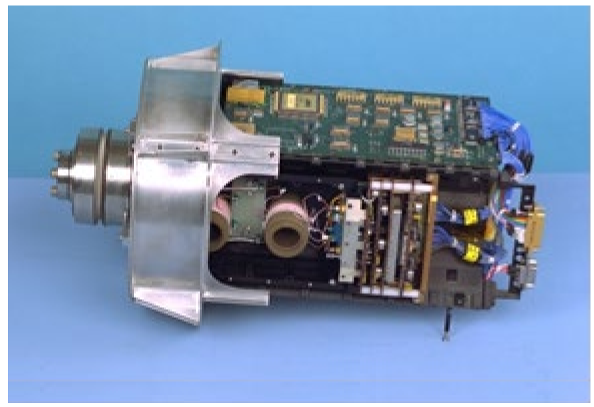

Figure 1: SEAL is a nearly identical replica of the Nozomi/NMS instrument shown. It leverages its compact low power design to provide in-situ measurements of the space environment at the lunar landing site.

Instrument Description: SEAL will be assembled from the refurbished spare unit of the Neutral Mass Spectrometer (NMS) instrument (Figure 1) flown in 1998 on the Japanese Nozomi mission (also known as Planet-B) [7]. NMS was built at Goddard Space Flight Center's Planetary Environment Laboratory (PEL). SEAL measures the composition and density of neutrals by converting the ambient neutral gas into an ionized stream using electron impact ionization driven by a pair of hot filament emitters. The stream of ions is filtered by a quadrupole analyzer and detected by Secondary Electron Multipliers. The analyzer is designed to resolve species in the 1 – 60 Da mass range, with unit mass resolution, suitable to characterize exhaust products, terrestrial gases released from the lander, and major species in the Moon's exosphere.

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