POLAR NIGHT: A MISSION TO THE LUNAR POLES P. G. Lucey[1] [1]Hawaii Institute of Geophysics and Planetology, University of Hawaii at Manoa, 2525 Correa Road, Honolulu HI 96822 (lucey@higp.hawaii.edu).

The Discovery Program, through measurements by the Lunar Prospector spacecraft, established that the volatile element hydrogen is enriched in the lunar polar regions. It is virtually certain that this enrichment is due to cold trapping of hydrogen in one or more chemical states owing to the low temperatures of obliquely illuminated and permanently shadowed regions near the Moon's poles. This measurement confirms suggestions that the lunar (and mercurian) polar regions can capture and retain volatiles that encounter these surfaces. Modeling of lunar polar temperatures has indicated that water ice at shallow depths can persist for geologic time, even at high latitude regions which are not permanently shaded. Modeling of permanently shadowed craters indicates that temperatures in the shallow subsurface are low enough, as low as 40 kelvins, to retain for geologic time extremely volatile ices including carbon dioxide, methane, ammonia, sulfur dioxide. These model temperatures are also low enough retain a host of low molecular weight organic compounds. Modeling of the Moon's obliquity over time indicates that permanently shaded regions can have persisted for 2.5 BY, exposing them to a host of potential sources of volatiles.

The confirmed existence of lunar cold traps raises the possibility that the lunar poles have trapped and retained volatile materials from sources which are central to many aspects of NASA's strategic plans. These sources include comets, asteroids, interplanetary dust particles, interstellar molecular clouds, the solar wind, and lunar volcanic and radiogenic gases.

In addition to the possible presence of volatiles originating from strategically important sources, the temperatures, energy available and plausible presence of feedstock elements captured by the cold trap raises the possibility of synthesis of organic molecules in situ on the Moon. Hydrogen is known to be present at reasonably high abundances even at the 50km scale of lunar prospector measurements. C and N may have accumulated in the form of volatile ices or or at least exists as cold-trapped solar wind on grain surfaces. These elements, coupled with low temperatures and temperature cycling, have been shown to produce organic molecules when exposed to a driving energy source. The polar surfaces are illuminated by Lyman alpha and by galactic cosmic rays. While the UV is limited to the optical surface, the upper few centimeters of the regolith experience a relatively high flux of energetic protons derived from the galactic cosmic ray cascade. The lunar poles may then provide a natural laboratory for organic synthesis on silicate grains which may mimic conditions found in interstellar space. At minimum, the lunar field conditions can enable a test of models of organic synthesis in space in a way that complements the organic rich conditions on Titan.

Despite these possibilities and plausibilities, all that is known about the lunar poles regarding this problem is that hydrogen is enriched, and that temperatures are low. There is no information on the presence of other volatiles and the temperatures and temperature variations of the coldest portions of the poles, the permanently shadowed regions, are unknown.

The Polar Night mission will conduct an inventory of volatiles and provide sufficient analysis to determine or greatly constrain the sources of polar volatiles and their nature. Polar Night will determine the chemical composition, abundance and deuterium to hydrogen ratio of volatiles cold-trapped in permanently shadowed regions of the lunar poles. These measurements will be conducted in situ using mass spectrometers, and neutron spectrometers deployed on six penetrator hard landers. The landing sites of the penetrators will be selected using remote measurements of the temperature, H-abundance at high resolution, and radar polarization properties measured from orbit during a six month remote sensing campaign.