Brief Report
on
ISECG Lunar Polar Volatiles Virtual Workshop #1: Lunar Datasets

On November 18, 2015 the ISECG held the first in a series of virtual workshops on exploring and using lunar polar volatiles, with a focus on understanding the various datasets that have been collected so far to assess lunar polar volatile deposits. Approximately 100 participants from various countries met online for a 2-hour session, representing not only space agencies, but industry and academia as well, and including planetary scientists, students, engineers, and other space professionals. ESA/James Carpenter moderated presentations by six expert panelists and addressed questions from attendees, while others participated simultaneously by exchanging text comments in an associated chat forum. All the presentation materials and a recording of the event were posted to the ISECG lunar volatiles website (http://lunarvolatiles.nasa.gov).

Overarching questions:

1. What remote sensing scientific instruments from lunar orbit or Earth have produced the most beneficial datasets to identify lunar polar volatiles deposits?

2. What are the most promising scientific instruments for use on the lunar surface to refine our understanding of the abundance, distribution, composition, form, and accessibility of lunar polar volatile deposits?

Panelists:

Dr. Mahesh Anand (Open University, UK) – Chair, ESA Topical Team on Exploitation of Local Planetary Materials
Dr. Ko Hashizume (Osaka University, Japan) – Lunar scientist
Dr. Paul Hayne (Jet Propulsion Laboratory, USA) – Lunar scientist
Dr. David Lawrence (Applied Physics Laboratory, USA) – Lunar scientist
Dr. Paul Lucey (University of Hawaii, USA) – Chair, LEAG Polar Volatiles Special Action Team
Dr. Paul Spudis (Lunar and Planetary Institute, USA) – Lunar scientist

Findings:

1. A variety of datasets acquired from lunar orbiting spacecraft pertain to lunar polar volatiles deposits, including imagery, topography, surface temperature, reflectance spectroscopy (UV, visible, and IR), neutron spectroscopy, and radar. Analysis of these data sets suggests the presence of volatiles, including water, hydrogen, carbon monoxide, methane, and others, though their concentration and distribution, both laterally and vertically, seem to be quite variable, and their physical form is not clear. The lunar poles seem to contain non-uniform patches of icy regolith at ~1 % water by weight in some permanently shadowed regions (PSRs)

and in some partially sunlit areas where average annual surface temperatures are below around 110K (allows for preservation of shallow buried ice for geologic time). A higher bulk concentration of water ice (~5%) was measured by LCROSS inside Cabeus crater, further indicating the apparent variability in polar volatile concentration and distribution. Preliminary bi-static radar data also seems to indicate the presence of a layer of blocky subsurface water ice beneath Cabeus's floor, and mono-static radar data from other locations in the polar regions might indicate water ice as well. 2. There are sufficient data, without additional new orbital measurements, to support near-term landing site selections for surface missions seeking to provide "ground truth" validation of existing datasets and to further characterize surface and subsurface polar volatiles. However, because polar volatiles, including water, may be distributed unevenly in patches, the likelihood of discovering significant amounts of ice during any single mission may depend heavily on the extent of mobility provided by surface rovers. Surface missions would also benefit greatly from the development of a model for predicting volatile distribution at high spatial resolution, and there is a need for hypotheses that can be tested with current and future datasets. Good models can help the exploration community identify attractive landing regions and sites, and provide structure to maximize the value of data collected from surface missions, regardless of how high or low the discovered volatile concentrations.

3. Several early surface measurements (and related instruments) were identified that would significantly advance the understanding of polar volatiles and could be achieved by relatively small missions. These include:

- Horizontal distribution of volatiles within the top 1m or 2m of regolith at the 1m to 1km scale (achievable from one or more mobile platforms with subsurface neutron spectrometer, sub surface sampling and mass spectrometer, gamma ray spectrometer, ground-penetrating radar);
- Vertical distribution of volatiles (drilled samples examined by mass spectrometers and NIR spectrometers, plus neutron spectrometer);
- Thermal and mechanical properties of polar soils (lander (even at dry sites) with differential scanning calorimeter or thermal gravimetric analysis, instrumented tooling measuring soil behavior during surface operations);
- Chemical phases of volatiles, e.g. water ice vs water-bearing minerals (small rover with infrared/optical spectrometer, gas chromatograph/mass spectrometer);
- Atmospheric flux of volatiles (e.g. lander next to permanently shadowed region with exosphere ion/neutral mass spectrometer);
- Volatile isotope abundance, e.g. hydrogen/deuterium ratio, to understand origins and migration processes (e.g. stable isotope mass spectrometer, laser spectrometer).

4. Additional orbital measurements that would improve the understanding of volatiles and support development of predictive models include:

- Higher spatial resolution neutron spectroscopy mapping of subsurface hydrogen (≤ 5 km per pixel, achievable with low altitude orbits); and
- Additional bi-static radar measurements to reveal locations of blocky subsurface ice. The LRO mini-RF instrument, though inactive, is still in lunar orbit and functional, and if turned back on and operated in a bi-static mode in conjunction with a radio telescope on earth, it could make targeted measurements to identify water ice deposits. Measurement depth is ≤ 2-3 m.