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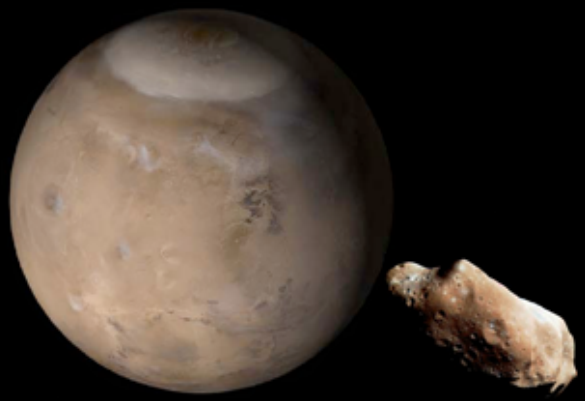
Lunar Exploration Analysis Group

Report to the Planetary Science Subcommittee

21 November, 2014



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Outline

- LEAG Annual Meeting
- LEAG Meeting Major Findings
- New Views of the Moon 2
- LEAG Charter
- Volatile SAT (V-SAT) Update
- South Korean Lunar Missions
- Science Nuggets

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LEAG Annual Meeting

22-24 October, 2014

- Focus on lunar volatiles;
- Next Generation Lunar Scientist travel grants supported four students to give presentations;
- Appearance by Buzz Aldrin – requested to come and give a presentation;
- All Meeting Findings at www.lpi.usra.edu/leag – present the most significant community findings here.

LEAG Townhall meeting at LPSC 2015

Next annual meeting 20-22 October, 2015, location TBD

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2014 LEAG Meeting Findings

Volatile Resources.

- With an emphasis on polar volatiles as a potential resource, the potential for other non-polar deposits to yield significant resources should not be ignored (e.g., Fe-rich pyroclastic deposits).

Volatiles from the Lunar Interior.

- As with surface volatiles, our understanding of volatiles in the lunar interior, first observed in sample in 2008, is also rudimentary. Targeted sample return from pyroclastic deposits and basalt flows of various ages would significantly aid our comprehension of the role volatiles played in the magmatic evolution of the Moon.

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2014 LEAG Meeting Findings

Resource Prospecting.

- The attendees of the LEAG meeting support the HEOMD **Resource Prospector Mission** concept as a good start in the "prospecting phase" for lunar resources. NASA's Planetary Science Mission Division (PSD) is encouraged to explore avenues for community participation in this mission (e.g., guest scientist program);
- Additional missions (that include competed payloads and payloads on missions of opportunity) to expand our understanding of the form, mobility, and resource potential of lunar volatiles would be the next logical step. These would include focused orbital, surface, and sample return missions.

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2014 LEAG Meeting Findings

The Future.

Momentum gained with recent lunar missions (LRO, LCROSS, LADEE, GRAIL, ARTEMIS) feed forward into key NASA science and exploration goals and horizons. It is critical that this pace of discovery be maintained to support our international partners, feed-forward technology, and operational developments for future crewed missions to Mars. A key finding from the 2014 LEAG meeting is that SMD and HEOMD, maintain a sustained program of lunar missions (e.g., Discovery; New Frontiers through SPA Sample Return & Lunar Geophysical Network; directed missions, etc.) focused on addressing key science, resource, and technology development issues in line with the decadal survey and to support long-term NASA goals.

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2014 LEAG Meeting Findings

International Cooperation.

- The creation of the Science White paper for ISECG Science Working Group, while coordinated by SSERVI, should have input from the broad lunar, small bodies and Mars communities in addition to the SSERVI nodes. The Analysis Groups can facilitate such input through coordination with SSERVI central.
- Comprehensive investigations of lunar volatiles for both science and exploration could be a rallying point for future international cooperation in lunar science and exploration.

New Views of the Moon 2

- Step 1 proposal to L-DAP discouraged.
- Suggested submission to the Topical Workshops, Symposia, and Conferences (TWSC)program, ROSES-2014, section E.2.
- Proposal to be submitted early 2015 to move the project forward.

Issue – LEAG Charter

- LEAG's joint charge by HEOMD and SMD needs to be confirmed.
- Any changes to the manner in which the LEAG (and SBAG) is(are) run will need to be coordinated by both HEOMD and SMD.
- SMD and HEOMD should be able to independently task an AG, but the rules of operation should be consistent.

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Volatile Specific Action Team

This SAT is requested to assess recent discoveries related to detection of volatiles on the Moon, to suggest lunar polar regions of interest, and to suggest possible mission strategies where NASA and international / commercial partners could operate on the lunar surface in a cooperative manner to further understand the size, distribution, form, and resource potential of deposits of water ice and other volatiles.

- Synopsize the current understanding of the type, form and distribution of polar volatiles and the requirements and measurements needed to fully characterize the quantity, distribution, accessibility, and extractability of water ice and other volatiles.
- A candidate prioritized list and discussion of lunar polar regions of interest.

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Volatile Specific Action Team

Update

Face-to-face meeting at APL before the LEAG meeting.

Follow-up telecon in November.

Criteria being developed for identifying the most promising locations for surface exploration.

Findings being prepared for release at the end of the year.

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South Korea Lunar Missions

Meeting in South Korea 12-13 November 2014:

- Lunar orbiter in 2017;
- Lunar orbiter and lander in 2020.

2017 Orbiter:

- 50 kg of payload (four instruments);
- Two instruments from Korea;
- Two from NASA – one contributed, one through an AO.

See next slide presented at the 2014 Dasan Conference in Jeju, South Korea, last week.

Science payloads for The Korean Pathfinder Lunar Orbiter

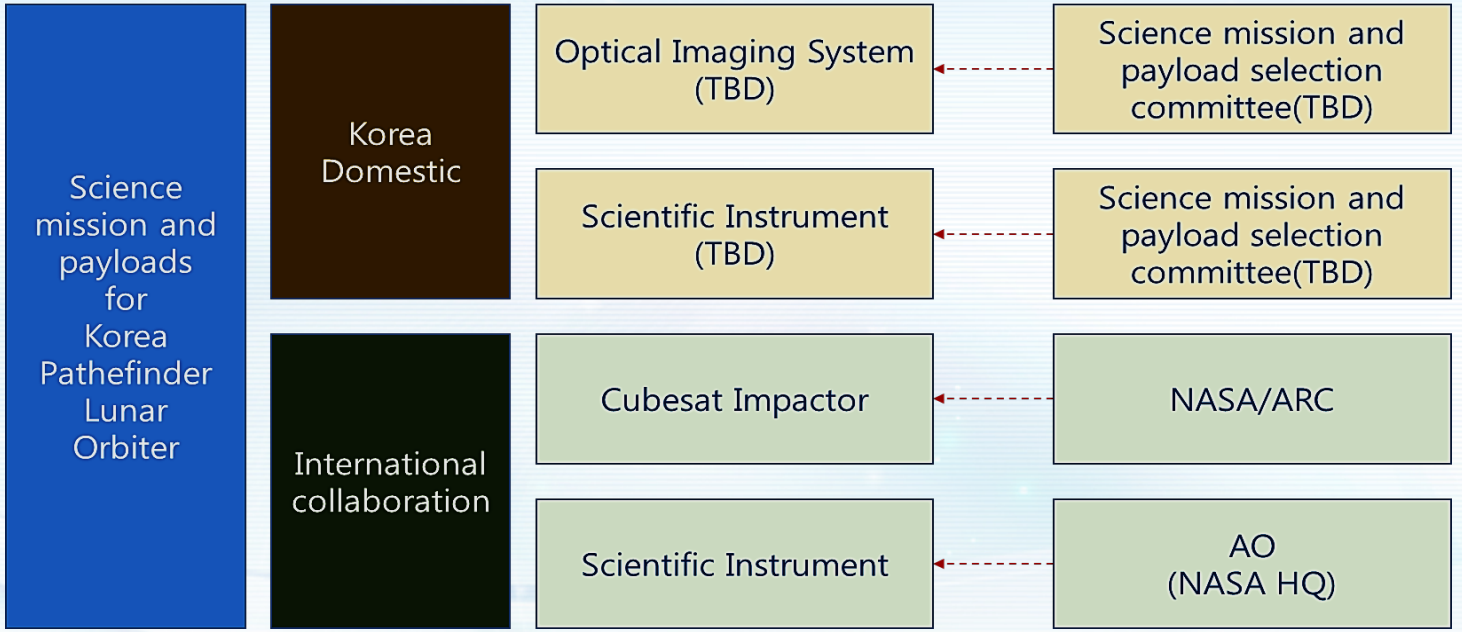
➢ **Total number of Science Payloads : 4**

- Domestic : 2

  (Optical Imaging System + Scientific payload; Selection by the Committee)

- International Collaboration : 2

  (CubeSat Impactor + Scientific payload by AO)



South Korea Lunar Missions

Are there any details on the NASA instruments that can be shared with the lunar community at this time?

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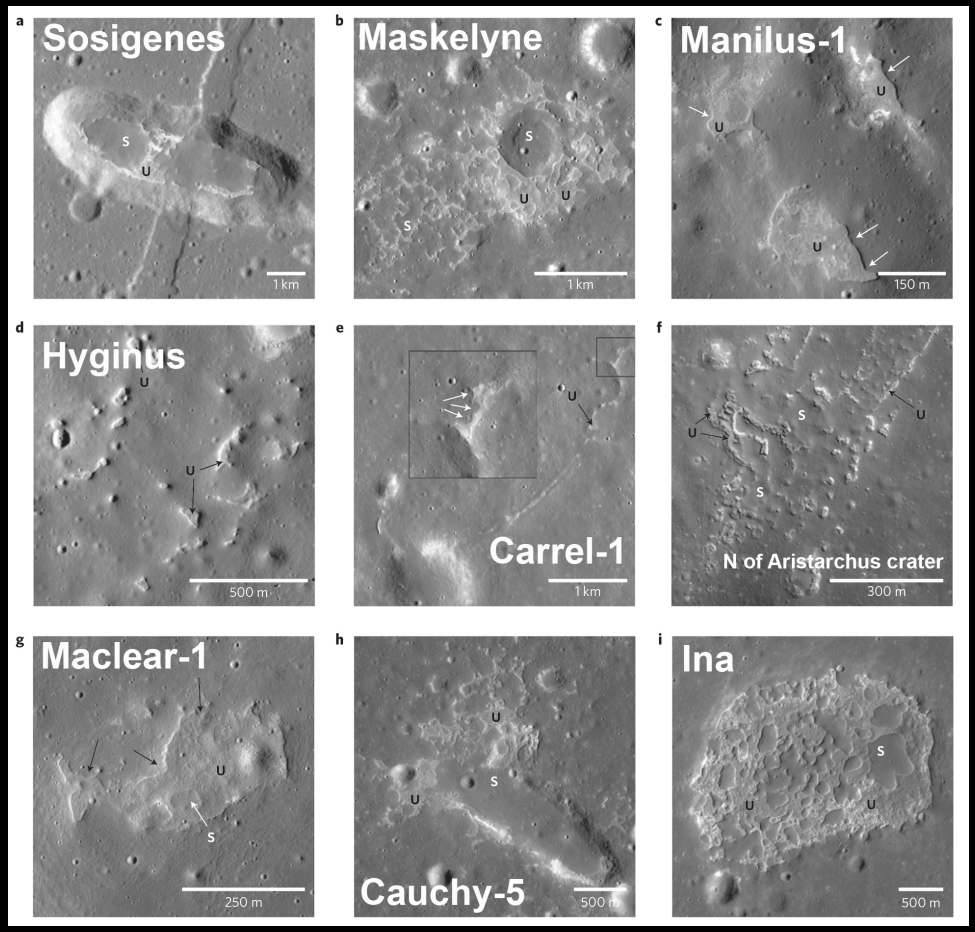
Science Nuggets

Braden et al. (2014) Evidence for basaltic volcansim on the Moon within the past 100 million years. *Nature Geoscience* **7**, 787-791.

- 70 small topographic anomalies – irregular mare patches (100-5,000 m maximum dimension).
- Irregular mare patches – IMPs.
- Crater distributions of the 3 largest = <100 Ma.



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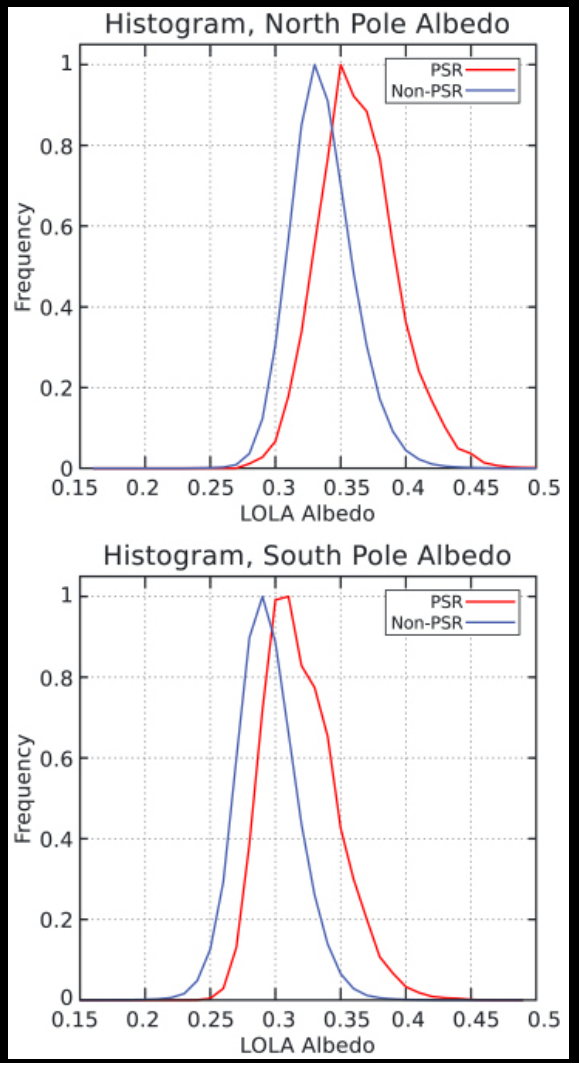
Science Nuggets

Lucey et al. (2014) The global albedo of the Moon at 1064 nm from LOLA. *J. Geophys. Res.* **119**, 1665-1679.

- The normal albedo of the lunar maria is similar to that of Mercury suggesting a similar abundance of space weathering products.
- Regions within permanent shadow in the polar regions are found to be more reflective than polar surfaces that are sometimes illuminated.
- Water frost and a reduction in effectiveness of space weathering are offered as possible explanations for the increased reflectivity of permanent shadow.



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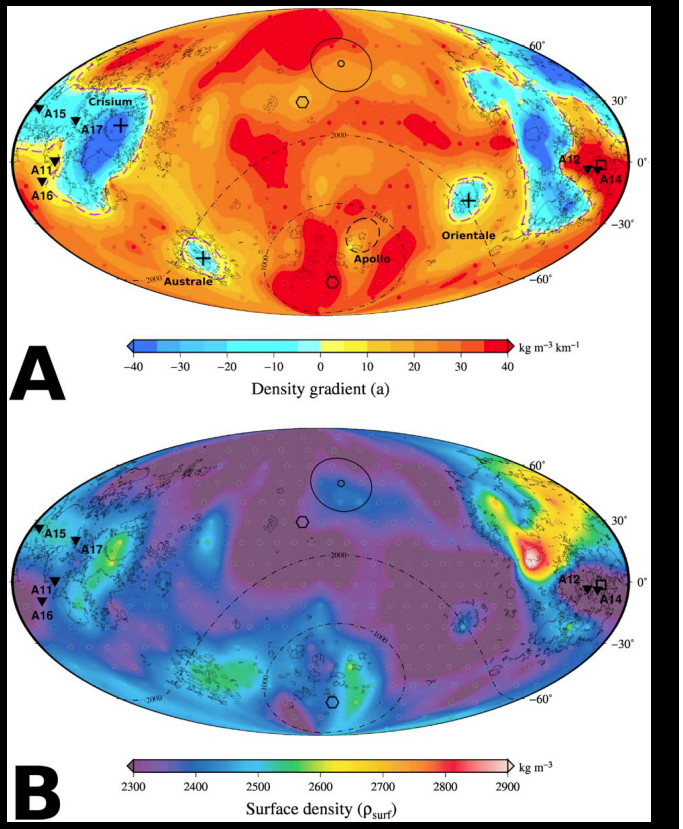
Science Nuggets

Besserer et al. (2014) GRAIL gravity constraints on the vertical and lateral density structure of the lunar crust. *Geophysical Research Letters* **41**, 5771-5777.

- Mare regions are characterized by a distinct decrease in density with depth, while the farside is characterized by an increase in density with depth.
- The Apollo 12 and 14 landing site region has a similar density structure to the farside, permitting a comparison with seismic velocity profiles.
- The interior of the South Pole-Aitken (SP-A) impact basin appears distinct with a near-surface low-density (porous) layer 2–3 times thinner than the rest of the farside.



- Redistribution of material during the large SP-A impact likely played a major role in sculpting the lunar crust

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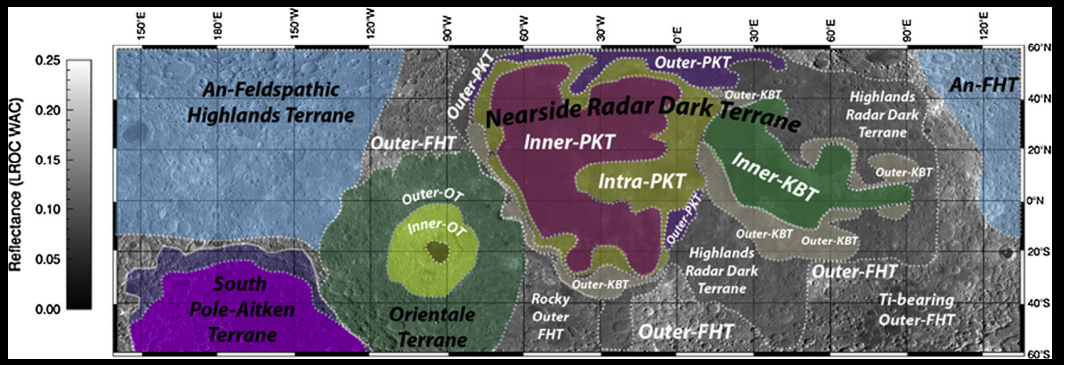
Science Nuggets

Cahill et al. (2014) The Miniature Radio Frequency instrument's (Mini-RF) global observations of Earth's Moon. *Icarus* **243**, 173-190.

- Mini-RF global orthorectified uncontrolled S-band maps of the Moon suggest three distinct terranes:



  - Nearside Radar Dark Region;
  - Orientale basin and continuous ejecta; and the
  - Highlands Radar Bright Region.
- Integration of geochemical data sets with new geophysical data sets allows us to refine these terranes.
- Results show a more complex view of these same crustal provinces and provides valuable scientific and hazard perspectives for future targeted human and robotic exploration.