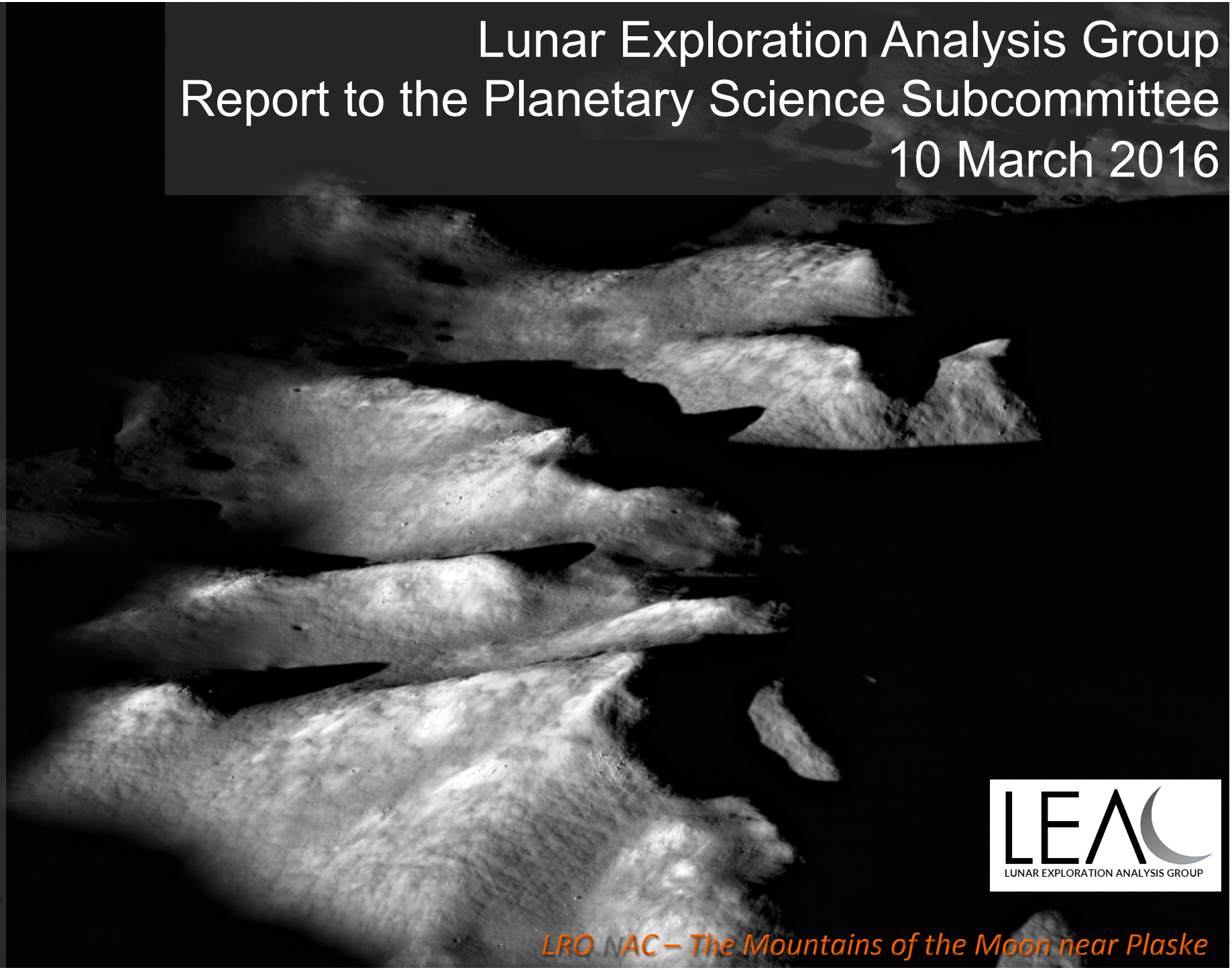
exploration science resources commerce

Lunar Exploration Analysis Group
Report to the Planetary Science Subcommittee
10 March 2016



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LRO NAC – The Mountains of the Moon near Plaske

LEAG Meeting 20-22 Oct. 2015 Findings

2015 LEAG Meeting Findings

Lunar Polar Volatiles [SMD-PSD, HEOMD-AES]

Finding 1. The LEAG community supports the selection of cubesat missions that can start to address the higher spatial resolution issue of lunar polar volatiles that will inform future rover missions to the lunar surface.

Finding 2. A broad understanding of the type, distribution, and distribution of lunar polar volatiles can only come from the synthesis of multiple data sets, including new observations. This synthesis should be considered in Senior Review decisions regarding LRO mission extensions, and will be significant in the formulation of future surface missions to the lunar poles.

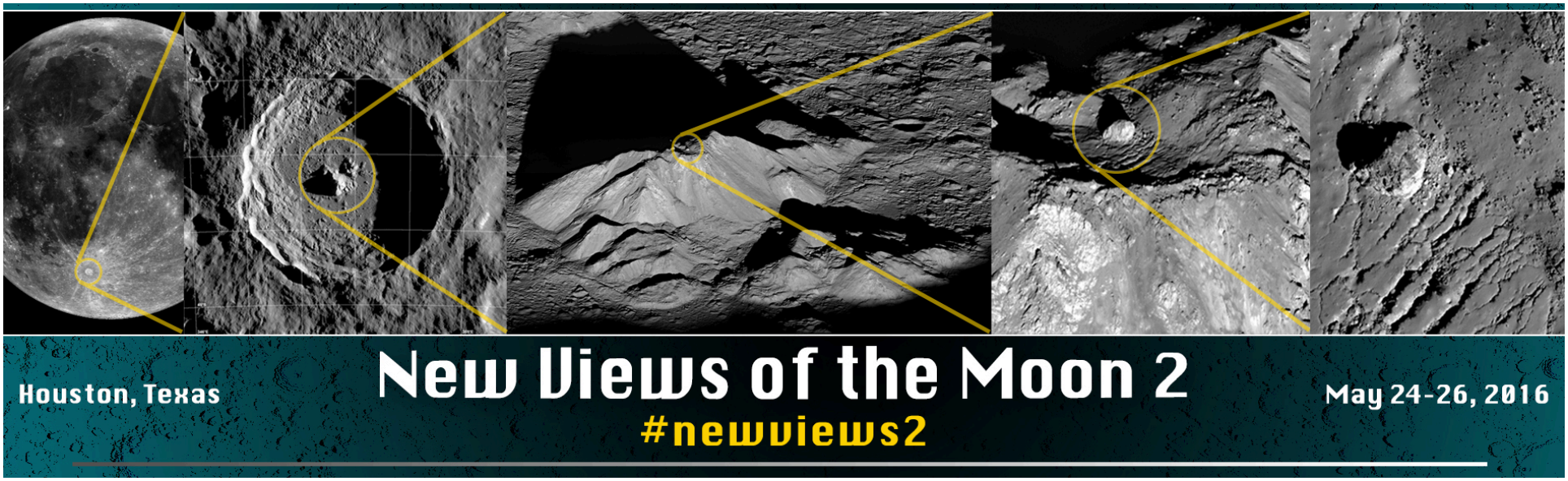
Background. Recent progress has been made in understanding of the amounts, distribution, and form of volatiles in lunar polar regions. However, higher spatial resolution and ground truth are still needed in order to assess lunar polar volatiles as a resource. Cubesats have a strong potential for providing individual measurements of great value for furthering the understanding of lunar polar volatiles both for science and exploration.

LEAG Meeting 20-22 Oct. 2015 Findings

LEAG Activities 2016

- **New Views of the Moon 2**

- Chapter co-leads identified and most have accepted;
- First workshop scheduled 24-26 May 2016 @ LPI.
  http://www.hou.usra.edu/meetings/newviews2016/



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LEAG Activities 2016 (cont.)

- **Geological Astronaut Training SAT**
  - Dean Eppler and Jake Bleacher co-chairs;
  - Face-to-face meeting in 12-14 January at GSFC;
  - Report delivered to HEOMD and Astronaut Office by the end of March.

- **SKG-2-SAT (Review of SKG Document)**
  - Chip Shearer, Chair
  - First two telecon meetings are completed
  - Report due end of 1st September 2016.

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LEAG Activities 2016 (cont.)

- **Human Exploration Proving Ground SAT**
  - Mark Jernigan and Clive Neal co-chairs;
  - Provide science objectives for the set of proving-ground missions to cis-lunar space;
  - Report delivered to JSC by the end of September.
- **LEAG Technology Roadmap**
  - Georgiana Kramer, David Lawrence co-chairs;
  - Soliciting community volunteers to help.

LEAG Activities 2016 (cont.)

LEAG @ LPSC

- LEAG Town Hall – Wednesday
- LEAG-NGLSE Networking gathering – Wednesday evening.

2016 Annual Meeting

- 1-3 November @ USRA HQ, Maryland;
- Won't conflict with the L-DAP deadline!

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LROC @ NASM

Reception 10 March 2016

https://airandspace.si.edu/exhibitions/lroc/online/

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Science Nuggets

Lunar volatile depletion due to incomplete accretion within an impact-generated disk

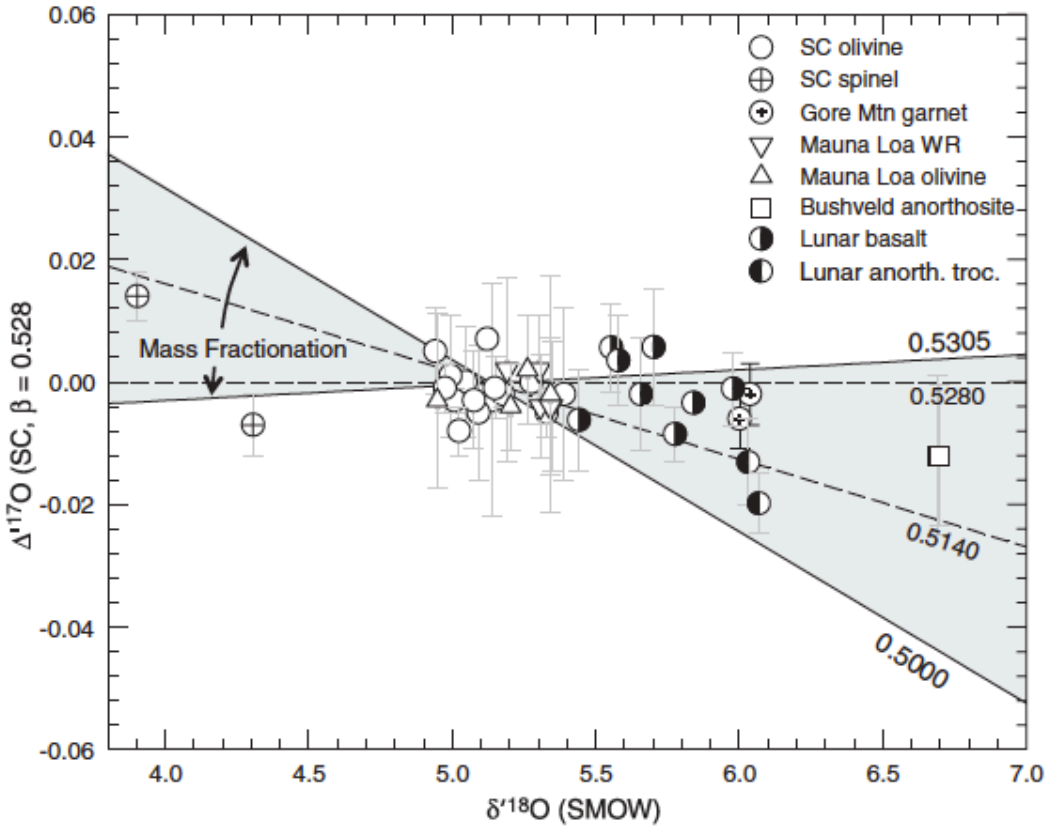
Canup R.M. et al. (2015) *Nature Geoscience* **8,** 918-921

- Dynamical models suggest that the Moon initially accreted from the outermost disk, but later acquired up to 60% of its mass from melt originating from the inner disk.
- New modeling shows the Moon can be explained by preferential accretion of volatile-rich melt in the inner disk to the Earth, rather than to the growing Moon.
- Simulations show the delivery of inner disk melt to the Moon effectively ceases when gravitational interactions
- cause the Moon's orbit to expand away from the disk, and this termination of lunar accretion occurs before condensation of potassium and more volatile elements.

Oxygen isotopic evidence for vigorous mixing during the Moon-forming giant impact

Young E.D. et al. (2016) *Science* **351**, 493-496.

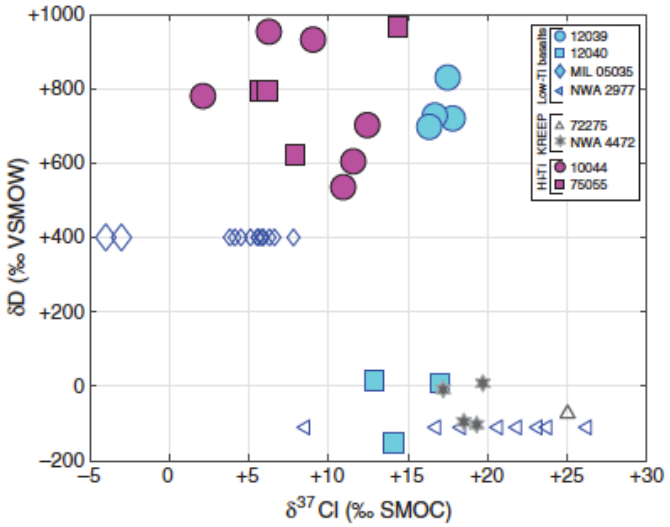
- Earth and the Moon are shown here to have indistinguishable oxygen isotope ratios, with a difference in $\Delta^{17}O$ of −1 ± 5 parts per million (2 sigma).
- Results favor vigorous mixing during the giant impact and therefore a high-energy, high-angular-momentum impact.
- Late veneer impactors had an average $\Delta^{17}O$ within approximately 1 per mil of the terrestrial value, limiting possible sources for this late addition.

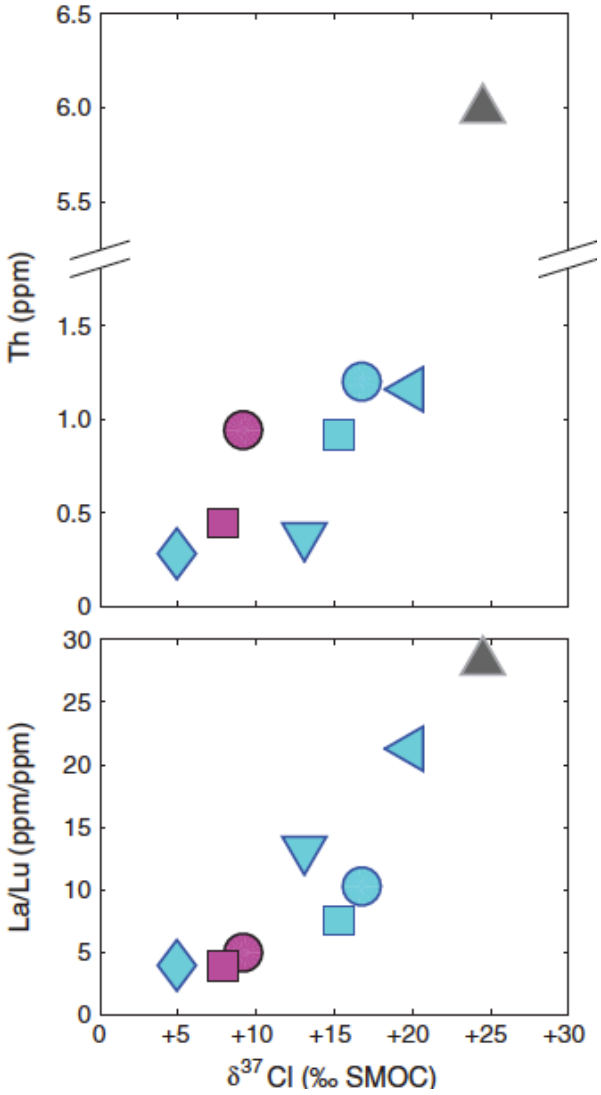


The chlorine isotope fingerprint of the lunar magma ocean

Boyce J.W. et al. (2015) *Science Advances*;1:e1500380

- The Moon contains chlorine that is isotopically unlike that of any other body yet studied in the Solar System
- Little evidence that anhydrous lava outgassing was important in generating chlorine isotope anomalies.
- The high 37Cl/35Cl in lunar basalts is inherited from urKREEP.
- The high chlorine isotope ratios of lunar basalts result not from the degassing of their lavas but from degassing of the lunar magma ocean early in the Moon's history.

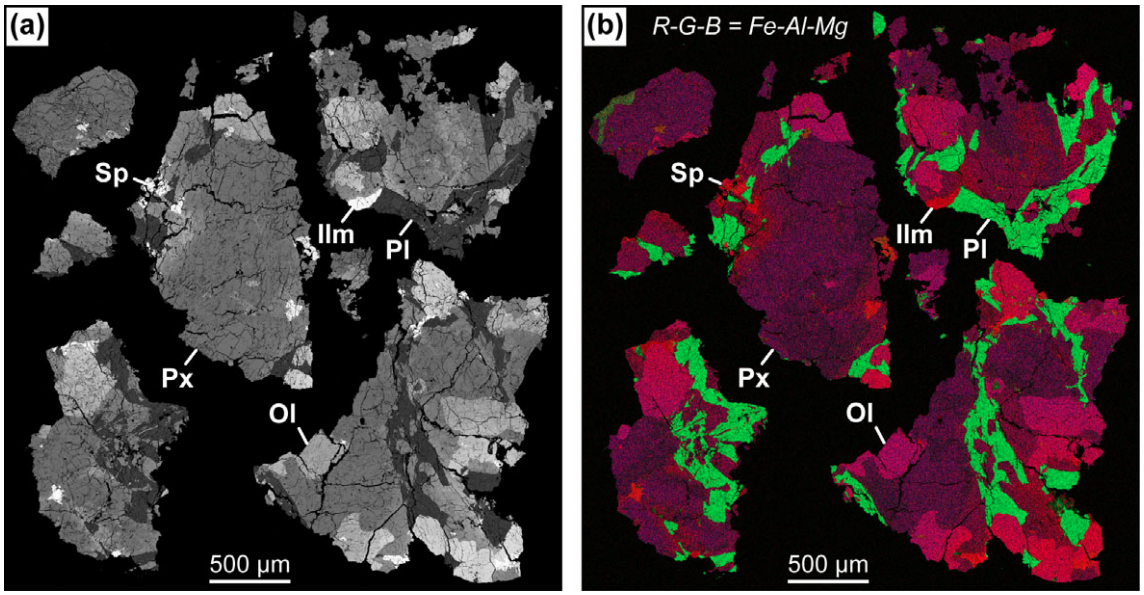


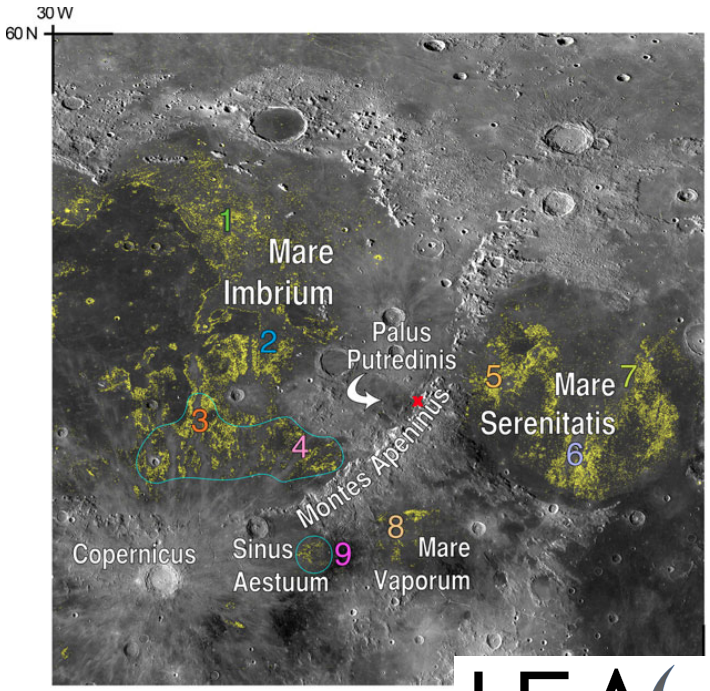


Petrology and provenance of a very-low-titanium picrite clast in lunar highland regolith breccia 15295

Yann SONZOGNI*, Georgiana Y. KRAMER, and Allan H. TREIMAN (2016)
Meteoritics & Planetary Science **51**, 31-55.

- Bulk composition of clast 15295,100 is primitive compared to those of known VLT basalts, and is similarto those of VLT picritic green glasses, especially the Apollo 14 A green glass.
- Represents a crystalline product of a picritic magma similar to the A-14 A glass.
- Areas in southern Mare Imbrium and the eastern half of Sinus Aestuum are source candidates.





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Lunar impact basins revealed by Gravity Recovery and Interior Laboratory measurements

Neumann G.A. et al. (2015) *Science Advances* **1**:e1500852.

- GRAIL data indicate a marked change in the gravitational signature of lunar impact structures at the morphological transition from complex craters to peak-ring basins.
- At crater diameters larger than ~200 km, a central positive Bouguer anomaly is seen within the innermost peak ring, and an annular negative Bouguer anomaly extends outward from this ring to the outer topographic rim crest.
- These observations demonstrate that basin-forming impacts remove crustal materials from within the peak ring and thicken the crust between the peak ring and the outer rim crest.
- Identifies basins that are now topographically indistinct.