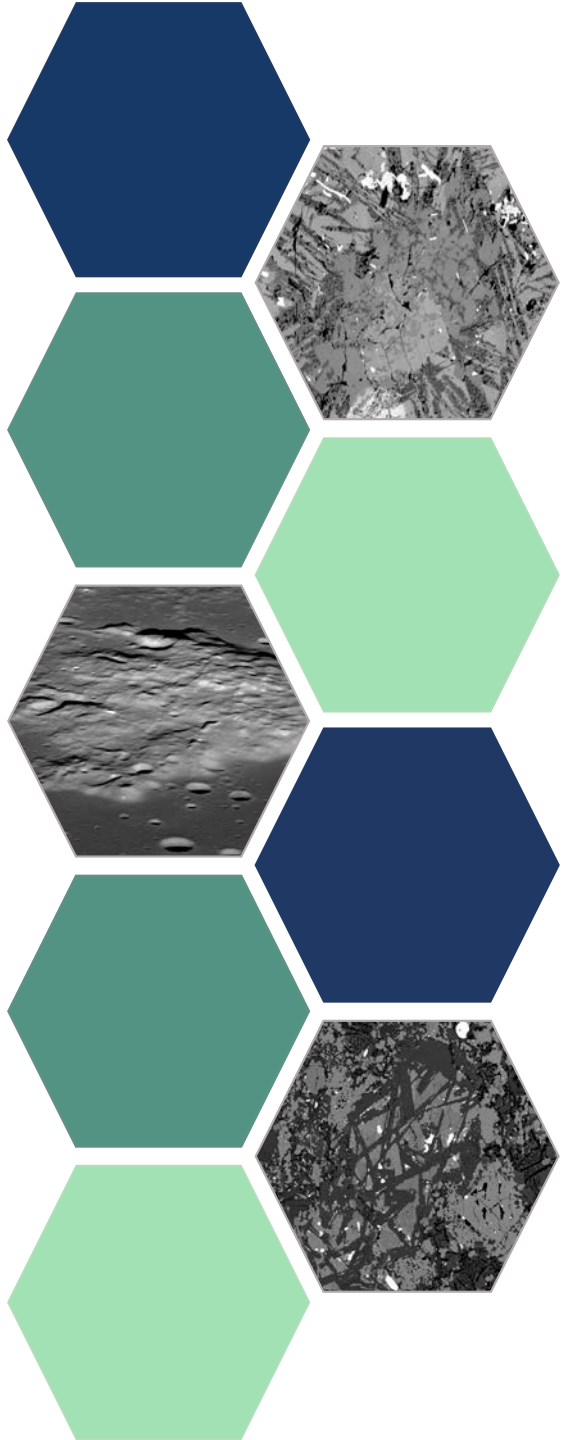
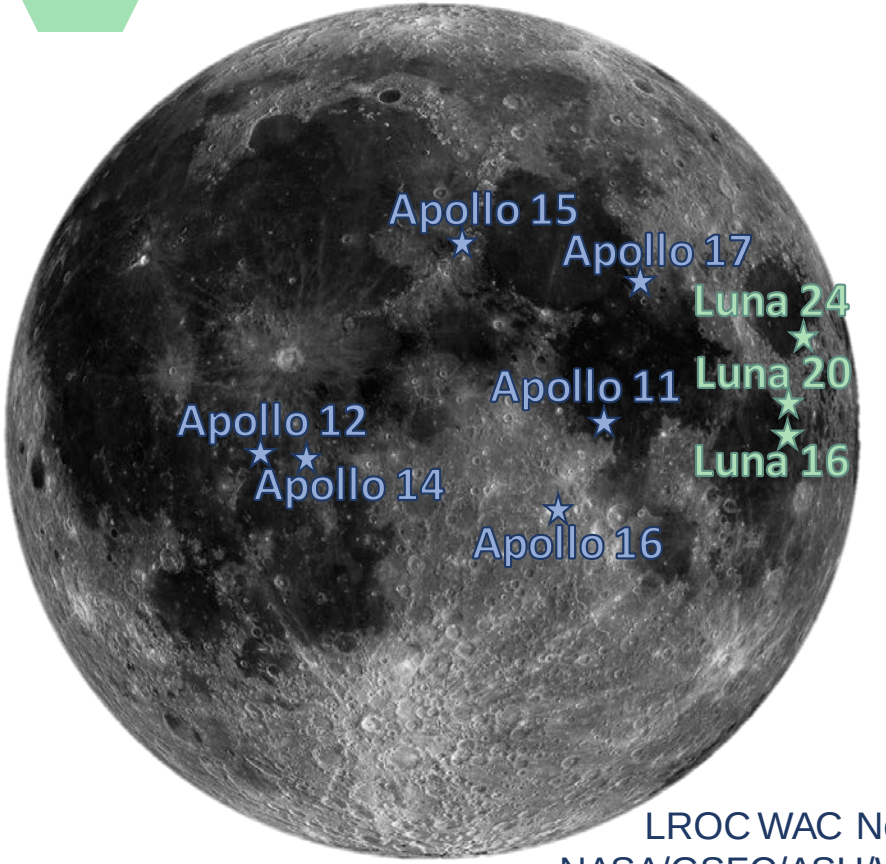


End-member Volcanism in the Absence of Plate Tectonics: Silicic Volcanism on the Moon

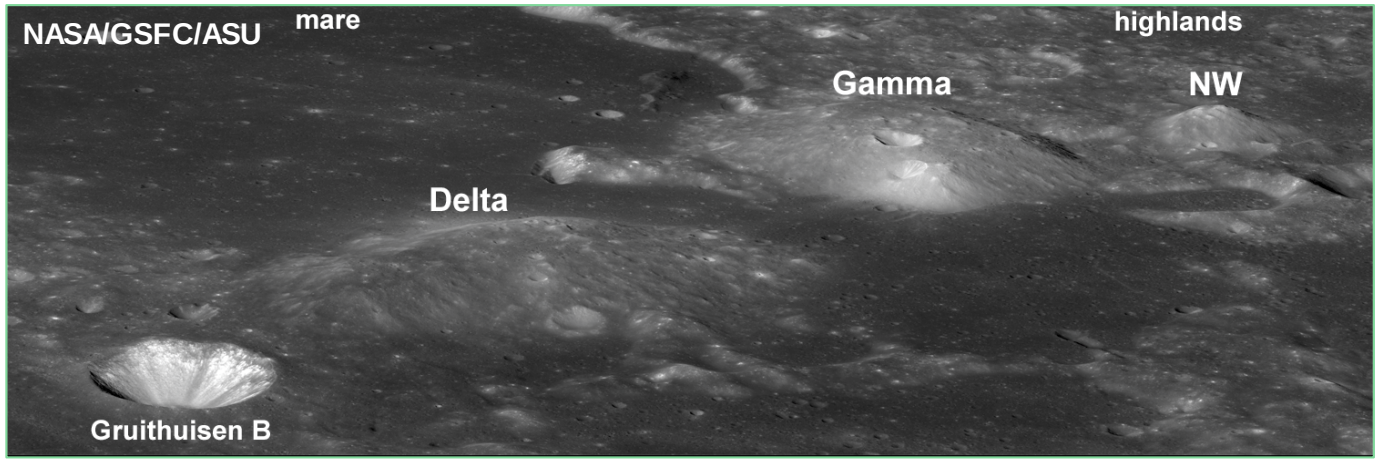
Sarah N. Valencia (UMCP/NASA GSFC) & Ryan N. Watkins (PSI)

Co-Authors: Jacob A. Richardson, Timothy Glotch, Erica Jawin, Srinidhi Ravi, & Brad L. Jolliff

Volcanism on the Moon



LROC WAC Nearside
NASA/GSFC/ASU/WUSTL



12032,366-19
Seddio et al., 2013

Silicic volcanism on the Moon is critically in need of targeted studies to answer outstanding questions about the evolution of the lunar interior and how silicic magmatism occurs on one-plate planets in our solar system.

How does granite form on the Moon?

1. Extended fractional crystallization of a KREEPy parent melt
2. Silicate-liquid immiscibility
3. Basaltic underplating

12032,366-19
Seddio et al., 2013

Granite is common on Earth but rare on the Moon

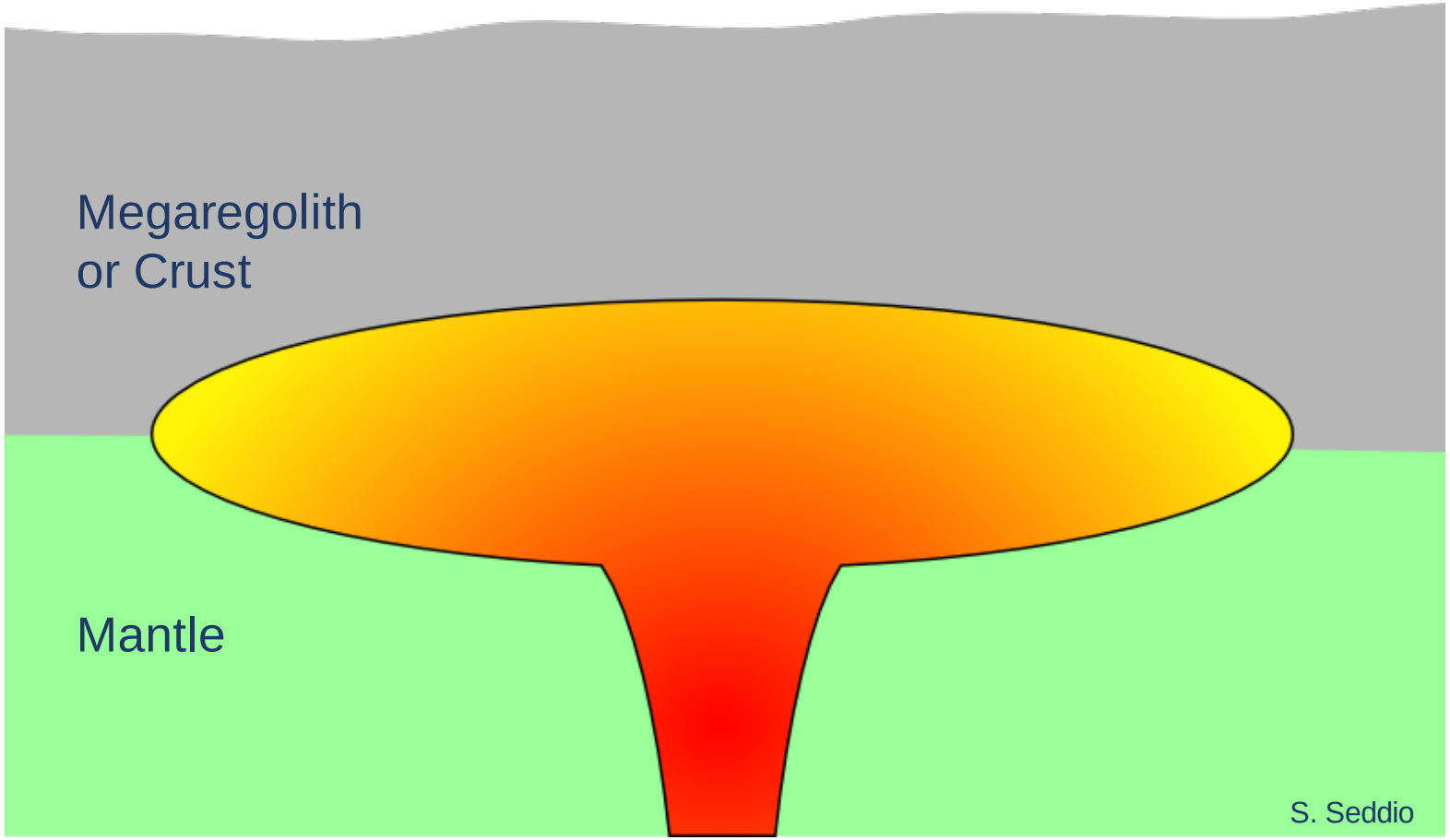
How does granite form on the Moon?

1. ~~Extended fractional crystallization of a KREEPy parent melt~~ Unlikely
2. Silicate-liquid immiscibility
3. Basaltic underplating

12032,366-19
Seddio et al., 2013

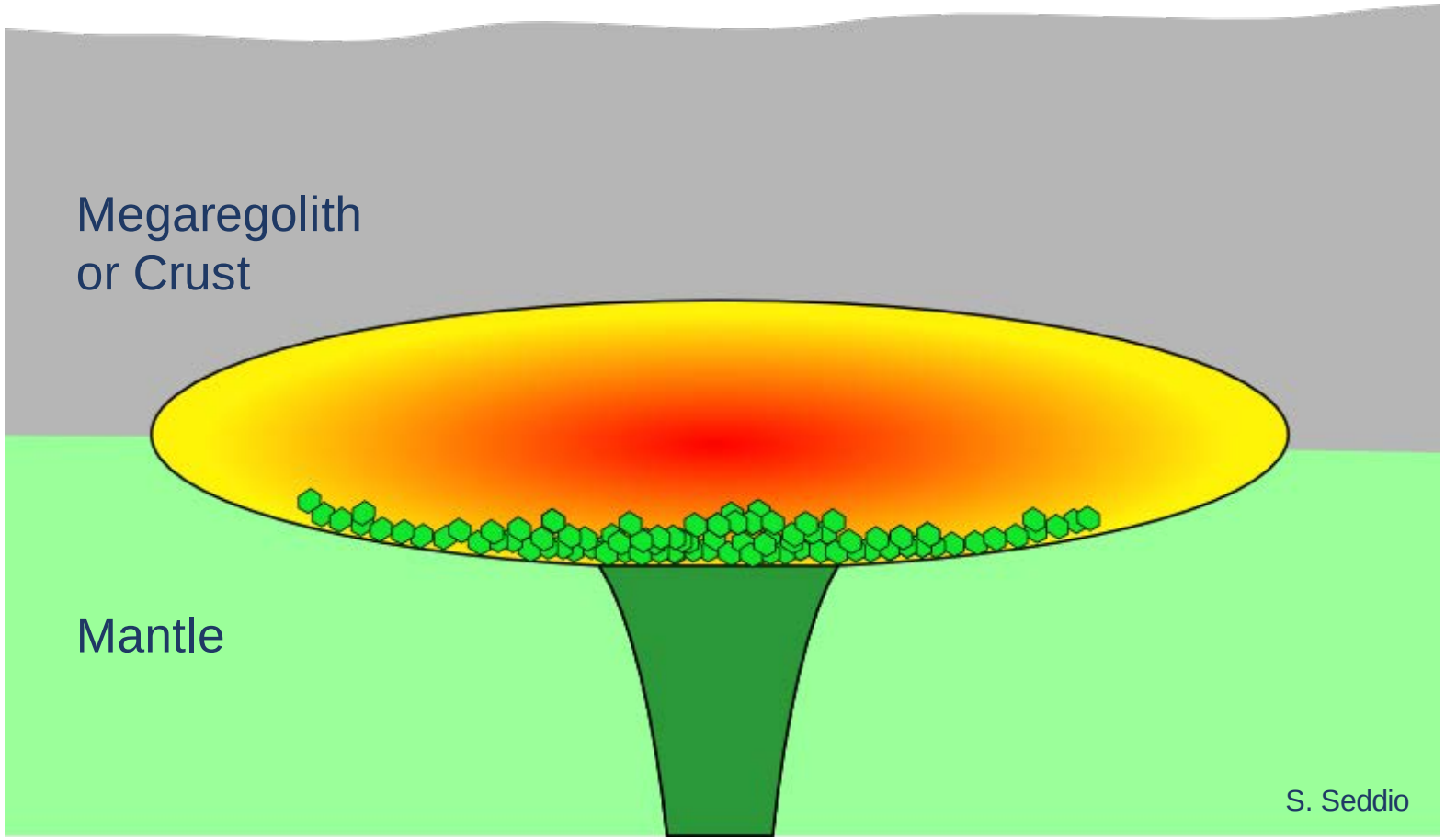
Silicate Liquid Immiscibility

KREEP rich magma intrudes and begins to cool



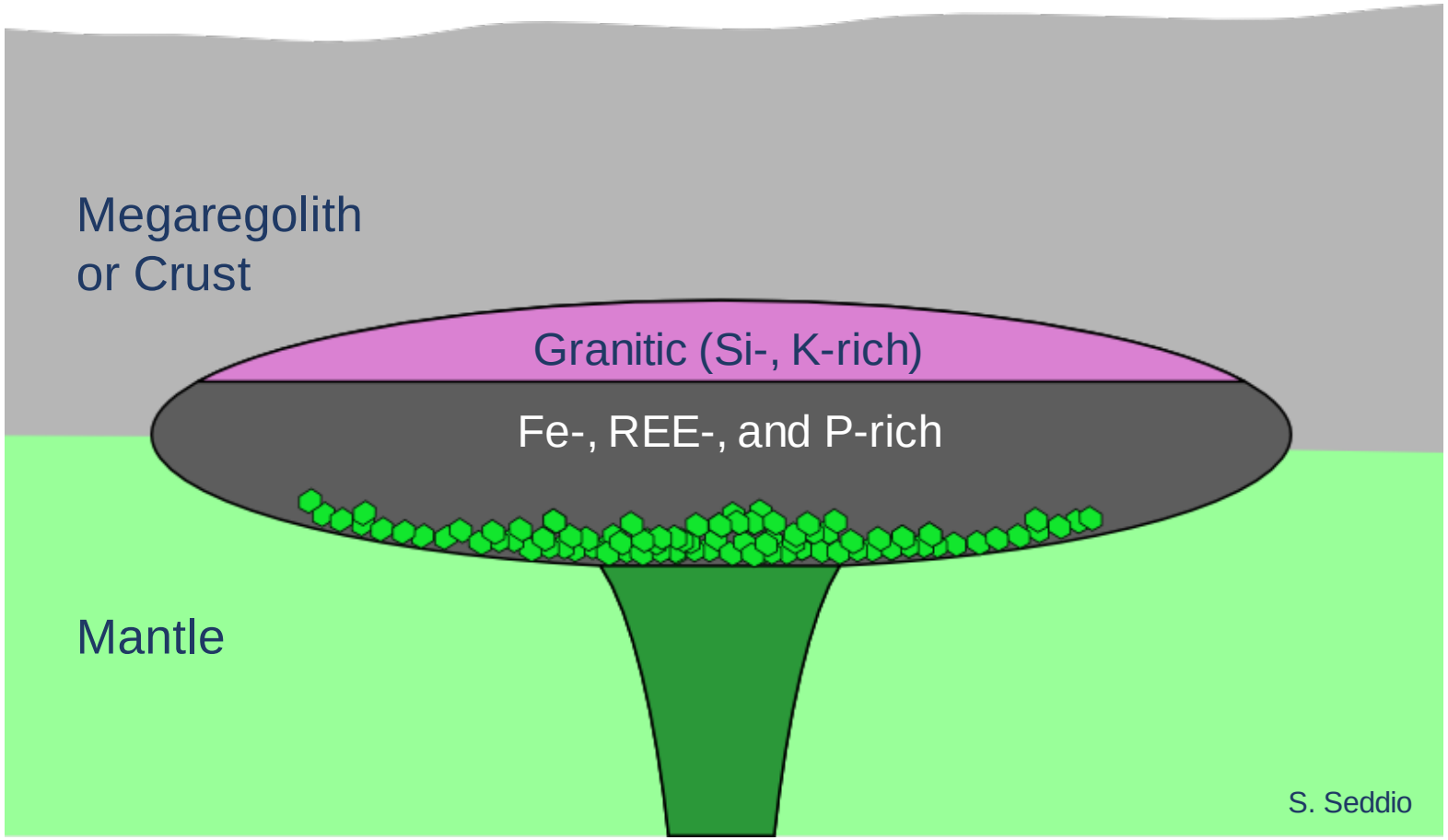
Silicate Liquid Immiscibility

Fractional crystallization of the melt begins

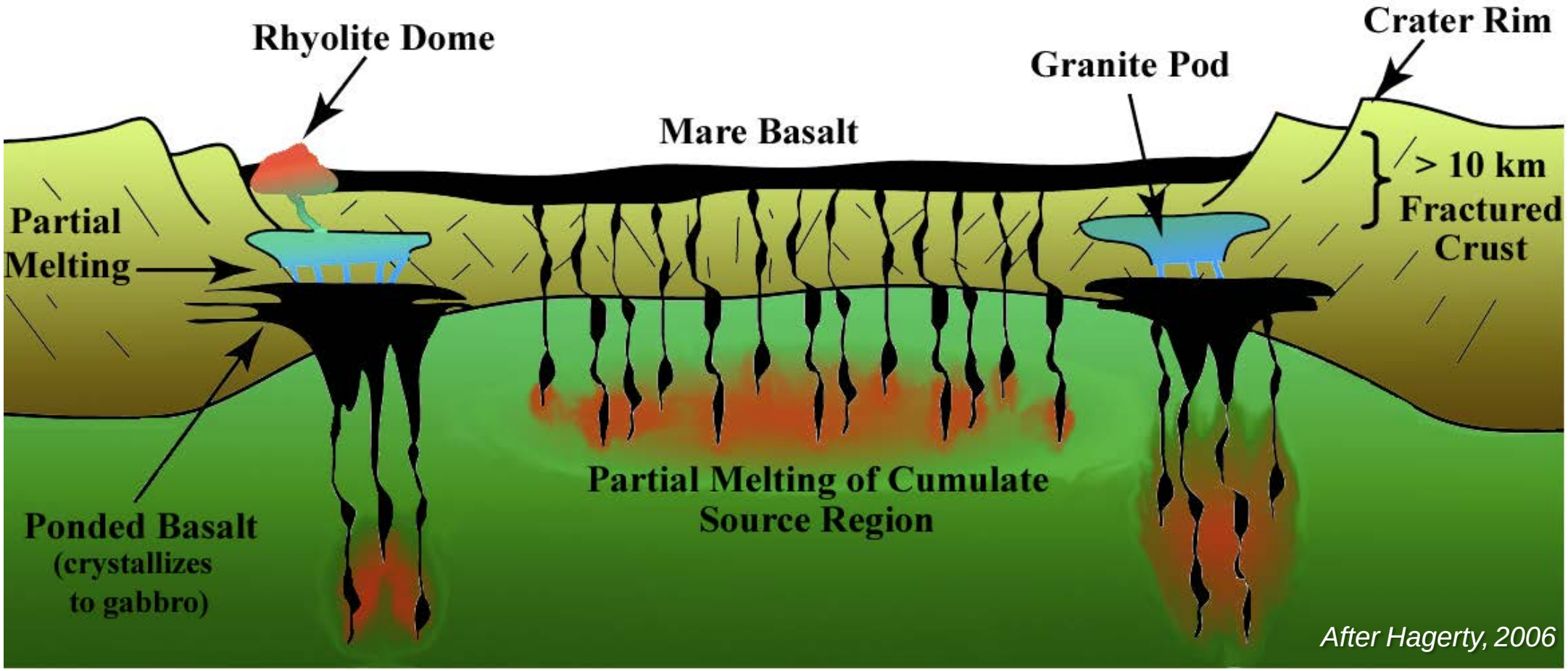


Silicate Liquid Immiscibility

The melt becomes immiscible and splits into two distinct melts



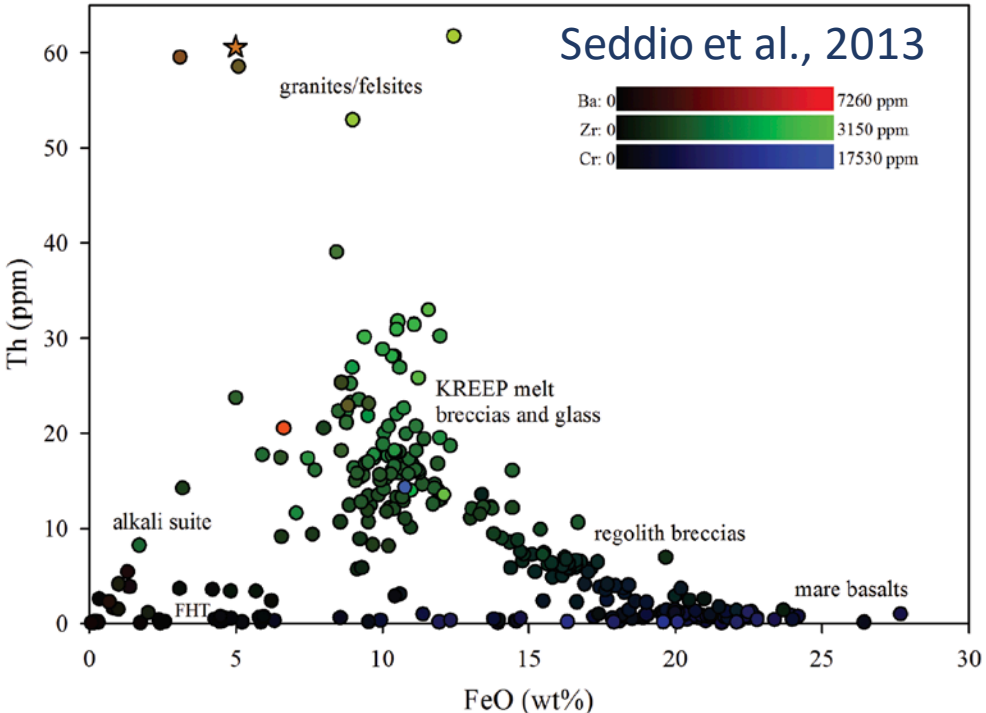
Basaltic Underplating

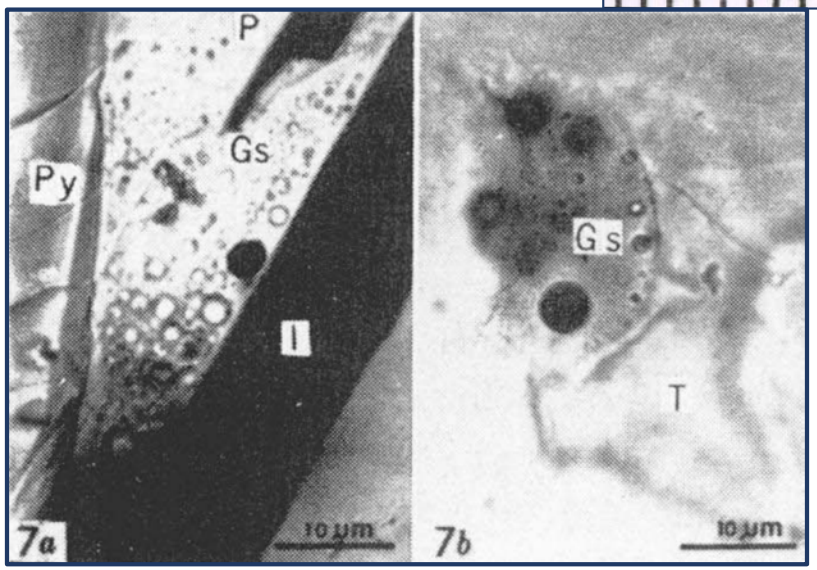


Observations from Samples

- < 20 samples known to have granite
- Found in rocks from Apollo 12, 14, 15, 17.
- Typically clasts within a breccia
- Often occur with a mafic rock
- Silicate liquid immiscibility occurs on sample scale

Slab 12013,9, Scale in mm; NASA# S70-40833

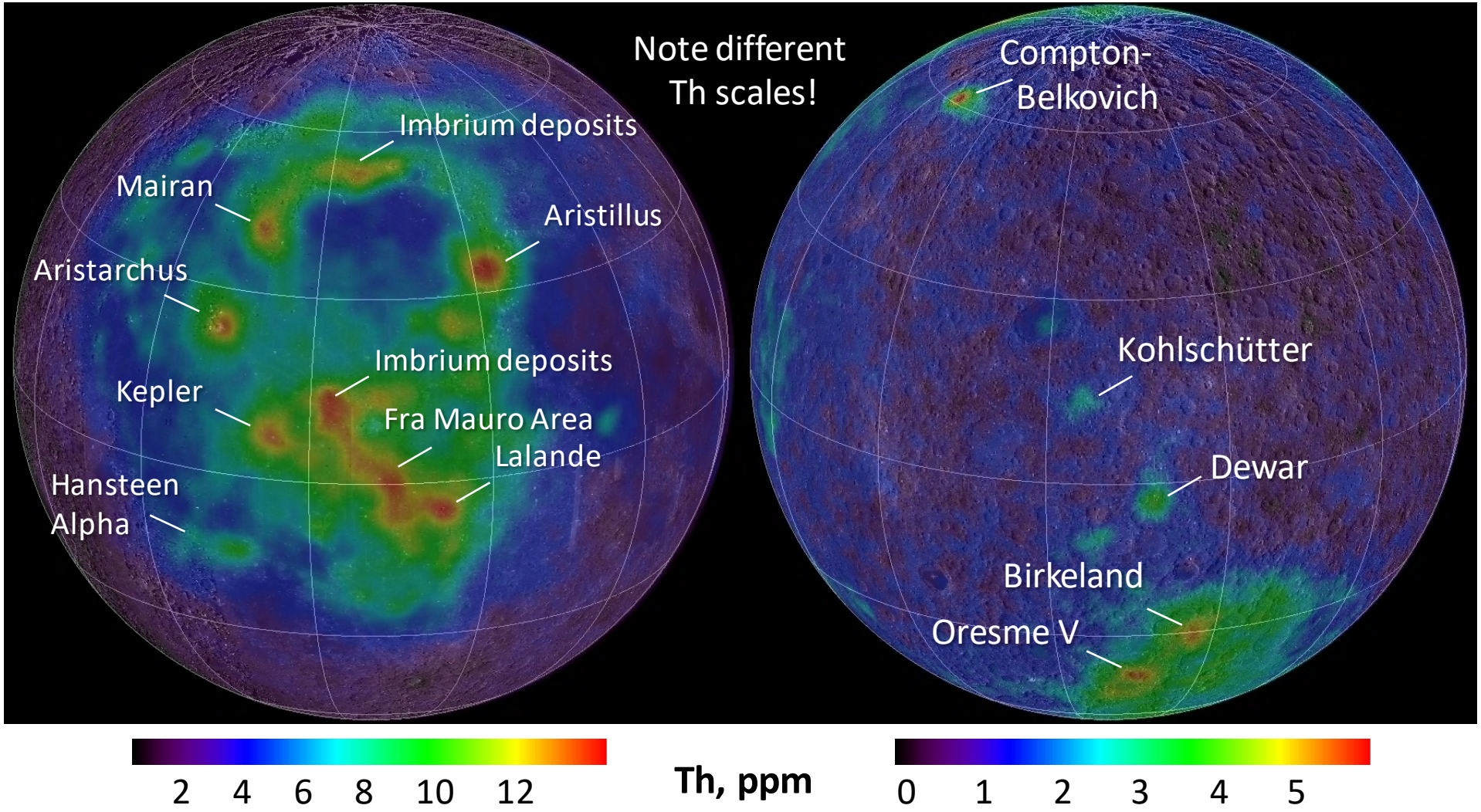




Roedder and Weiblen, 1970

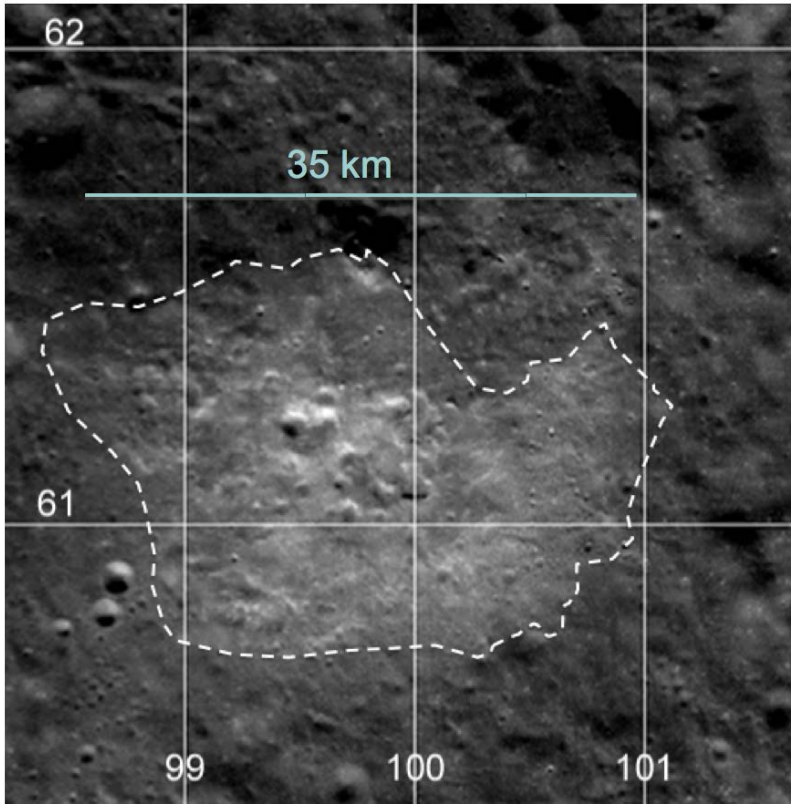
Lunar Prospector Detected Th

- Many Th hot spots correlate with spectral “red spots”
- These red spots are likely composed of viscous, silicic magma

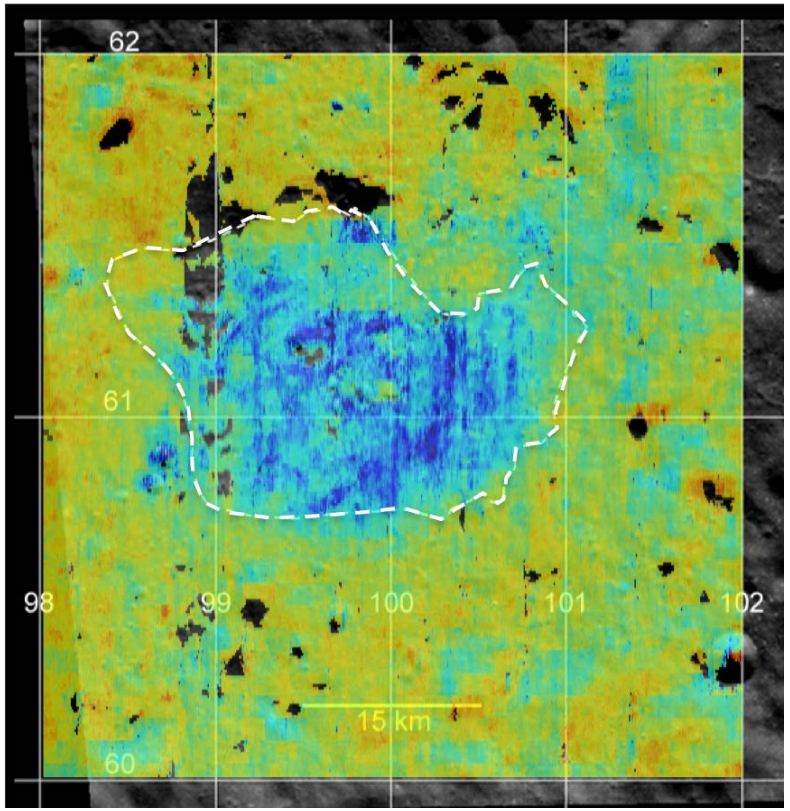


LP-GRS, 0.5 degree; Lawrence et al., 2003

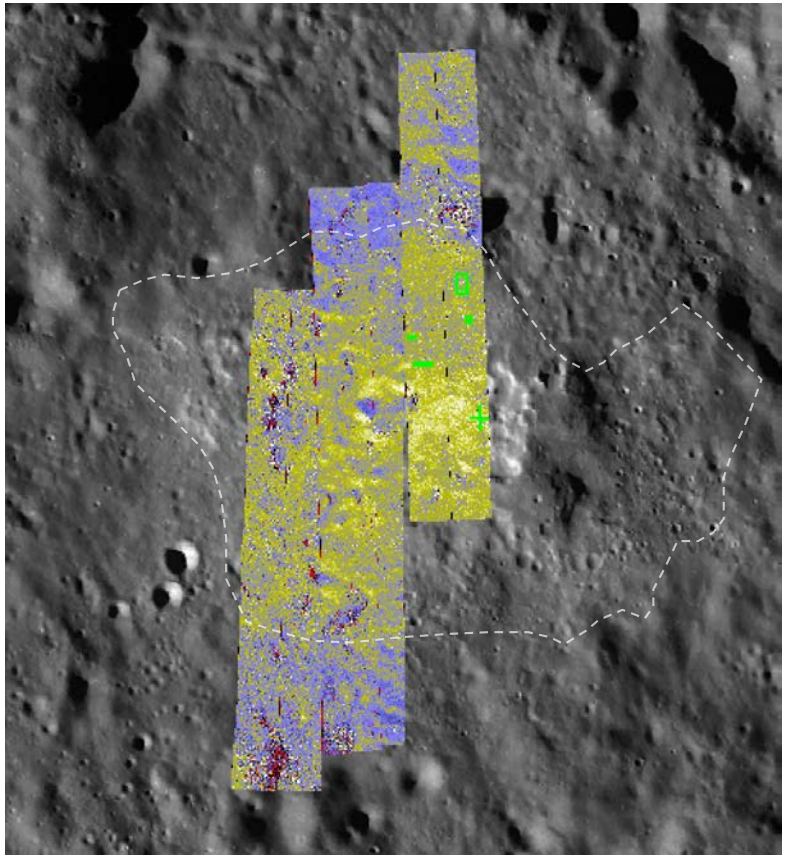
Remote Observations of Silicics



Reflectance 25-40 % higher than surroundings.
LROC Wide Angle Camera, 604 nm



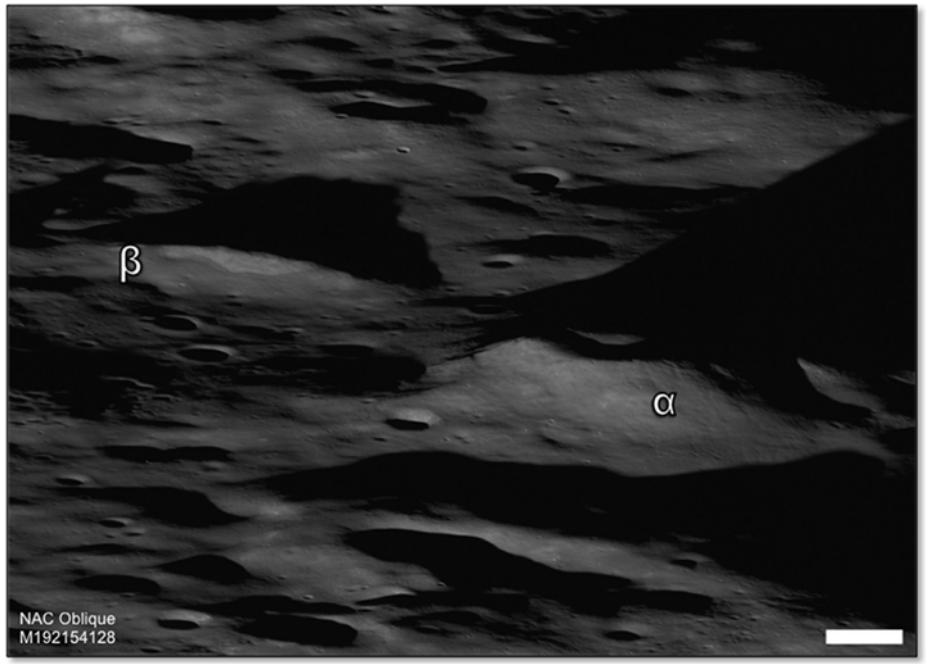
LRO Diviner Christiansen Feature (CF) data (Greenhagen et al., 2010, *Science* 329)
- indicates silica enrichment.



NAC-derived albedo (SSA or *w*) using NAC DTMs to account for topography.

Remote Observations of Silicics

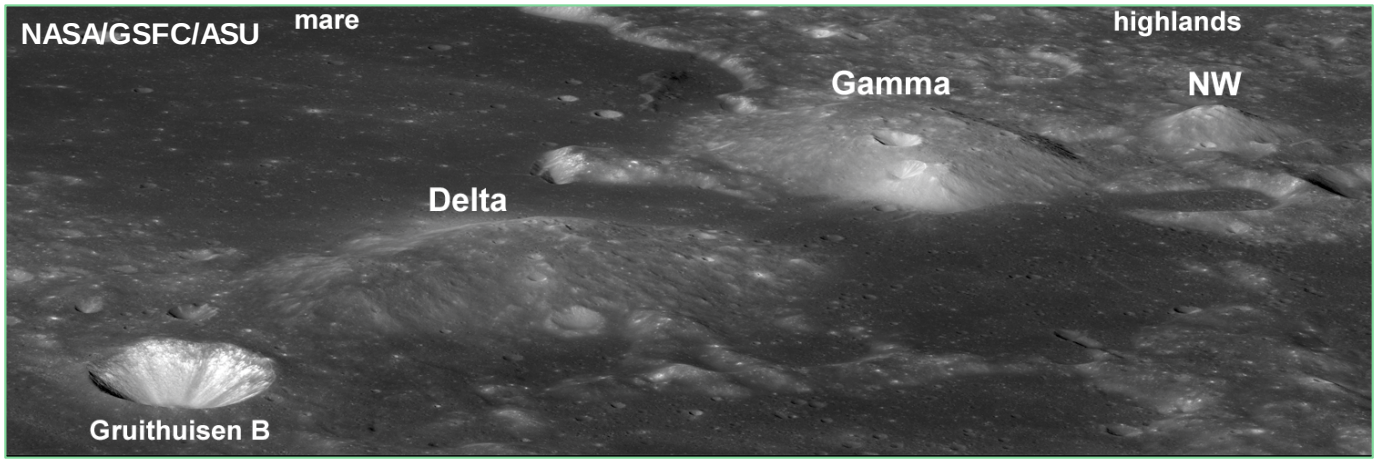
Aristarchus Crater:
Intrusive & Extrusive
Silicics
Adjacent mare



Compton-Belkovich Volcanic Complex:
Extrusive Silicics
Outside PKT

Clegg-Watkins et al., 2017

Gruithuisen Domes:
Extrusive silicates
Adjacent mare

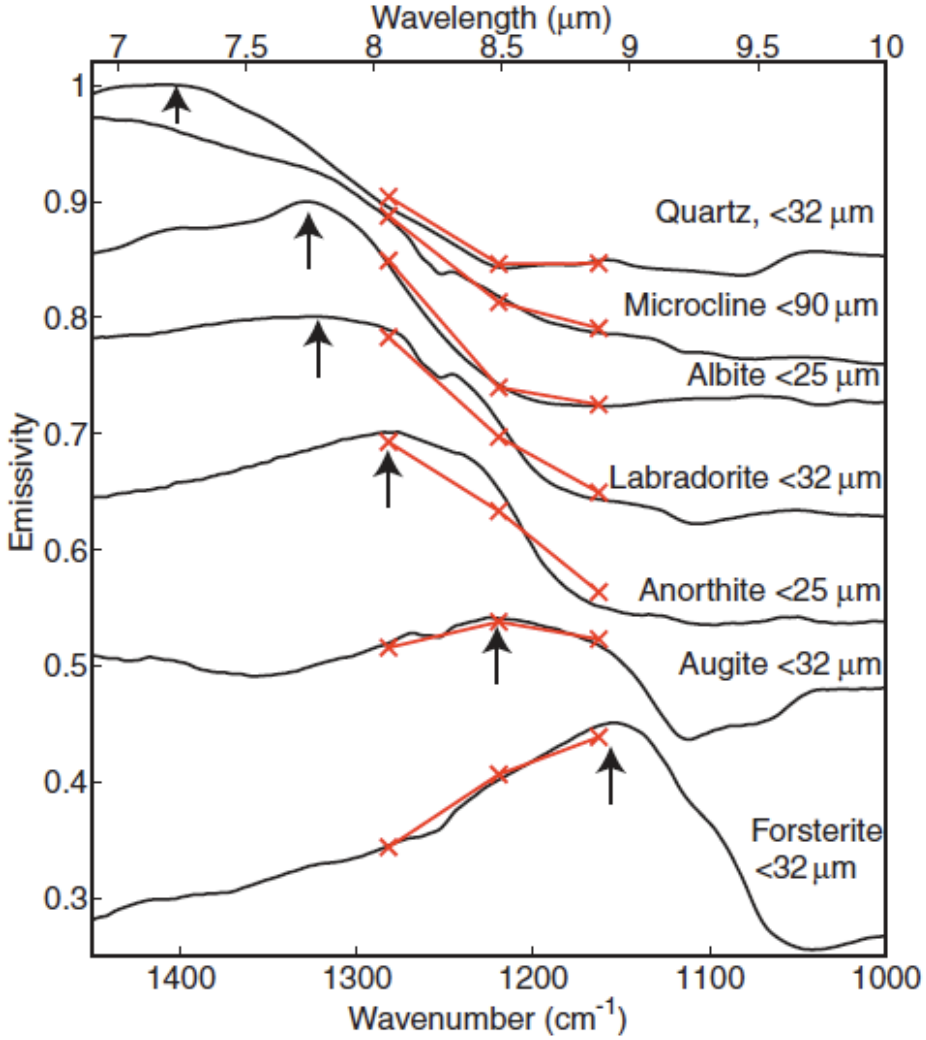


Outstanding Questions

- What is the variability in composition of silicic rocks across the Moon?
  - How silica-rich are volcanic constructs on the Moon?
  - Are the spectral signatures seen in Diviner data and photometry owing to silicic material mixing with surrounding material, or do andesitic/dacitic materials occur on the Moon?
- What is the formation mechanism for silicic rocks on the Moon?
  - What role did silicate liquid immiscibility play?
  - Did basaltic underplating of a fertile crust play a role in the formation of silicic magmas on the Moon? Are the basaltic flows adjacent to silicic constructs on the Moon related petrologically despite their differences in age?
- What role did the presence of volatiles play in the formation of silicic lithologies?

Science From Orbital Missions

- No previous missions have been optimized for the study of silicic rock types
- Hyperspectral thermal IR spectrometry would provide a robust determination of silicic anomaly compositions
- Spatial resolution of ~100 m/pixel desired
- Coincident hyperspectral VNIR spectroscopy covering the ~3 µm would help to determine the role of water in the formation of silicics



Glotch et al., 2010, Science

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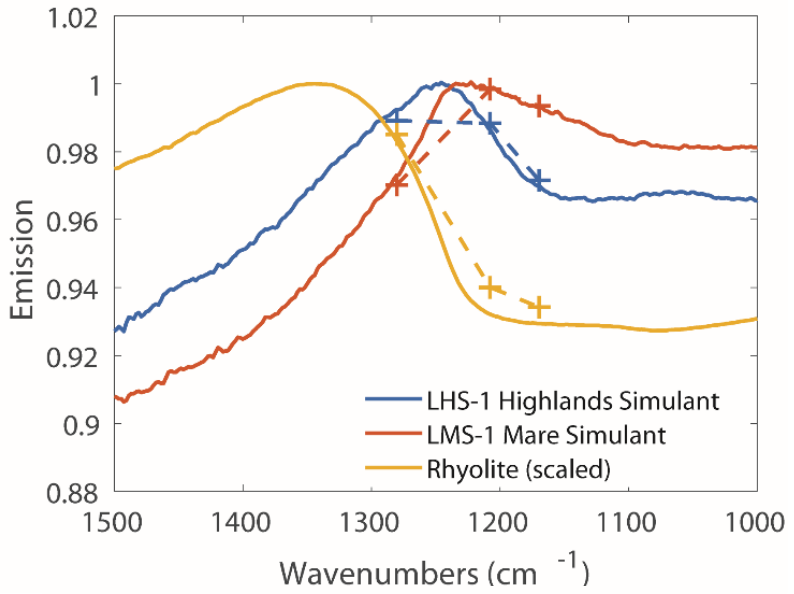
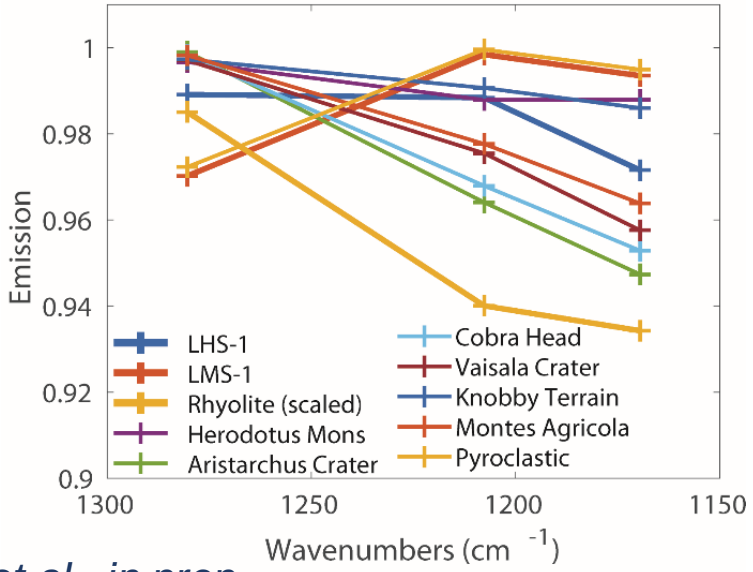




Glotch et al., in prep.

Science From Landed Missions

- Hyperspectral imaging
- In situ age determination
- APSX, XRF, and/or XRD instruments for bulk chemistry and/or mineralogy
- Gamma ray spectrometer & neutron detector for volatile abundances

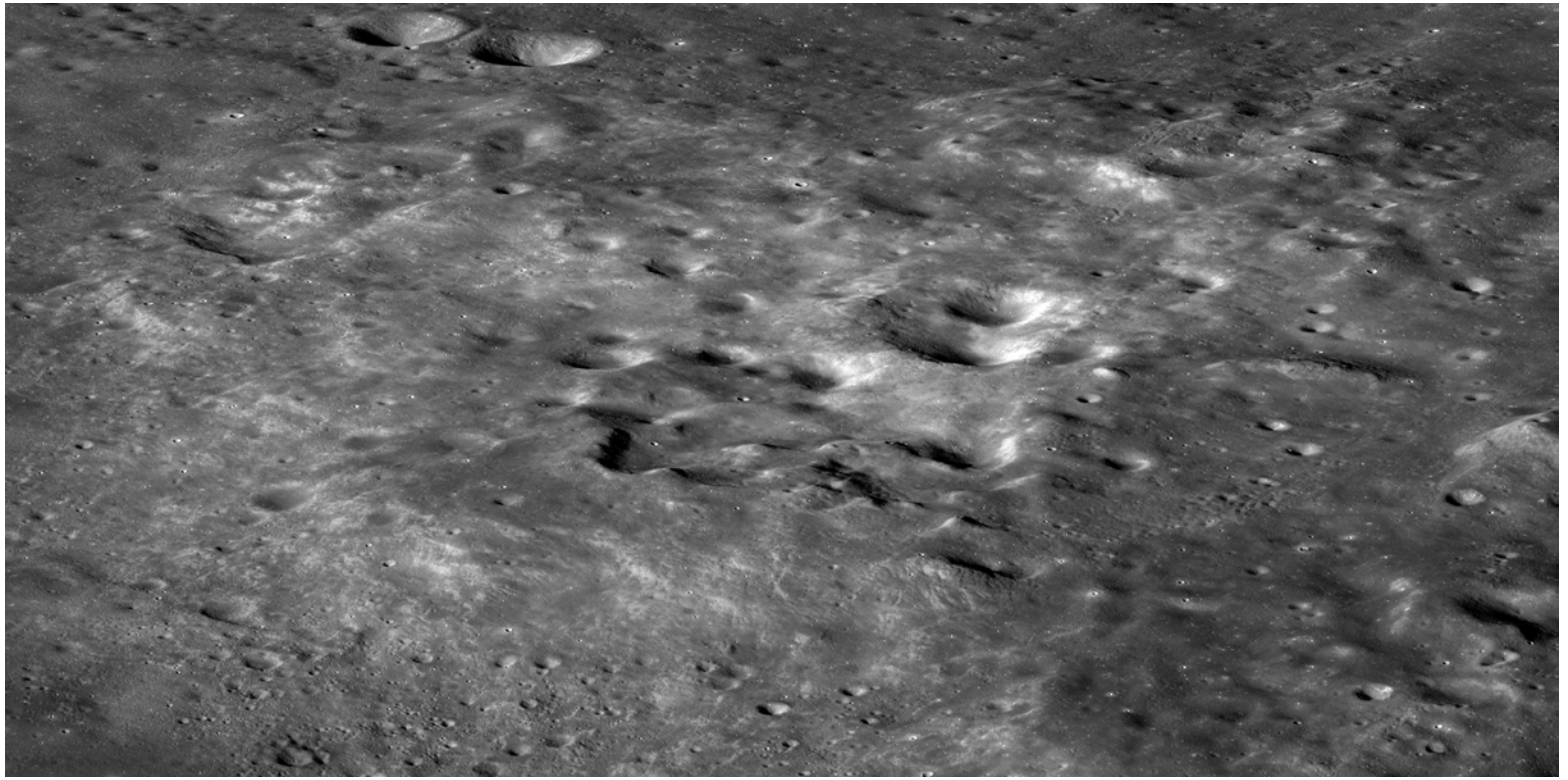
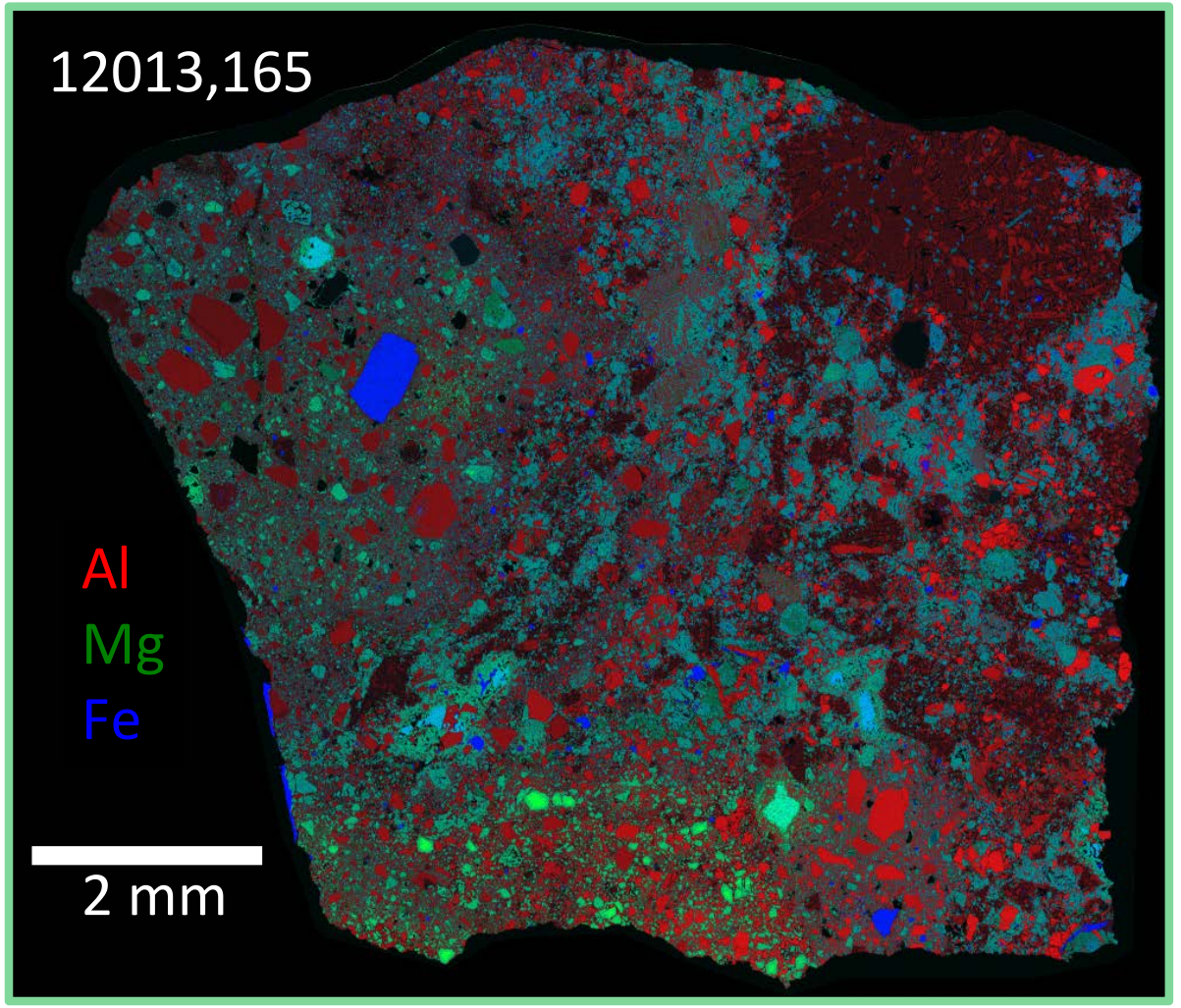
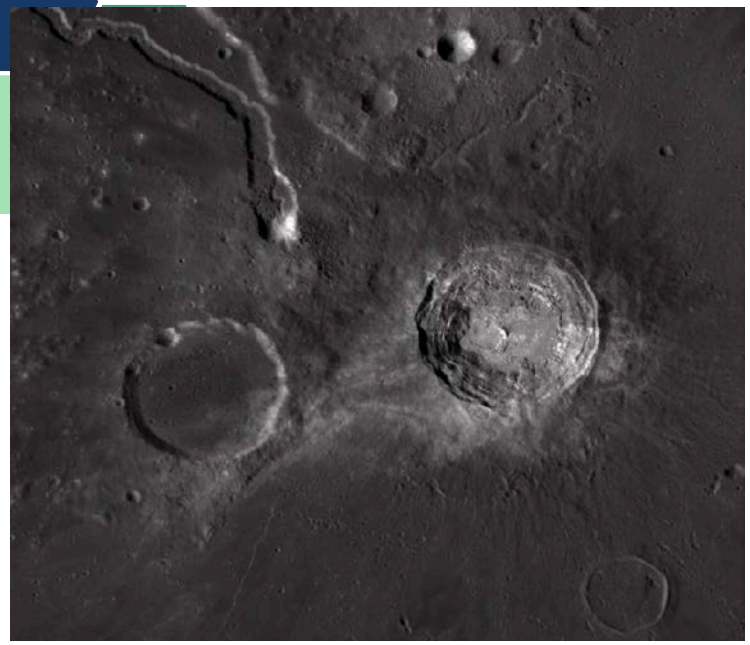


Image: M174549036 NASA/GSFC/ASU

Science From Sample Return

- Highest precision & accuracy investigations completed on Earth
  - Petrography
  - Trace-element chemistry
  - Isotopic analyses
- Most complete information on the formation and evolution of the silicic bodies from which they are sampled
- Samples from both intrusive and extrusive regions desired





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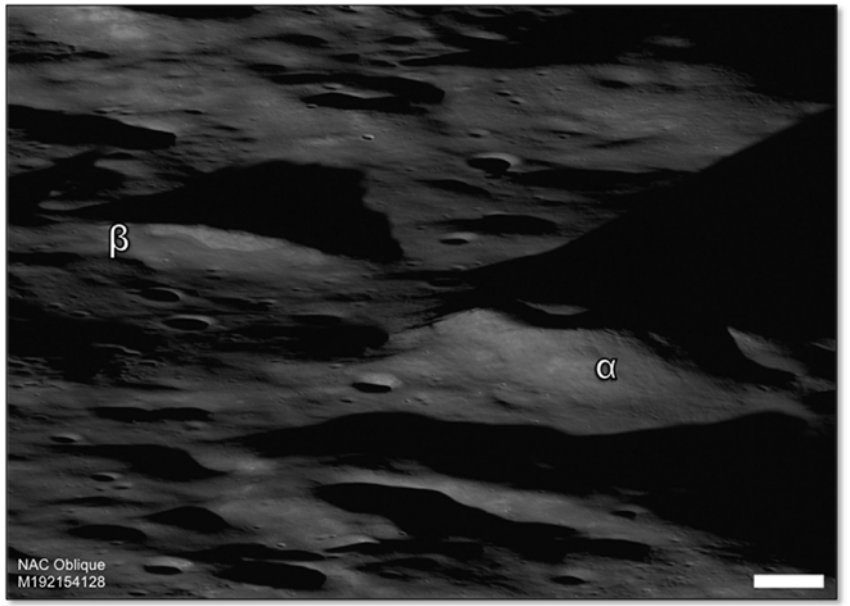

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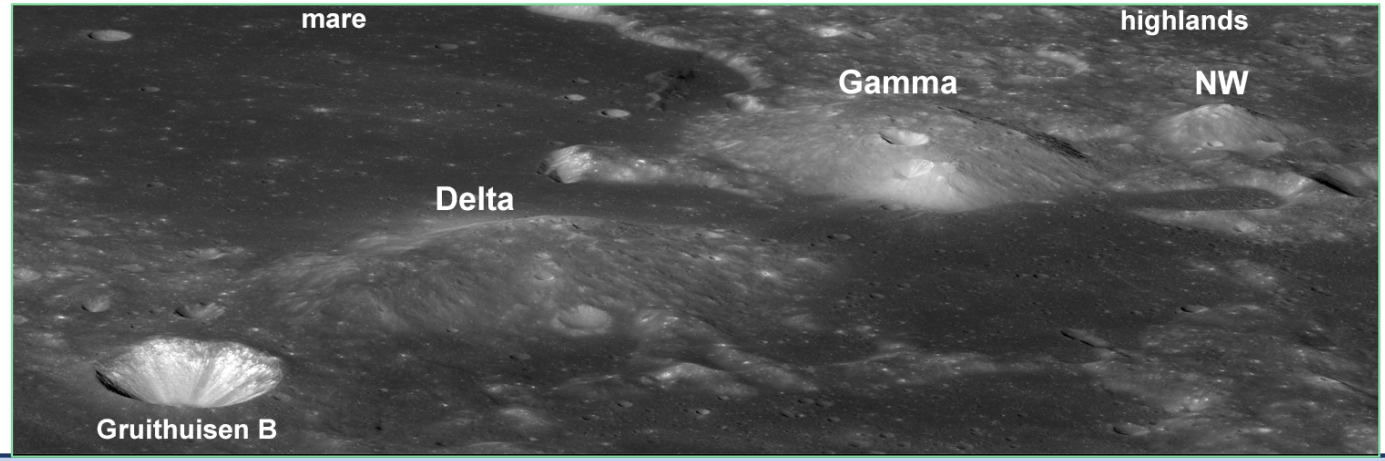

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