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The Aristarchus Plateau: Surface Analysis and Sample Return of Pyroclastic and Silicic Lithologies

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Why go there:

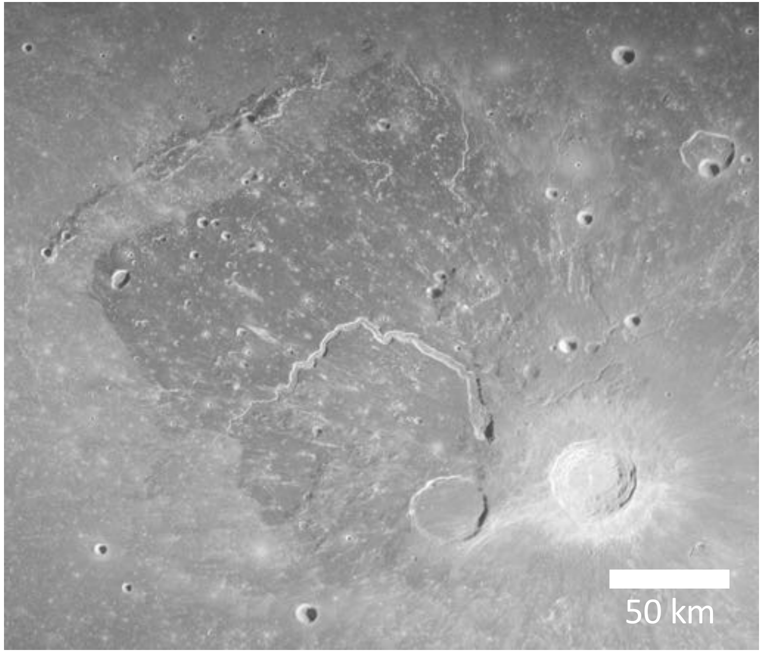
- Thick (~20 m) beds of pyroclastic deposits with up to 300 ppm H_2O
  - Opportunity to return primitive H_2O-bearing samples that will provide new insight into lunar mantle.
  - Chance to test ISRU technologies at near-side mid-latitude landing site
- Previously unsampled silicic lithologies (both intrusive and extrusive)
- Youngest basalts on the Moon in close proximity
- Opportunity to sample multiple lithologies at one site

Site Characterization: Radar

- ~10-20 m thick based on ground-based radar imagery and excavation of pyroclastics by small craters

- Buried lava flows (spillover from Vallis Schröteri?) cover much of the plateau.

- Lots of 10 cm and larger cobbles mixed with pyroclastics.



12.6 cm radar image of Aristarchus plateau region
Campbell et al. (2008)

Site Characterization: Slopes

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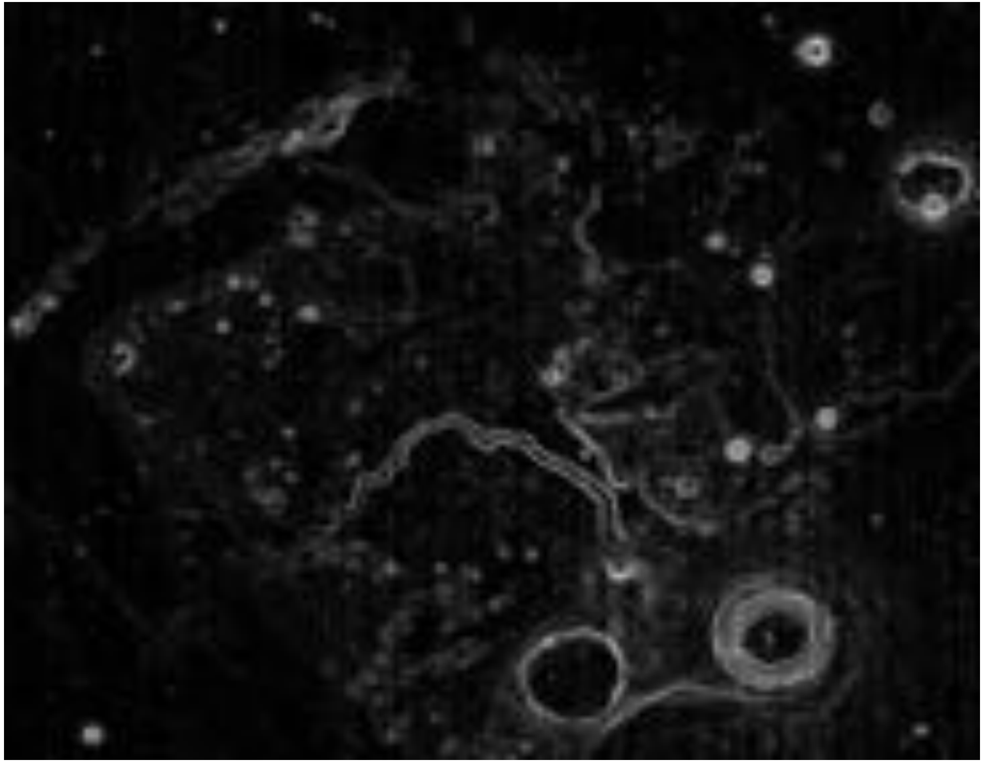
- Slopes characterized by LOLA
- Slopes across much of pyroclastic blanket range from 0 to ~4 degrees.
- Local excursions above 10 degrees for small craters.
- Slopes on Aristarchus ejecta blanket range from ~2-20 degrees.
- Slopes around the Cobra Head higher than 30 degrees.



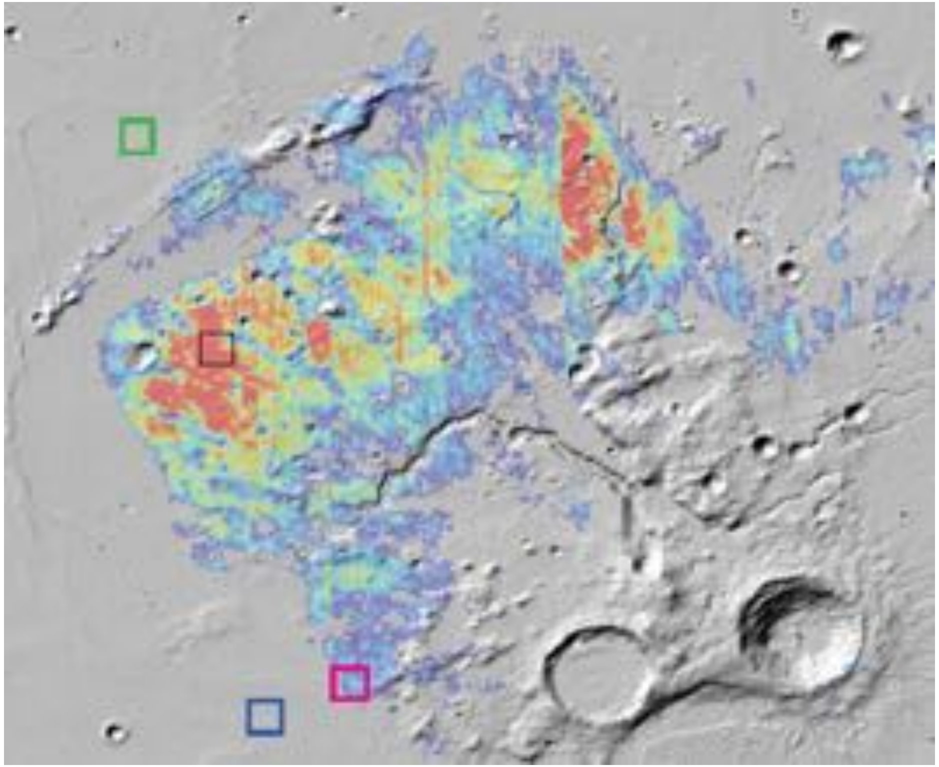
512 ppd LOLA-derived slope map

Site Characterization: VNIR

- Analysis of M^3 3 μm region provides quantitative estimates of surface hydration.

- Pyroclastic deposits on the lunar surface likely preserve indigenous lunar water.

- Water distribution on the plateau is heterogeneous, with abundances ranging from <50 ppm to > 300 ppm H_2O.



Hydration map from Milliken and Li (2017). Hydration ranges from <50 ppm (dark blue) to >300 ppm (red) H_2O.

Site Characterization: VNIR

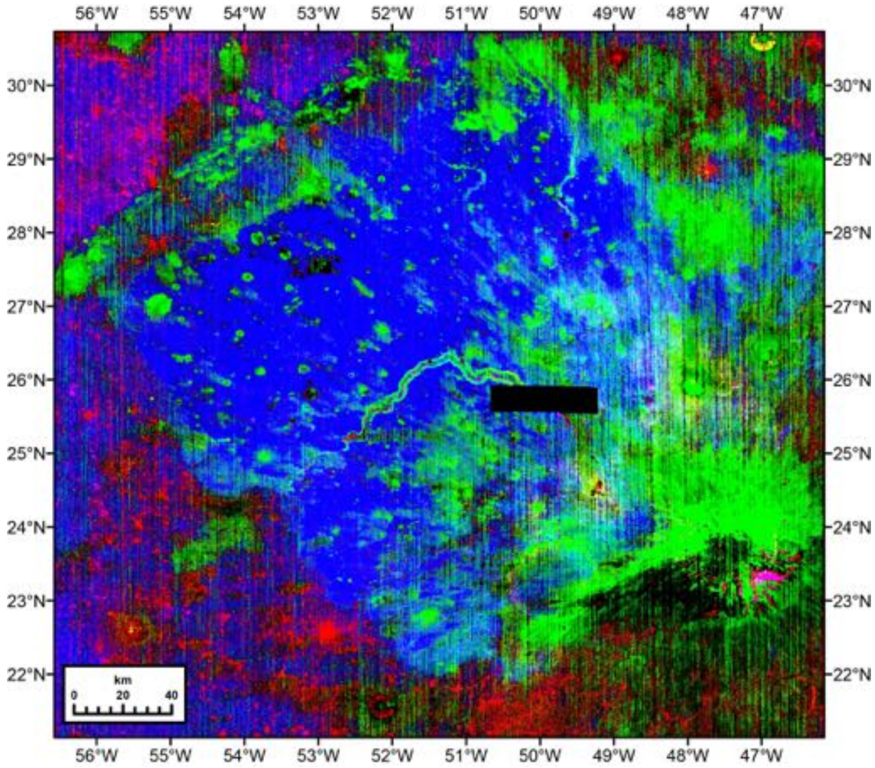
- Model of Jawin et al. utilizing M^3 data provides insight into distribution of phases in and around the plateau.

- Model prefers moderate-Ti orange glass end-member for plateau materials, but result is non-unique and other glasses could also fit.

- Model result does support other data analyses (e.g., LP-GRS) showing moderate Ti abundances on the plateau.

- Difficult for model to address abundance and distribution of low-Fe silicic lithologies in the region.

- Model still being updated, results could change.

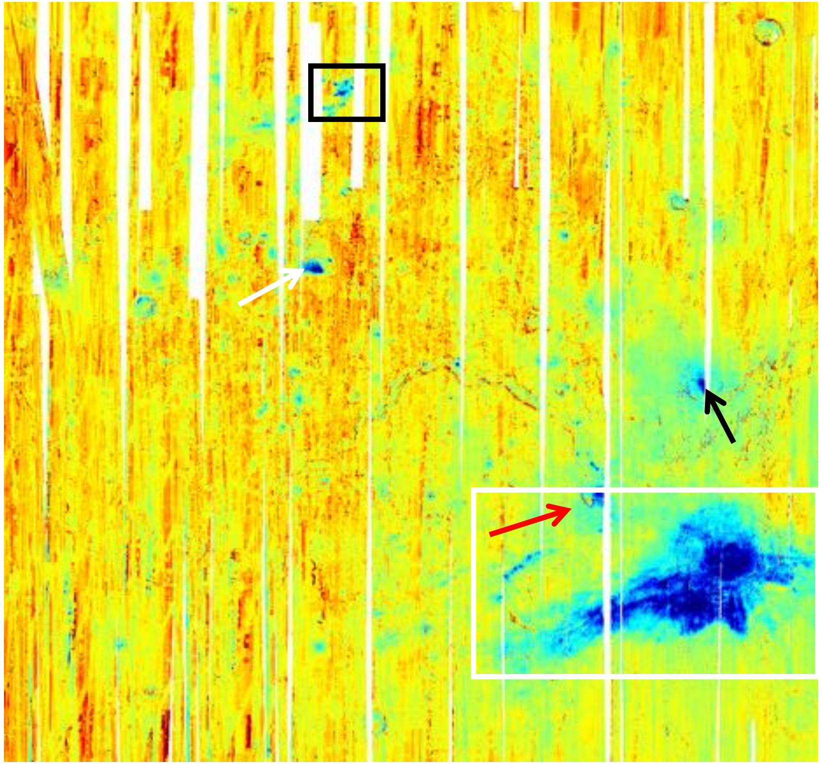


Color composite from Jawin et al. (this meeting). Red=olivine, G=orthopyroxene, B=synthetic orange glass.

Site Characterization: TIR

- Pyroclastics have mafic CF, similar to surrounding mare.

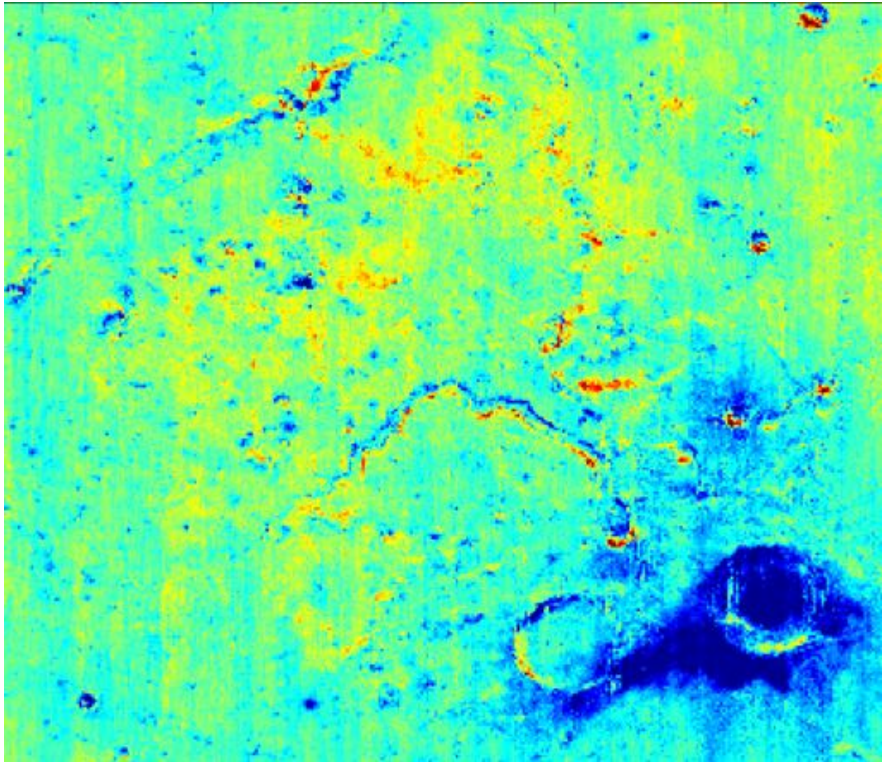
- Numerous highly silicic features consistent with granite/rhyolite composition:
  - Central peak of Aristarchus and portions ejecta (white box)
  - Cobra head (red arrow)
  - Väisälä crater (black arrow)
  - Mons Herodotus (white arrow)
  - Portions of Montes Agricola (black box)



Diviner CF map (blue to red = 7.0 – 8.6 µm).

Site Characterization: TIR

- Pyroclastics are apparent in Diviner 7/3 ratio map (ratio of bands centered at 31 and 7.8 µm).
- Band ratio highlights silicic features and separates pyroclastics from surrounding mare.
- Band ratio appears to correspond with pyroclastic blanket thickness. Note low ratio values in proximity of Vallis Schröteri, where blanket is thin.
- Likely contribution of pyroclastic thermophysical characteristics.


Diviner Band 7/3 ratio map.

Young basalts

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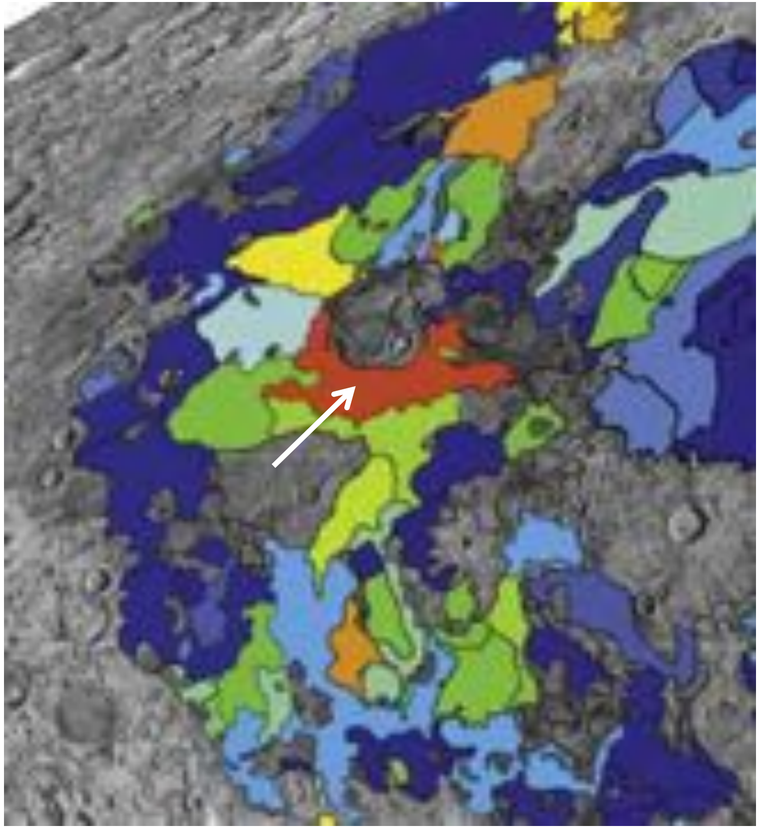
- Crater counts indicate young (~1Ga) basalts south of the plateau.

- Youngest basalts on the Moon. Would act as new pin in lunar chronology, and provide new constraints for crater-count based ages in the inner solar system.

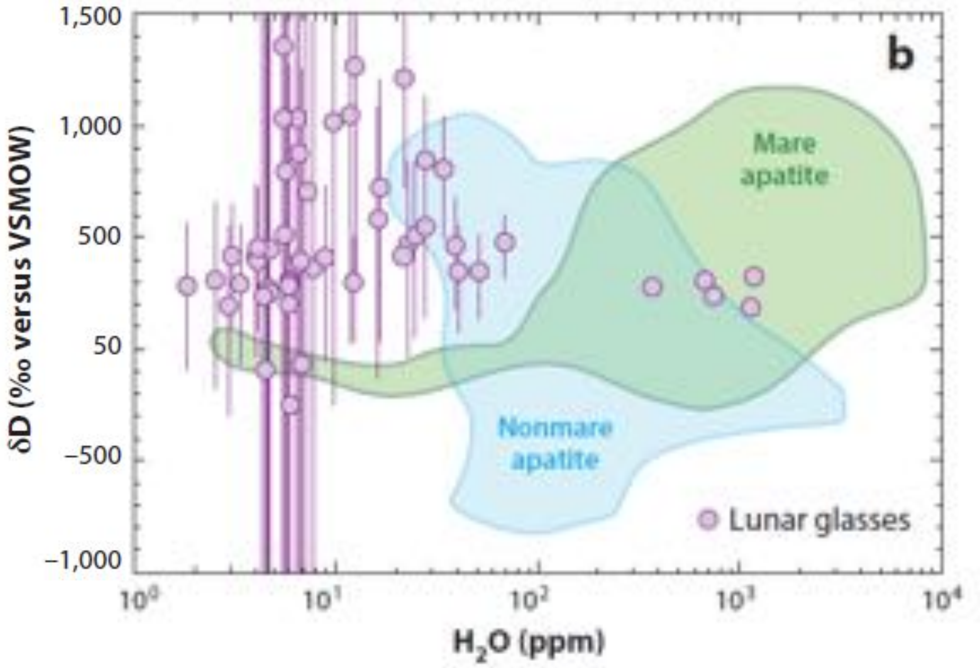
- See presentations by Sam Lawrence and Scott Anderson this afternoon for more detail.



Pyroclastics

- Saal et al. (2008) demonstrated that glass beads returned by Apollo contain measureable indigenous H_2O. Subsequent analyses indicate H_2O abundances from ~20-1000 ppm.

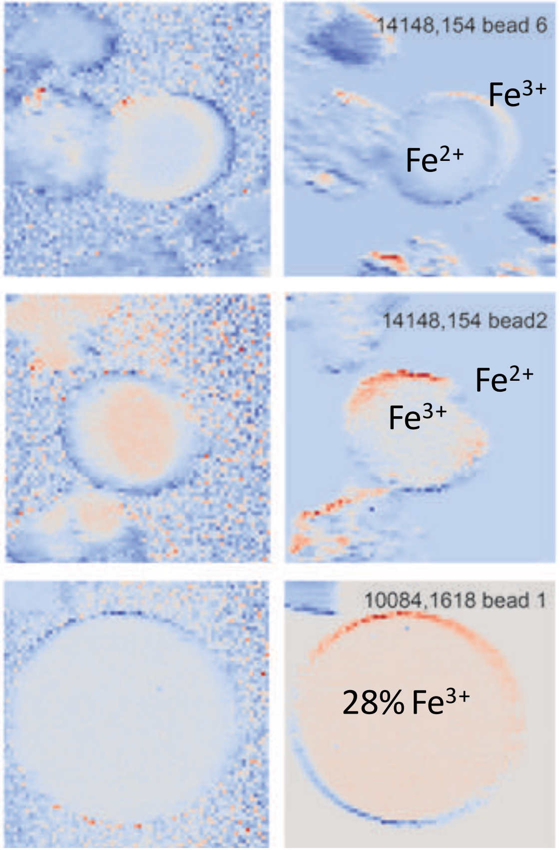
- Remote sensing data indicate regions of plateau with H_2O abundances on roughly the same order.



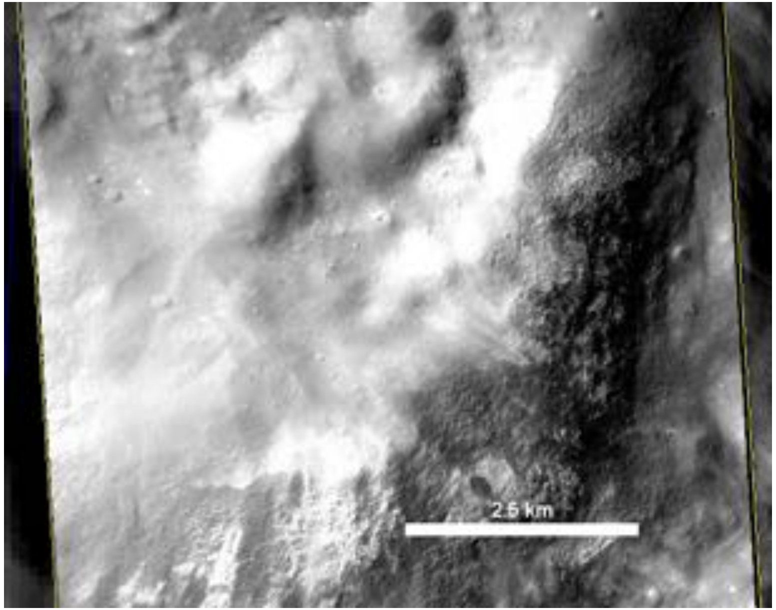
Hauri et al. (2017), Ann. Rev. Earth. Planet. Sci.

Pyroclastics

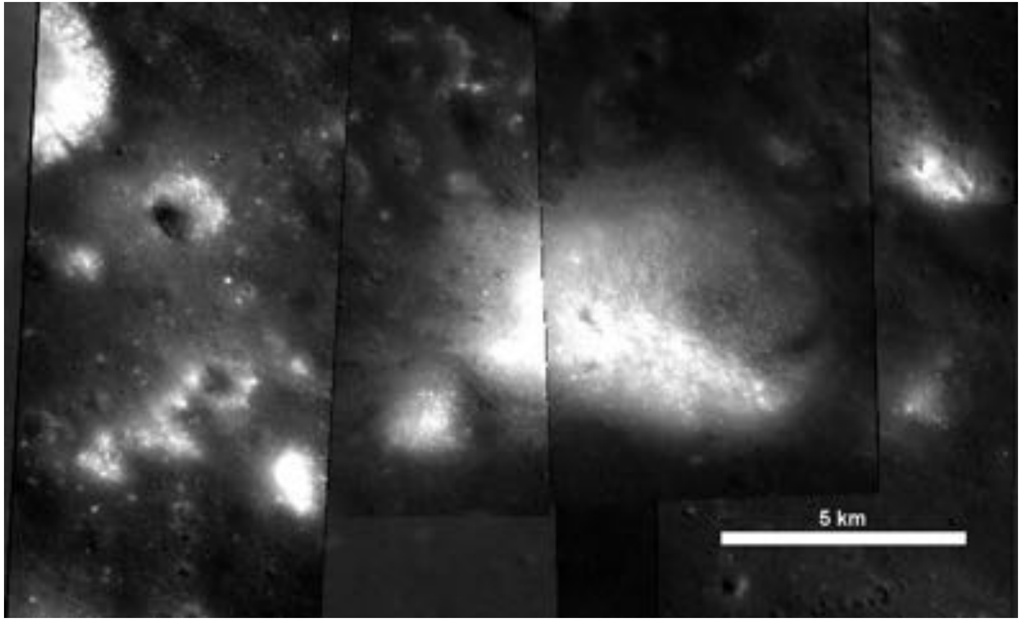
- New work by Darby Dyar, Molly McCanta, and Tony Lanzirotti:
- Variable Fe oxidation states in glass beads record ascent and eruption conditions.
- (TOP) Loss of water from the ascending melt, as predicted by Rutherford et al. (2017), produces melt oxidation through the reaction: $4OH=H_2O+H_2+1.5O_2$, starting from the rim and proceeding inward
- (MIDDLE) Reduction either in the lunar vacuum or in the dissipating, reducing gas cloud
- (BOTTOM) Even unzoned glasses typically show a range of oxidation states, consistent with closure temperatures at varying times during the eruption and quenching process



Silicic lithologies



- Cobra Head, source of Vallis Schröteri.



- Herodotus Mons, ~180 km NW of Aristarchus Crater. Surrounded by hydrous pyroclastics.

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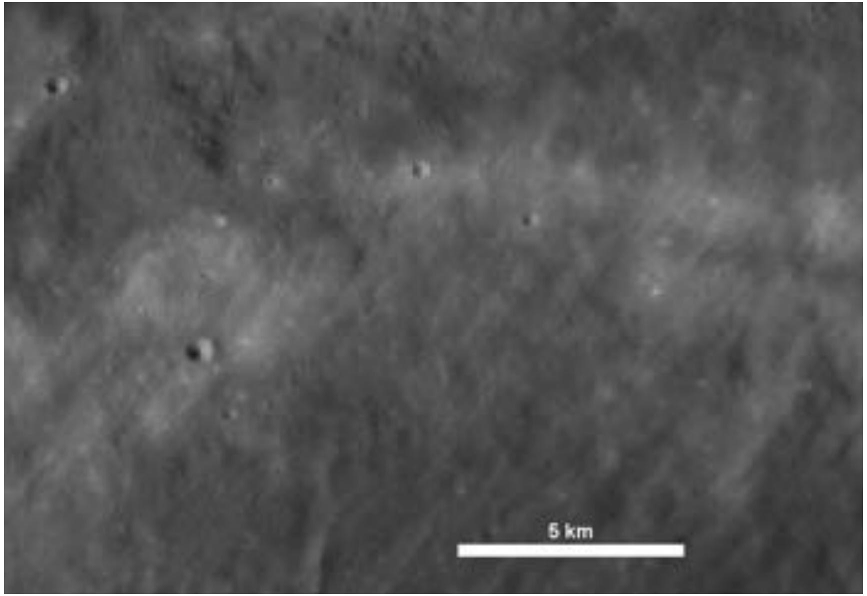
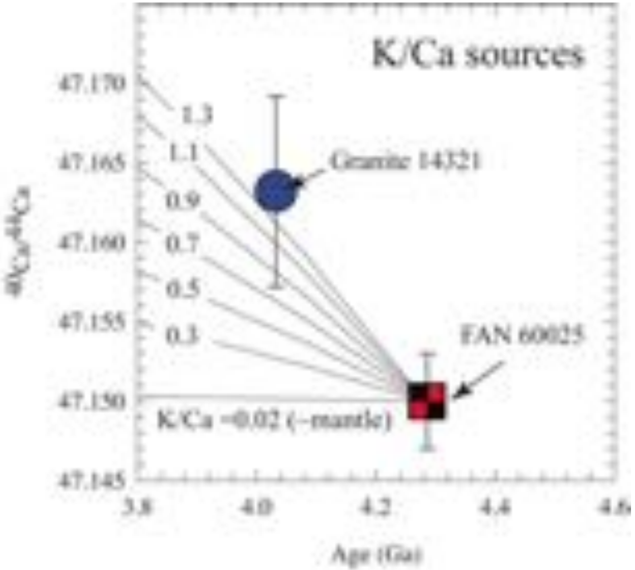
Silicic lithologies



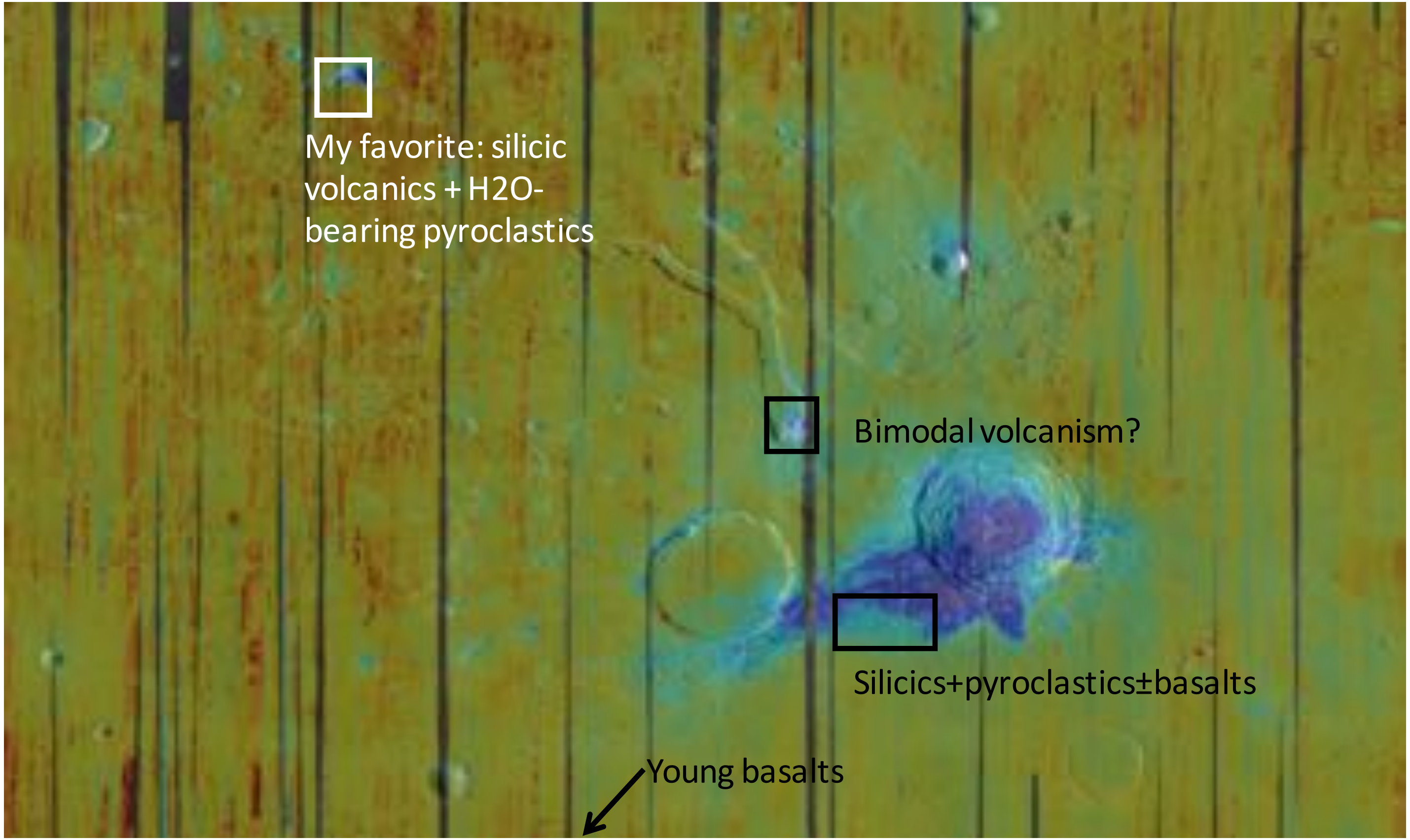
- Ejecta of Aristarchus southwest of the crater (bright material). Potential to sample silicic and pyroclastic materials at the same site.



- K/Ca isotopes of a returned granite clast indicate a strongly enriched source, probably separate from FAN.

- How representative are Apollo granites of lunar silisic sites? Samples skew old compared to crater counts of silicic spots.

Let’s go here.


My favorite: silicic volcanics + H2O-bearing pyroclastics
Bimodal volcanism?
Silicics+pyroclastics±basalts
Young basalts

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Think Big

- Multi-mission campaign to study Aristarchus crater and its ejecta, young basalts, Vallis Schröteri and the Cobra Head, pyroclastics, and Herodotus Mons.

- Systematic exploration with missions of increasing complexity
  - Multiple rovers with substantial scientific payload (GPR, cameras, vis/IR/Raman spectrometers, APXS, etc.)
  - Sample return—must determine highest priority between pyroclastics/silicics and young basalts
  - Human exploration

- Low-latency telerobotic operation from Deep Space Gateway