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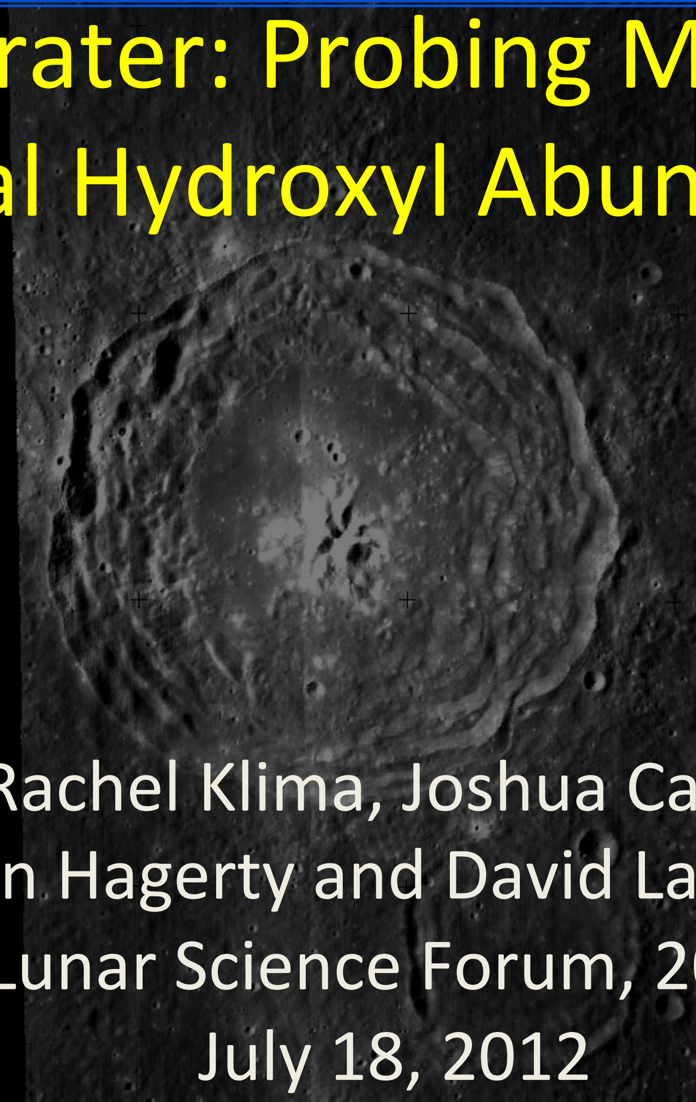
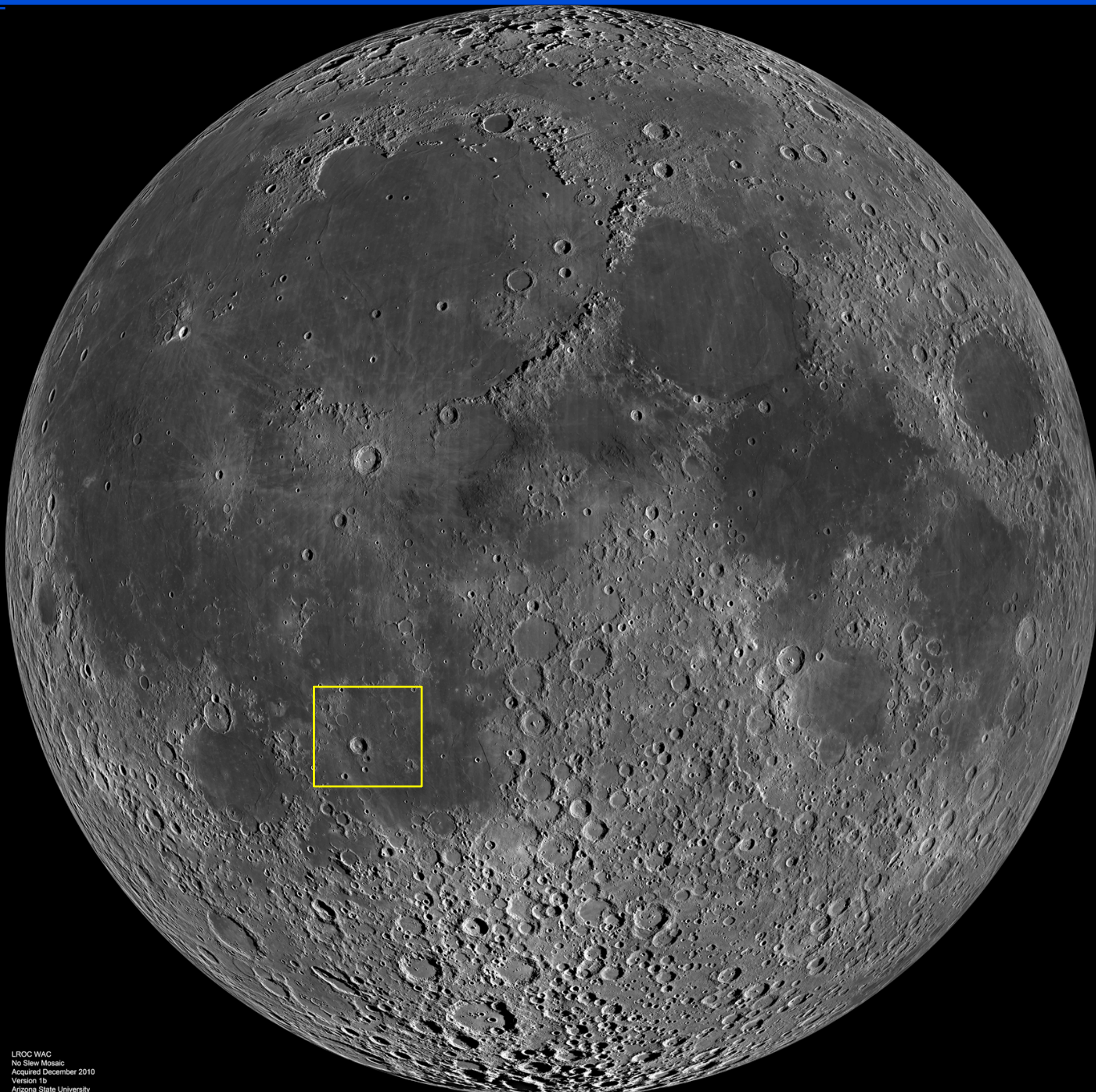
Bullialdus Crater: Probing Mineralogy and Local Hydroxyl Abundance



Rachel Klima, Joshua Cahill,
Justin Hagerty and David Lawrence

Lunar Science Forum, 2012
July 18, 2012

Bullialdus Crater



LROC WAC
No Slew Mosaic
Acquired December 2010
Version 1b
Arizona State University

- 20.7°S, 22.2°W on western edge of Mare Nubium
- 61 km diameter
- Eratosthenian-aged

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Bullialdus Crater

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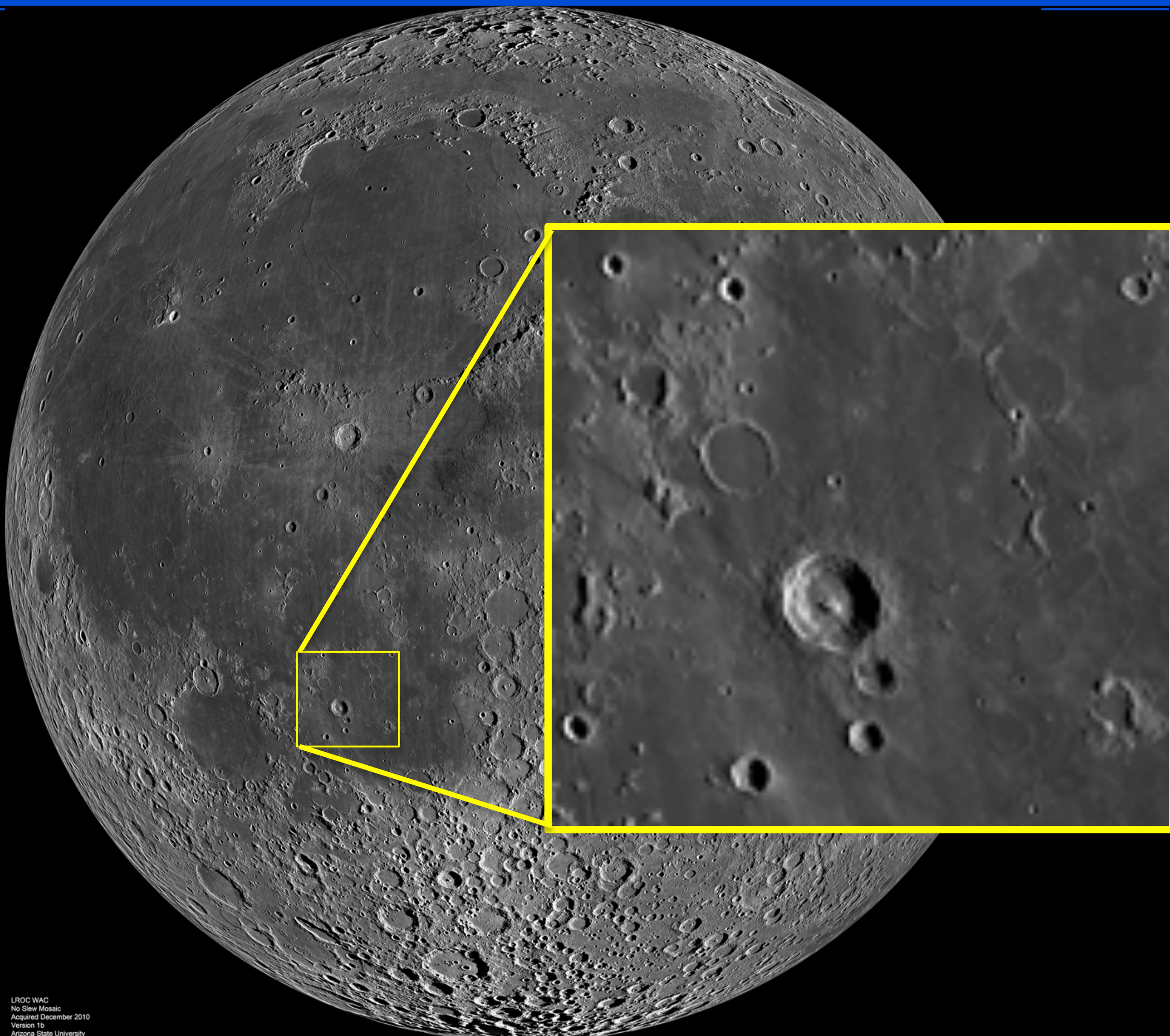

- Central peak nortic, walls more enhanced in clinopyroxene
- Layered mafic pluton (Pieters, 1991)
- Other possibilities include impact through thin old basalt flows, or through a differentiated melt sheet from the Nubium impact (Tompkins et al., 1994).
- Radiative transfer modeling suggests immature regions of the peak range from anorthositic norite, anorthositic gabbronorite to norite (Cahill and Lucey, 2007)
- Mean Mg' 70 (Cahill et al. 2009)
- Norites in central peak modeled to be >Mg'$_{75}$ (Klima et al. 2011).

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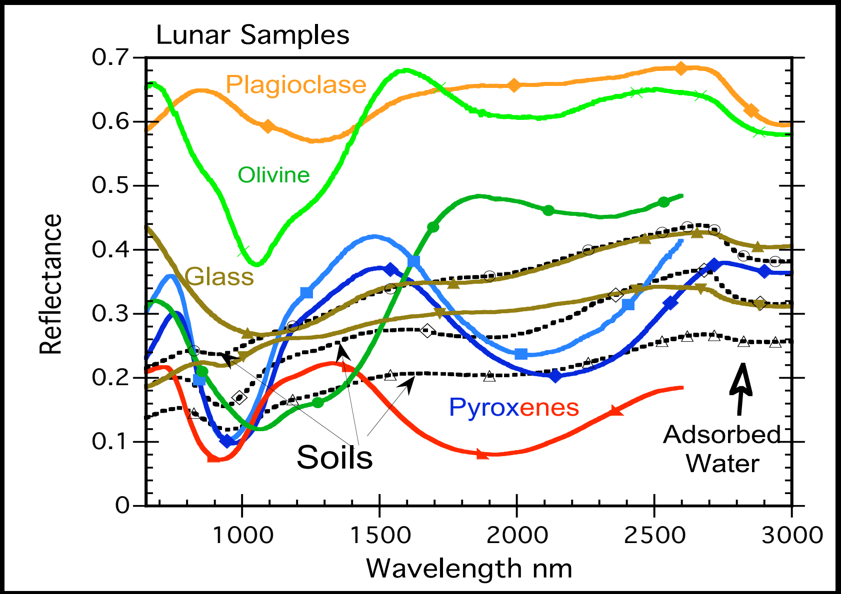
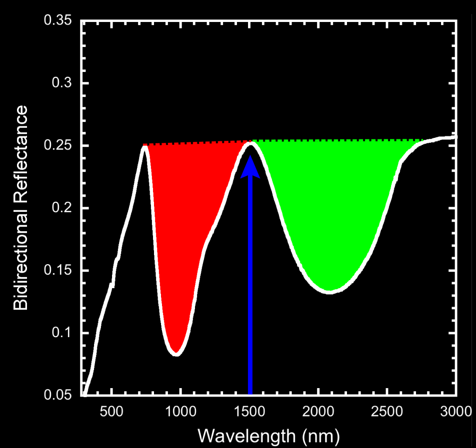
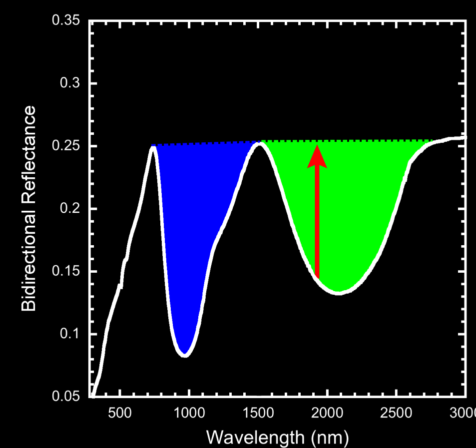
M^3 Data: Color Composites

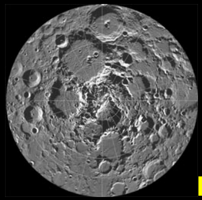
- M^3 standard color composite:
  Red = Integrated 1 µm band depth
  Green = Integrated 2 µm band depth
  Blue = Reflectance at 1.58 µm
  Highlands Blue, Pyroxene Yellow
- Pyroxene composite:
  Red = 1.9 µm band depth
  Green = Integrated 2 µm band depth
  Blue = Integrated 1 µm band depth
  Highlands Black, LCP Yellow, HCP Cyan







APL



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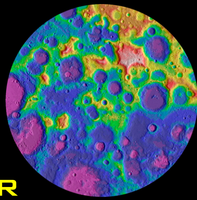
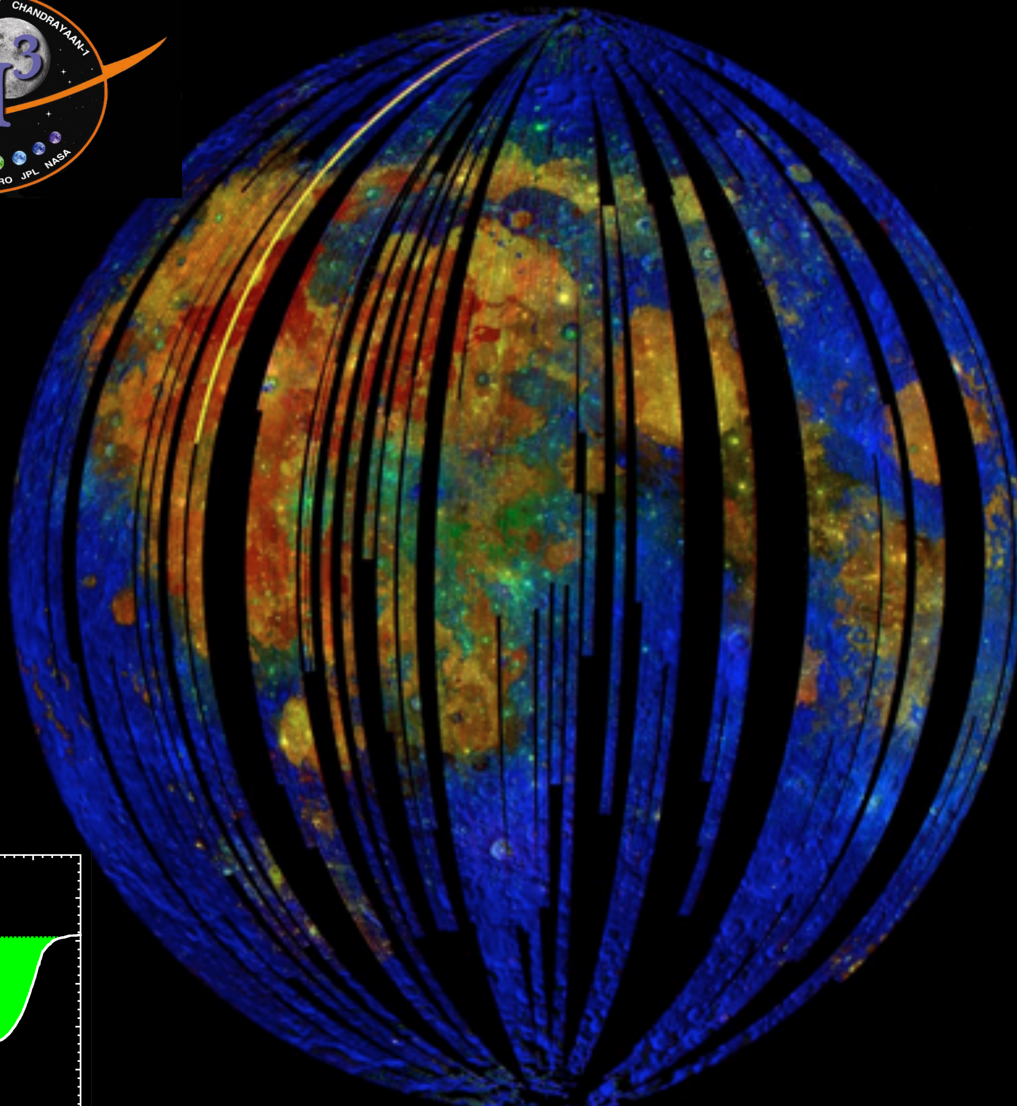


Lunar Mineralogy: A Hyperspectral View



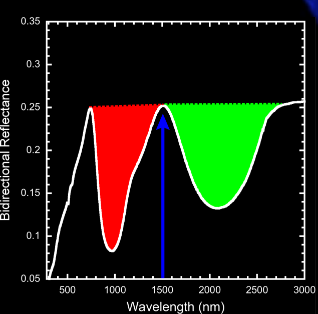
Moon Mineralogy Mapper (M^3)
Vis-NIR Imaging Spectrometer

Global Mode:
85 bands

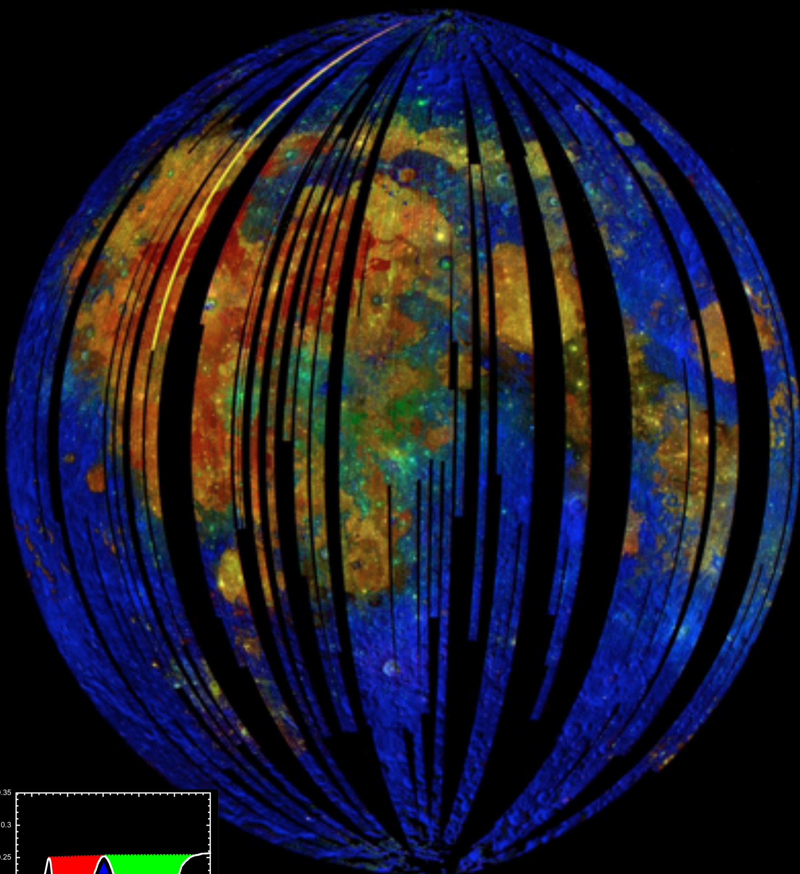
20-40 nm spectral sampling

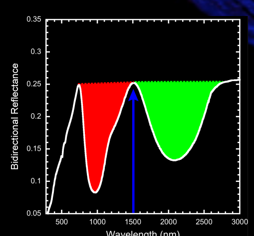
140 m/pixel at 100 km orbit

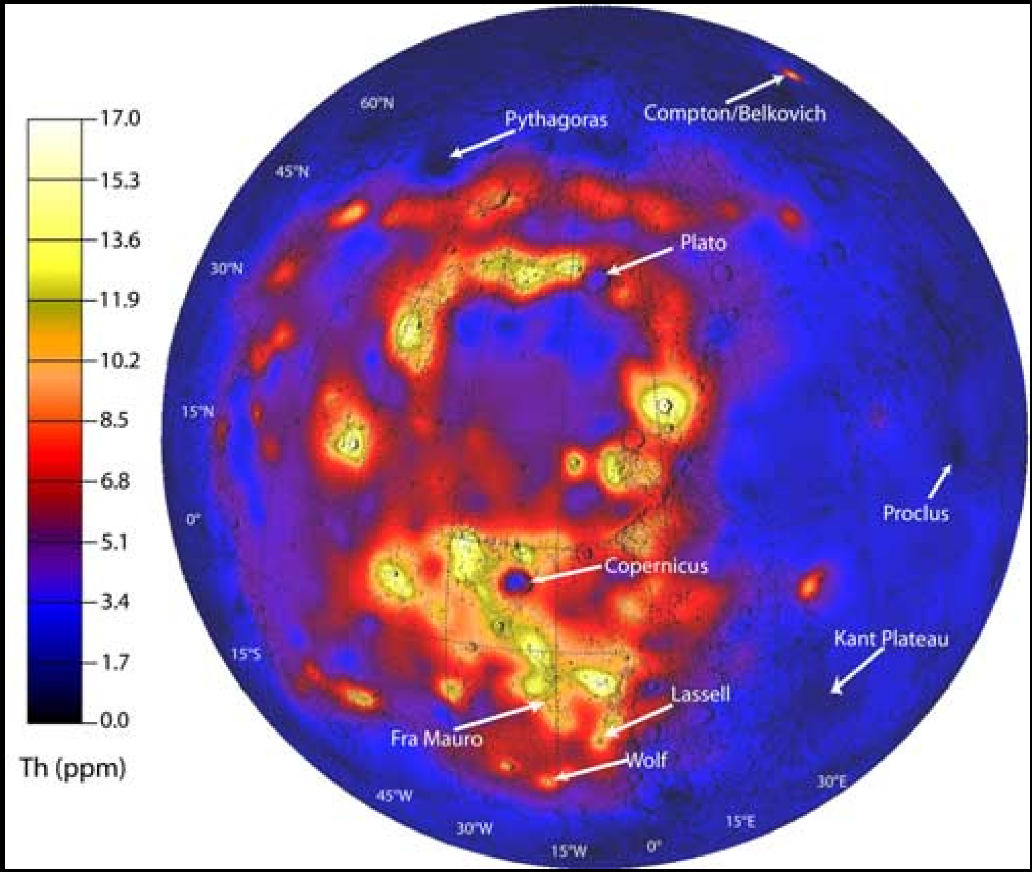
0.4-3 um wavelength range



Southern PKT – Mineralogy and Thorium







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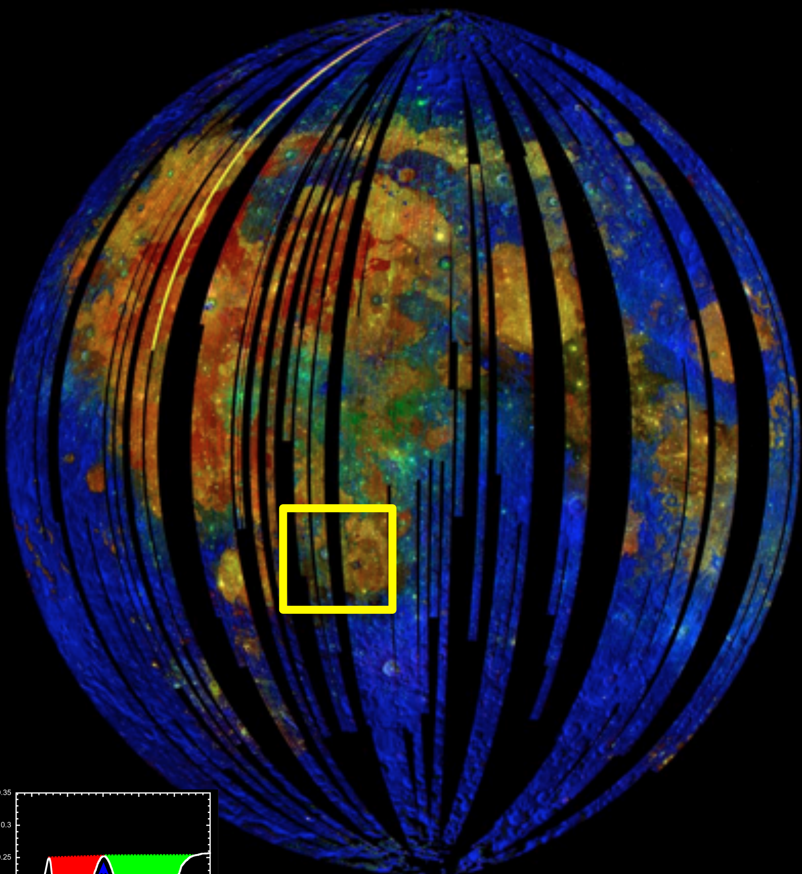
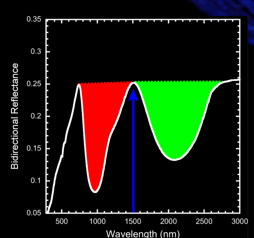
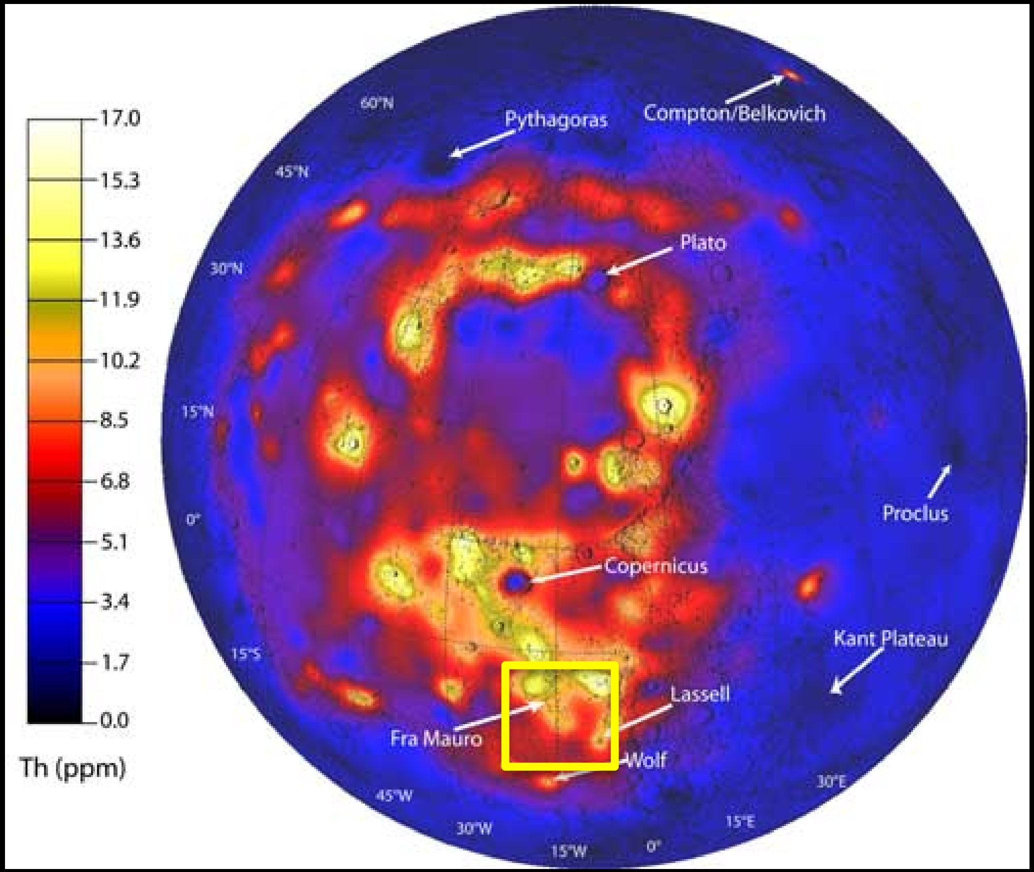
Southern PKT – Mineralogy and Thorium







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Bullialdus Region: Thorium

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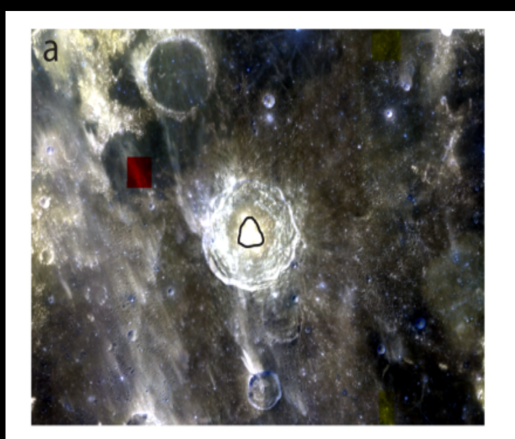
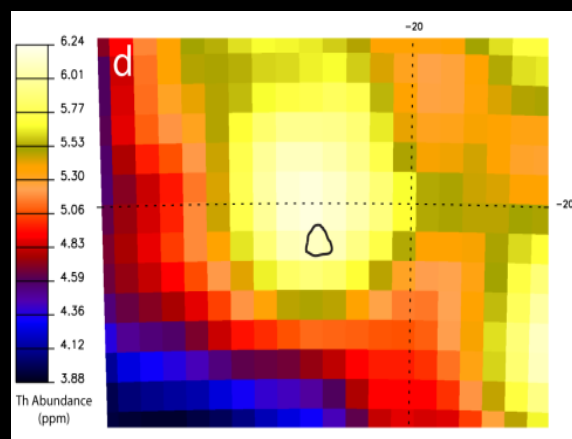
Enhanced Thorium detected at Bullialdus corresponds to anorthositic and noritic terrain

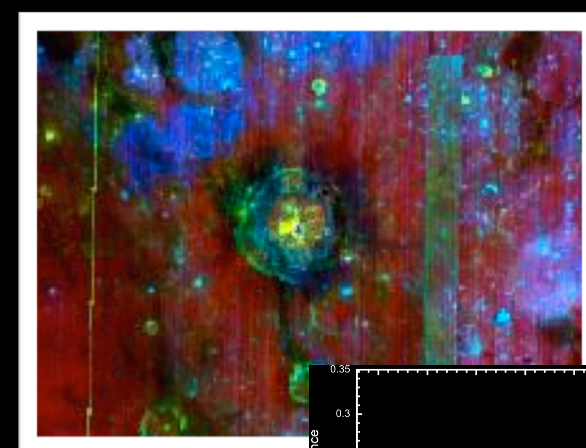
Clementine

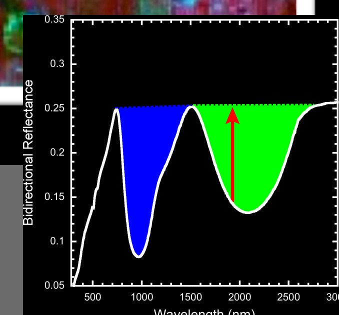


Lunar Prospector Thorium



M^3



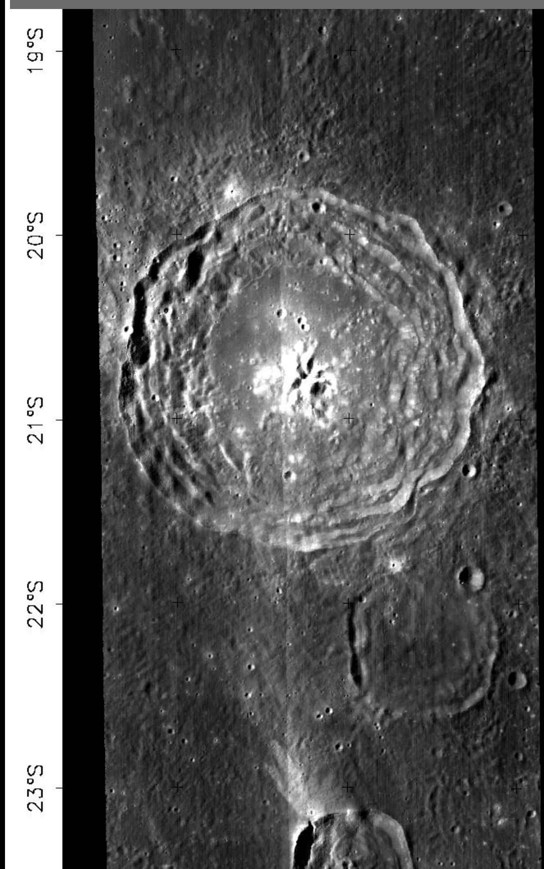


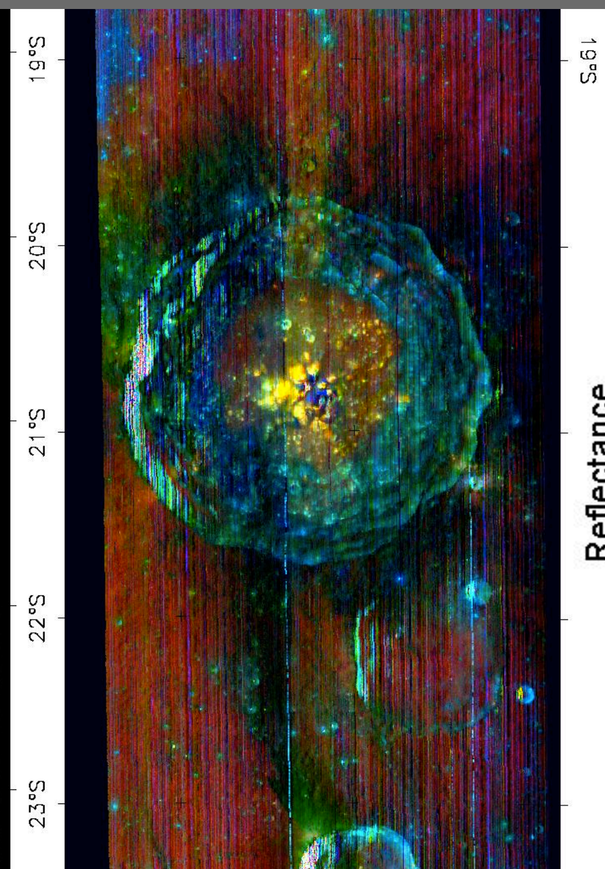
M^3 Color Composite:
Yellow: Low-calcium pyroxene Black: Anorthosite
Blue/Cyan/Purple: Mare basalt or enriched in high-calcium pyroxene

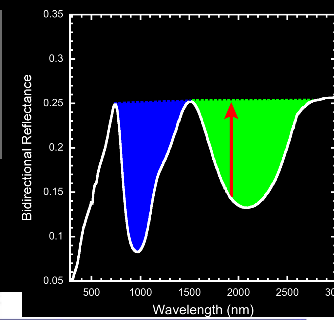
APL

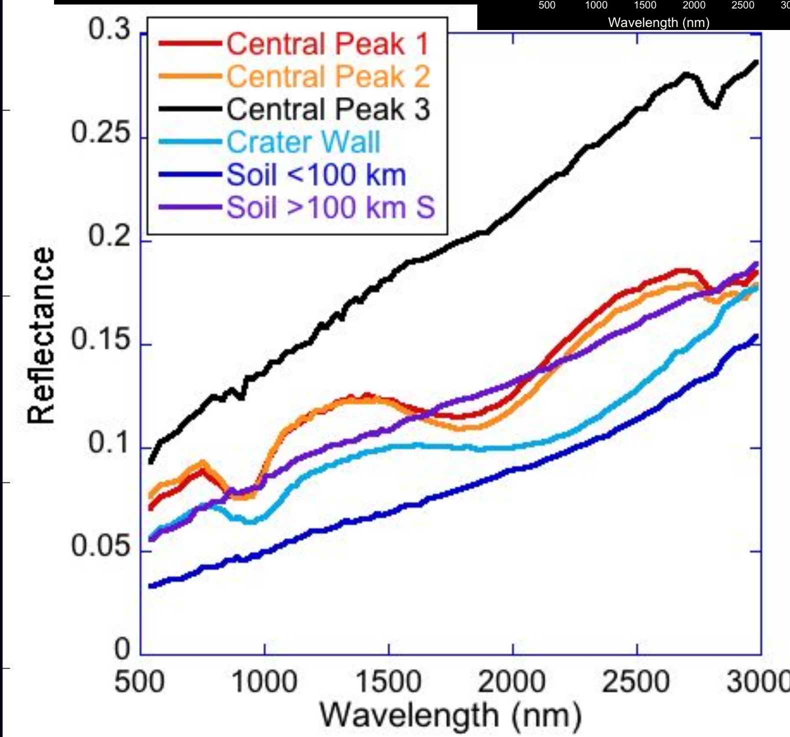
Crater Mineralogy

Yellow: Low-calcium pyroxene Black: Anorthosite
Blue/Cyan/Purple: Mare basalt or enriched in high-calcium pyroxene

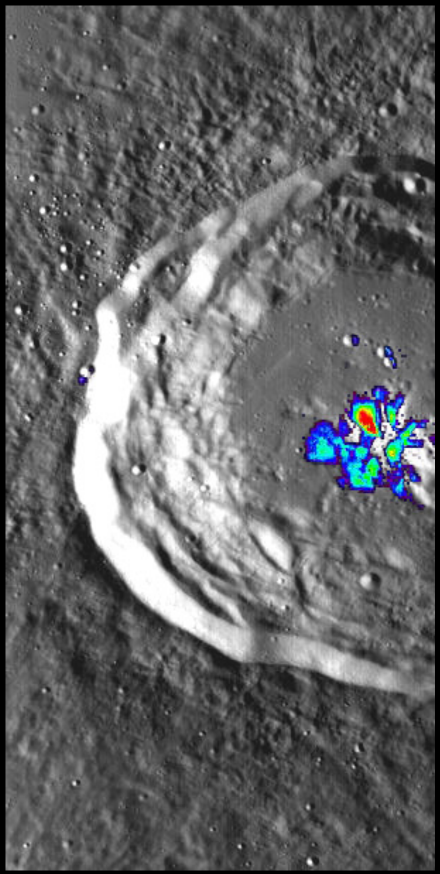


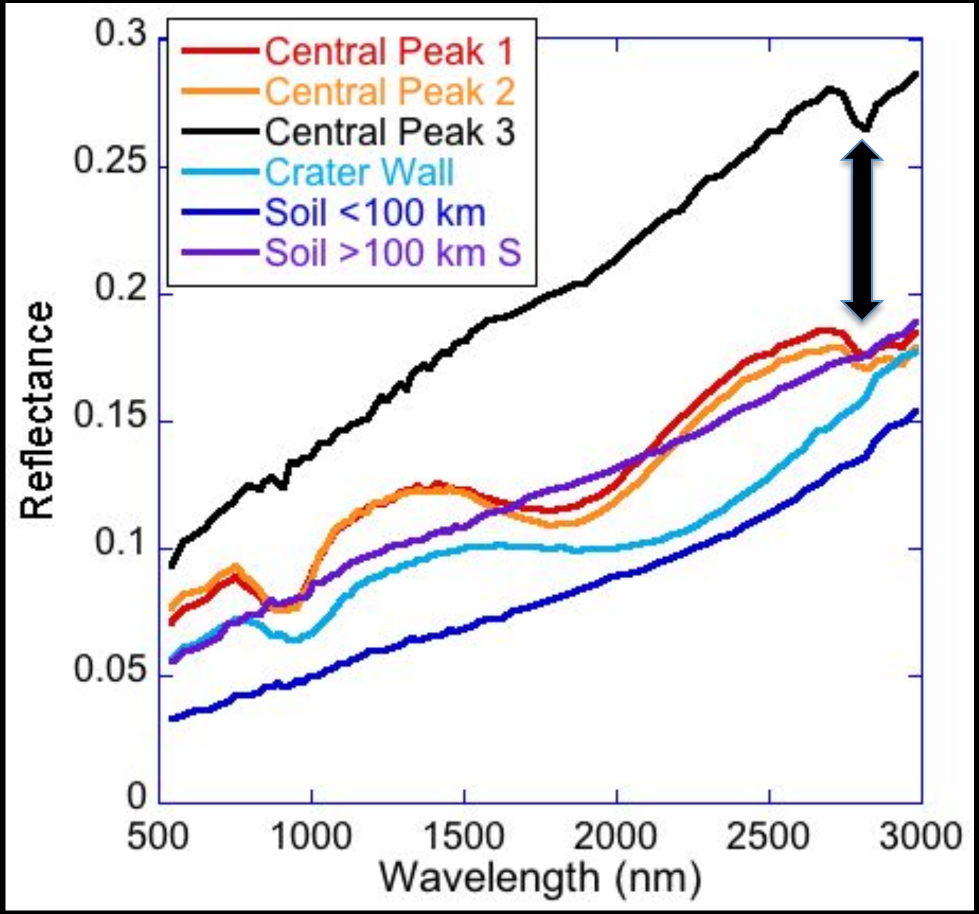






Hydroxyl at Bullialdus crater





Absorption at 2.8 um: OH^- strongly enhanced *only in central peak*

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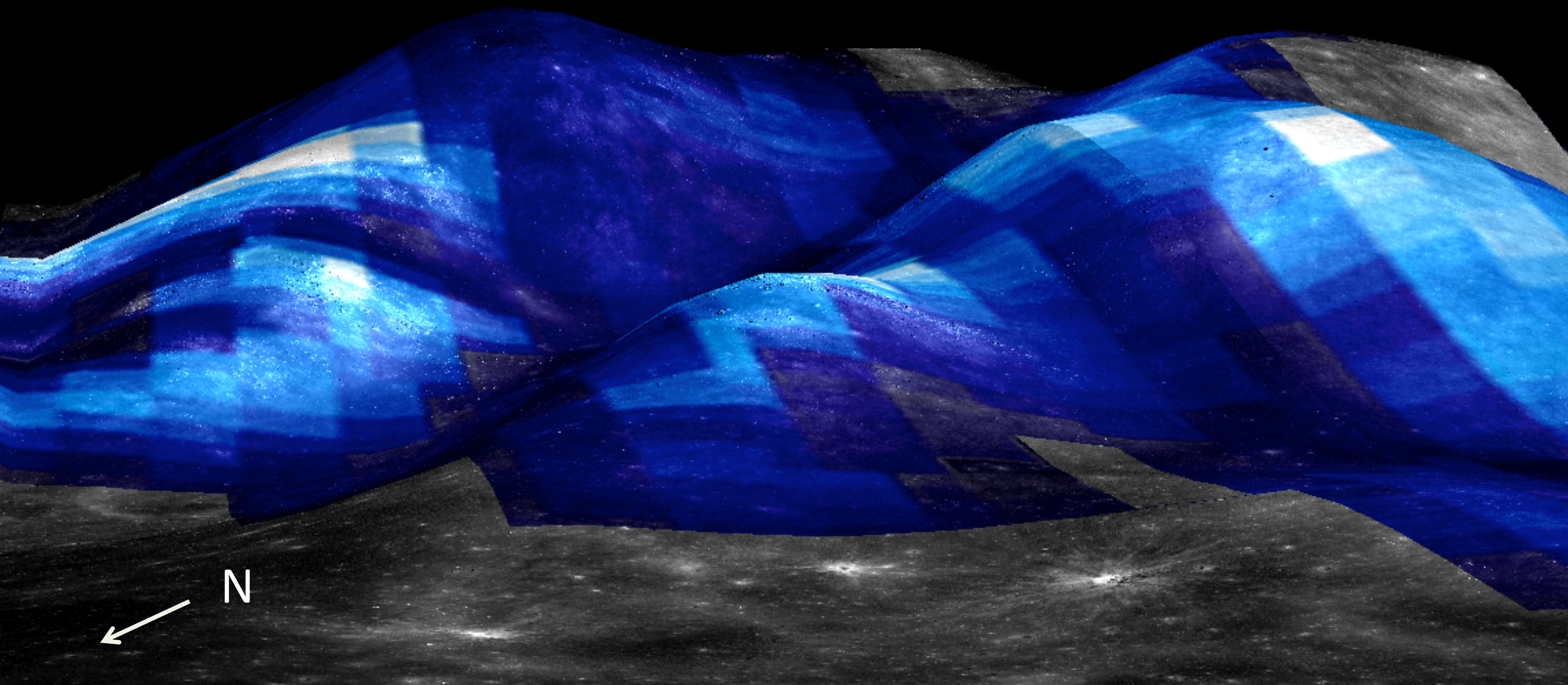
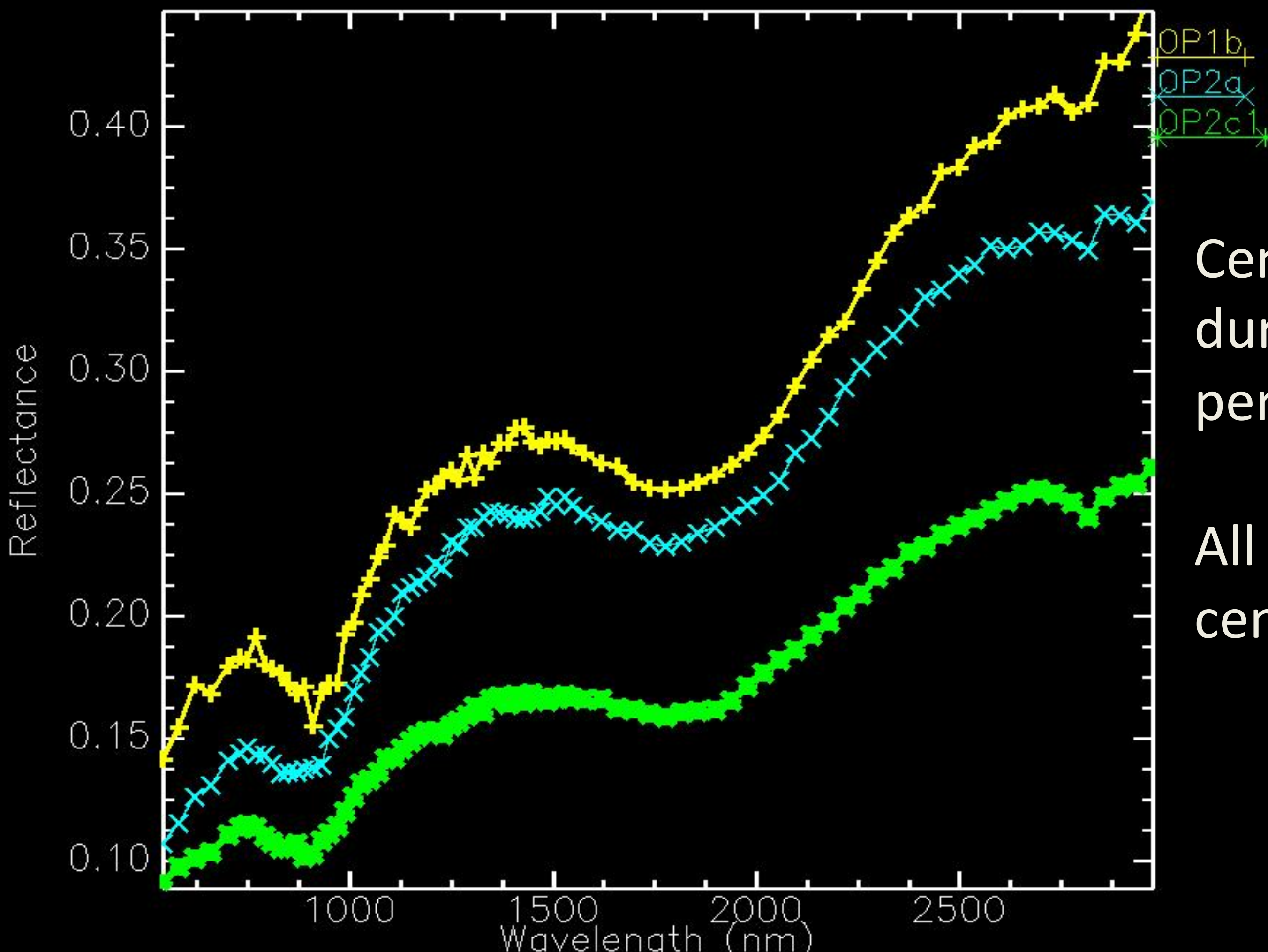
Hydroxyl overlain on NAC + LROC DEM



View is from North. Color ramp grades from dark blue (low) through white (high) OH^- abundance. High OH^- appears to correlate with higher albedo, more boulder-rich regions of the central peak.

Hydroxyl at Bullialdus crater



Central peak imaged during three optical periods.

All show OH^- band in central peak

Hydroxyl at Bullialdus crater

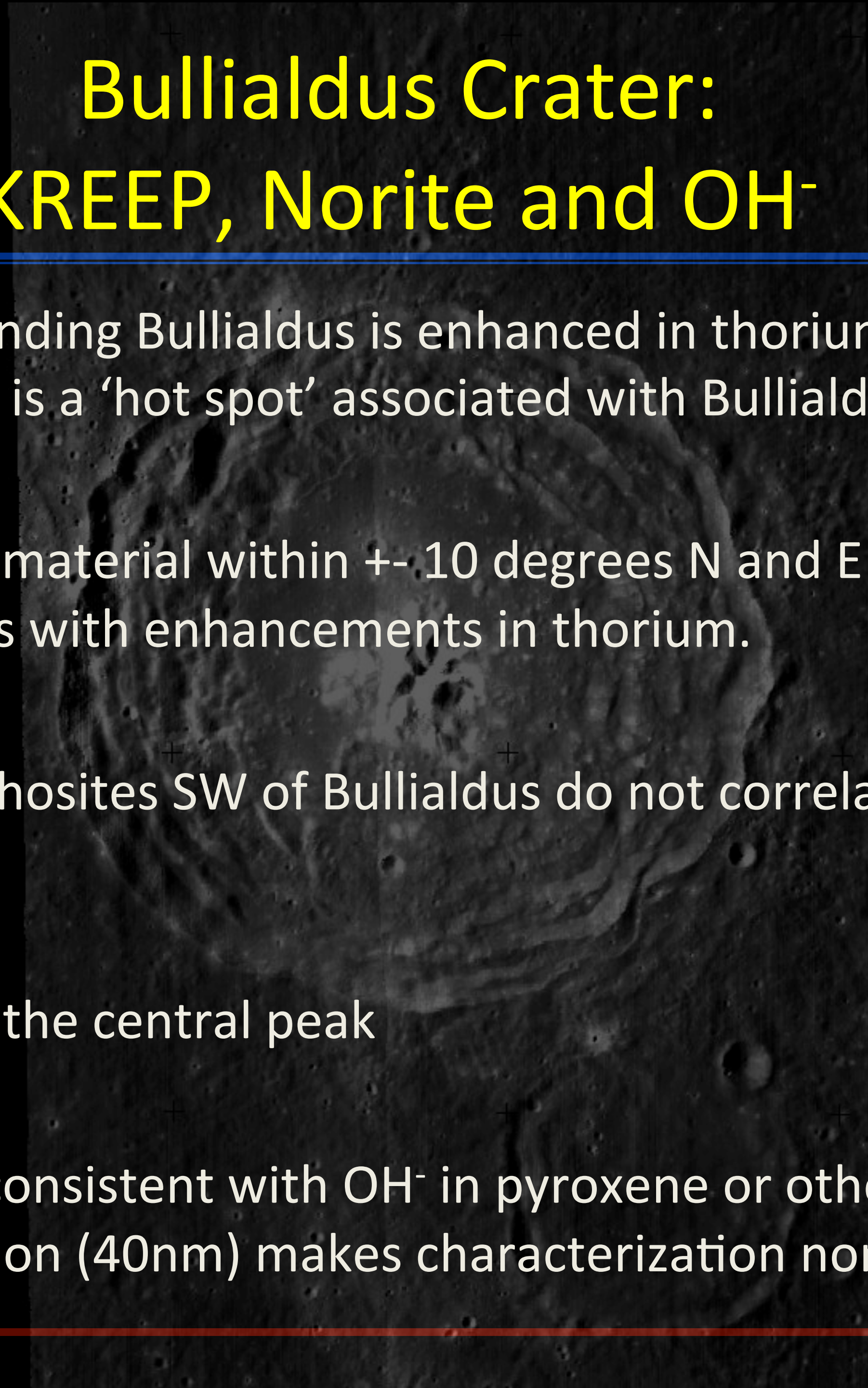
- Typically, non-polar OH^- is likely to be present as a thin surficial layer, likely produced by interactions of the solar wind with the lunar regolith (e.g., Pieters et al., 2009; Sunshine et al., 2009).

- Bullialdus was fully imaged by M^3 at three different times in the lunar day. The 2.8 um absorption is observed and is of roughly equivalent strength during all of them.

- Highlands soils typically exhibit stronger OH^- bands, but those surrounding Bullialdus show little to no absorption.

- Fresh craters are observed to exhibit stronger OH^- bands, potentially due to an abundance of fractured bonds facilitating in-situ OH^- production. Bullialdus central peak is relatively immature due to mass wasting, but not freshly impacted.

Bullialdus Crater: KREEP, Norite and OH^-



- While the region surrounding Bullialdus is enhanced in thorium relative to the bulk Moon, there is a ‘hot spot’ associated with Bullialdus.
- Noritic and anorthositic material within +- 10 degrees N and E of Bullialdus also correlates with enhancements in thorium.
- ‘Normal’ highland anorthosites SW of Bullialdus do not correlate with enhanced thorium.
- OH- is enhanced only in the central peak
- Position of OH^- band is consistent with OH^- in pyroxene or other silicates, but low spectral resolution (40nm) makes characterization non-unique

Bullialdus Crater: Implications

- The mineralogy of the central peak of Bullialdus is consistent with material from a KREEP-rich, Mg- or Alkali-suite pluton. Deconvolved thorium abundance is most consistent with the Alkali suite. If the OH^- is internal to the rocks, it supports OH^- enrichment in late stage urKREEP liquids.

- As a mafic pluton, less OH^- would have degassed than in KREEP-rich basalts.

- Further work is ongoing to characterize the nature of the OH- band in more detail and to place bounds on the amount of OH^- detected.

Bullialdus Crater

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- 61 km diameter
- Eratosthenian-aged
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