Status of Geomorphic and Geologic Mapping of the Lunar South Pole

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Outline

- Scientific Objectives
- Why Re-map the Moon?
- Previous lunar polar mapping studies
- Methodology
- Observations / Current map status
- Summary

- Many thanks to Lauren van Arsdall (College of Charleston, 2007 NASA USRP) and David Shulman (Mt. Hebron H.S., 2007 NSCS).

Scientific Objectives

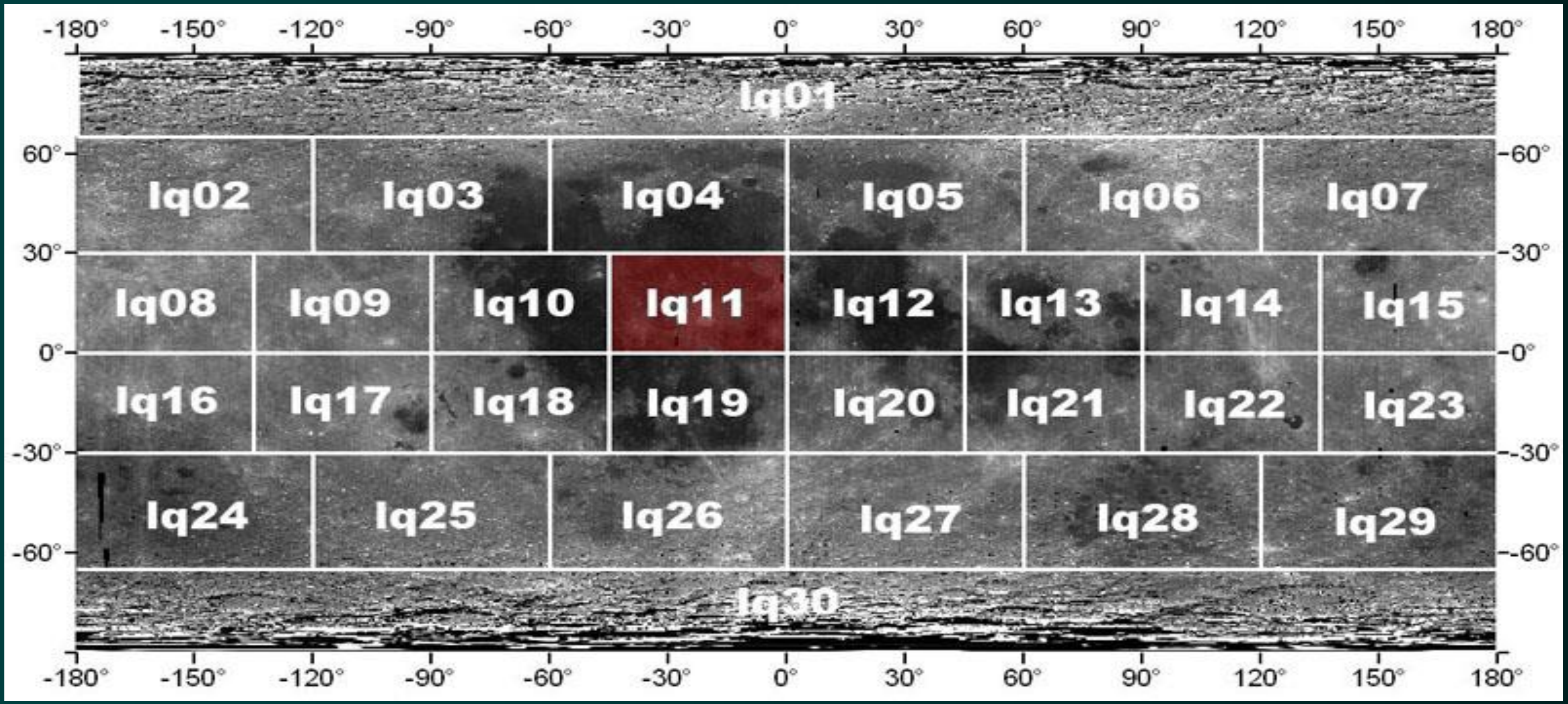
- Determine the vertical and lateral structure of the lunar crust
  - Multispectral analysis of central peaks and basin uplift structures
  - Correlation with topography, gravity and magnetic data
- Assess the lateral distribution of materials by impacts
  - Multispectral analysis of surface materials
- Evaluate the nature of volcanic materials in the study areas
  - e.g., maar crater identified in Schrödinger basin [*Shoemaker et al., 1994*]
- Constrain the timing and determine the affects of major basin-forming impacts on crustal stratigraphy in the map areas
  - South Pole-Aitken basin, Amundsen-Ganswindt and Schrödinger basins
- Assess the distribution of resources and their relationships with surficial materials
  - Hydrogen, iron, titanium [*Feldman et al., 1999, 2000*]
  - Correlation of elemental abundance maps with lithologic units, age-dating

Why Re-map the Moon?

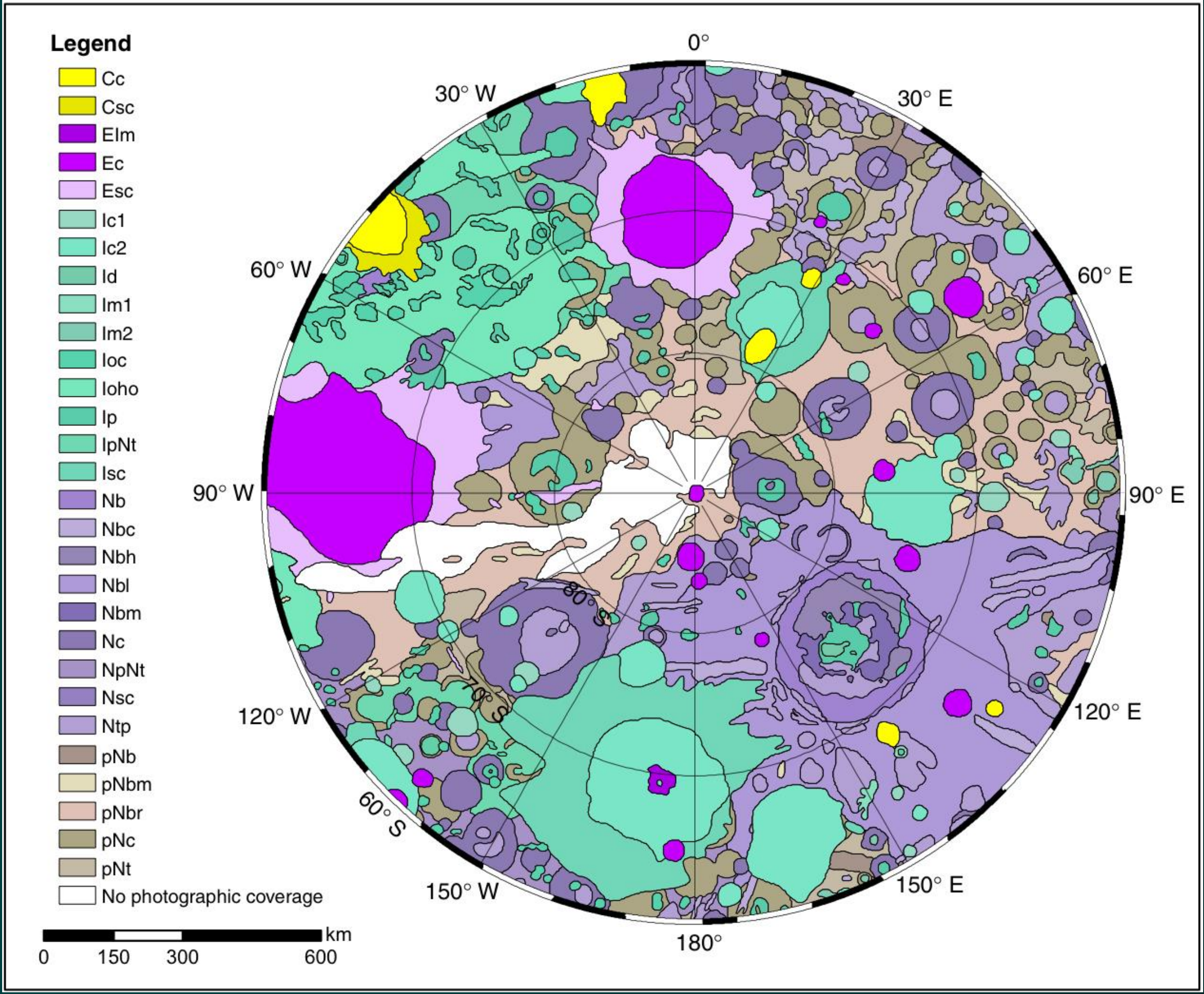
- New . . . And Improved . . . Views of the Moon
  - South Pole mapped by *Wilhelms et al. [1979]*, poleward of 45°, 1:5M scale
  - Lunar Orbiter-based
  - Clementine UV-vis, NIR, topography (also Earth-based radar)
  - Lunar Prospector GRS elemental maps (H, Fe, Ti)
  - Higher-resolution images can improve contacts, crater size-frequency distributions
  - High resolution data from Kaguya and Smart-1
  - Forthcoming high-resolution data from Chandrayaan 1 and LRO
- Ideas about lunar science issues have evolved significantly
  - e.g., spatial and temporal distribution of ancient lunar maria and highland volcanism, ages and compositions of basin impact melt sheets, and the dating of the lunar cataclysm
- Important resources for GSFC PIs proposing instruments and missions
- Important resource for polar landing site selection

Lunar Geologic Mapping Program

- Sponsored by NASA Planetary Geology and Geophysics (PGG) program
- 30 quadrangle scheme at 1:2,500,000 scale
- Pilot program started in 2004 [*Gaddis et al., 2004, 2005, 2006*]; geologic mapping of Copernicus crater region (Lq11)
- Pilot project includes:
  - selection of appropriate digital map basemaps to be provided by the USGS (Lunar Orbiter photomosaics, Clementine 5-band UVVIS and 6-band NIR mosaics) and coregistered to the ULCN;
  - development of geologic mapping techniques that incorporate data from remote sensing sources at varied spatial scales



Previous Lunar South Polar Mapping - *Wilhelms et al., 1979 [I-1162]*



- Lunar Orbiter-based:
  Image res. ≈ 100 m/pix
- Few Copernican- and Eratosthenian-aged materials
- Mostly preNectarian-Imbrian in age
- Formation of SPA (pN)
  Excavated crustal material; much of near-polar terrain contained within SPA or covered by SPA ejecta.
- Impact craters, small basins (D<300 km) dominate pN-I.
- Most deposits associated with impact features (floor, rim and ejecta materials)
- Materials from L. Imbrian-aged Schrödinger basin cover much of surface in farside quadrant. Few mare deposits poleward of 70° S; largest on floor of Schrödinger basin

Current Mapping Methodology

- Digital Geologic Mapping
  - Lq30: Poleward of 60° S, 0-±180° ; 1:2.5 M
  - ESRI ArcGIS 9.2:
    - Multi-parameter digital database (data and maps)
    - Queriable data layers
    - On-the-fly projection
    - New data (e.g., LRO LOLA, LROC, etc.) easily added
    - Rapid conversion to publication quality map product
    - Easily incorporated into GSFC-sponsored projects (e.g., GIS-based ILIADS)
  - Adobe Illustrator and Photoshop, ISIS:
    - Image enhancement / image processing

- Determine relative age relationships for geologic units
  - Calculate crater size-frequency distribution statistics (stick around for Noah's talk, coming up next!)
  - Superposition / cross cutting relationships

Imagery:

CL: 5-band UVVIS Digital Image Cubes (100 m/pix)

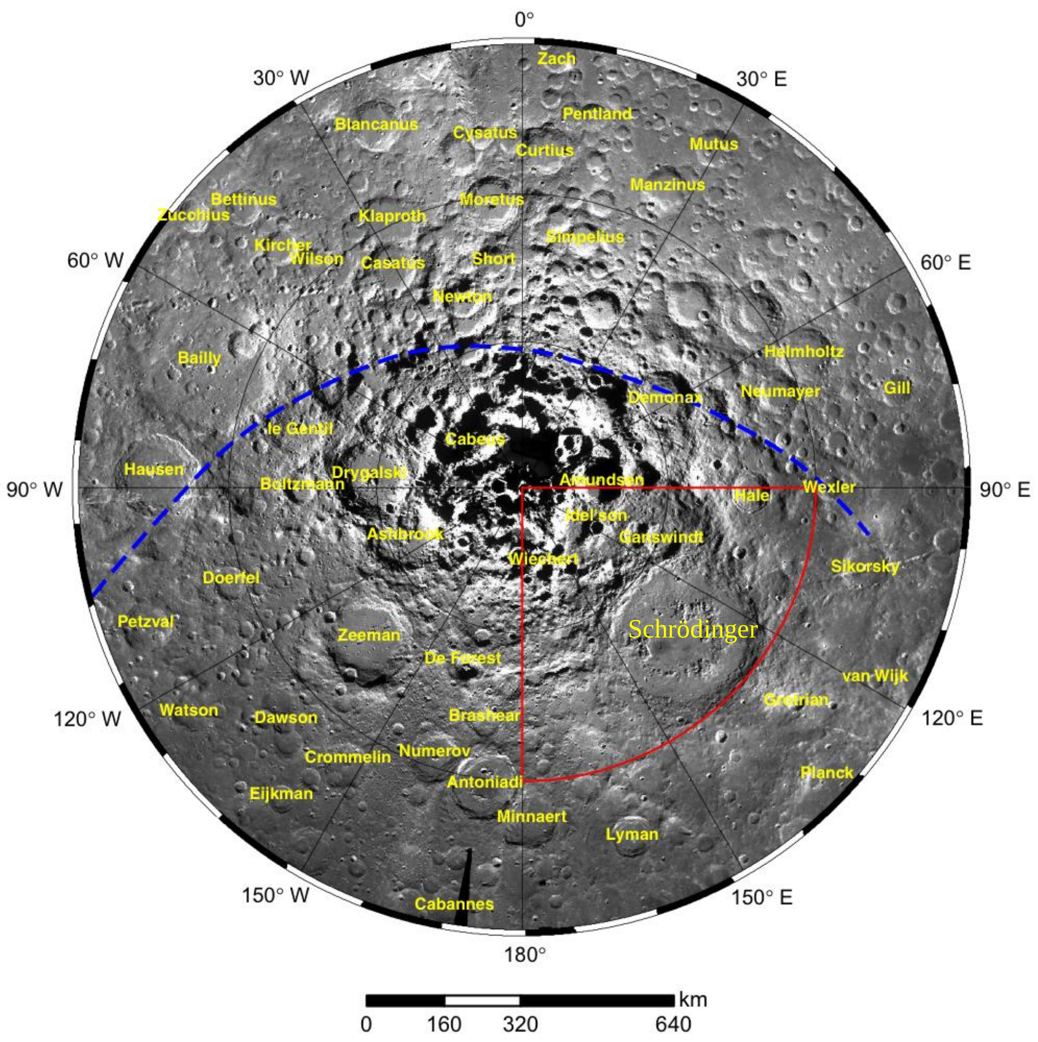
CL: 6-band NIR (500 m/pix)

CL: Single-band LWIR (8750 nm; 55-136 m/pix) brightness temp - full coverage 85˚ -90˚

CL: 4-band HIRES (10-20 m/pix)

Lunar Orbiter IV and V images (~100 m/pix)

Data:



Clementine UVVIS 750 nm mosiac.

Data:

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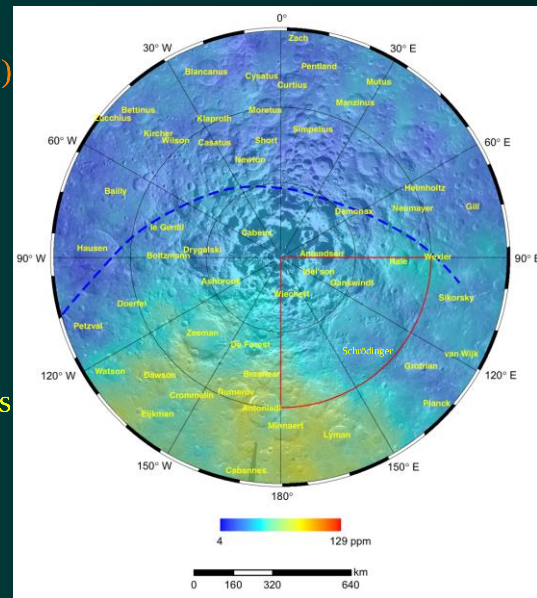
Lunar Orbiter IV and V images (~100 m/pix)

Spectroscopy:

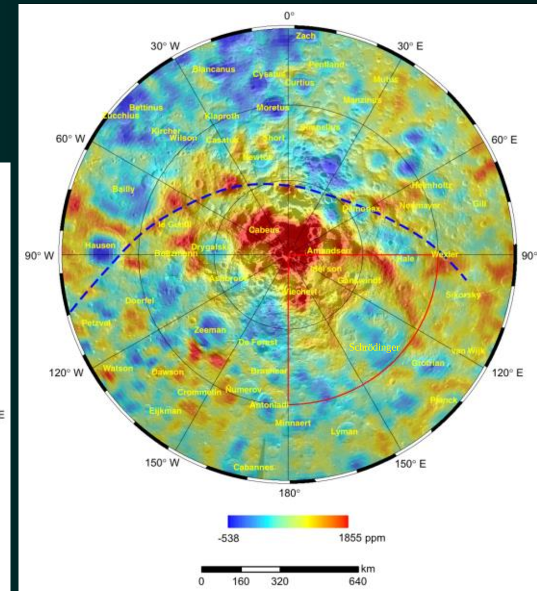
LP: Gamma Ray Spectrometer-derived elemental maps (e.g., H, Fe, Th); 1/2 deg resolution

LP: Neutron Spectrometer maps

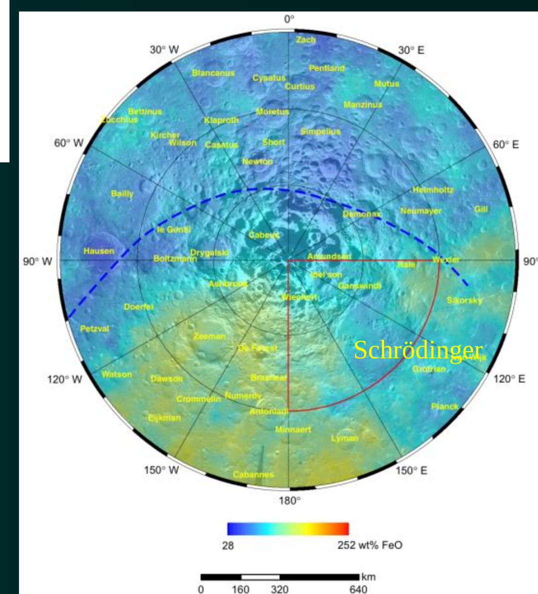
CL: UVVIS color ratios (R=750/415 nm, G=750/950 nm, B=415/750 nm)



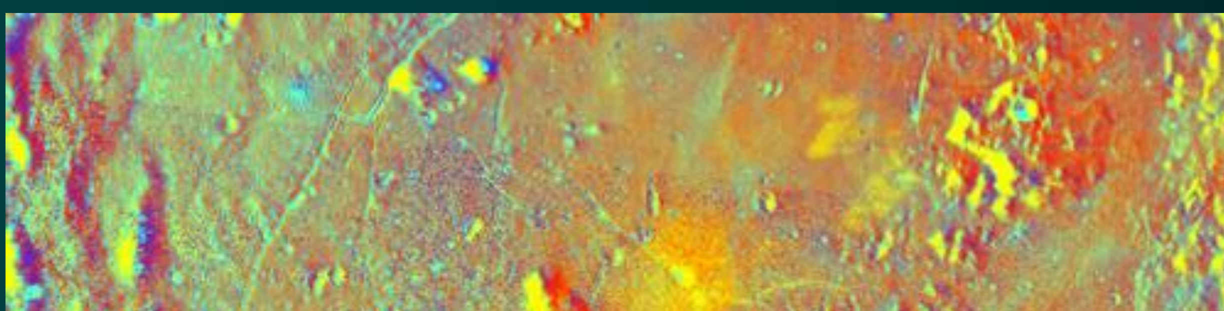
Lunar Prospector Th abundance.



Lunar Prospector H abundance.



Lunar Prospector Fe abundance.



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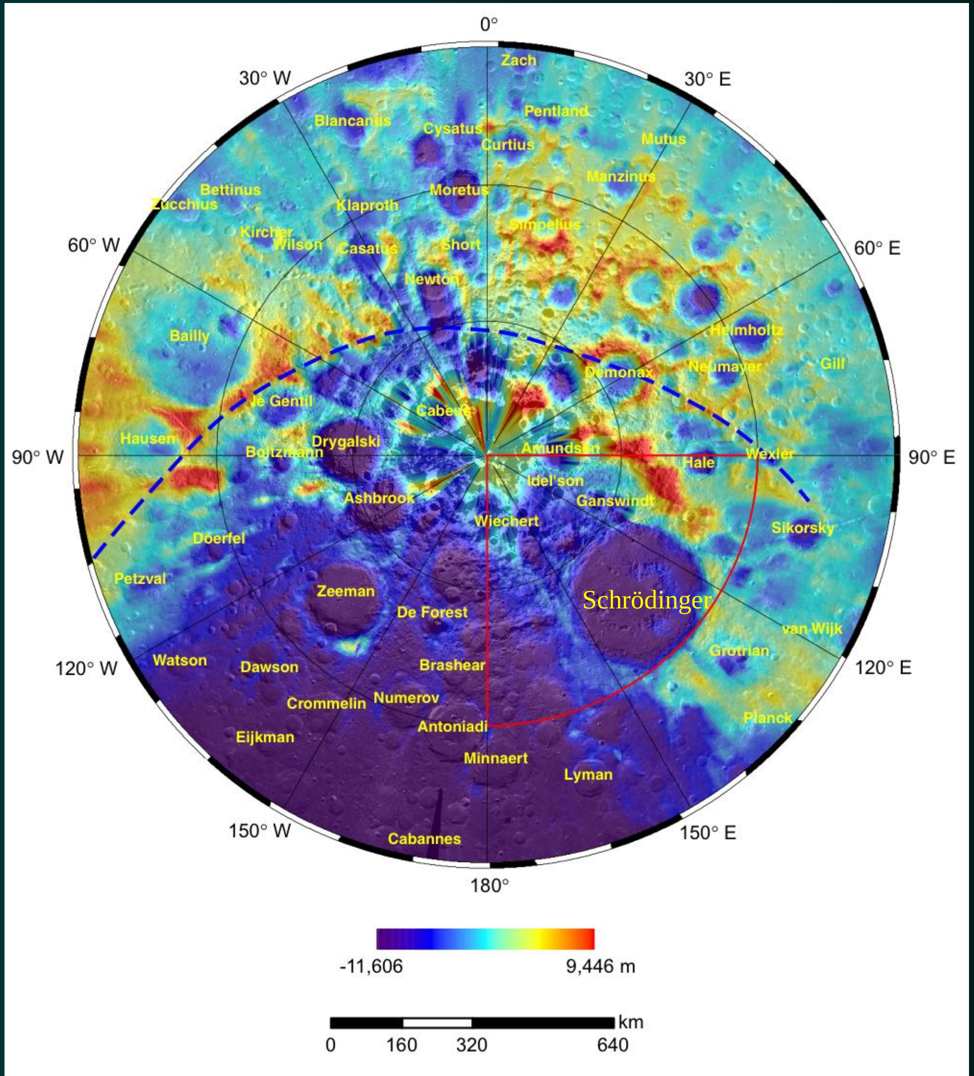
Topography:

CL: Unified Lunar Control Network (ULCN)

CL: LIDAR (40 m vertical resolution, 100 m spot res.); only extends to 75° S

CL: UVVIS stereo-generated DEMs (~1 km/pix)

Earth-based radar (Arecibo, 12.6 and 70 cm; Haystack 3.83 cm (3.1 km/pixel))



Unified Lunar Control Network (ULCN).

Map as presented at LPSC 39 *[van Arsdall and Mest, 2008]*

LEGEND

Units

Crater Materials

- cr — Rough inter-crater material
- ch — Hummocky crater material
- sc — Rough mantling material
- cf — Bright inter-crater material
- oce — Outer crater material
- cs — Crater fill material

Basin-related Materials

- dpm — Dark plains material
- lpm — Light plains material
- rb — Rugged basin material

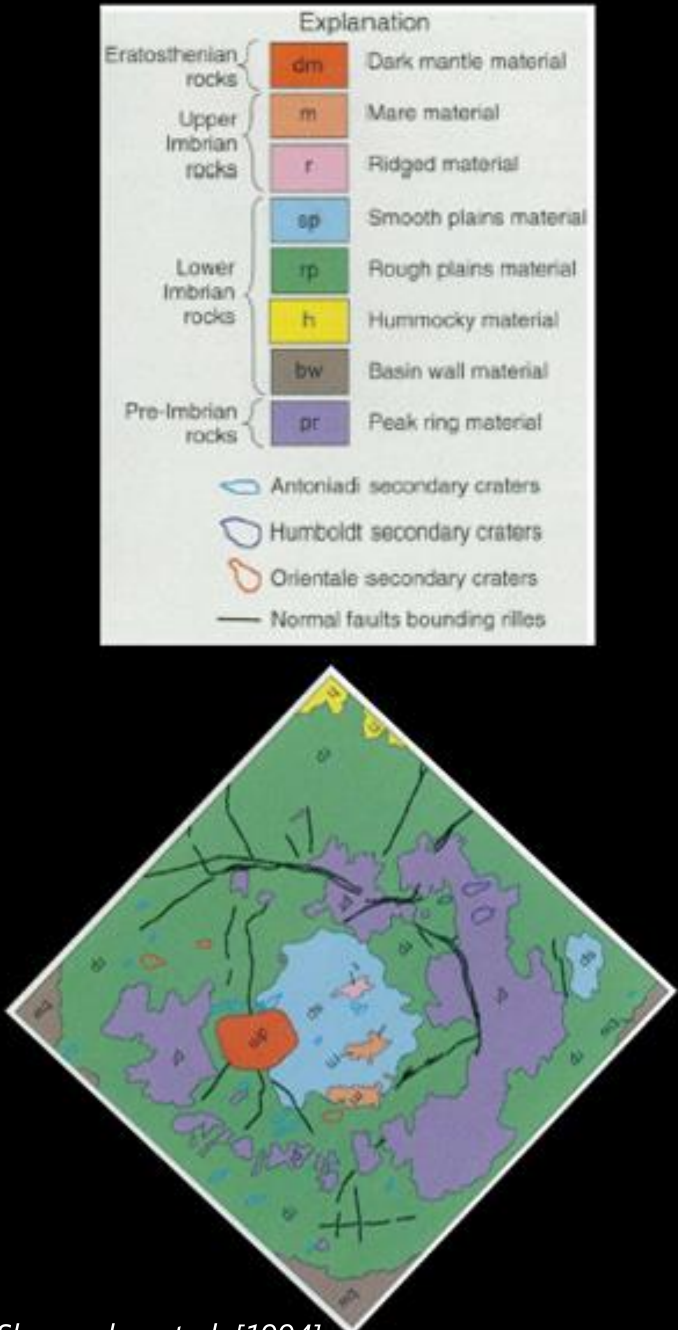
Schrodinger Group

- sr — Rim material
- wm — Wall material
- sh — Rough material
- sf — Bright floor material
- ss — Smooth floor material
- sd2 — Dark material, younger
- sd1 — Dark material, older
- re — Basin-massif material

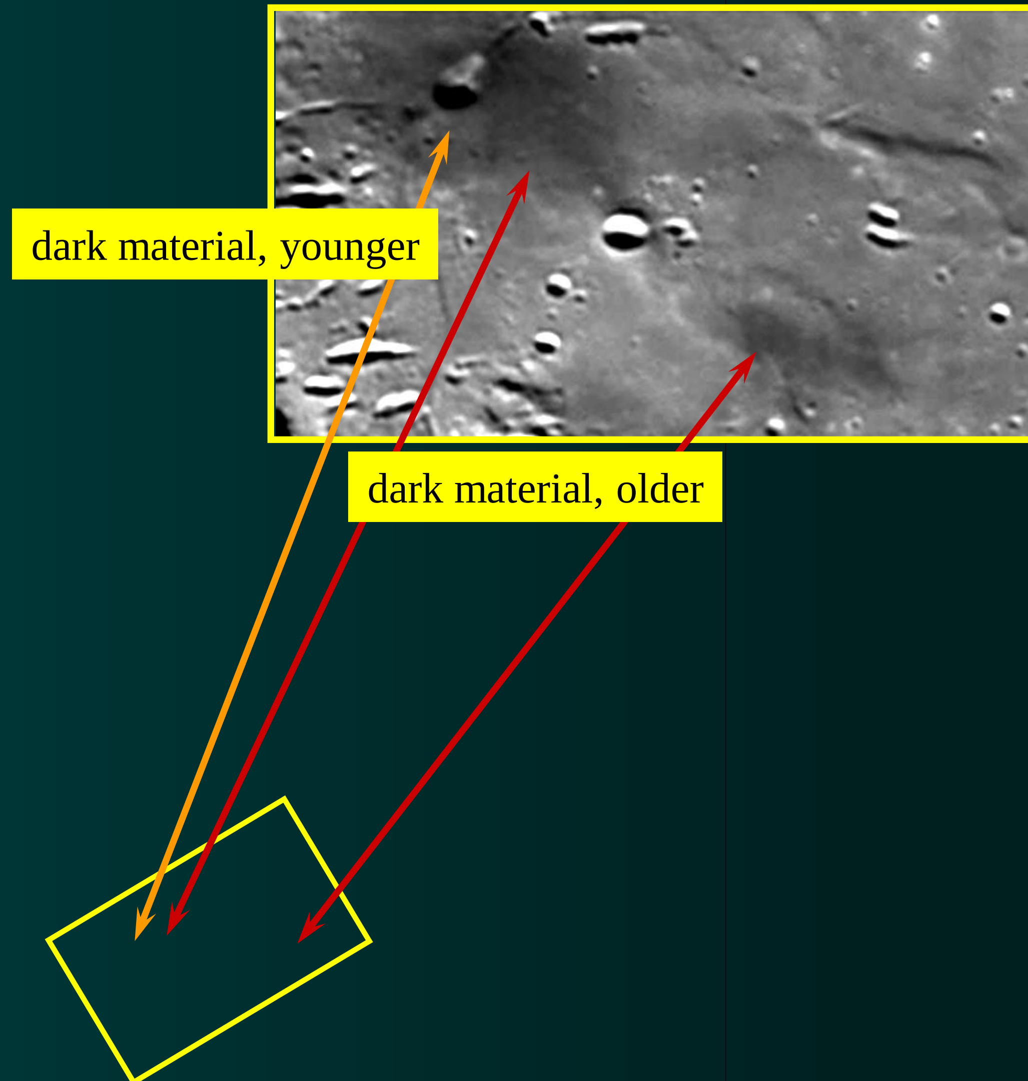
Structures

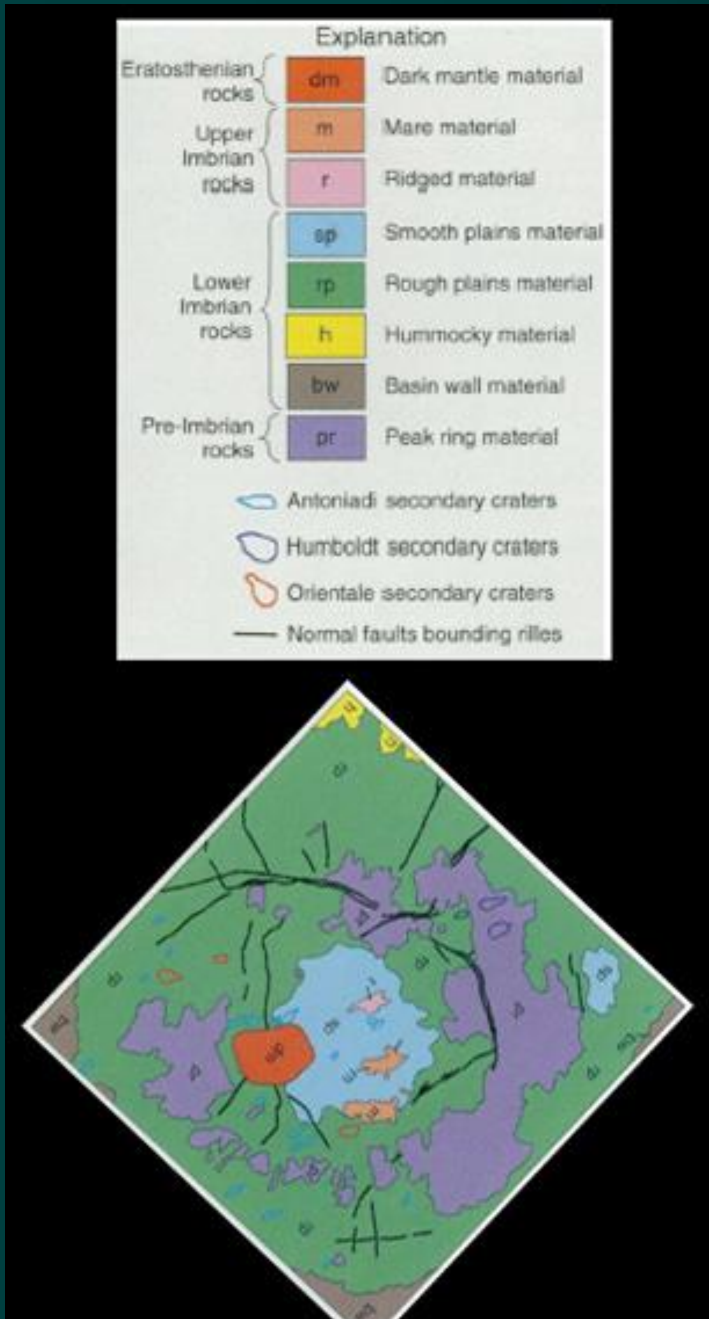
- Fault with apparent normal offset
- Fault with undifferentiated offset
- Ridge with broad base and crenulated crest
- Topographic rim of impact crater
- Topographic scarp, barbs point downslope

rough mantling material



Shoemaker et al. [1994]





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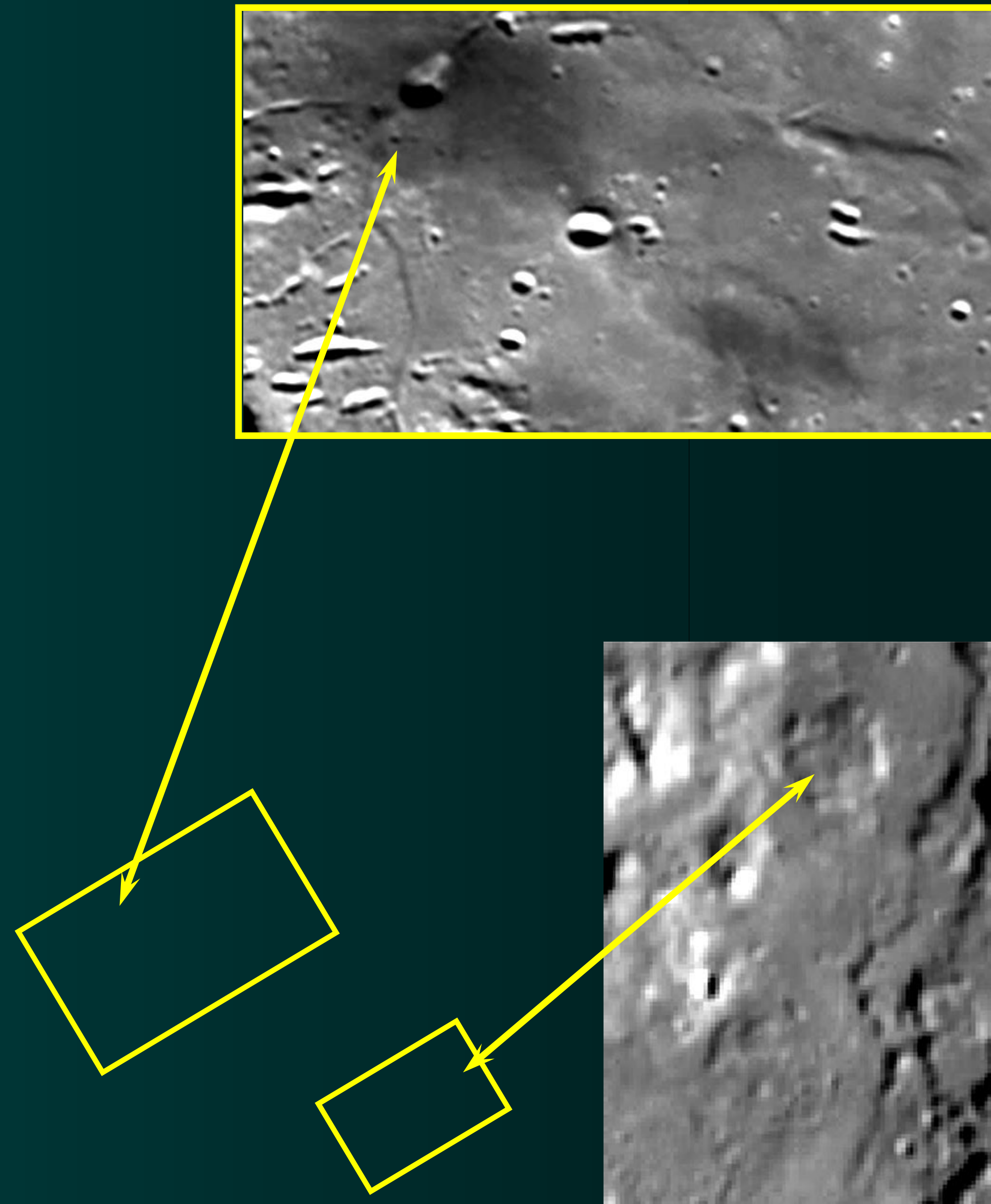
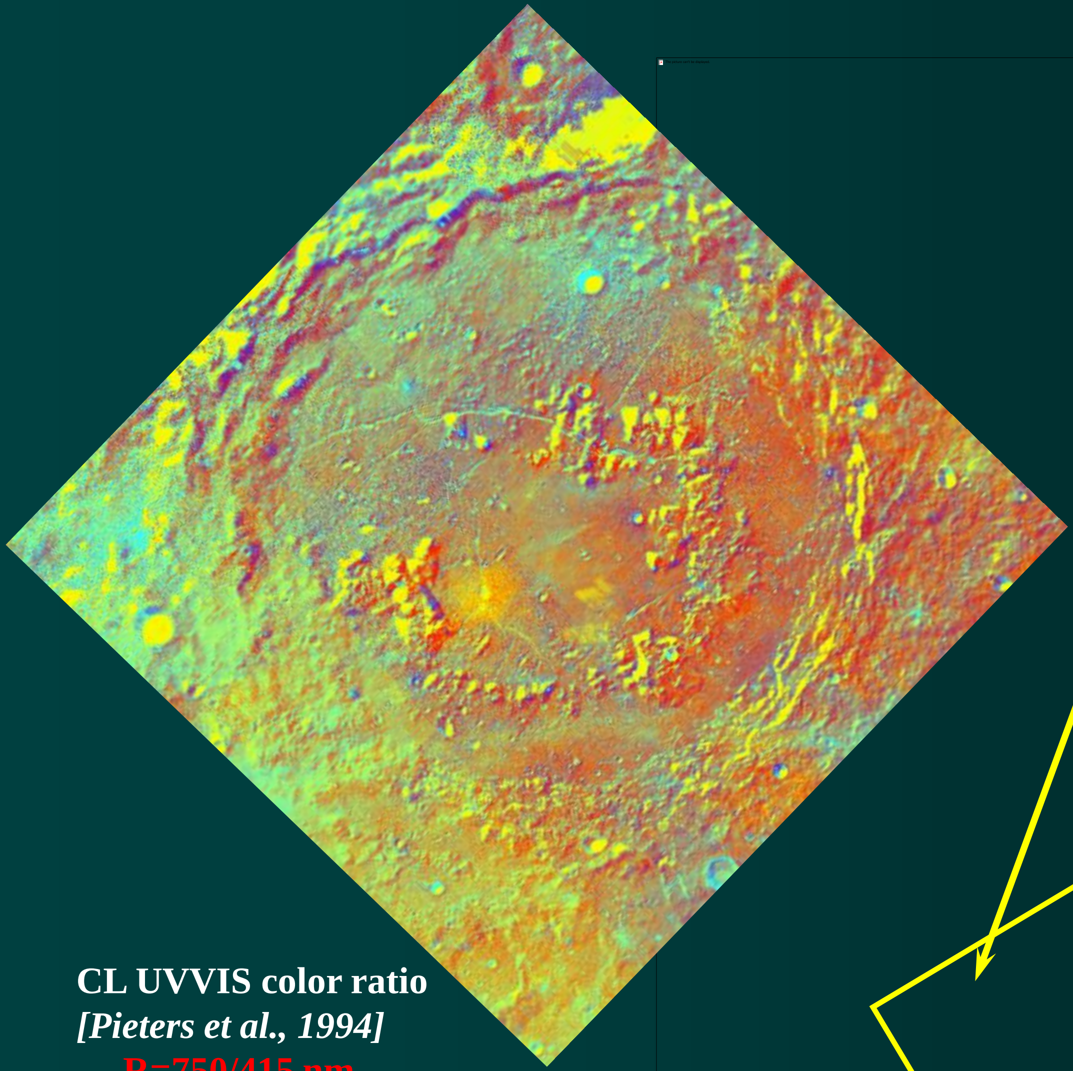
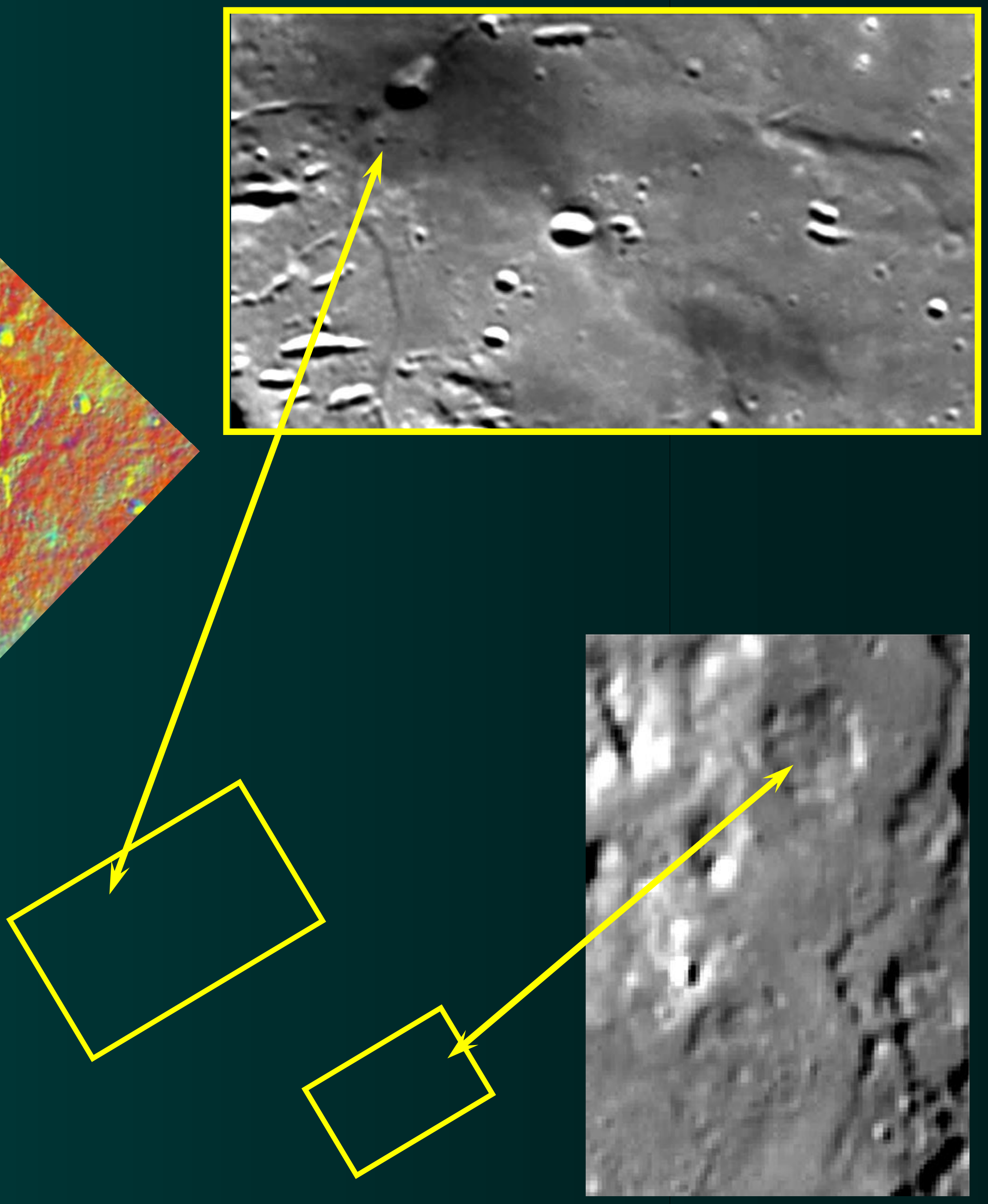






CL UVVIS color ratio
[Pieters et al., 1994]
R=750/415 nm
G=750/950 nm
B=415/750 nm)

yellow-orange tones ≈ mafic-rich
green-blue tones ≈ feldspathic

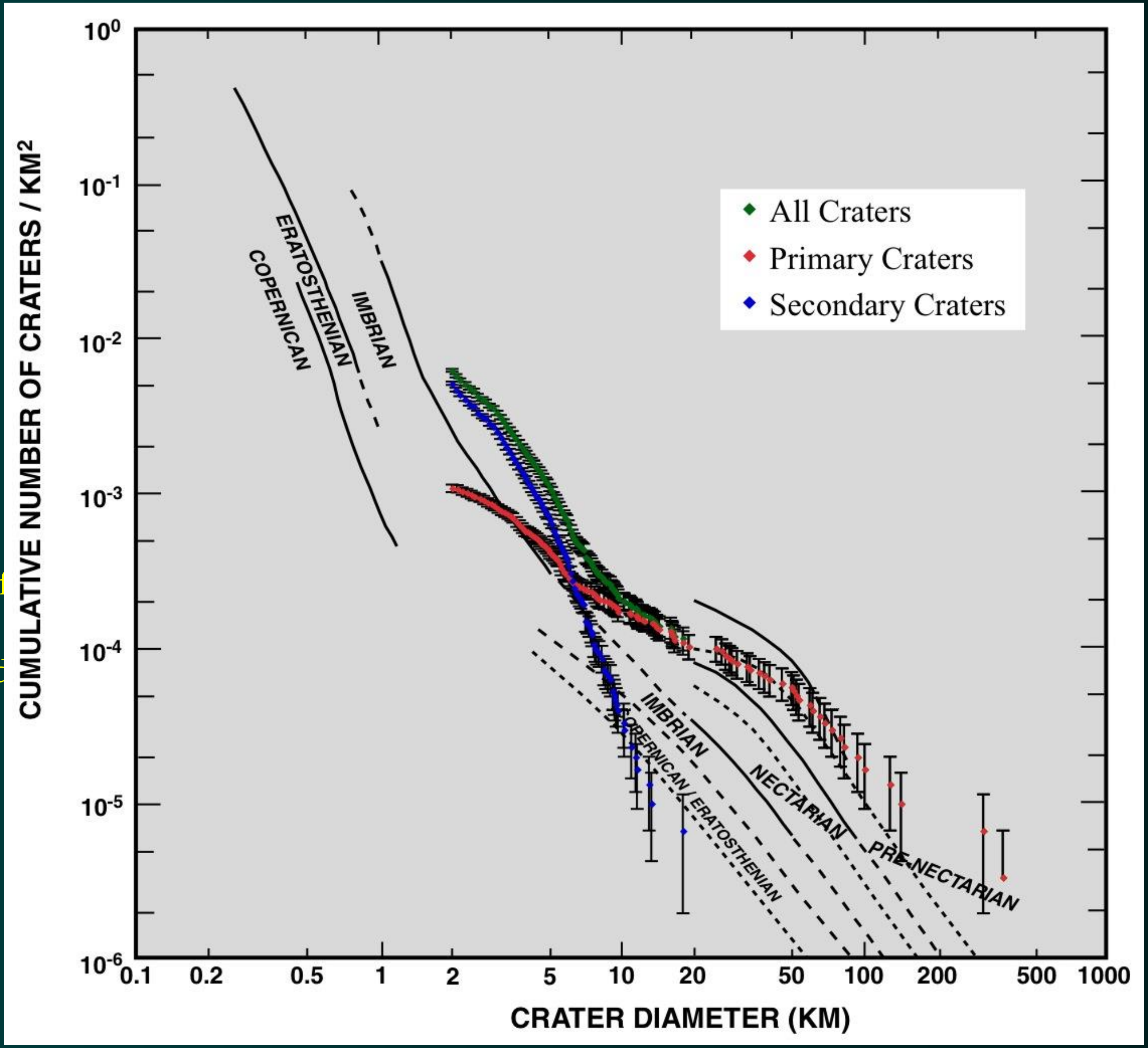
Crater Size-Frequency Distribution - Schrödinger Area Regional Statistics

- Identify impact craters
  - D > 2 km
- Total crater population
  - 1867
- Classify craters:
  - Primary
  - Secondary

    (non-circular, clusters, chains)

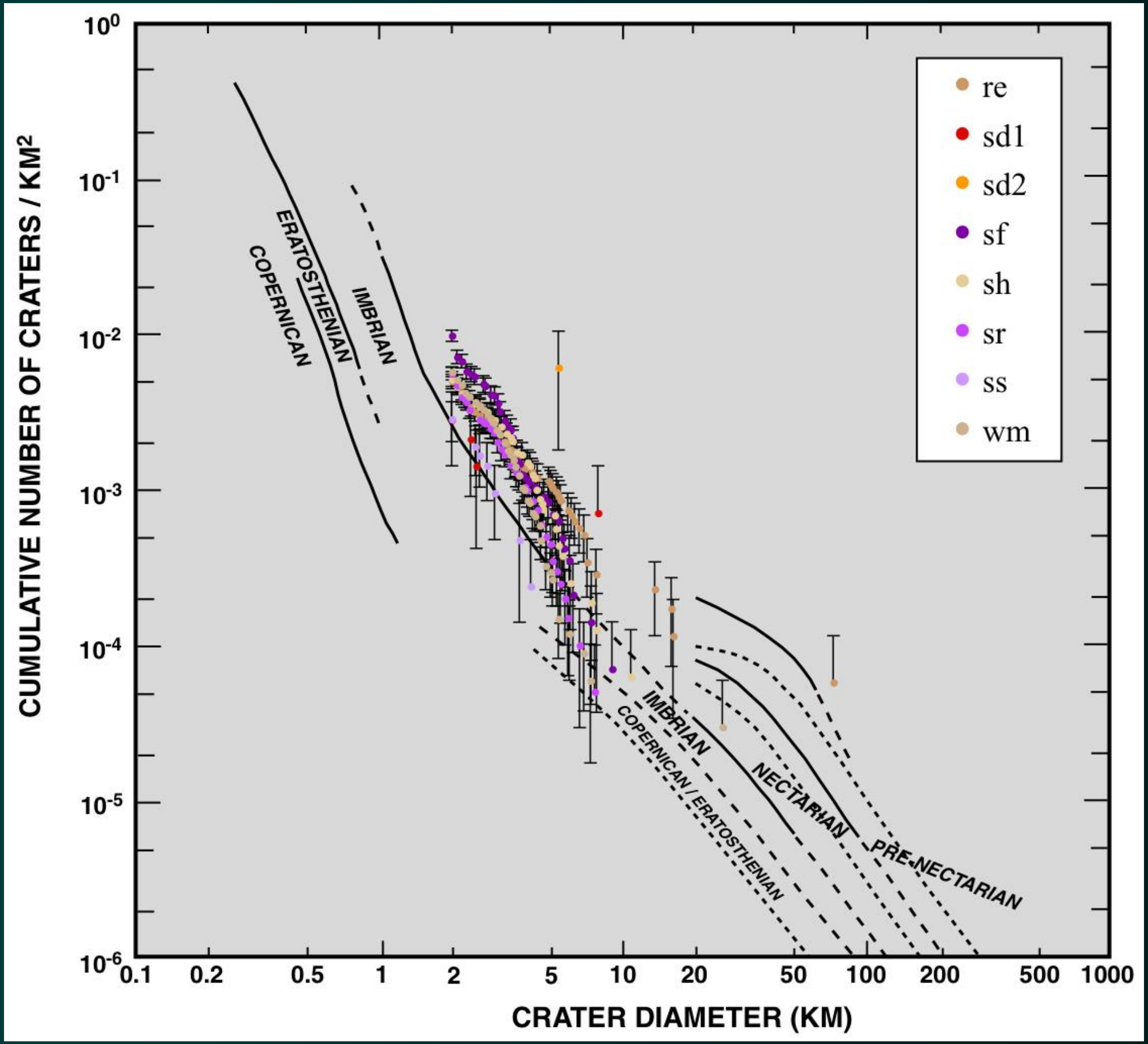
    Accurate classification of secondaries unreliable

    Only Total Population used to estimate surface ages
- preNectarian to Nectarian



Crater Size-Frequency Distribution - Schrödinger Area Unit Statistics

- All Schrödinger floor materials (except sd_1, sd_2) large enough to provide accurate calculation of CSFDs.
- Units sh and wm (Schrödinger peak ring and wall materials) span Nectarian-Eratosthenian; Schrödinger believed to be Lower Imbrian (3.8 by) [*Wilhelms, 1987; Shoemaker et al., 1994*].
- Most plains units yield surface ages of Nectarian-preNectarian, much older than age of basin.
- sd_1 and sd_2 (youngest in basin) show Nectarian ages.
- Discrepancies due to:
  - Incorporation of secondaries
  - Misidentification of units
  - Lack of preservation
  - Small areas



Summary

- Large part of map area (60° -90° S) within SPA
  - Near-surface likely consists of ancient crustal materials exposed by impact event
- Remainder of map area on and just outside of SPA rim
  - Likely consists of mixed SPA ejecta
- Age of quadrant (70° -90° S, 90° -180° E) estimated to be preNectarian to Nectarian
- Schrödinger rim and peak ring materials estimated to be Lower Imbrian in age, consistent with *Wilhelms [1987]* and *Shoemaker et al. [1994]*
- Youngest materials in Schrödinger, and possibly in region, likely Eratosthenian/Copernican in age, consistent with *Shoemaker et al. [1994]*

Next steps:

- Revise “contacts” in quadrant map
- Recalculate crater size-frequency distributions
- Resubmit South Polar mapping proposal to Planetary Geology and Geophysics program

T-MINUS 1 MONTH!