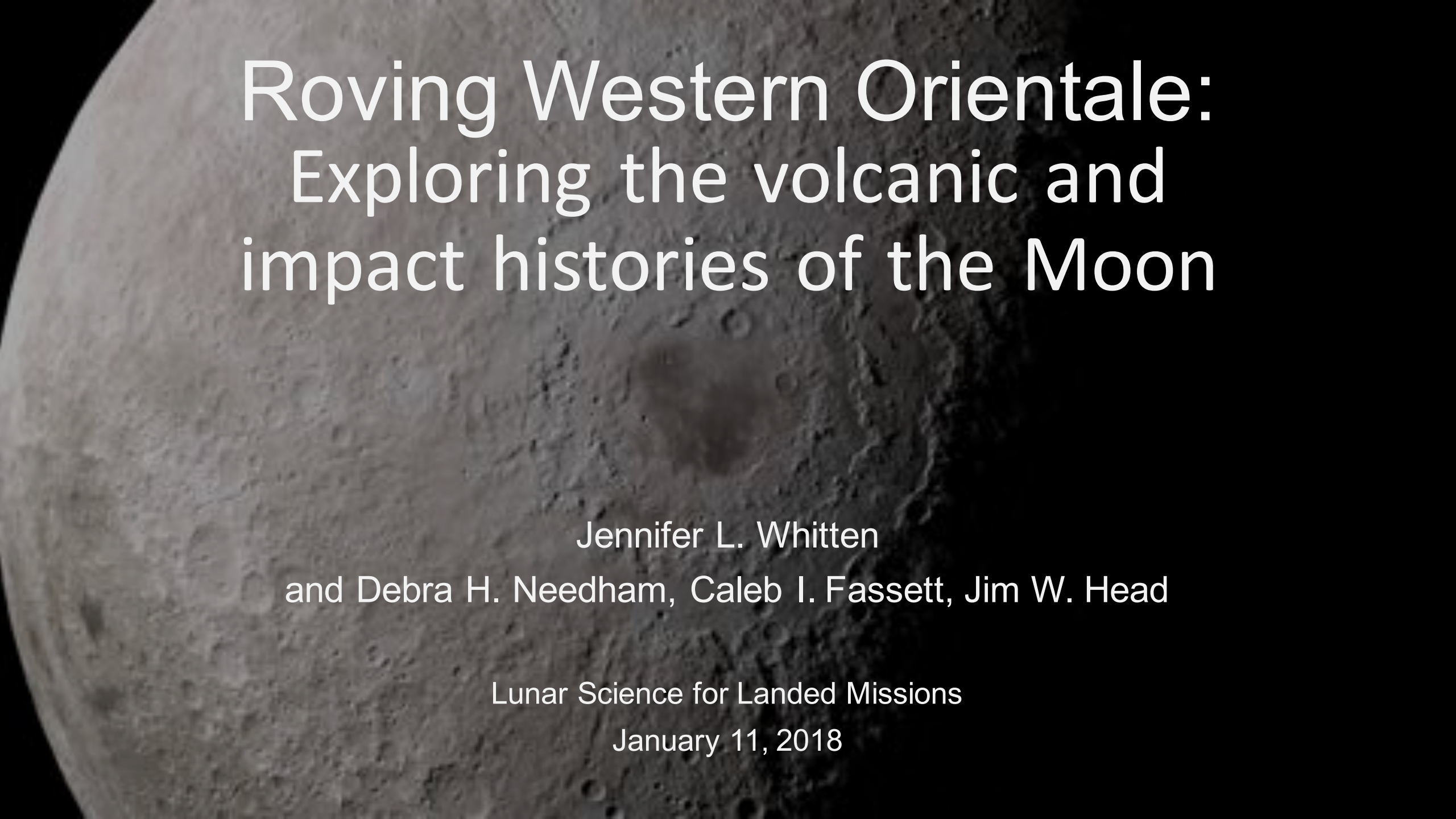

Roving Western Orientale: Exploring the volcanic and impact histories of the Moon

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and Debra H. Needham, Caleb I. Fassett, Jim W. Head

Lunar Science for Landed Missions
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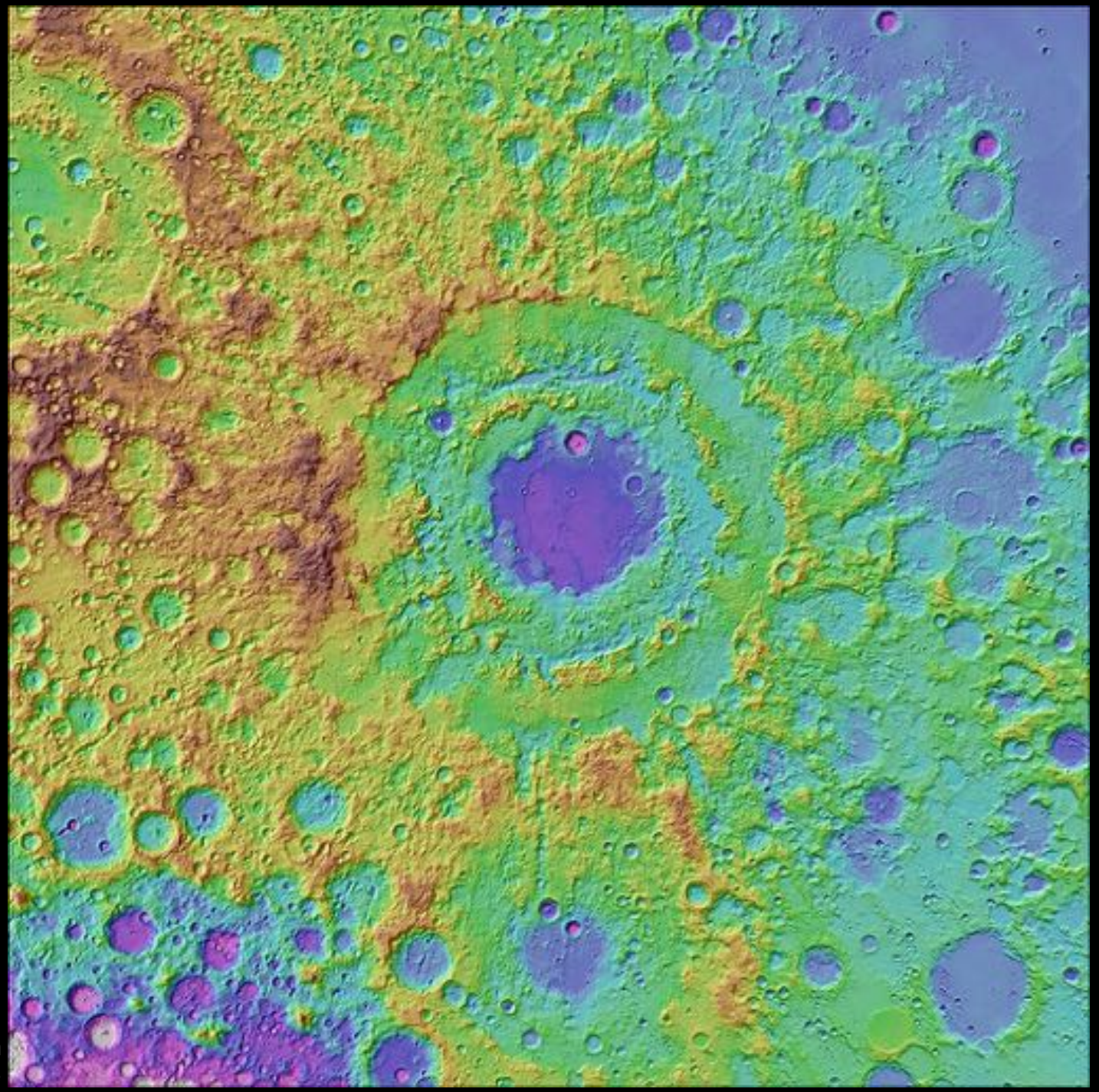
Orientale Basin

- Youngest and most well-preserved basin impact on the Moon.
- Stratigraphic marker whose age can be clearly constrained.
- Uniquely situated on the nearside-farside boundary, enabling measurement of farside materials and material outside of the Procellarum KREEP Terrane.
- Mare basalts span a large age range (based on crater model ages [*Whitten et al.*, 2011]) and deposition environments (e.g. location within the basin, crustal thickness).



LRO-LOLA 118 m
DEM and hillshade

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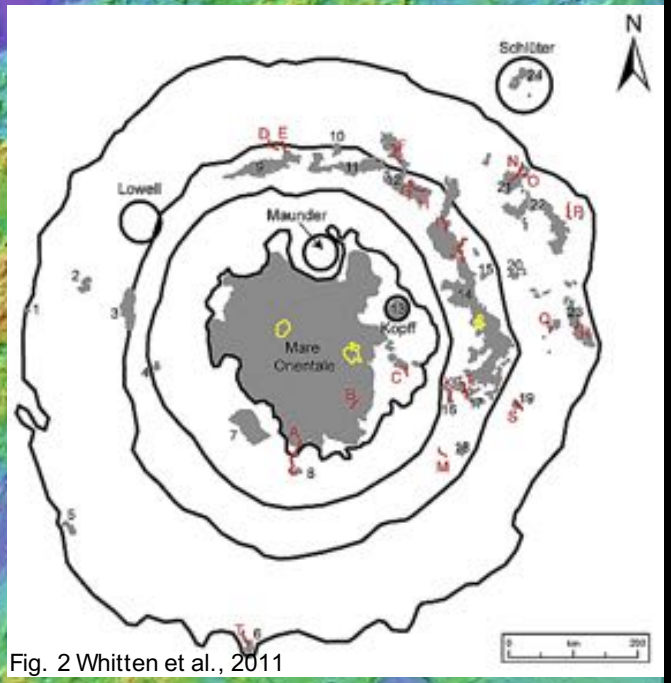


Fig. 2 Whitten et al., 2011

Proposed Landing Sites

Western Orientale
between the Inner and Outer Rook Ring

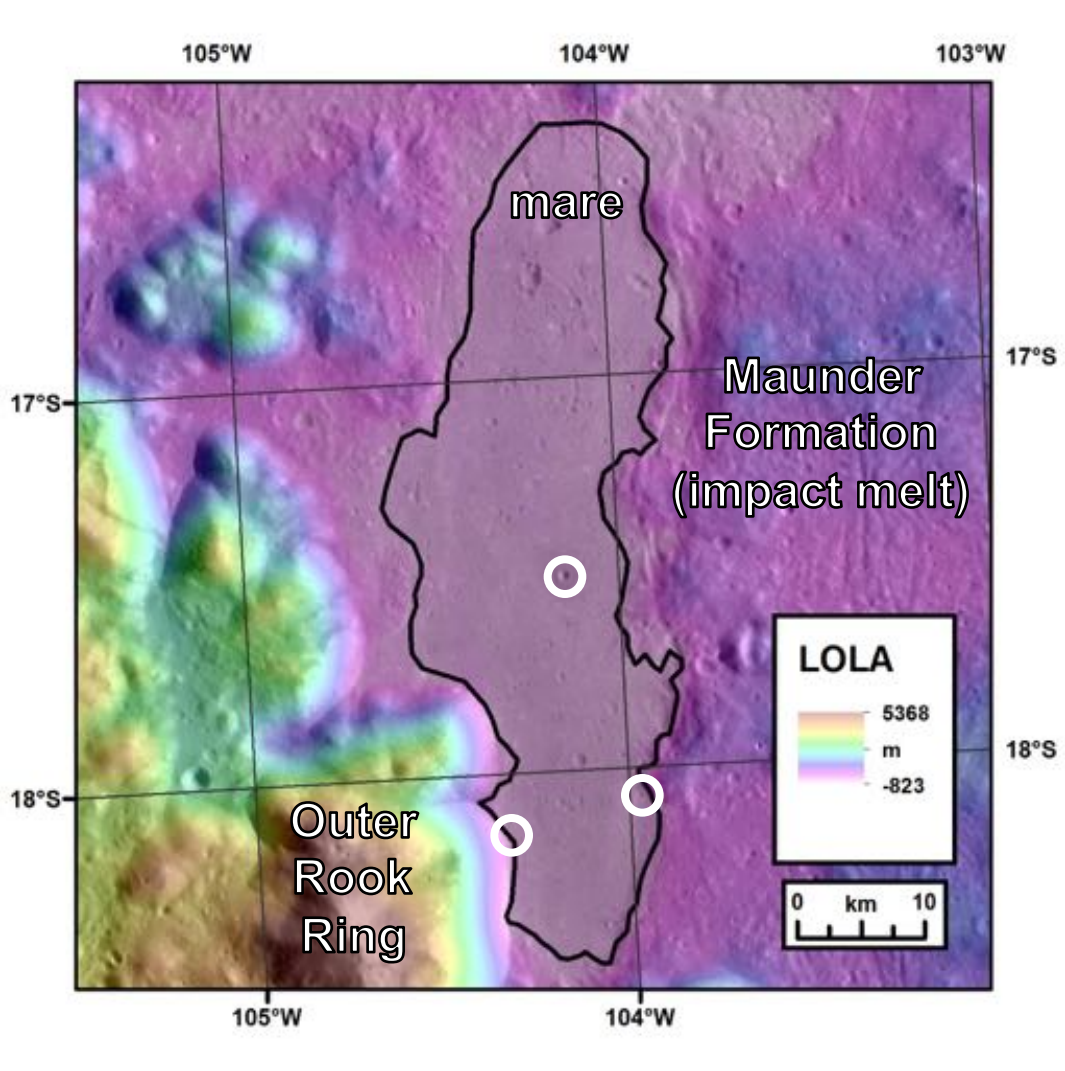
Selected because:

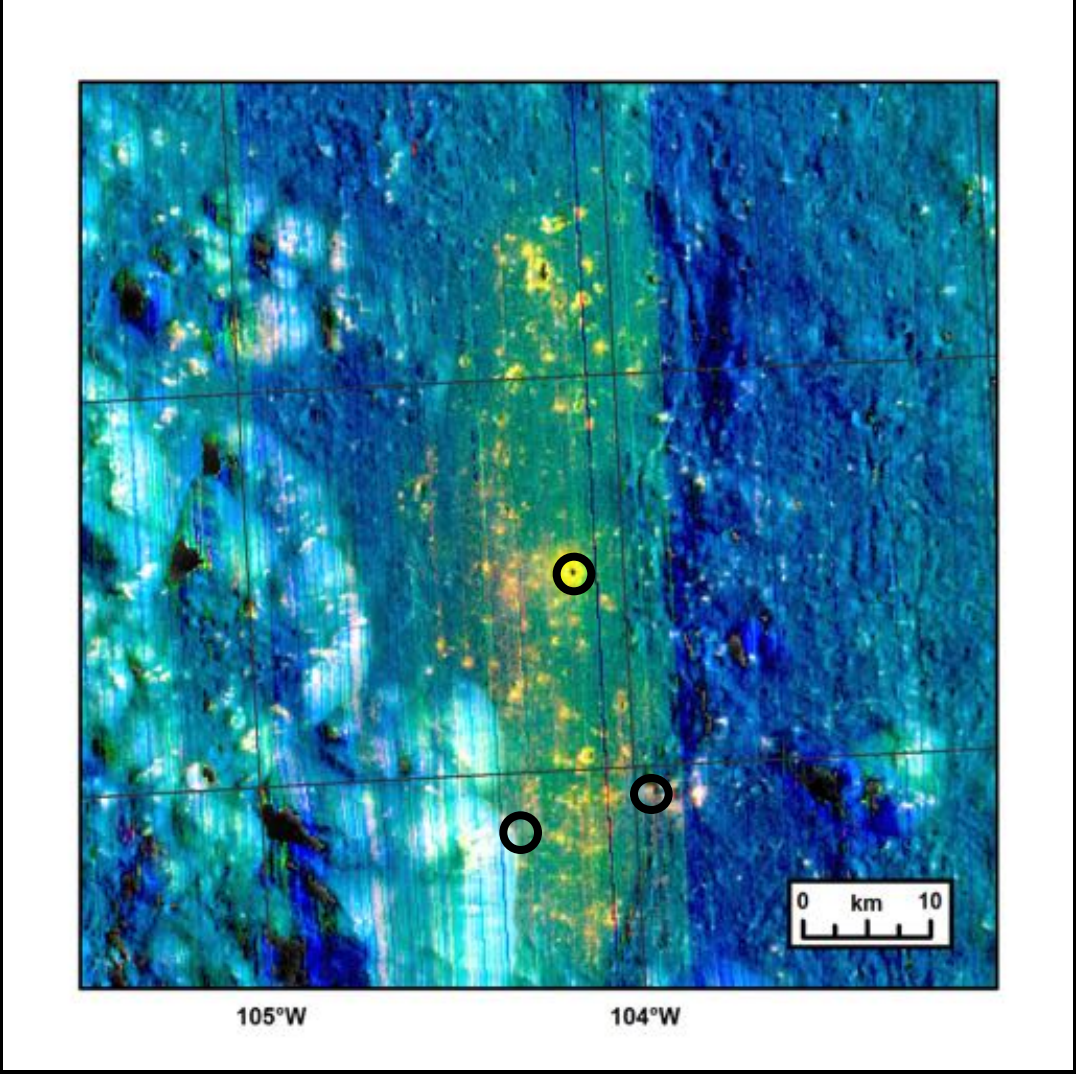
- Proximity of a variety of geologic units:
  - mare,
  - impact basin melt sheet,
  - basin ring materials.

Eastern Orientale
[Needham et al., *this meeting*]

LROC WAC

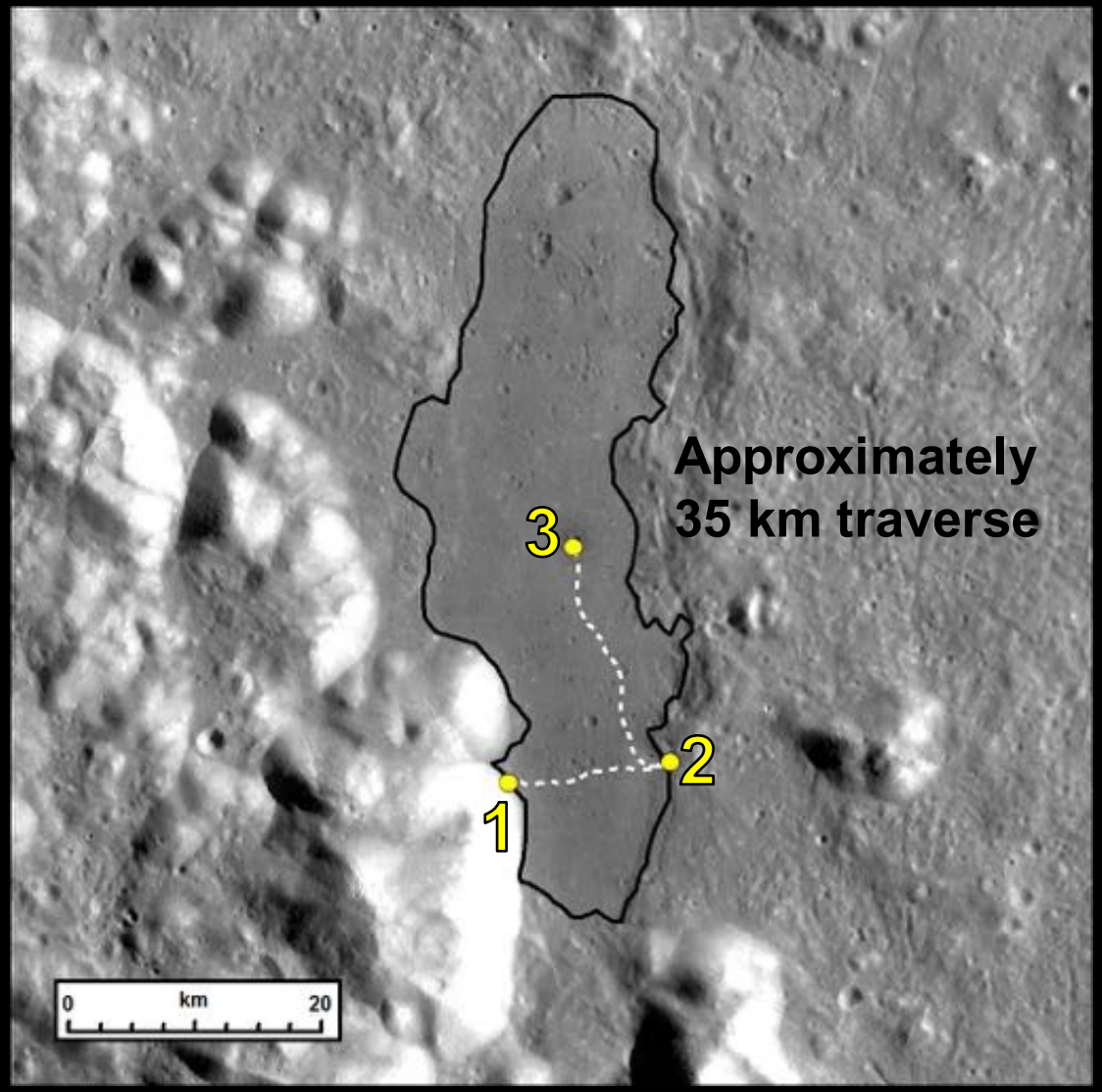
Western Orientale Landing Site



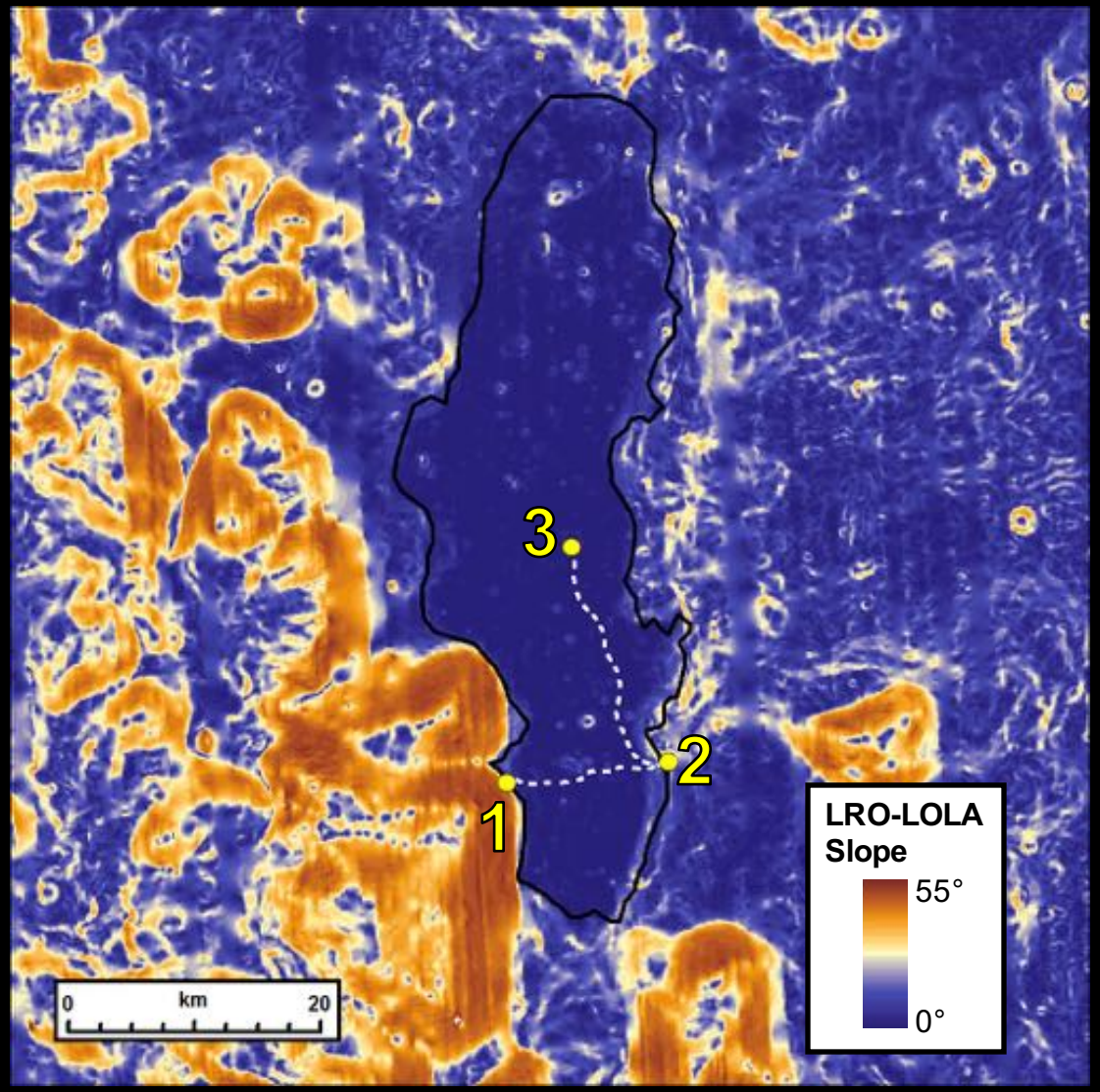


M^3 color composite, highlighting mafic mineral absorptions
(R 1.0 µm IBD; G 2.0 µm IBD; B refl. 1489 nm).

Proposed Traverse



LROC 110 m WAC mosaic

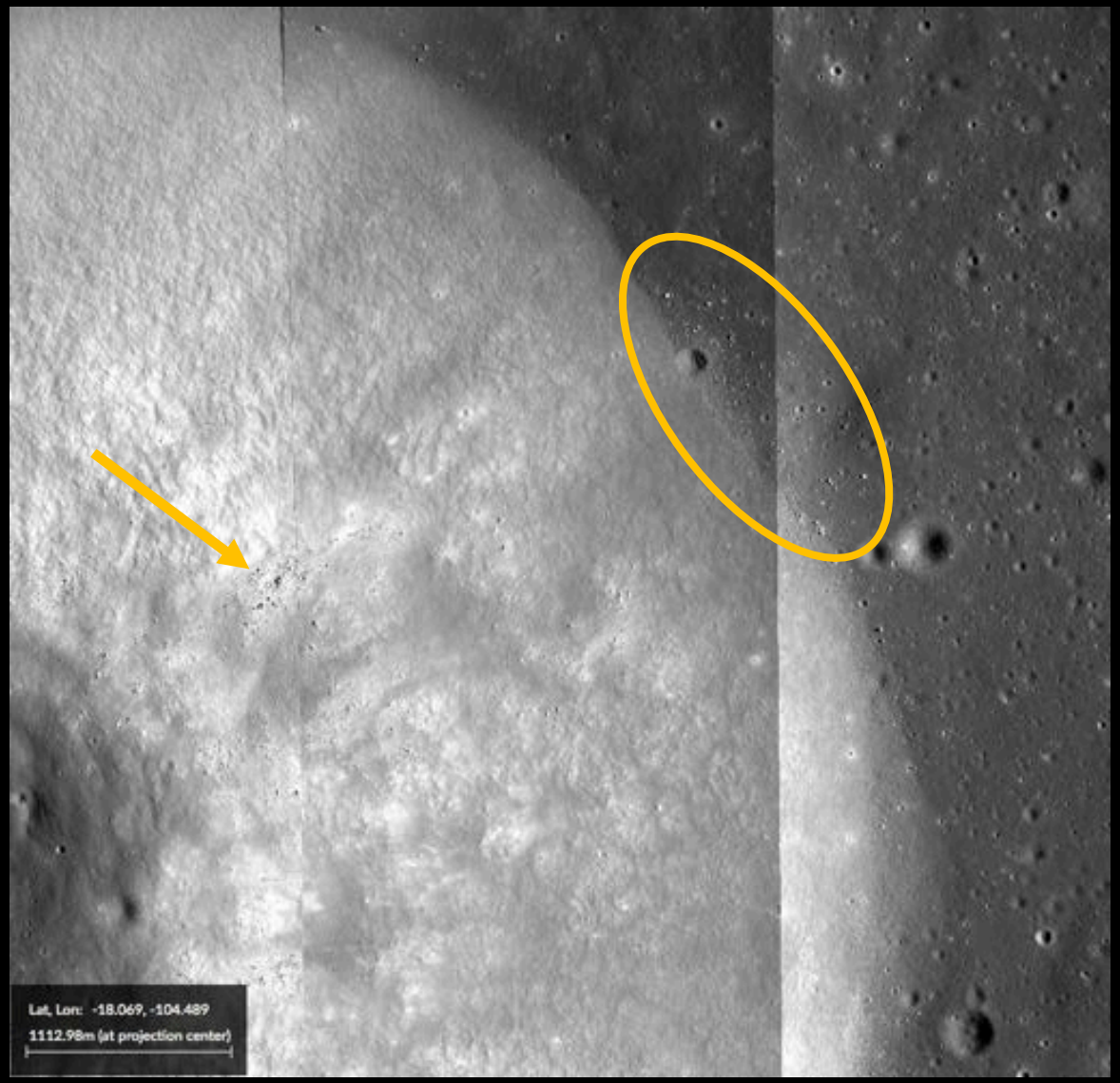


Slope derived from LRO-LOLA 118 m DEM

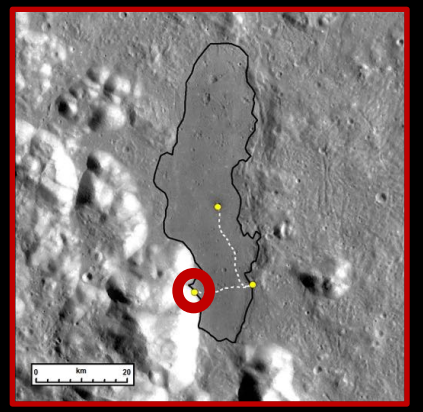
Science goals:

- Constrain the bombardment history of the inner solar system and large-scale impact events by determining age of the Maunder Formation impact melt.
- Characterize the diversity of lunar rocks through measurements of the composition of mare basalts, impact melt (Maunder Formation), and crustal materials (primary crust).
- Investigate volcanic materials to constrain the thermal and compositional evolution of the Moon with measurements of the composition and age of mare basalts located in thicker crust.
- Investigate regolith processes and weathering on airless bodies by measuring the composition of regolith at and between sample sites.

Sample Site 1: Outer Rook Ring



LROC NAC



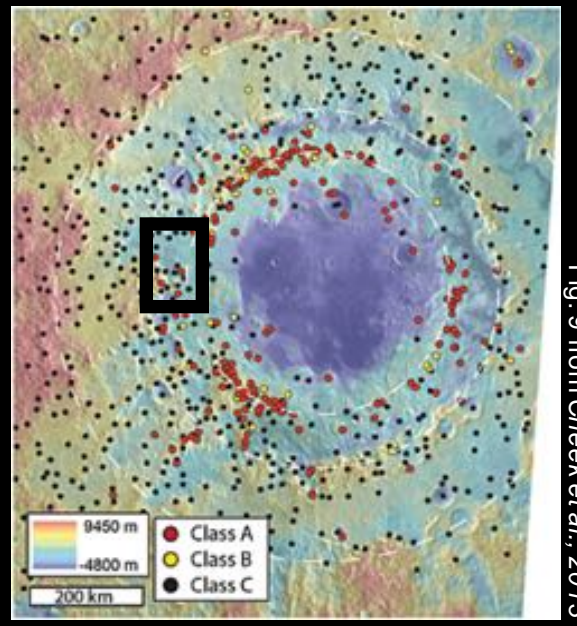
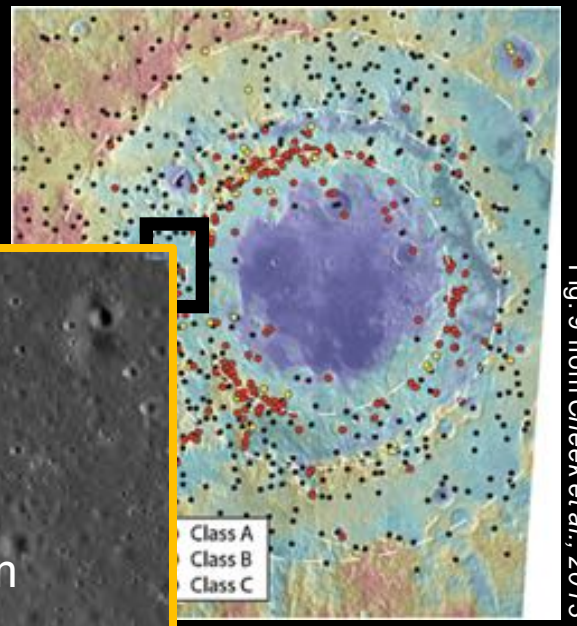


Fig. 9 from *Cheek et al., 2013*

- Sample boulders at base of Outer Rook Ring massif.
  - Mineralogical similarities in the M^3 data suggest that these boulders are similar to the massif outcrop upslope.
- Sample regolith at this location, as well as on the drive to the next sample site.

Sample Site 1: Outer Rook Ring



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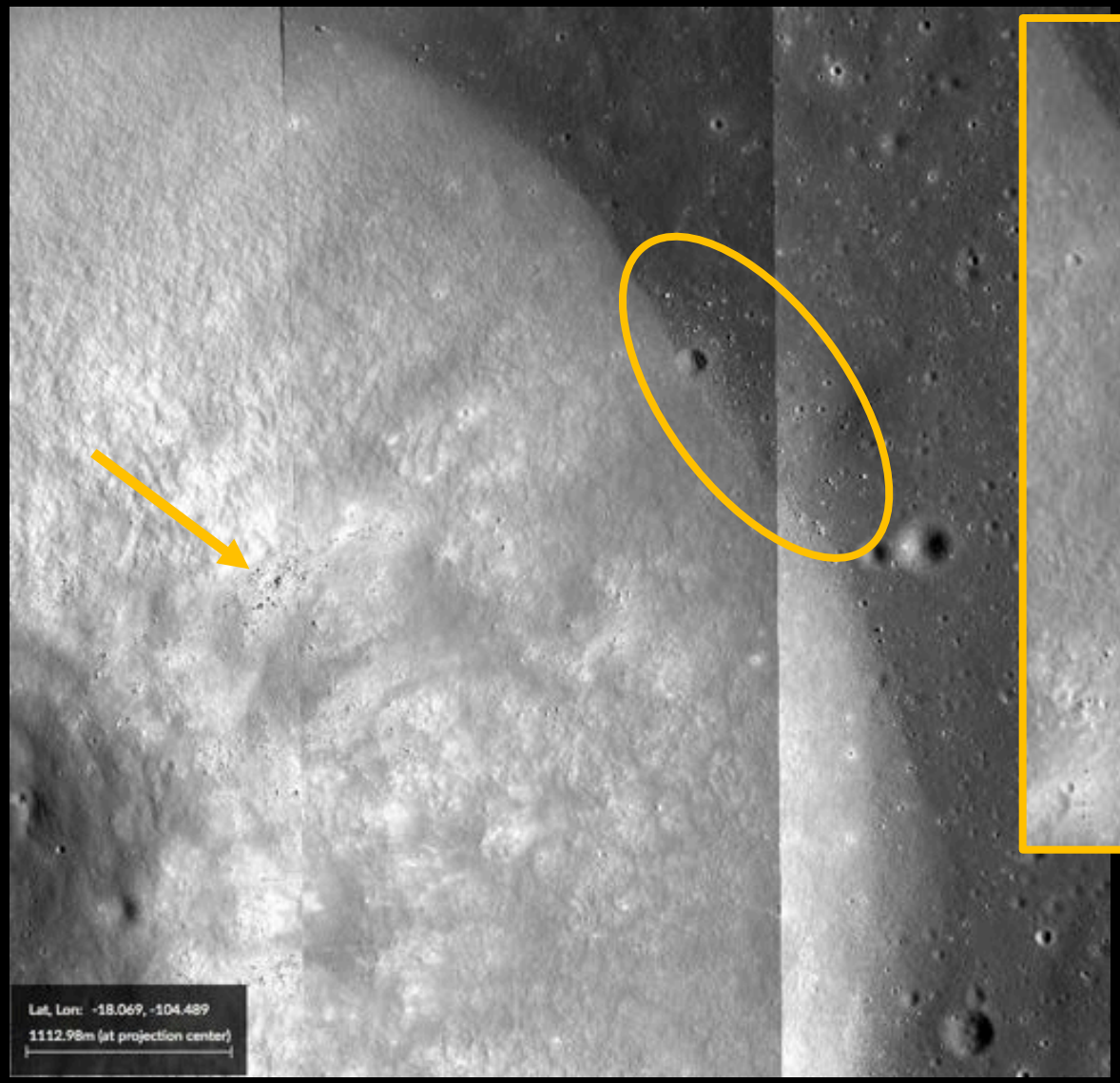
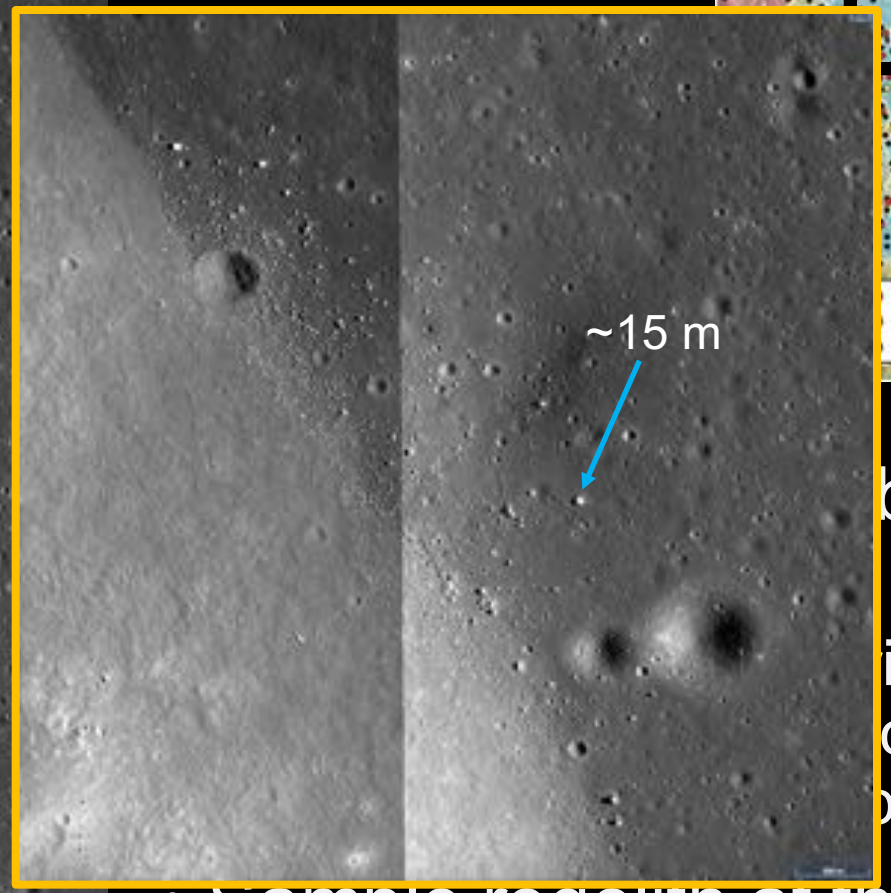


LROC NAC

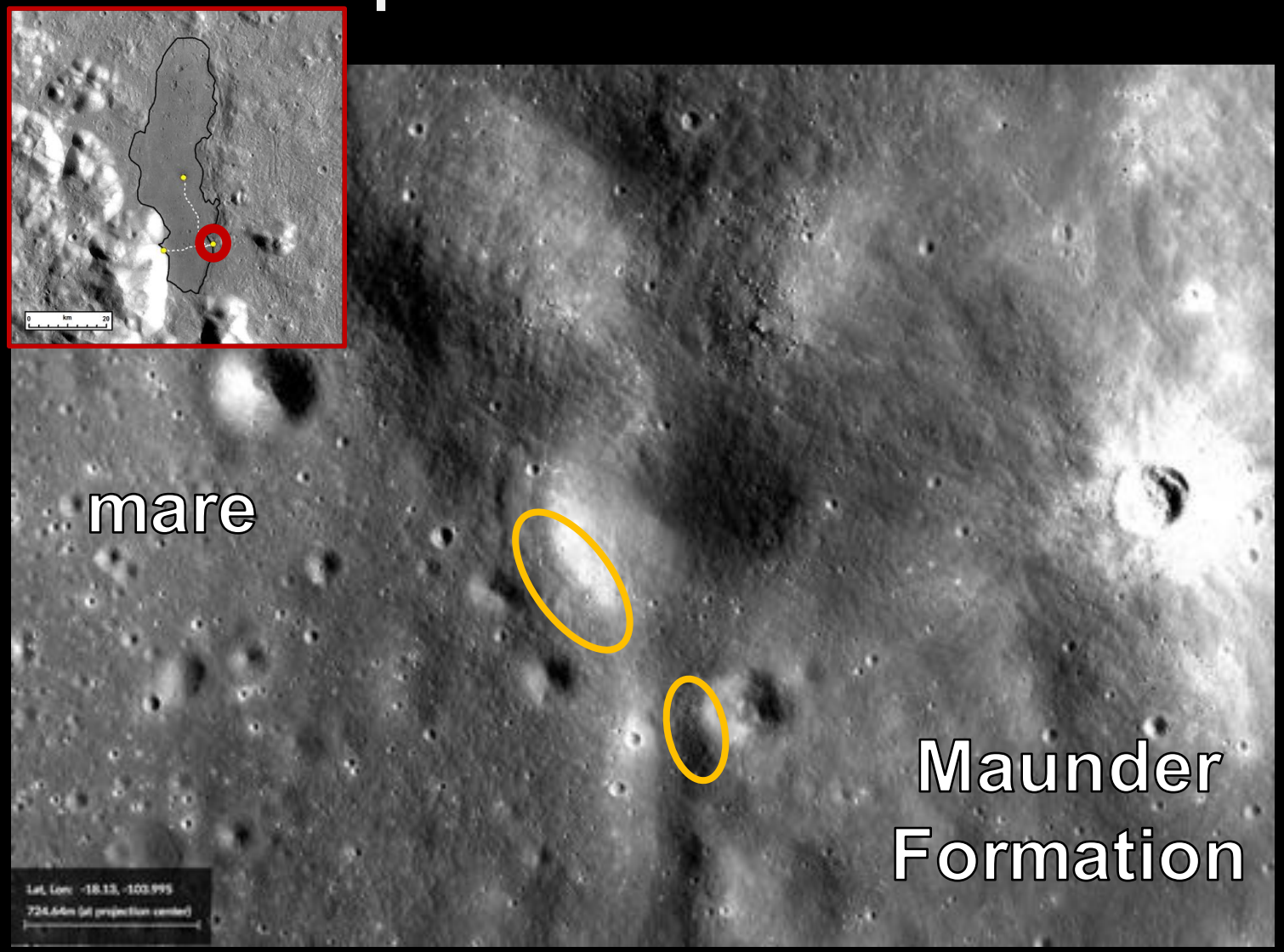


base of Outer

ities in the M^3 data
oulders are similar
upslope.

- Sample regolith at this location, as well as on the drive to the next sample site.

Sample Site 2: Maunder Formation (MF)

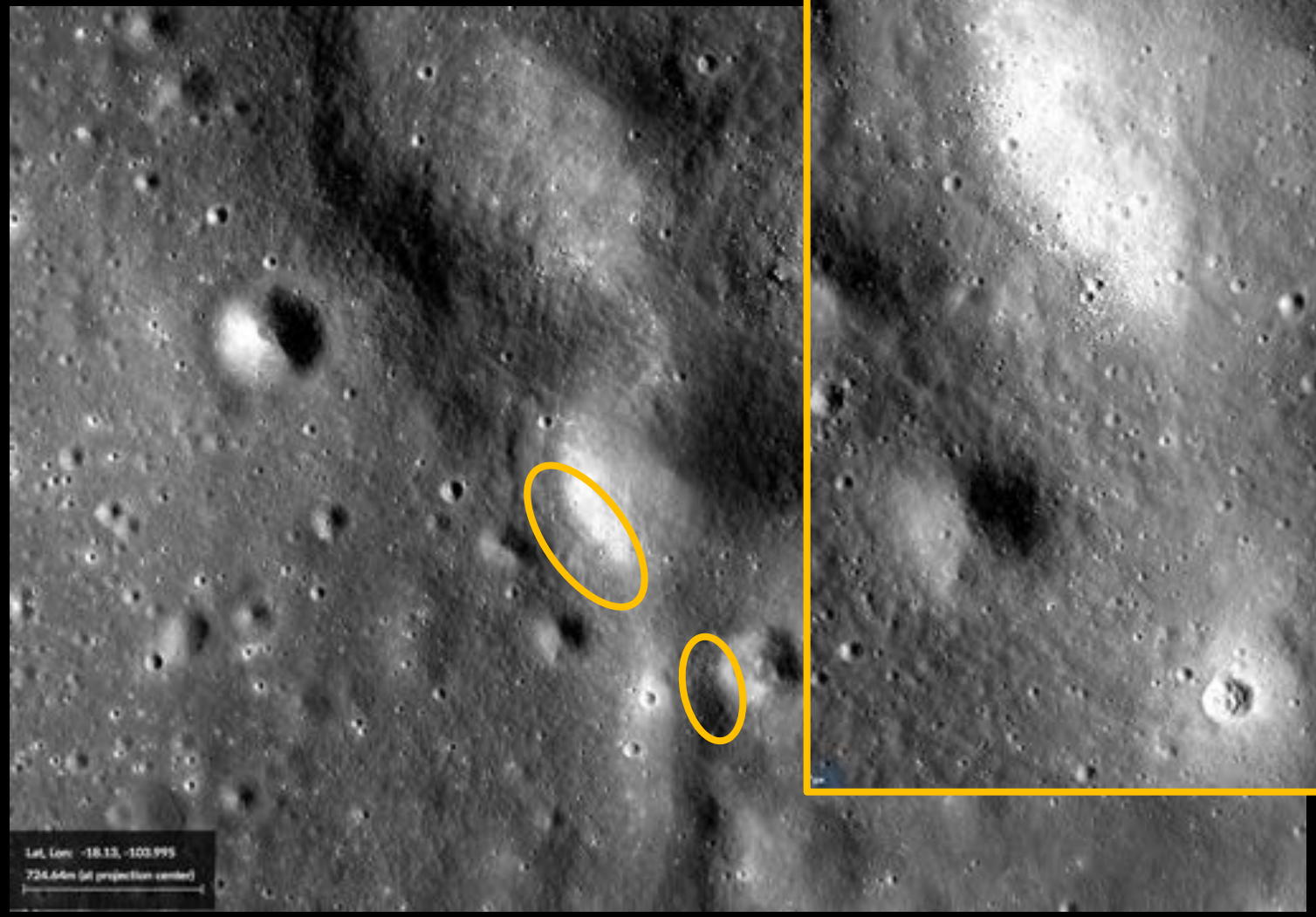


LROC NAC

- Sample boulders on impact crater rims at the mare-MF boundary.
  - Boulders on the western edge of the crater rims located on slopes that reach up to 15°*.
- Mineralogical similarities in the M^3 data suggest that these boulders are similar to other MF mineralogy.
- Sample regolith at this location, as well as on the drive to the next sample site.

*Curiosity has navigated slopes of 32°.

Sample Site 2: Maunder Formation (MF)



LROC NAC

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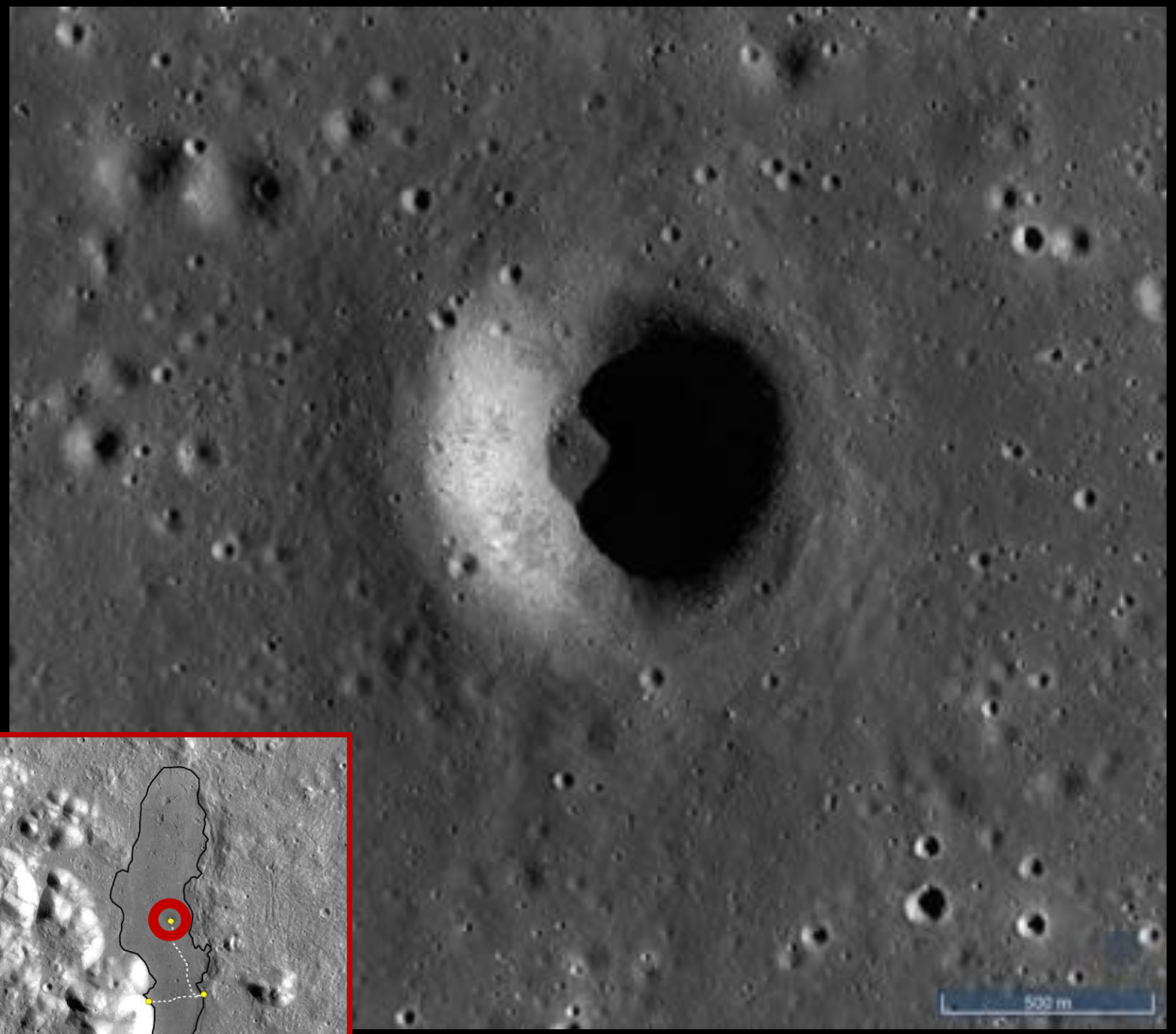
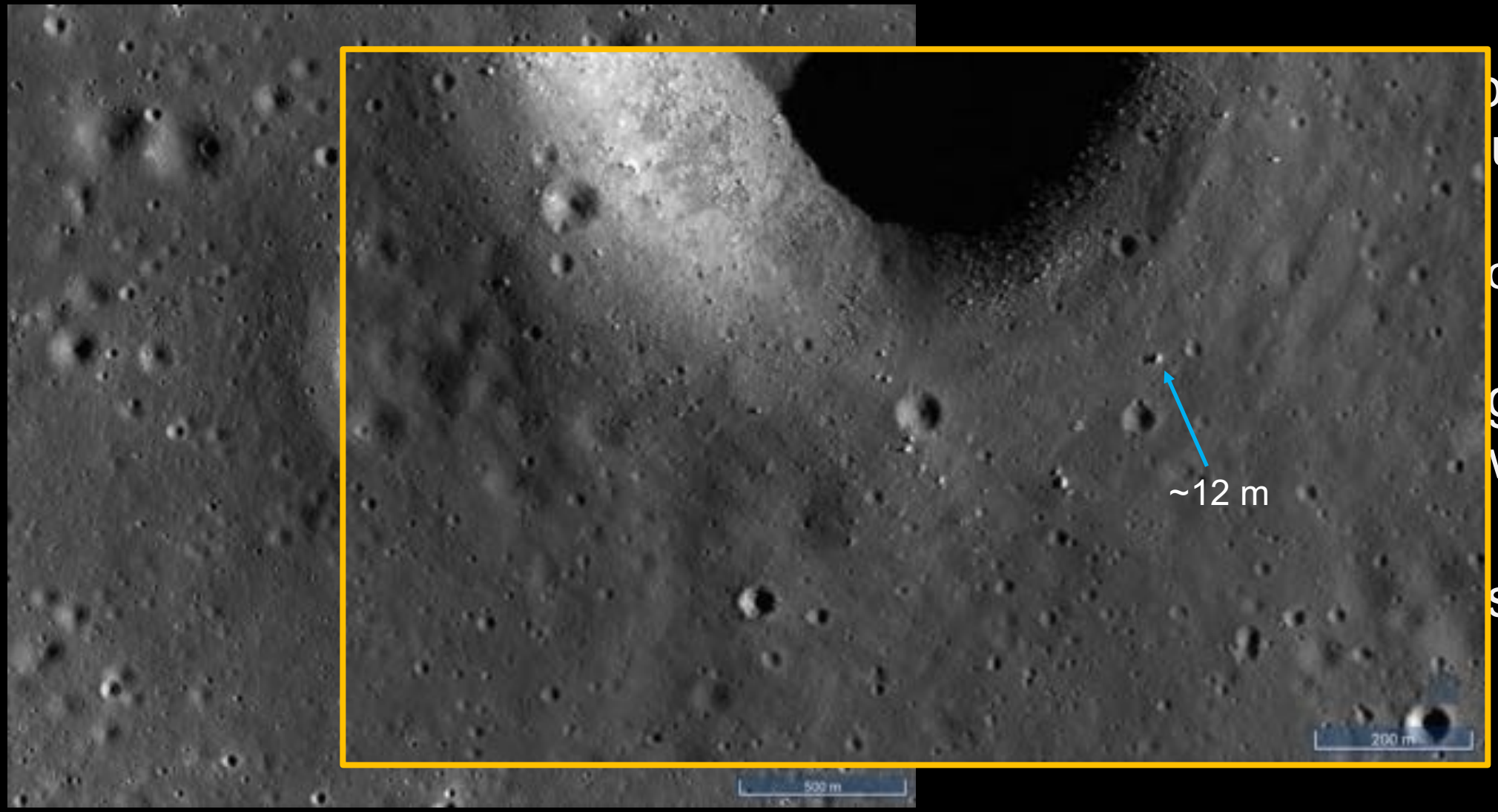
Sample Site 3: Mare basalt



LROC NAC

- Sample mare basalt boulders from region on the southern edge of crater rim.
  - Slopes near this part of the crater rim are <5°.
- M^3 data show a strong basaltic signature associated with this impact crater.
- Sample regolith at this location.

Sample Site 3: Mare basalt



LROC NAC

boulders
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of the crater

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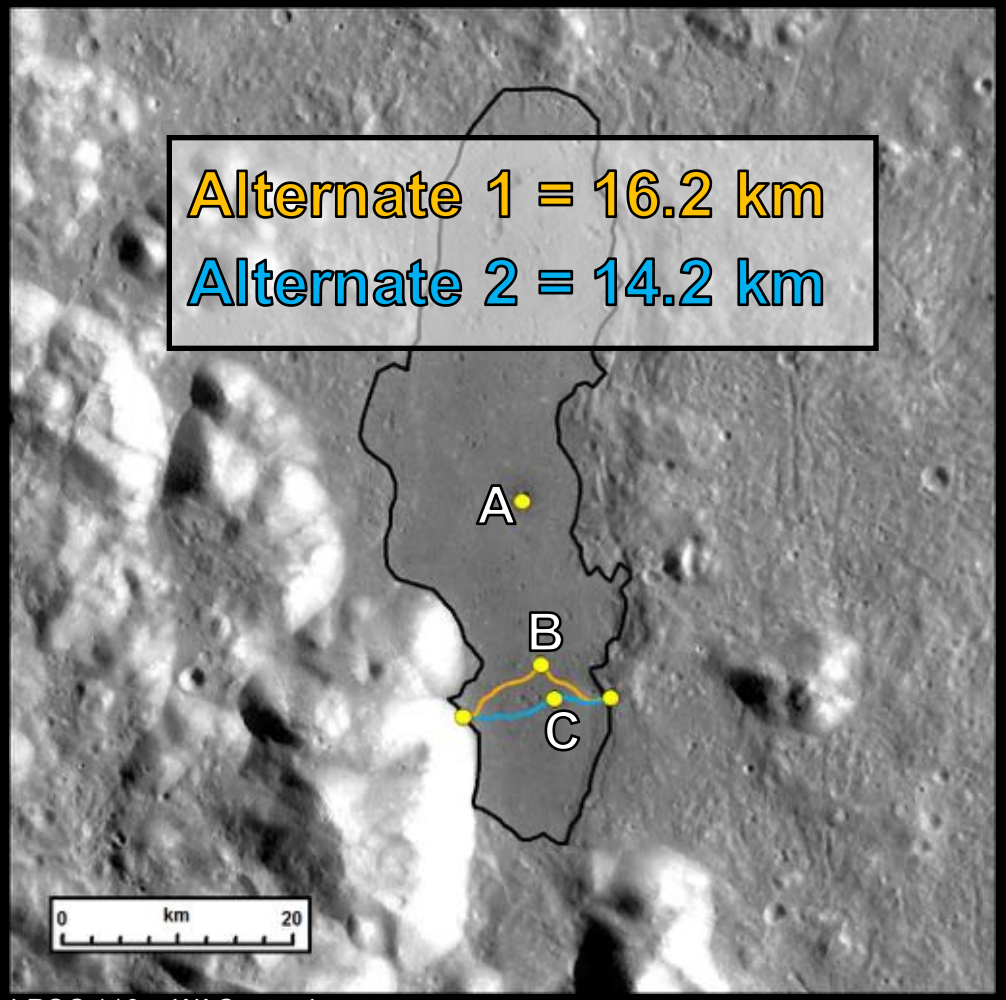
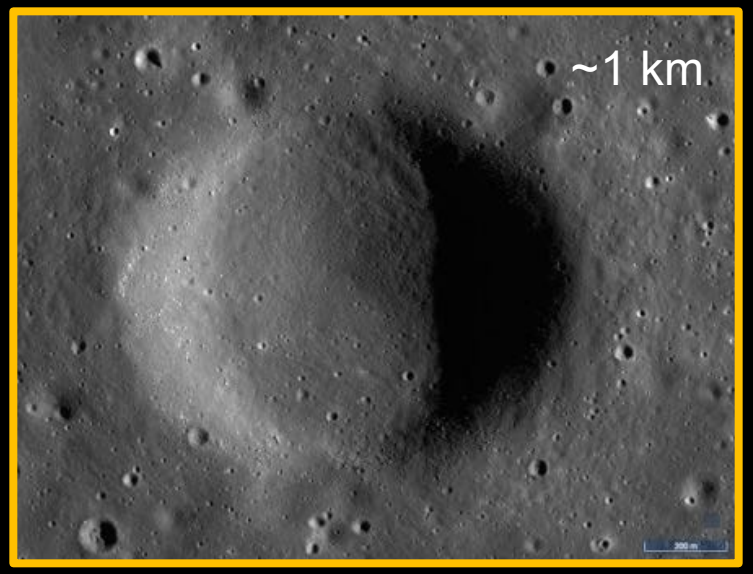
with this

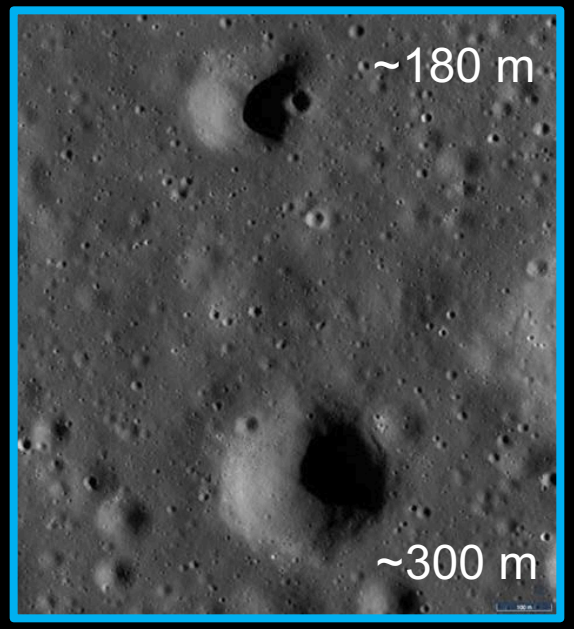
s location.

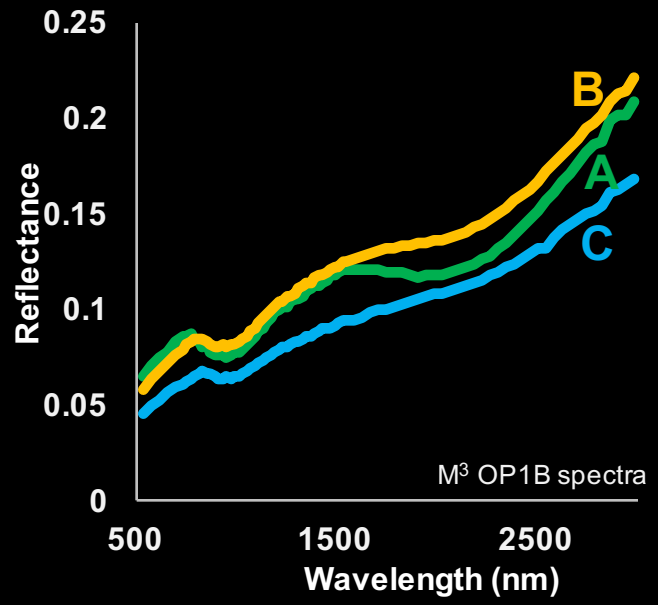
Alternate Traverses: Shorter travel distances



LROC 110 m WAC mosaic







Proposed Instruments for Mission

Honeybee Robotics

Rock abrasion tool:

- To ensure clear measurements of the interior of sampled rocks, rather than just the weathered exterior.

Compositional analyses:

- X-ray diffraction (XRD)/X-ray fluorescence (XRF) to measure elemental composition, as well as crystallographic information about the sample.
- VNIR imaging spectrometer to quickly characterize the mineralogy of terrain at a sample site or along the traverse. This instrument would also act as ground truth for orbital datasets.

Olympus Terra XRD

NASA/JPL-Caltech/Cornell/Max Planck Institut für Chemie/University of Guelph

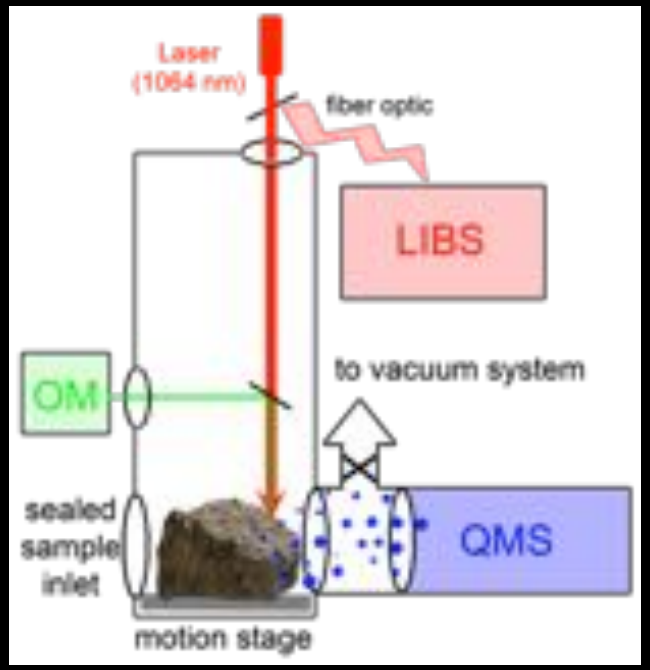
Proposed Instruments for Mission

MSSS

NASA/JPL-CalTech

Cameras:

- High resolution (cm/pixel from 1 km) for navigation and hazard avoidance, as well as sample selection.
- “Hand lens” camera for microscopic imaging rock sample minerals and textures.



KArLE instrument
MSFC

Age dating:

- Instruments capable of measuring K-Ar concentrations to determine the age of sampled materials.
- Has been successfully done using the SAM instrument on Curiosity [*Farley et al.,* 2014].

Summary

Send rover mission to the western edge of Orientale basin to conduct in situ analyses at three sample sites.

Science Goal	Science Objective	Measurements	Instruments
Constrain bombardment history of the inner solar system	Determine age of basin impact melt.	• K/Ar	• KArLE
Characterize the diversity of lunar rocks	Determine composition of mare basalts, basin impact melt, and basin ring material.	• Bulk, trace elements • Mineralogy • K/Ar • Micro-structures	• XRF/XRD • KArLE • Micro-imager • VNIR spectrometer
Constrain thermal and compositional evolution of the Moon	Determine composition and structure of mare basalt.	• Bulk, trace elements • Mineralogy • K/Ar • Micro-structures	• XRF/XRD • KArLE • Micro-imager • VNIR spectrometer
Investigate regolith processes and weathering	Determine composition of lunar regolith.	• Bulk, trace elements • Mineralogy • Soil structure	• XRF/XRD • Micro-imager • VNIR spectrometer

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