

Reiner Gamma Swirl: A Remarkable Science and (Partially?) Safe-Haven Nearside Site

Carle M. Pieters and Ian Garrick-Bethell



Context: Lunar Exploration in the Early Years

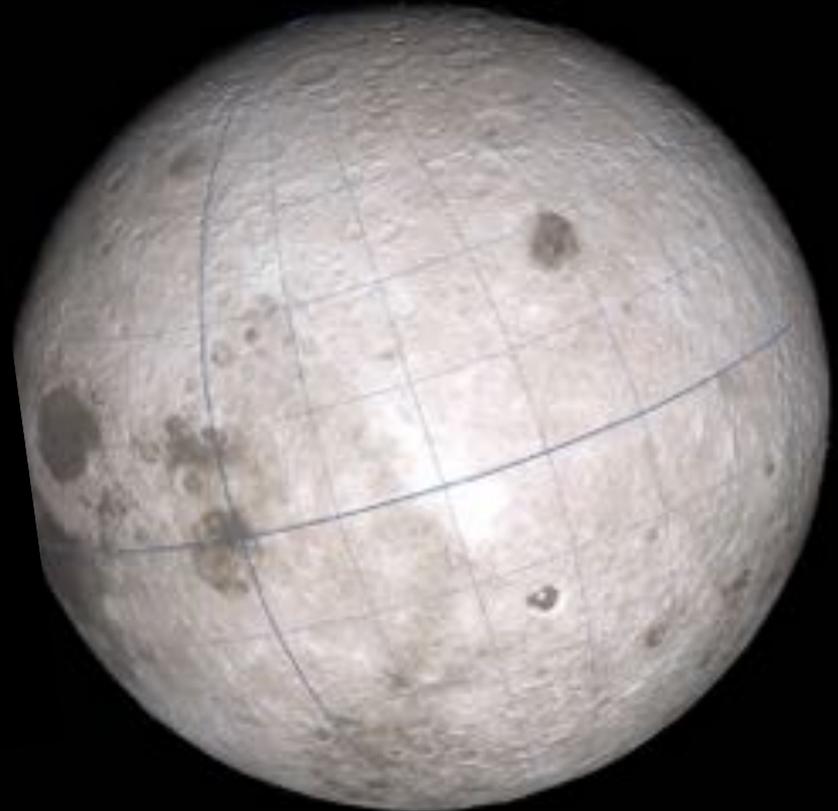
Sequence of exploration [1959-1969+7]:

- Flyby, orbit and map the surface
- Land and test soil properties
- Rove and explore the environment
- Return Samples
- Brief human exploration

1959 Luna III sees the Farside



Luna 3
Launched in 1959

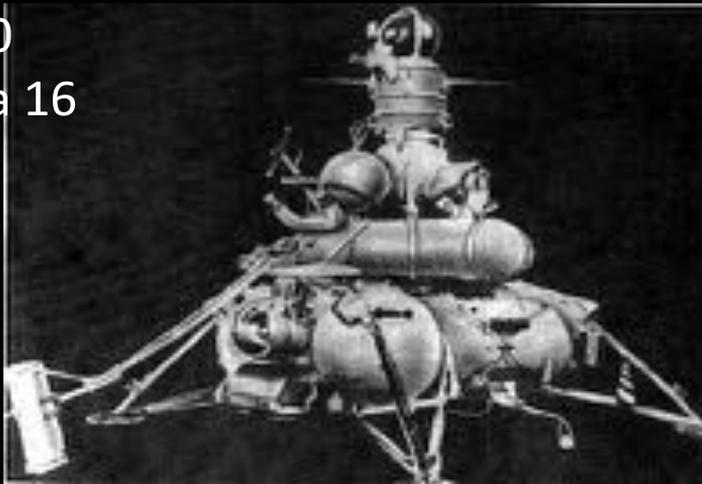


Lunar Reconnaissance Orbiter
Launched in 2009

From ORBIT 50 years later....

Luna and Apollo *RETURN SAMPLES* 1969-1976

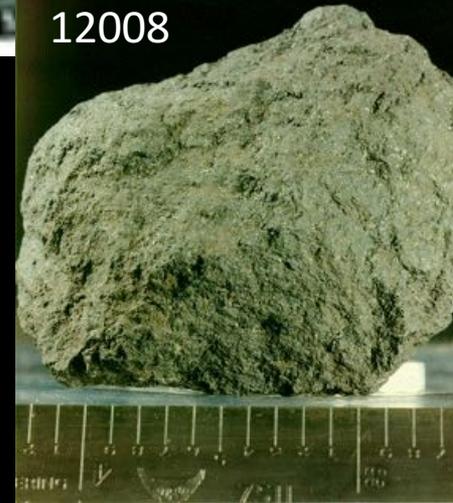
1970
Luna 16



1969
Apollo 12



12008



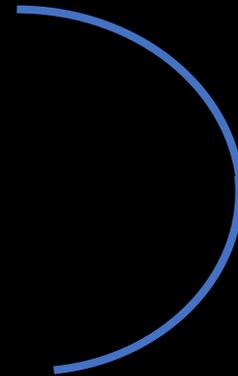
Lunar Exploration in the Current Context

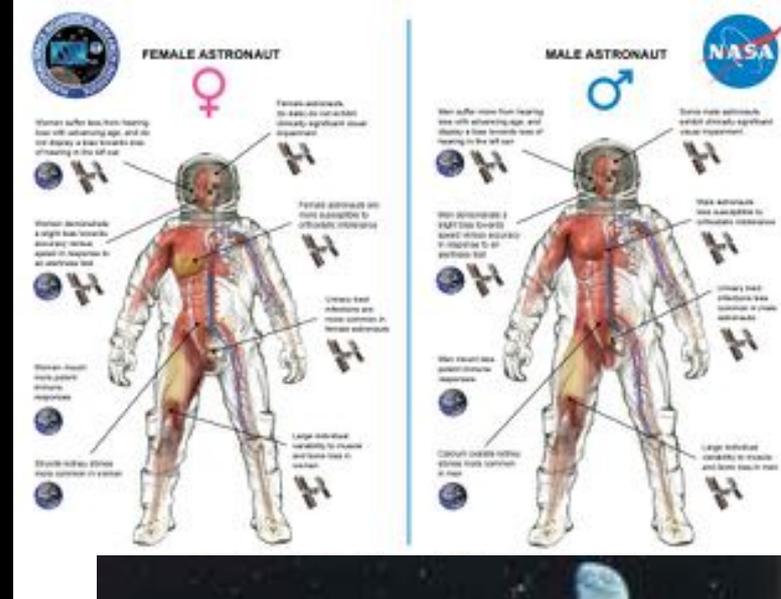
Sequence of exploration [1959-1969+7]:

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..... Leading to.....

- **Long term human presence**

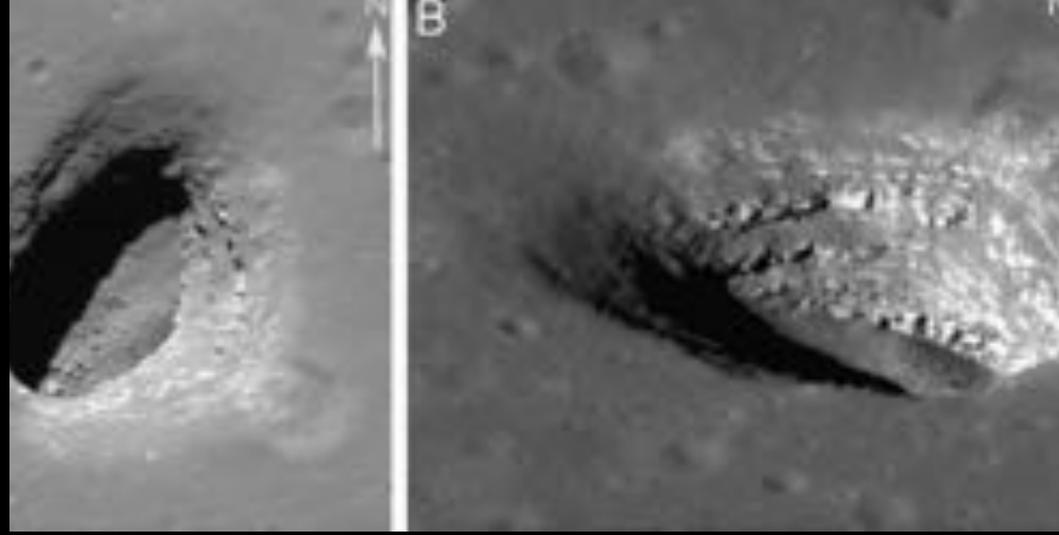




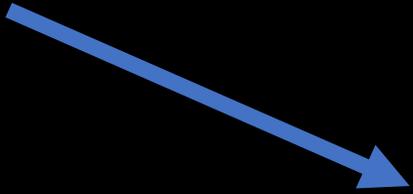
For long-term Human involvement, space hazards must be significantly reduced.



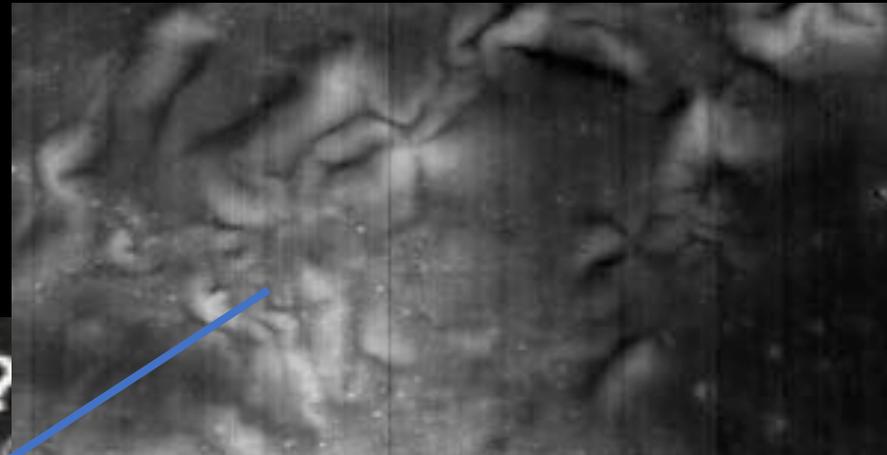
We now know the Moon has natural environments that *may* protect from some of the hazards.



Pits: Holes to underground chambers



Mini-magnetospheres
At SWIRLS



What/where are lunar SWIRLS?

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Review: Lunar Albedo Variations

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Review: Lunar Albedo Variations

- Mare – Highlands
 - Composition differences



What/where are lunar SWIRLS?

Review: Lunar Albedo Variations

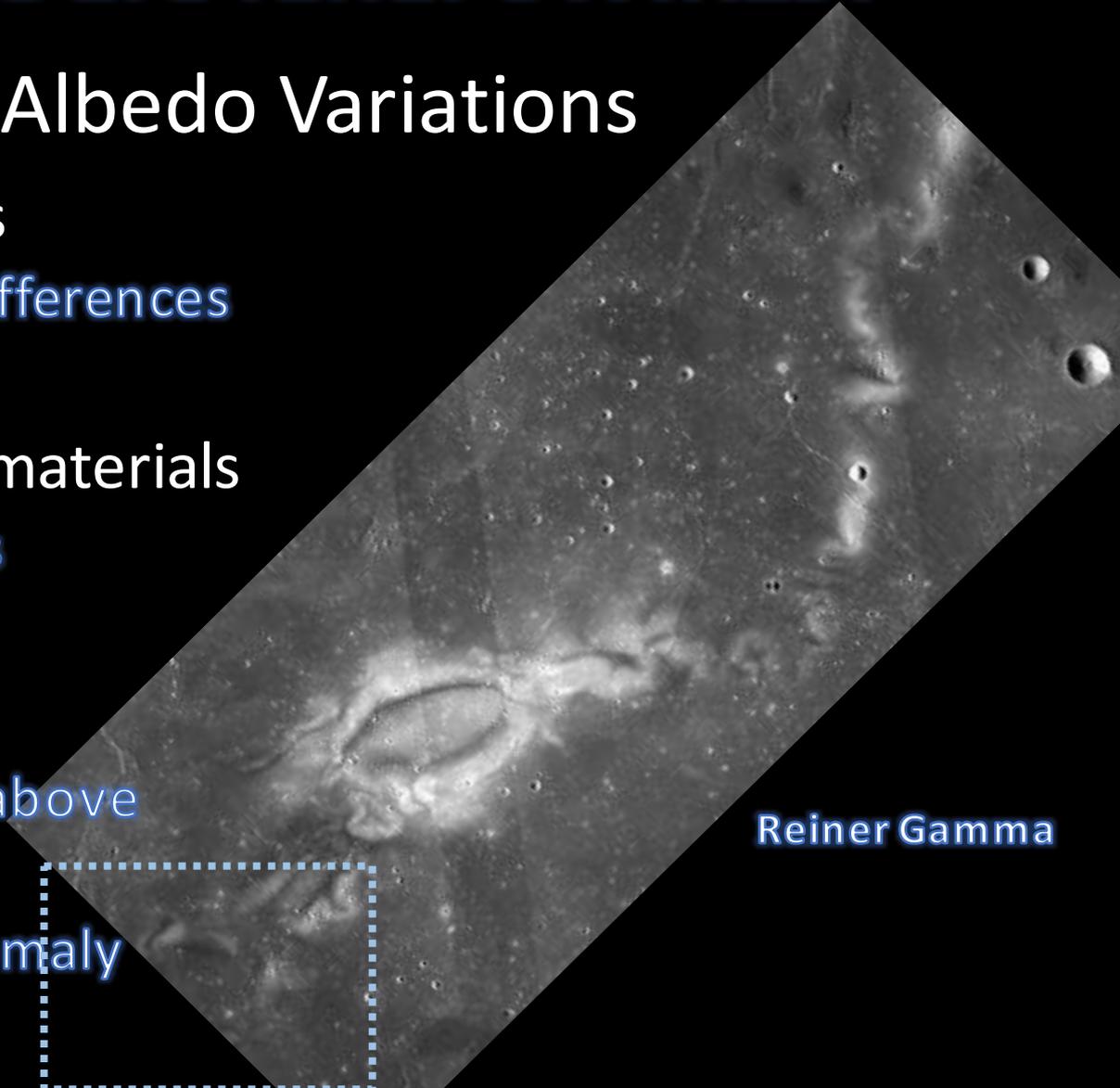
- Mare – Highlands
 - Composition differences
- Freshly exposed materials
 - Age differences



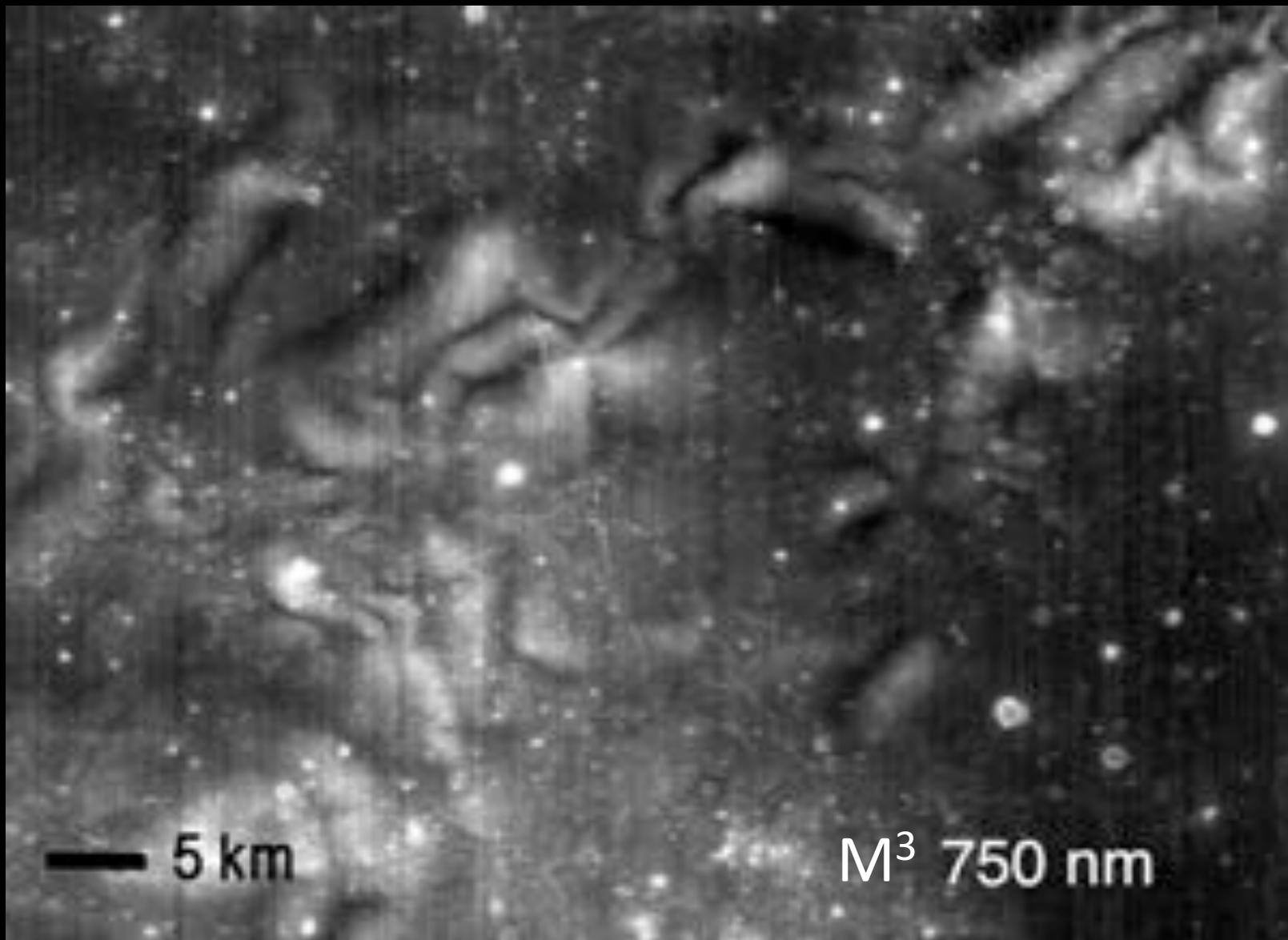
What/where are lunar SWIRLS?

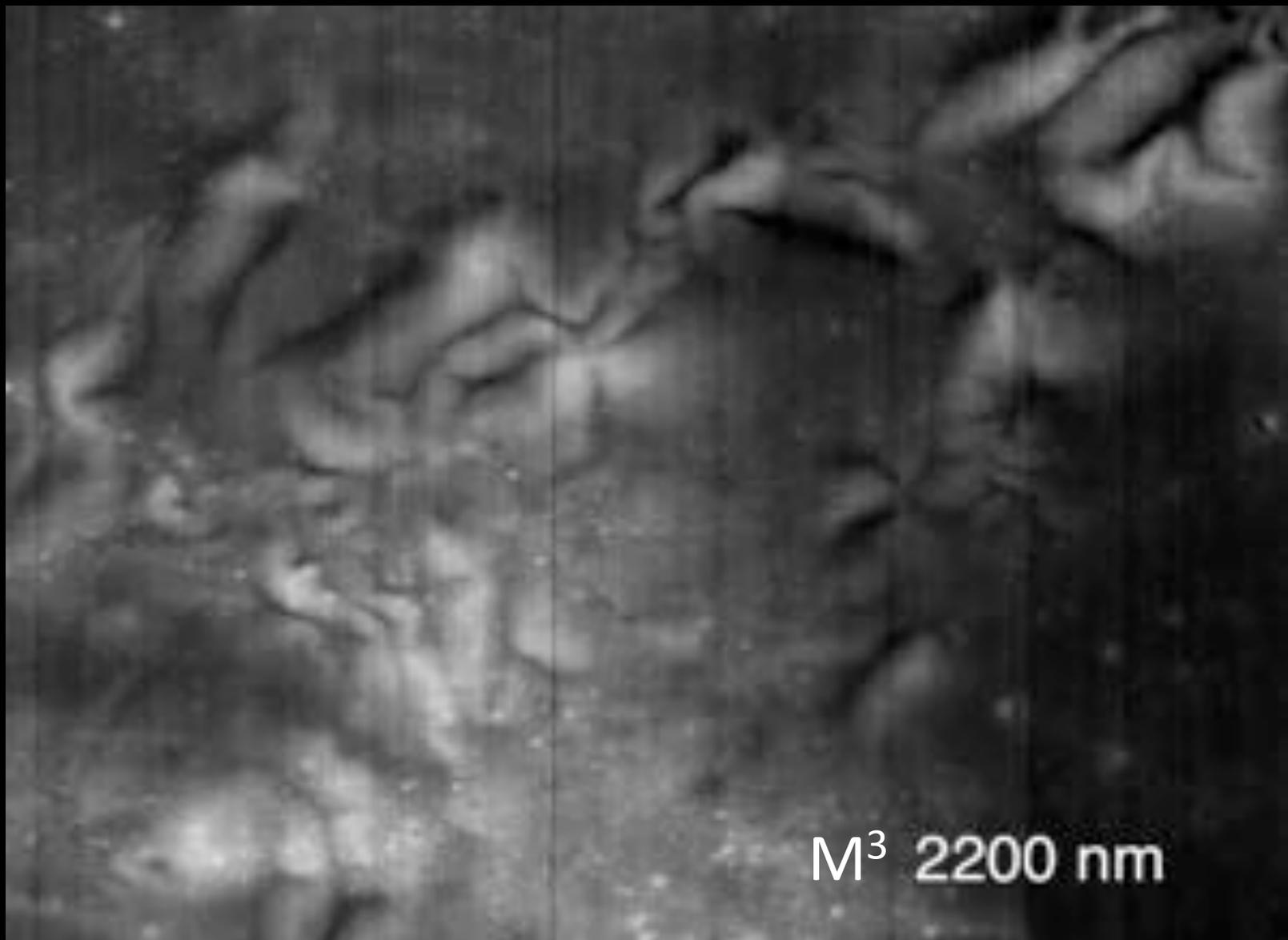
Review: Lunar Albedo Variations

- Mare – Highlands
 - Composition differences
- Freshly exposed materials
 - Age differences
- Swirls
 - Neither of the above
 - no topography
 - + magnetic anomaly



Reiner Gamma





M³ 2200 nm

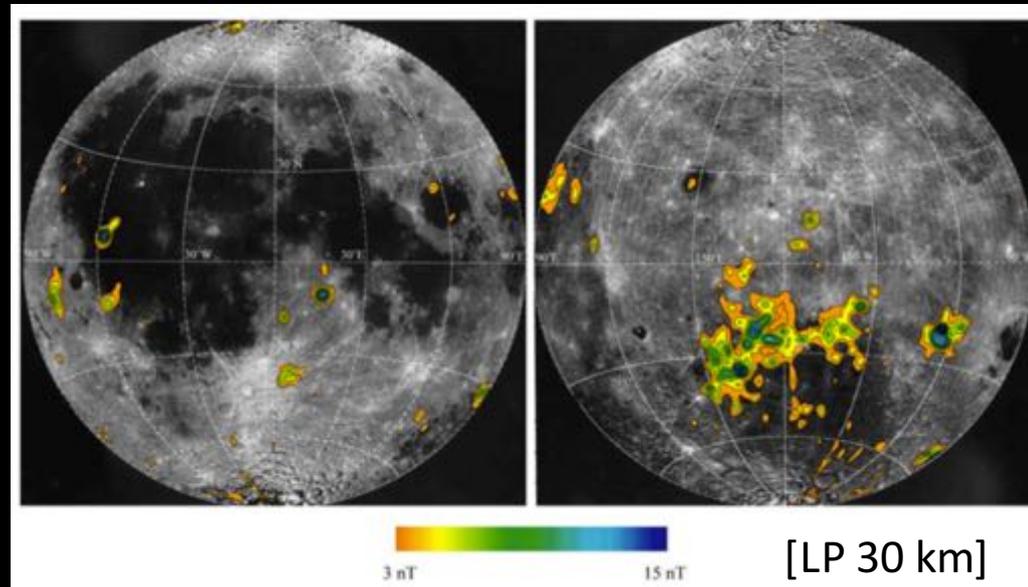
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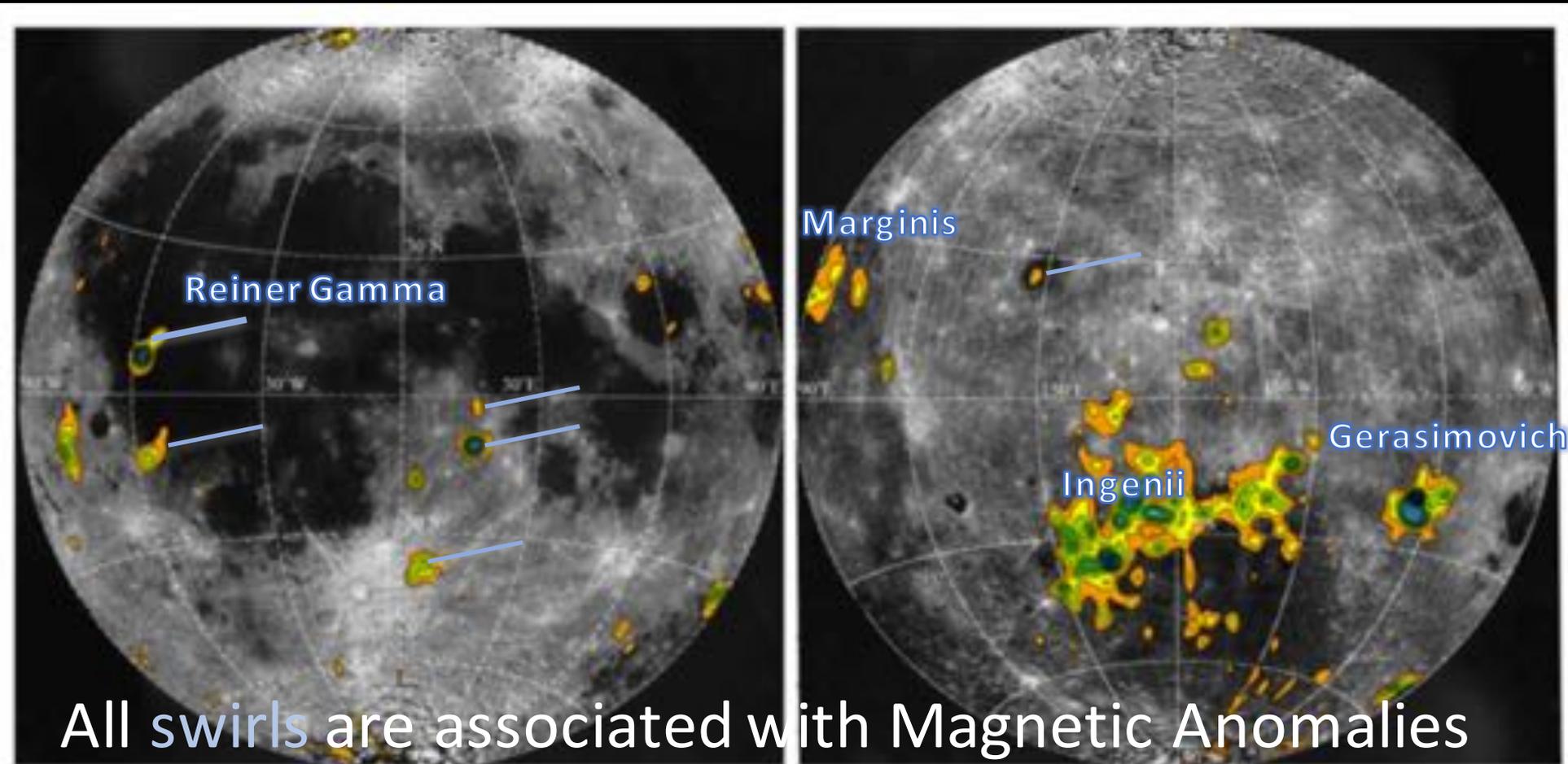
Magnetic Anomalies

[Richmond and Hood 2008]



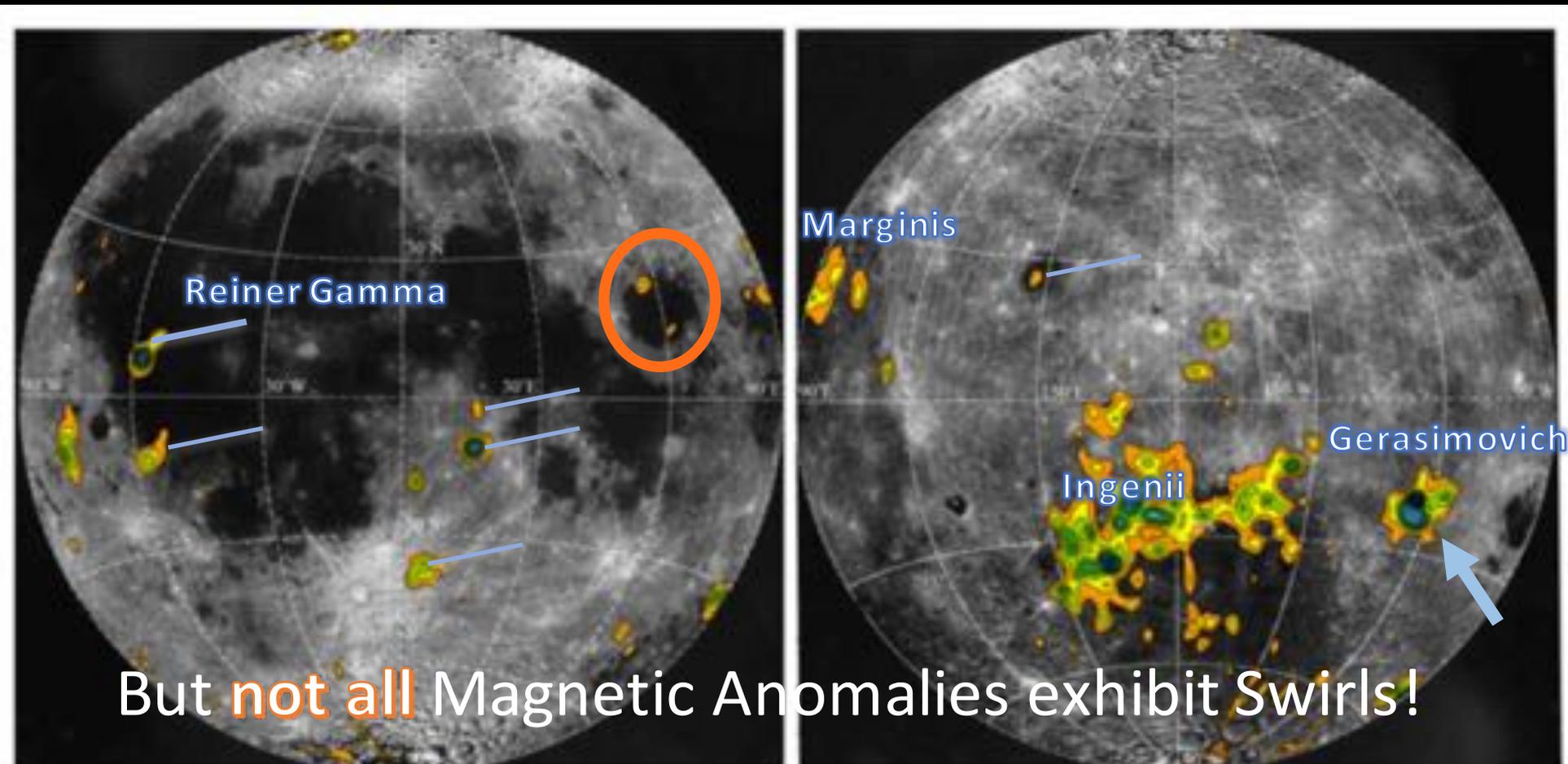
Magnetic Anomalies [LP 30 km] + Swirls

[Richmond and Hood 2008]



Magnetic Anomalies [30 km] + Swirls

[Richmond and Hood 2008]

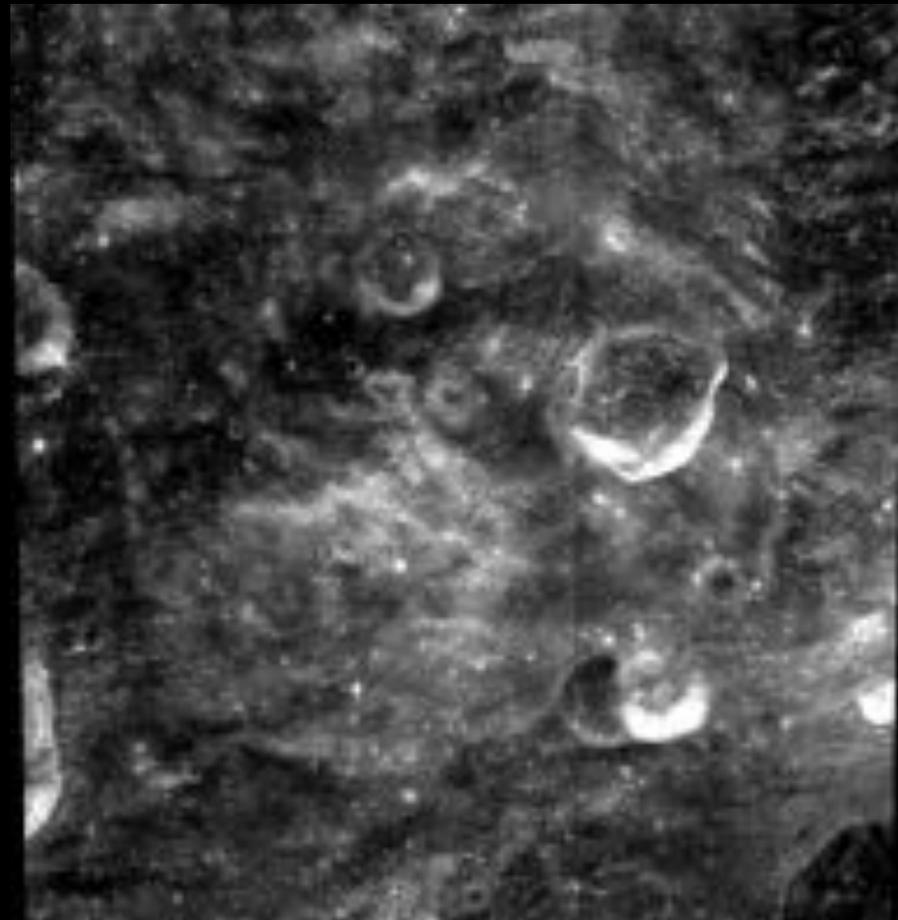


What/where are lunar SWIRLS?

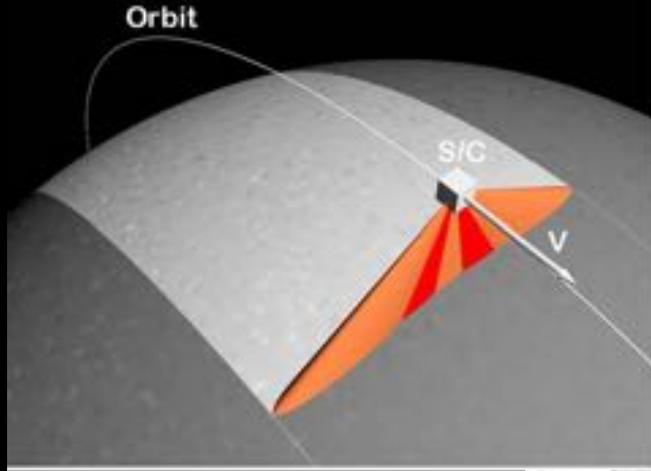
Review: Lunar Albedo Variations

Gerasimovich

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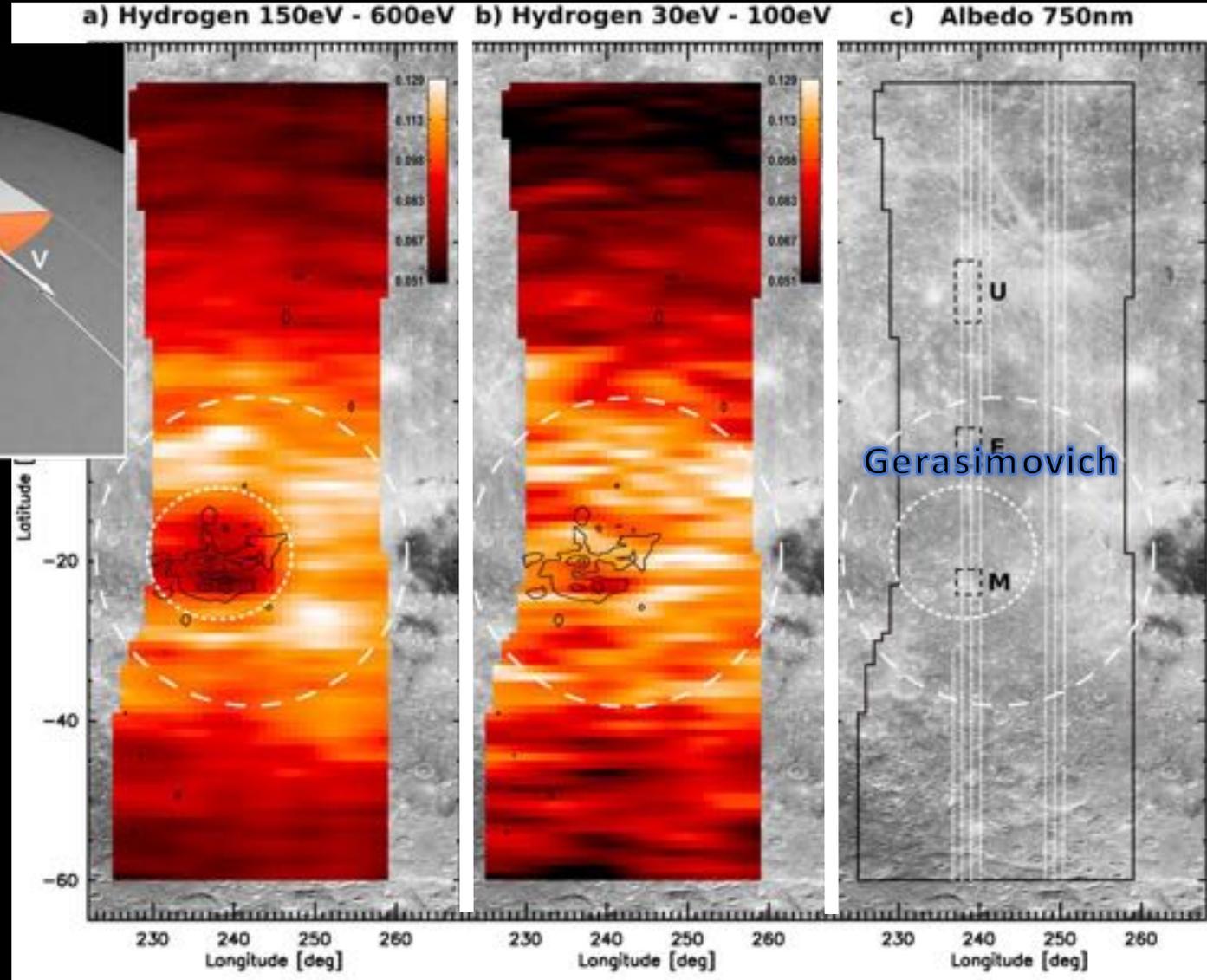
SARA* on Chandrayaan-1 detects mini-magnetosphere at Gerasimovich



Wieser et al., 2010 GRL

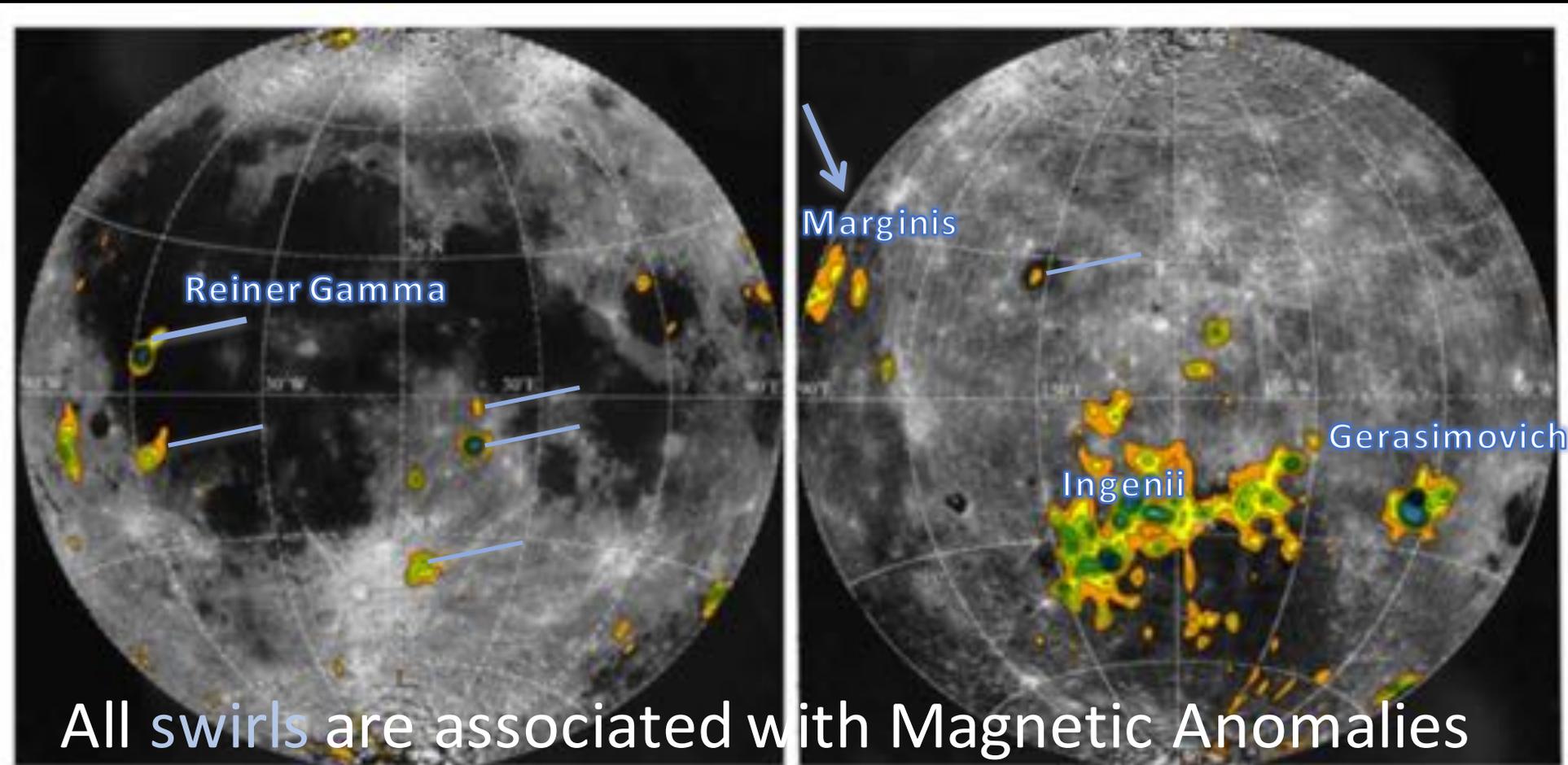
SW backscattered hydrogen deflected from Mag anomaly to surroundings.

*Sub- keV Atom Reflecting Analyzer [Sweden & India]



Magnetic Anomalies [LP 30 km] + Swirls

[Richmond and Hood 2008]



What/where are lunar SWIRLS?

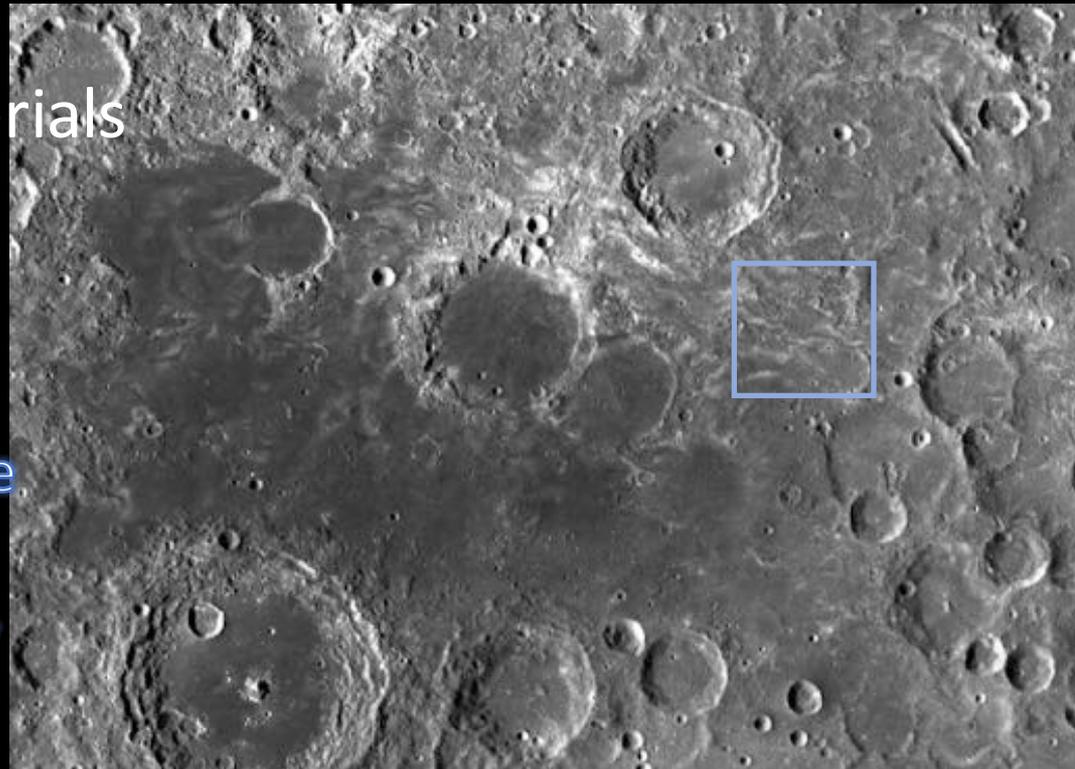
Review: Lunar Albedo Variations

- Mare – Highlands
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Marginis

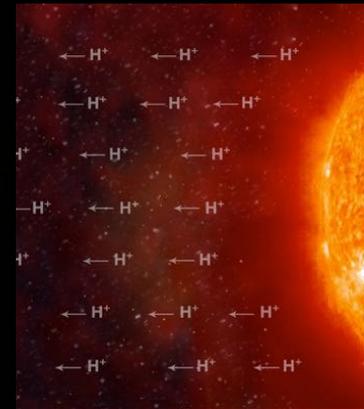
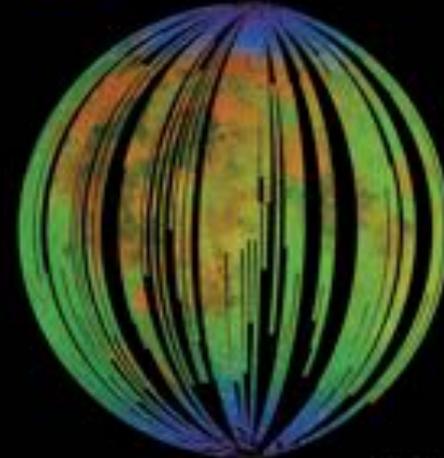
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Solar Wind and Lunar Water

M³ Data [Moon Mineralogy Mapper]



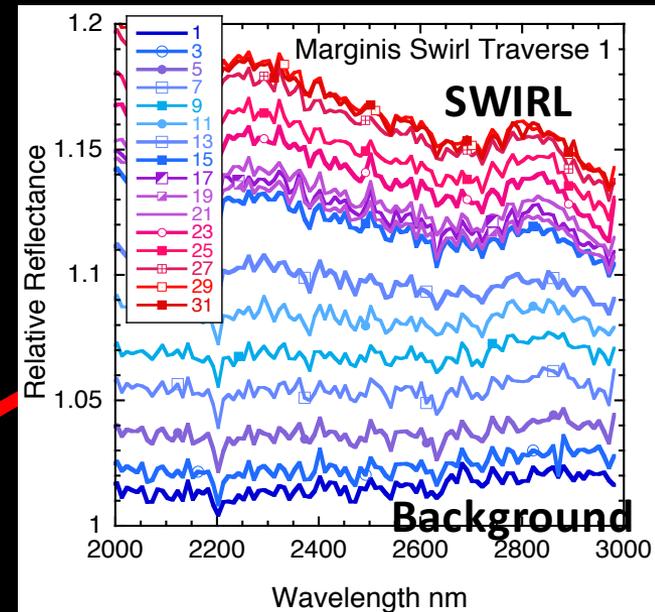
Compared to local background, SWIRLS exhibit **lower** amounts of OH.

[i.e. surface is partially 'protected' from solar wind.]

Marginis

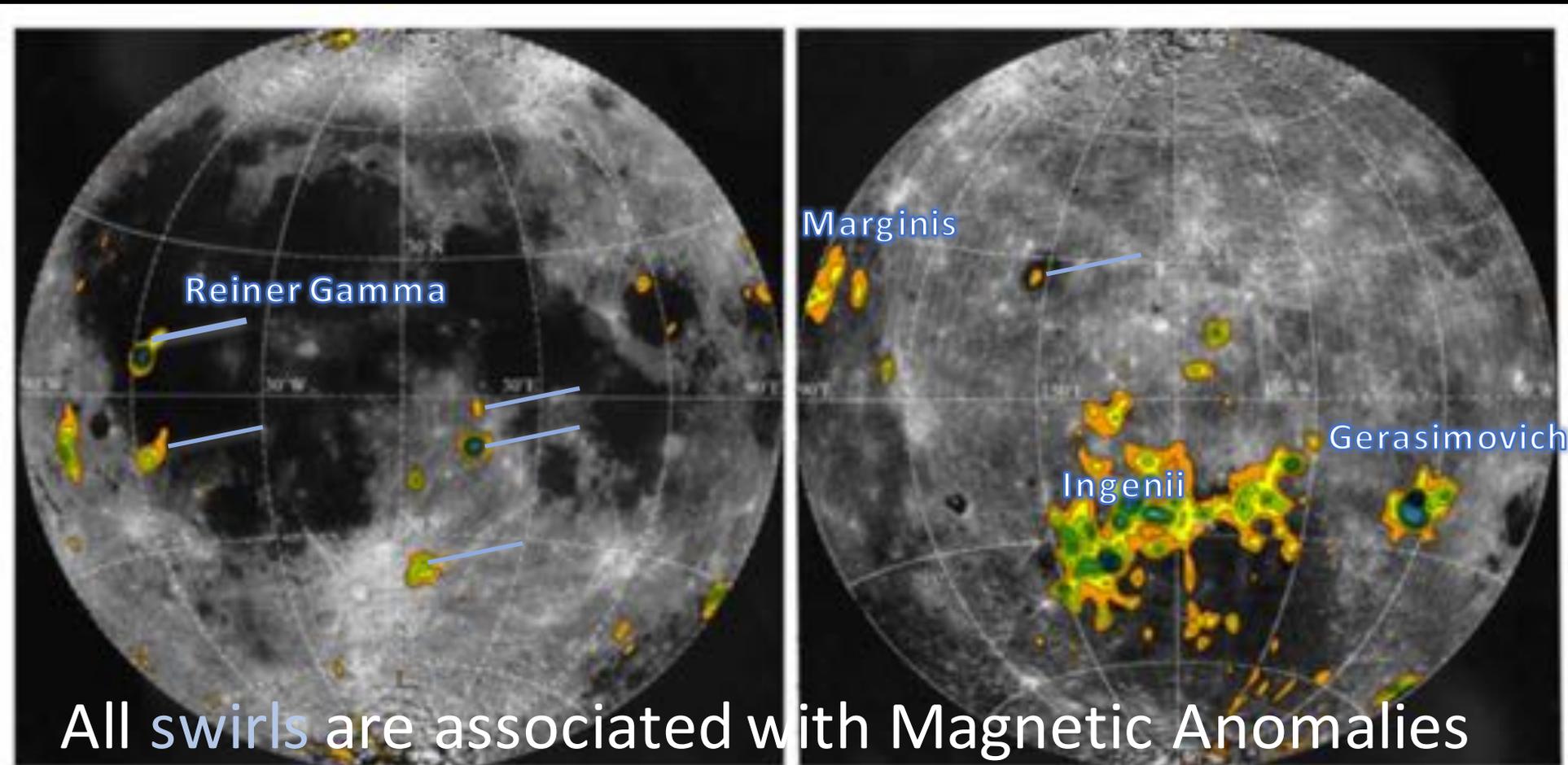
755 nm

OH Band Depth



Magnetic Anomalies [LP 30 km] + Swirls

[Richmond and Hood 2008]



Moon mini-magnetospheres may be good sites for a Lunar Base.

A surface rover is best suited to investigate:

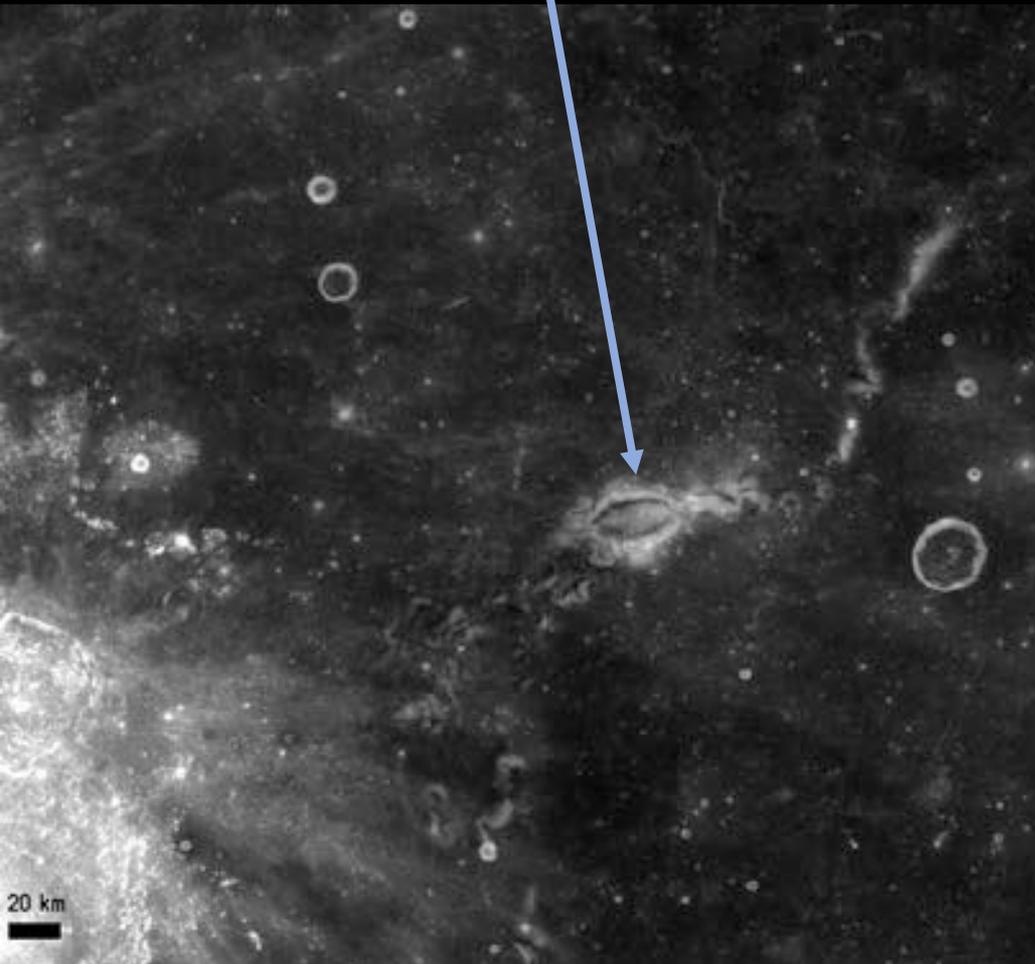
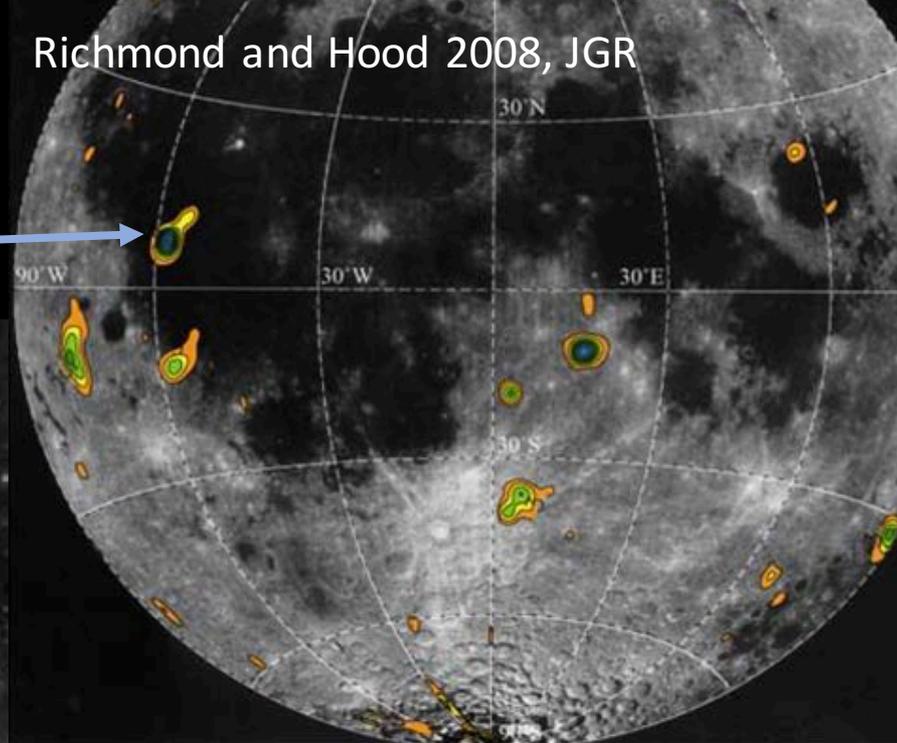
- Surface with partial protection [TBD] from radiation
- Possible nearby lanes of OH *production* (H focus)
- Overall surface accessibility [no inherent topography]
- Valuable geology and space physics science

Reiner Gamma, case study

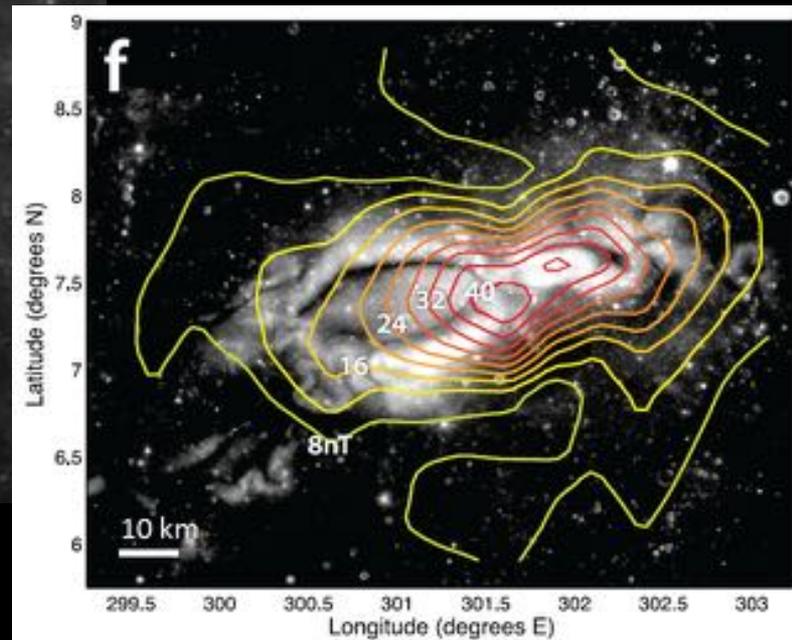
Rover capabilities?

Reiner Gamma region

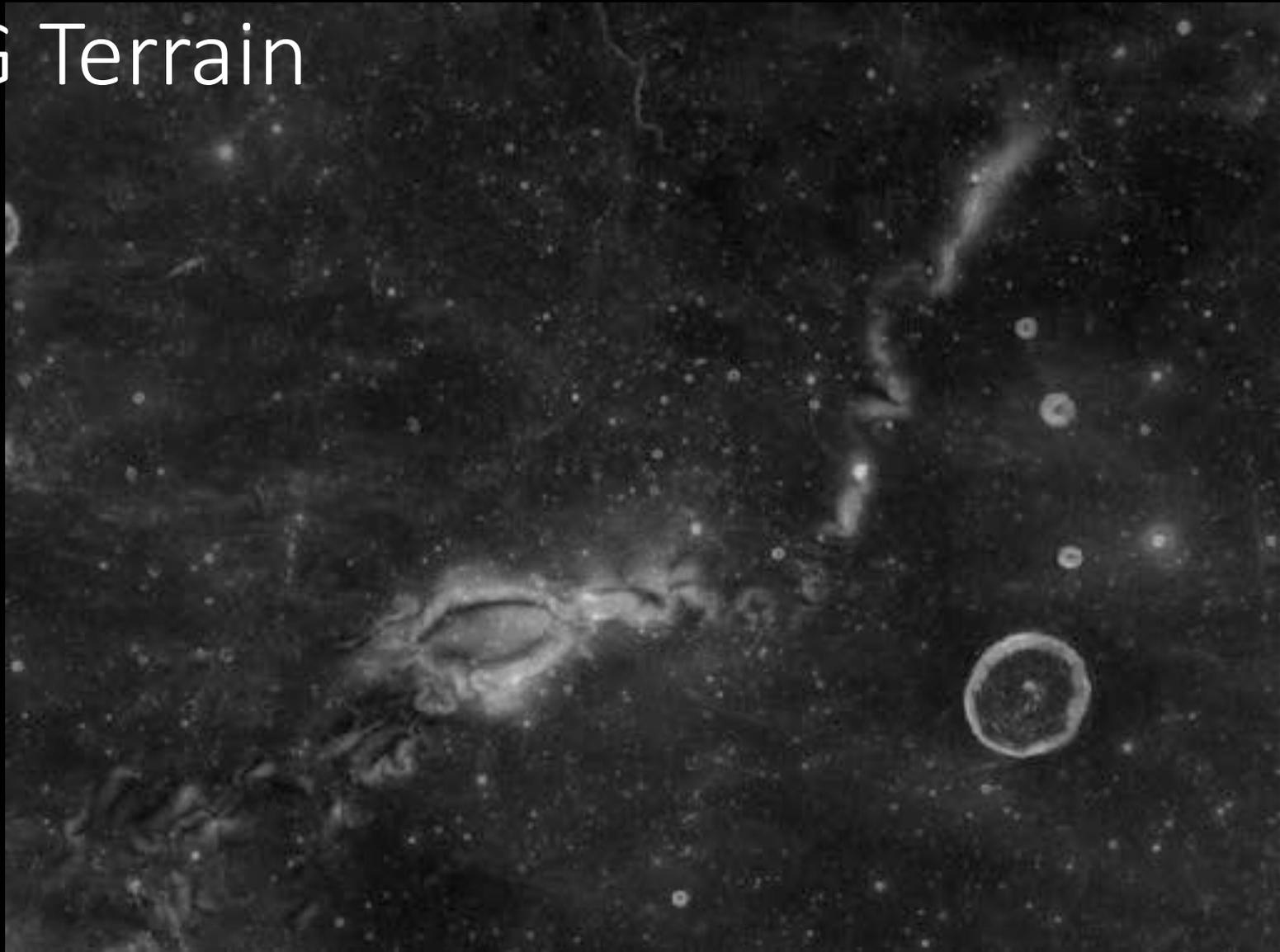
Richmond and Hood 2008, JGR



Hemingway and Garrick-Bethell 2012, JGR
Horizontal component from 18 km [40nT]



RG Terrain



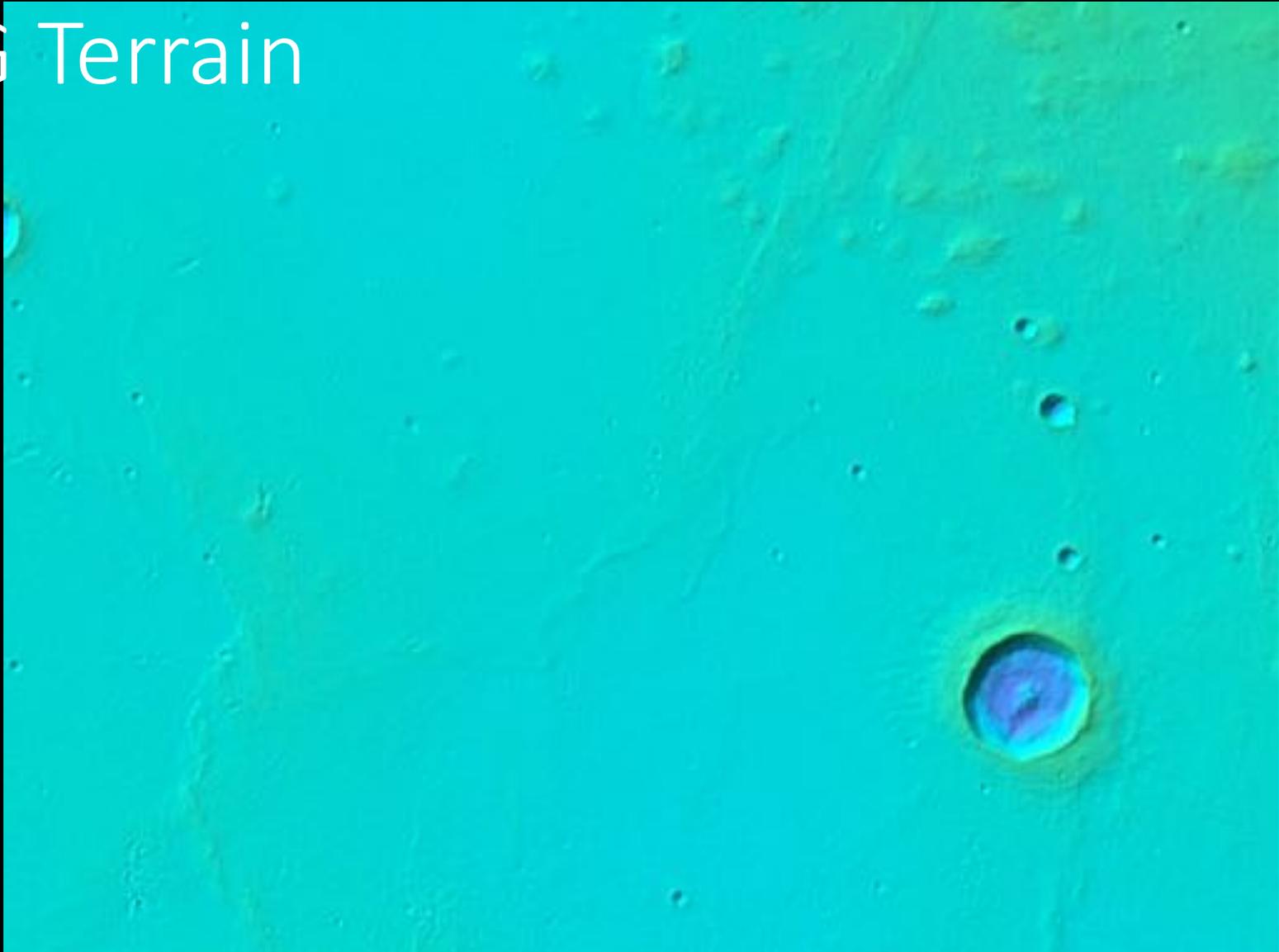
High Sun

RG Terrain



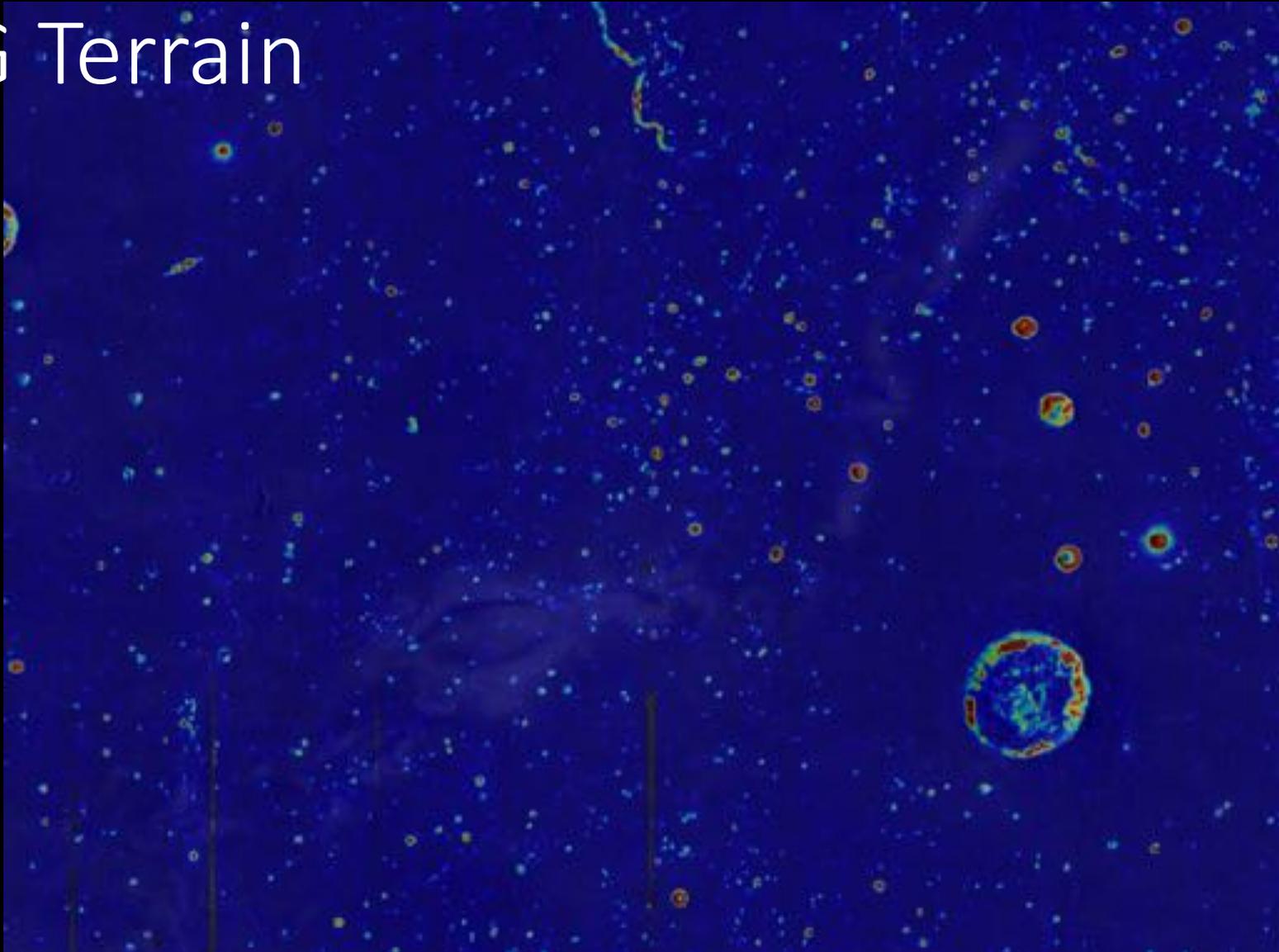
Low Sun

RG Terrain



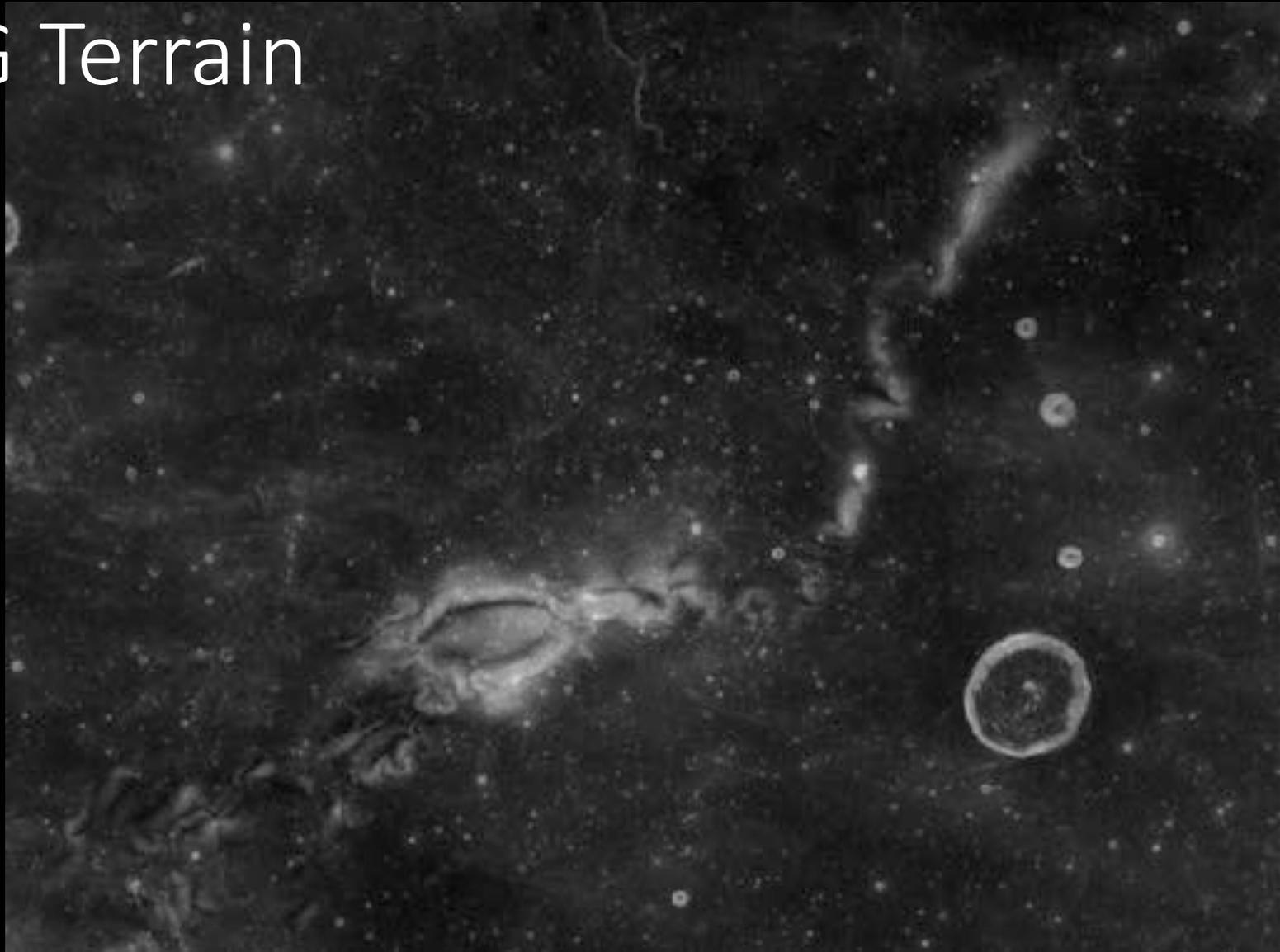
Digital Terrain Model

RG Terrain



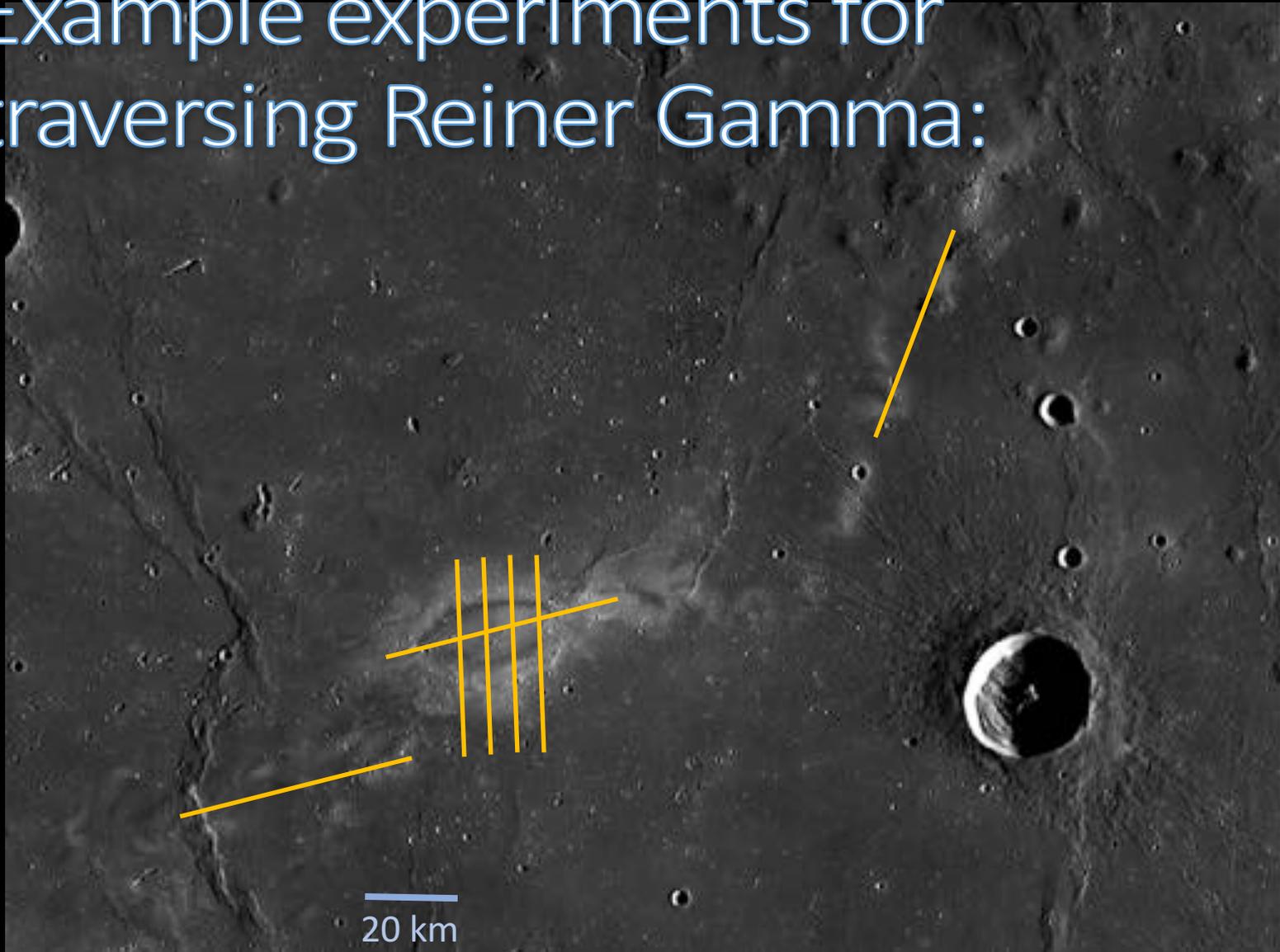
DIVINER Rock Abundance

RG Terrain



High Sun

Example experiments for traversing Reiner Gamma:



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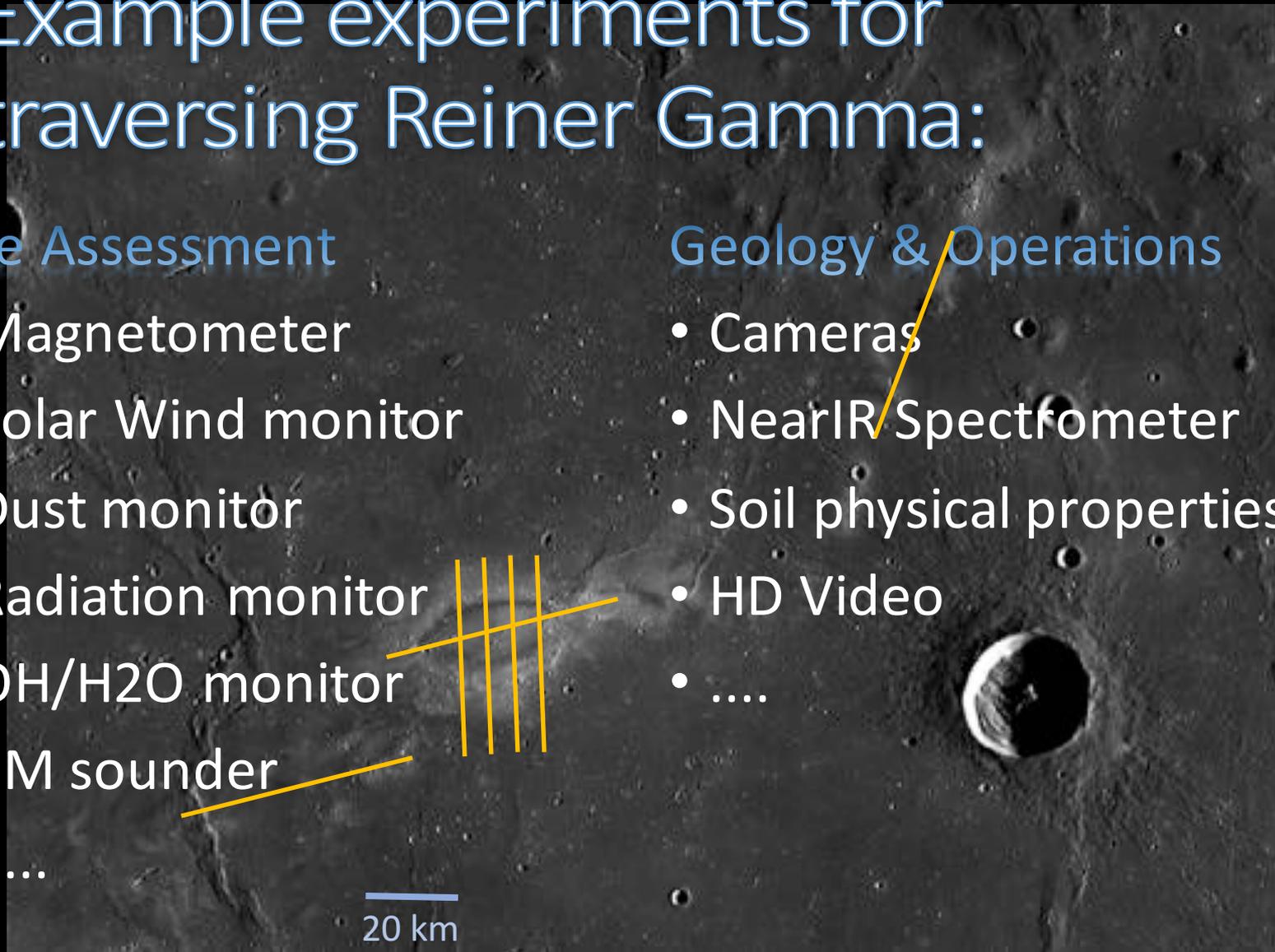
Site Assessment

- Magnetometer
- Solar Wind monitor
- Dust monitor
- Radiation monitor
- OH/H₂O monitor
- EM sounder
-

Geology & Operations

- Cameras
- NearIR Spectrometer
- Soil physical properties
- HD Video
-

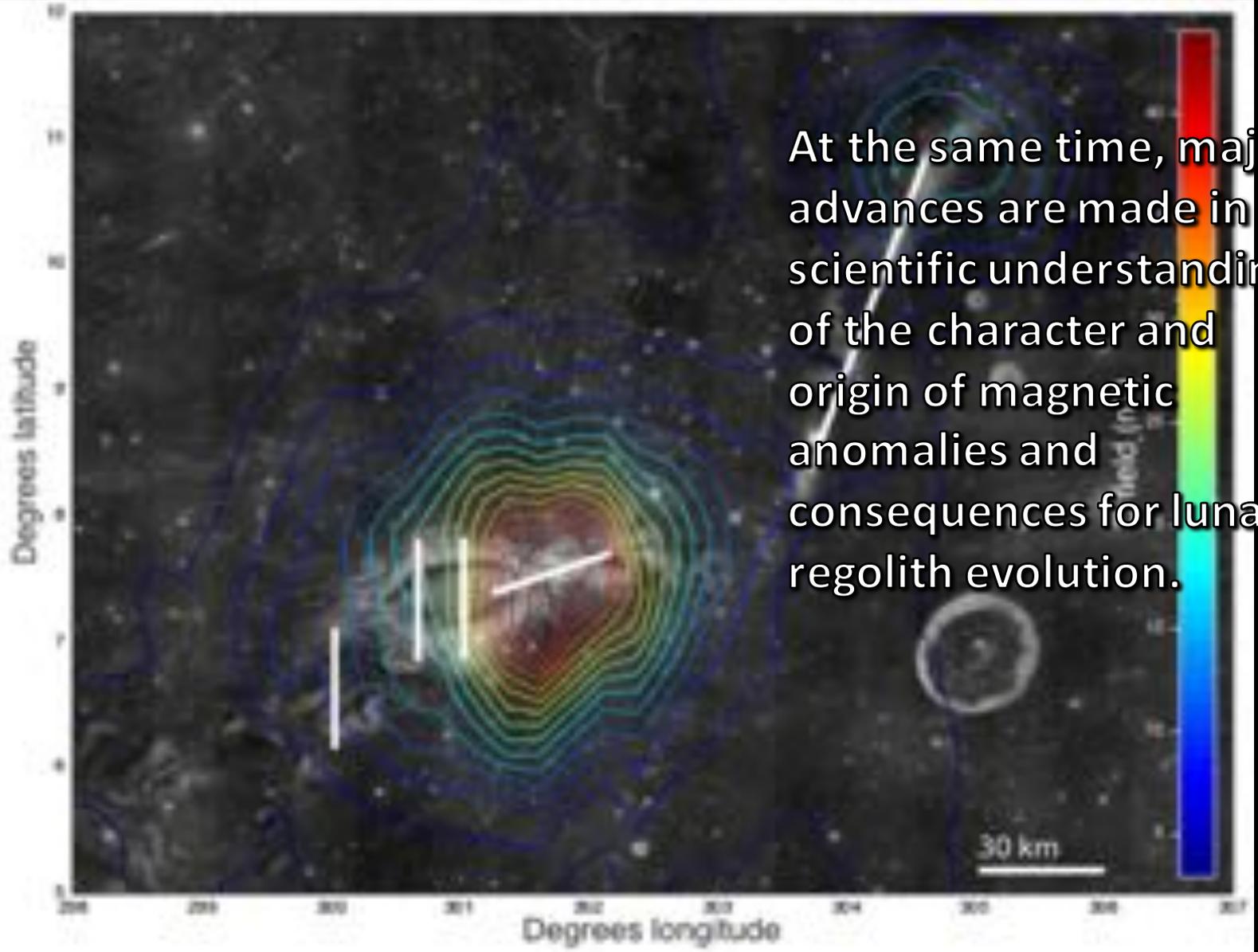
20 km





Once the properties of lunar terrain within a mini-magnetosphere are better known, some of the constraints for a human habitat may be considerably easier to implement.





At the same time, major advances are made in our scientific understanding of the character and origin of magnetic anomalies and consequences for lunar regolith evolution.