

The Moon's Most Explosive Eruption: The Aristarchus Plateau as a Future Exploration Destination

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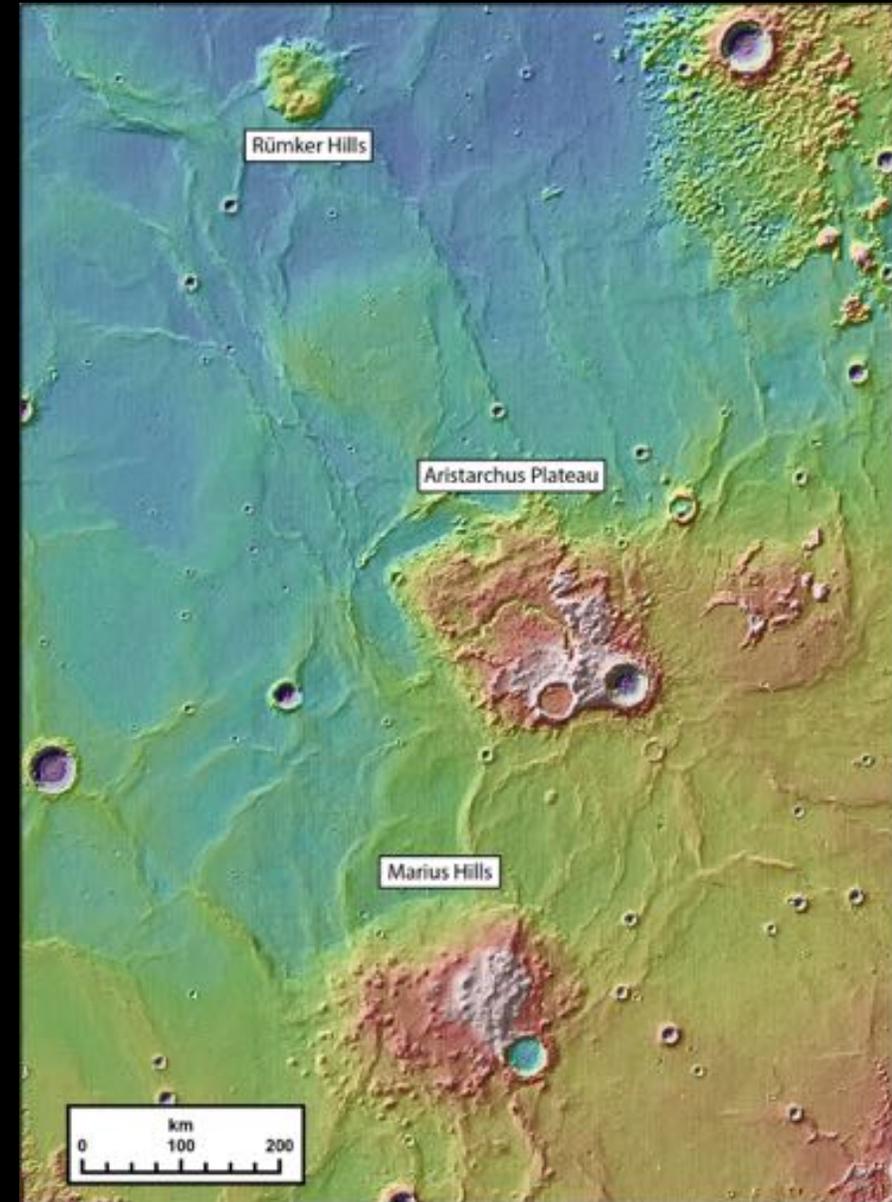
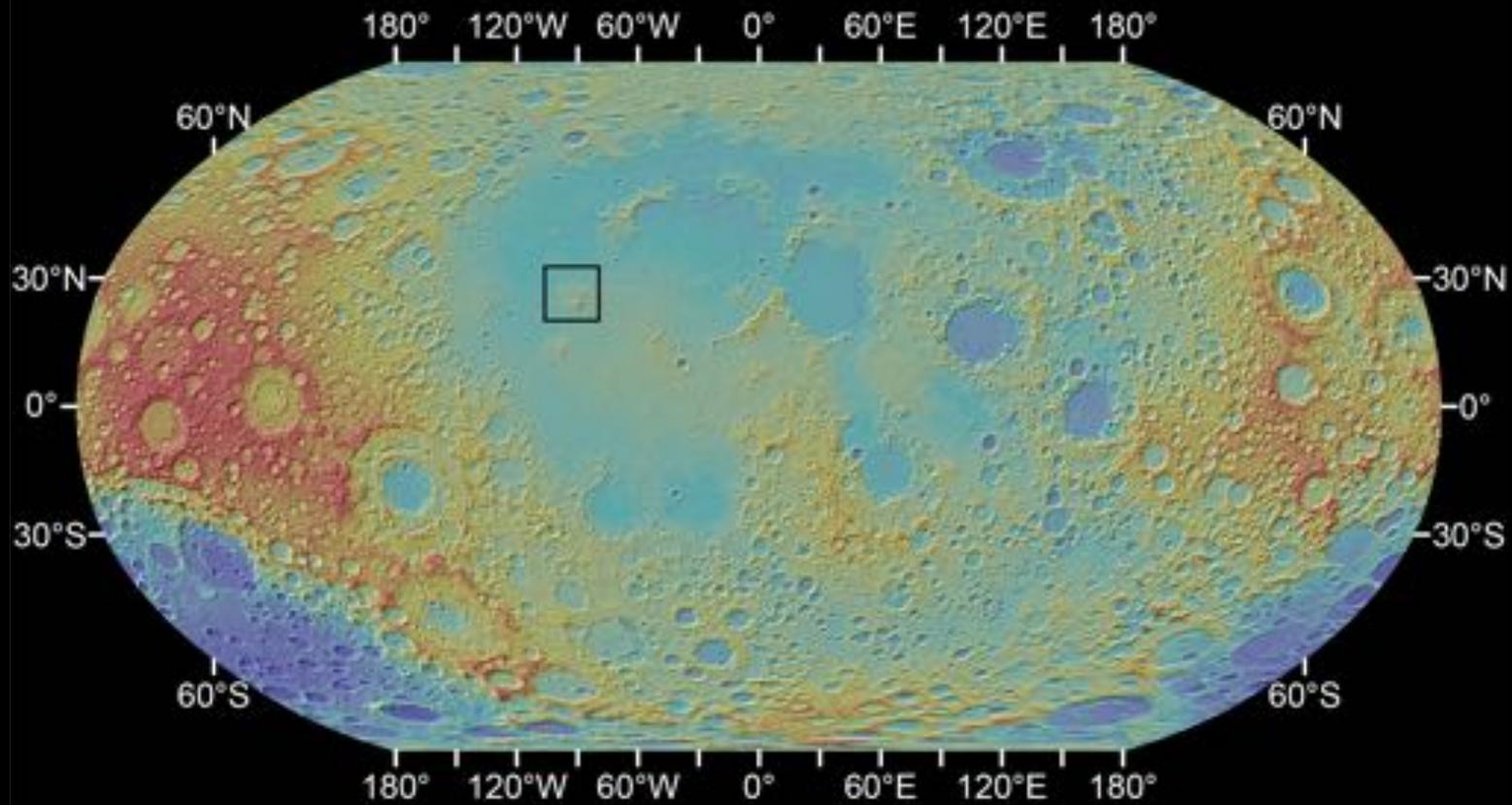
Lunar Science for Landed Missions Workshop

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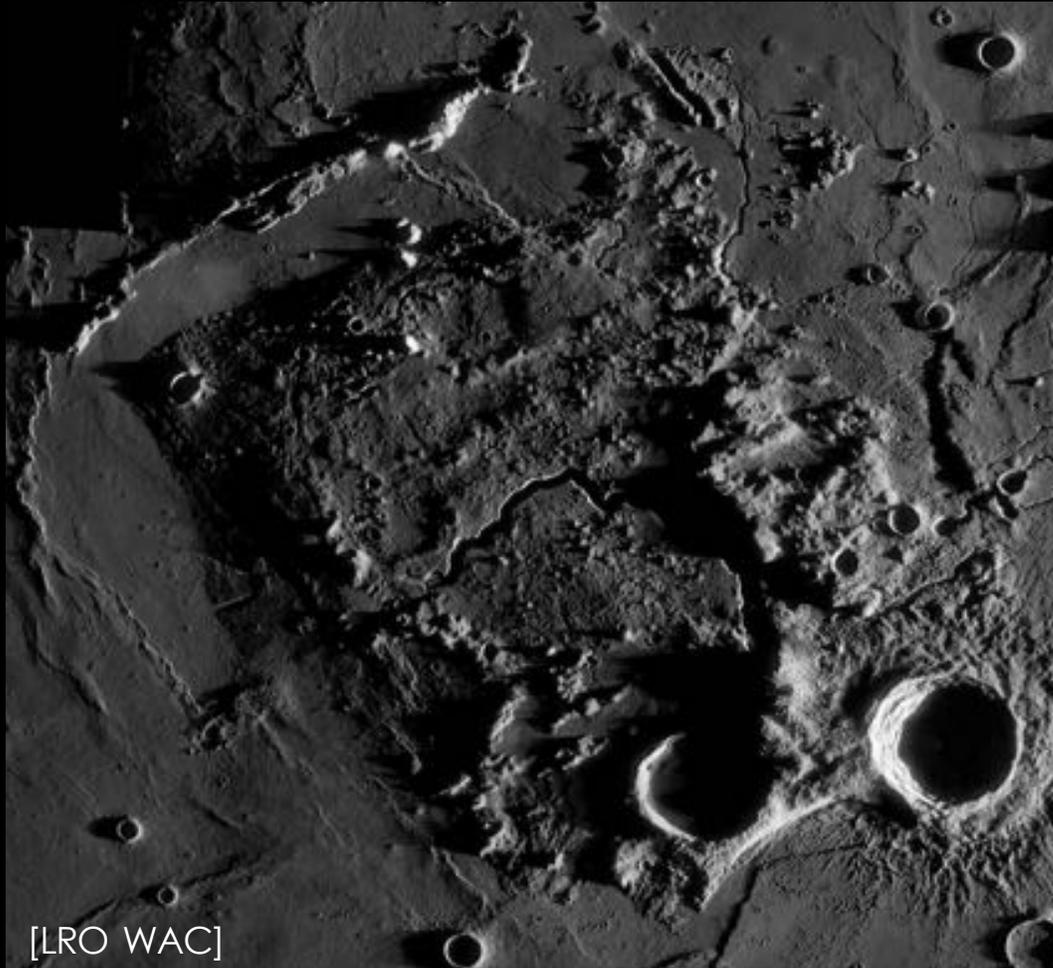
NASA Ames Research Center



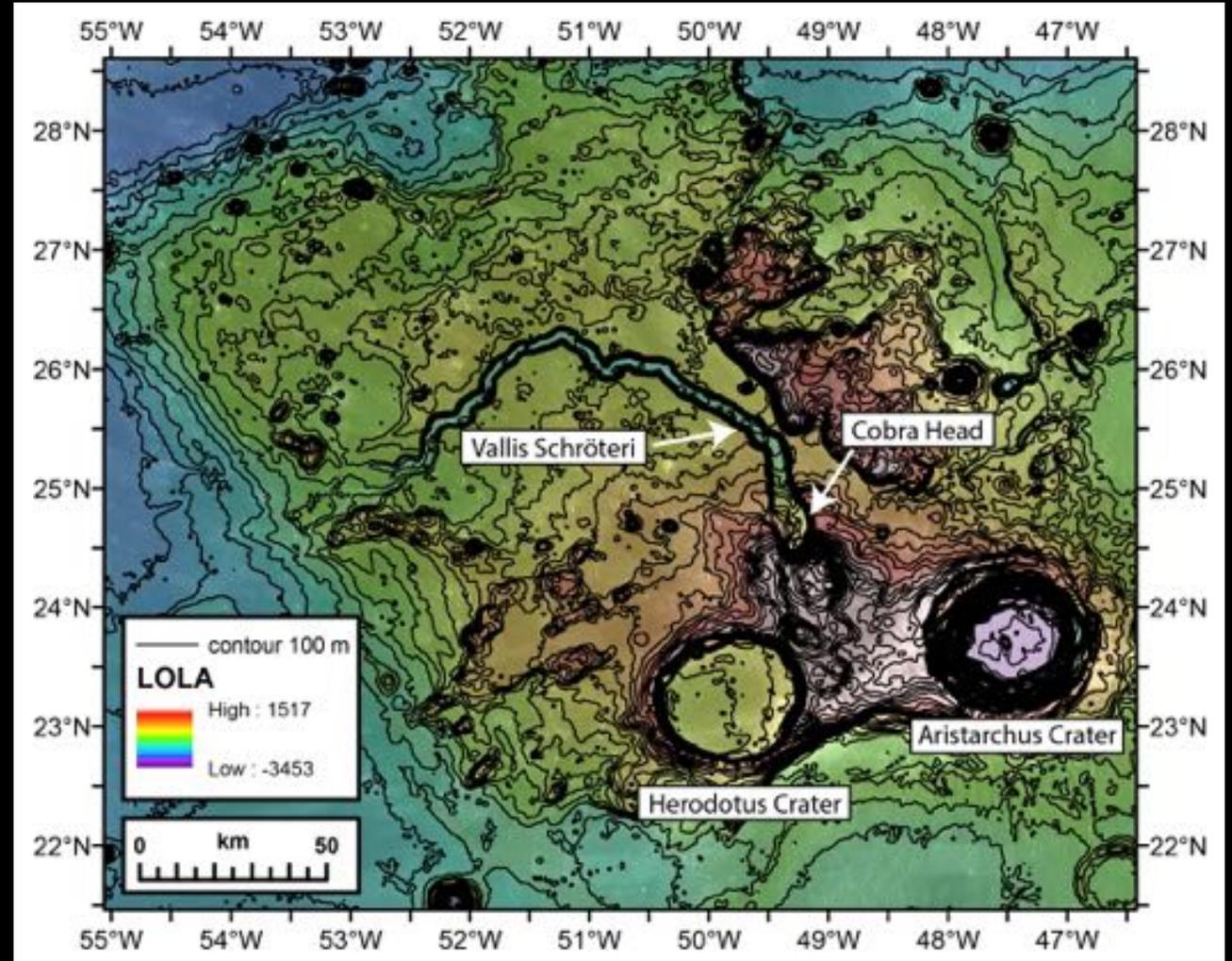
Aristarchus: Lunar Volcanic Complex



Aristarchus Plateau

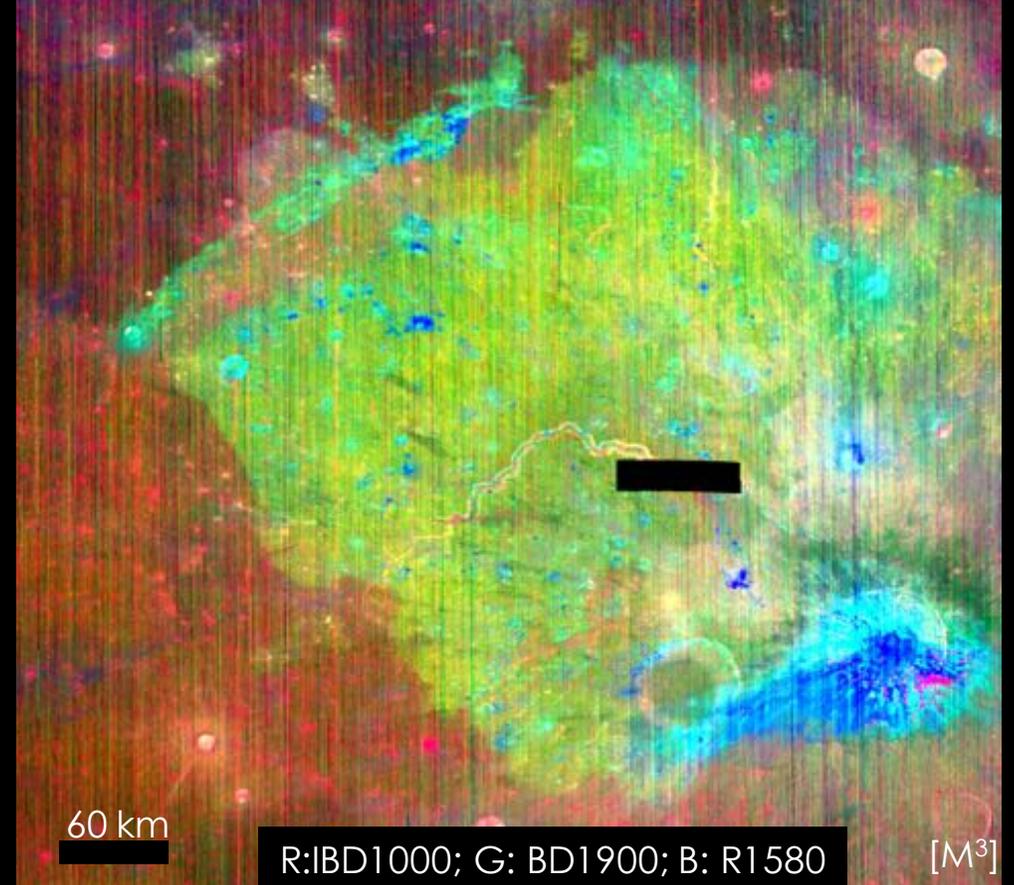
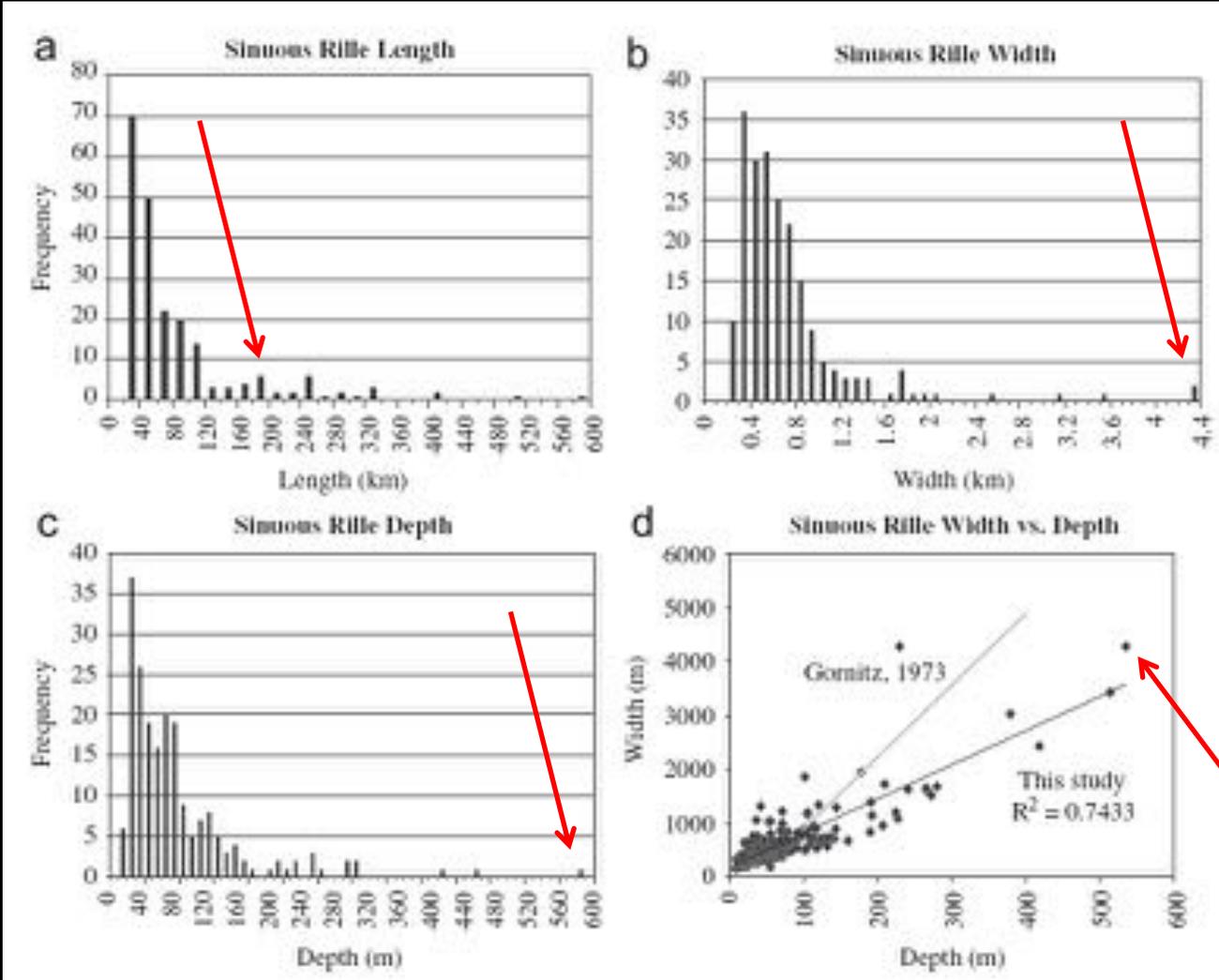


Uplifted Highlands Block
Sinuous Rilles
Pyroclastic Deposit



[Zisk et al., 1977; Hurwitz et al., 2013]

Aristarchus: Endmember Lunar Volcanism



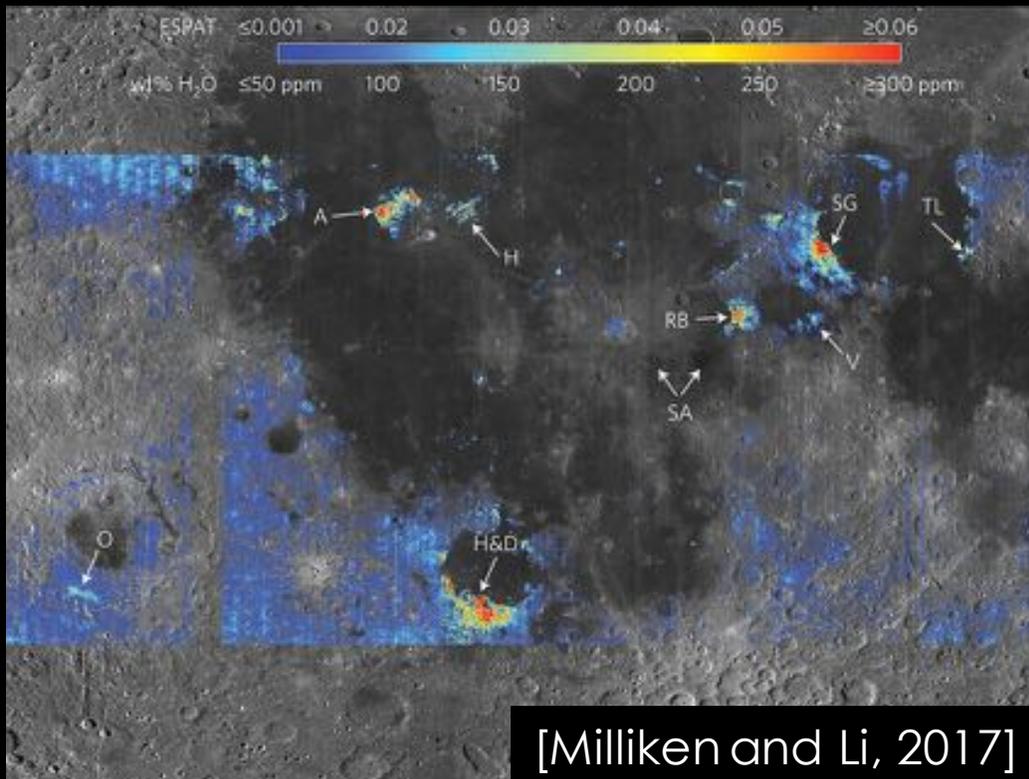
Largest pyroclastic deposit: 50,000 km²

Widest, deepest sinuous rille

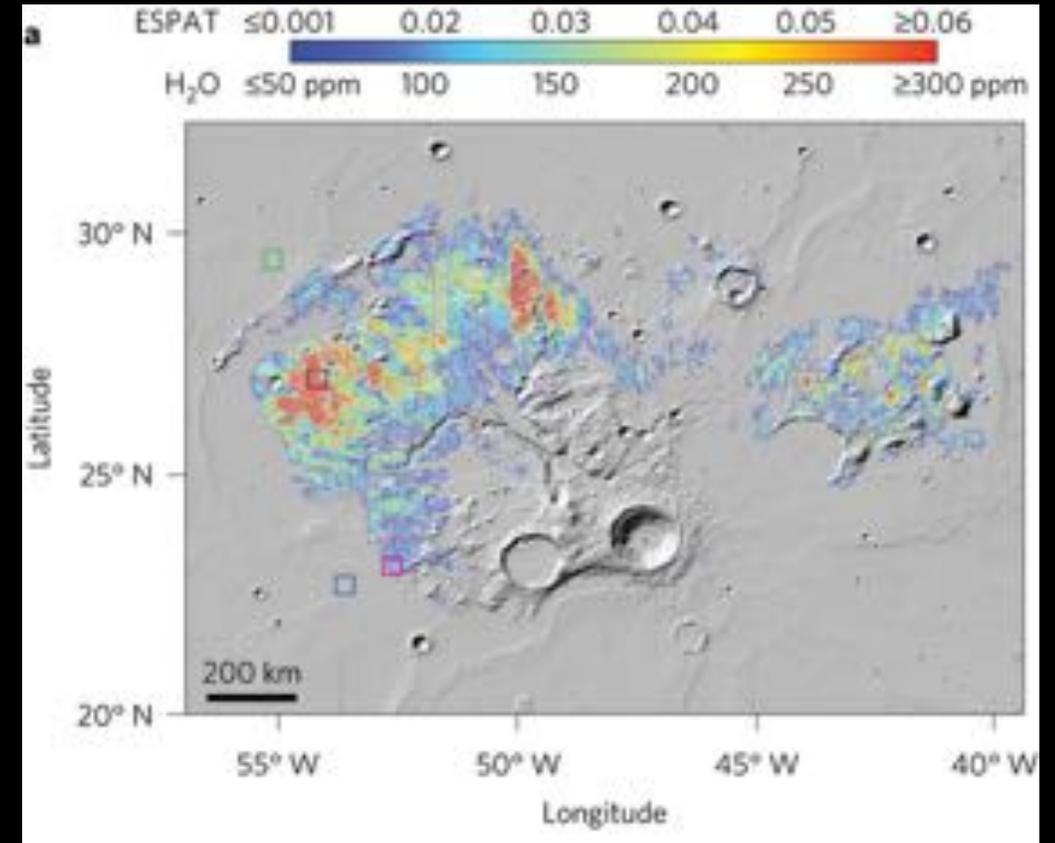
[Gaddis et al., 2003; Hurwitz et al., 2013]

Aristarchus Pyroclastic Deposit: Wet and Glassy

- Glass rich: >90% Fe²⁺ glass [Lucey et al., 1986]
- ~10-20 m thick [Campbell et al., 2008]
- Trapped volatiles in volcanic glasses [Saal et al., 2008; Milliken and Li, 2017]



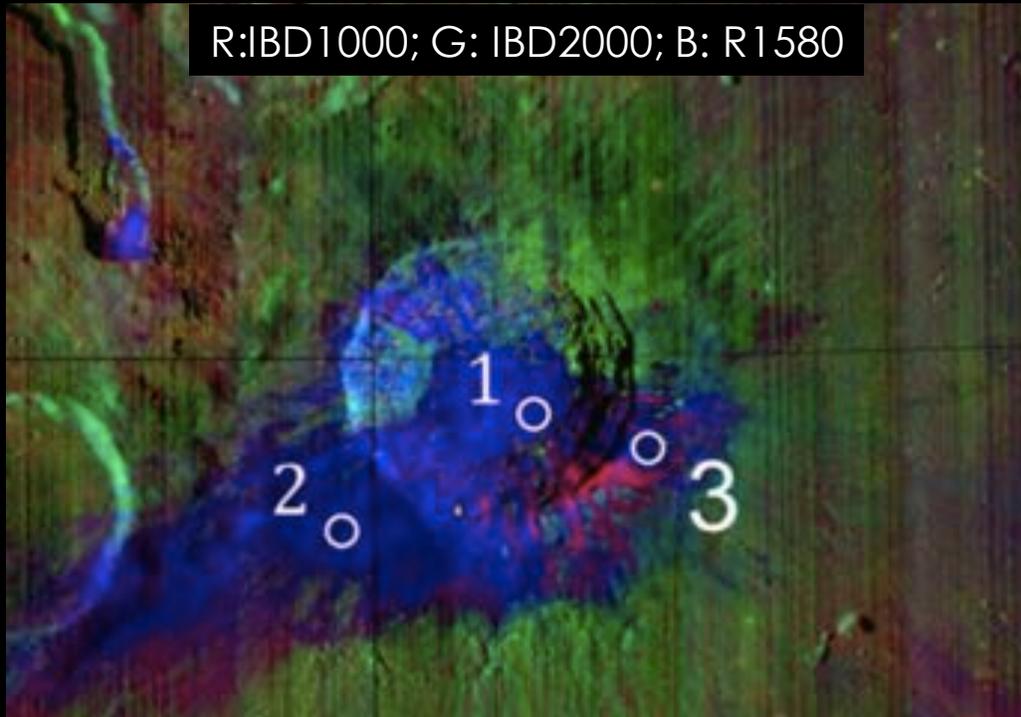
[Milliken and Li, 2017]



Aristarchus: Record of Lunar Impact Chronology

Plateau uplifted during formation of Imbrium

Aristarchus crater is a well-preserved Copernican crater, excavating a diverse suite: plagioclase-rich upper crust, olivine, pyroclastic glass, impact glass, etc.



[Zisk et al., 1977; Mustard et al., 2011]

Science Questions to be Addressed at Aristarchus

1. Volatiles

- 1.1 What is the volatile budget of the Moon?
- 1.2 Do volatiles on the Moon constrain ancient atmospheric origins, sources, and loss processes?
- 1.3 How are volatile elements/compounds transported and sequestered in the near-surface?

2. Volcanism

- 2.1 What is the distribution and timescale of volcanism on the Moon?
- 2.2 How was volcanism affected by the thermal and compositional evolution of the Moon?
- 2.3 *What is the relationship between explosive and effusive volcanism on the Moon?*
- 2.4 *What is the nature of the mantle source for Aristarchus volcanism?*

3. Impact cratering

- 3.1 What were the sources and timing of the early and recent impact flux of the inner solar system?
- 3.2 *What is the source of diverse units excavated by Aristarchus crater?*

Decadal Survey
Scientific Context for
Exploration of the Moon
My own additions

Exploration Questions to be Addressed at Aristarchus

1. The lunar resource potential

1.1 Composition/volume/distribution/form of pyroclastic deposits

1.2 Quality/quantity/distribution/form of H species and other volatiles

1.3 Preservation of volatile components during sampling

2. The lunar environment and effects on human life

2.1 Radiation environment at the lunar surface

2.2 Radiation shielding effects of lunar material

SKG SAT Review

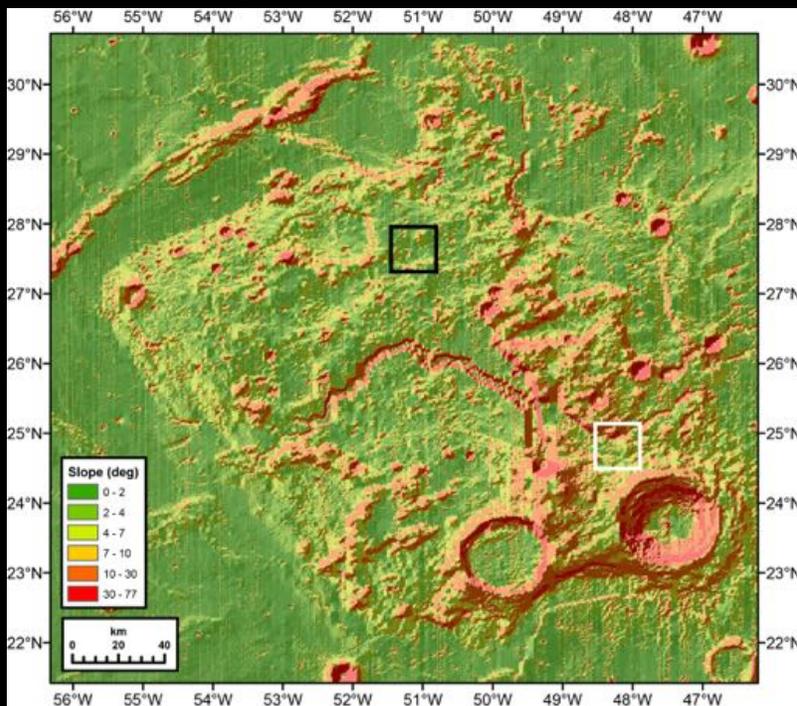
3. How to work and live on the lunar surface

3.1 Excavation, transportation, comminution of lunar resources

3.2 Lunar surface trafficability

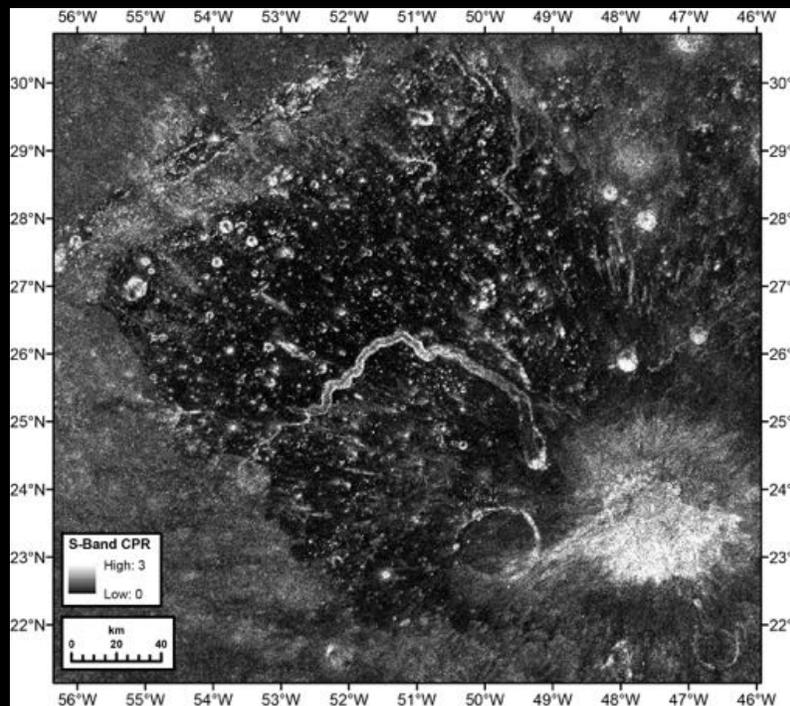
Aristarchus: A Safe Place to Explore

[Kaguya-LOLA DEM]



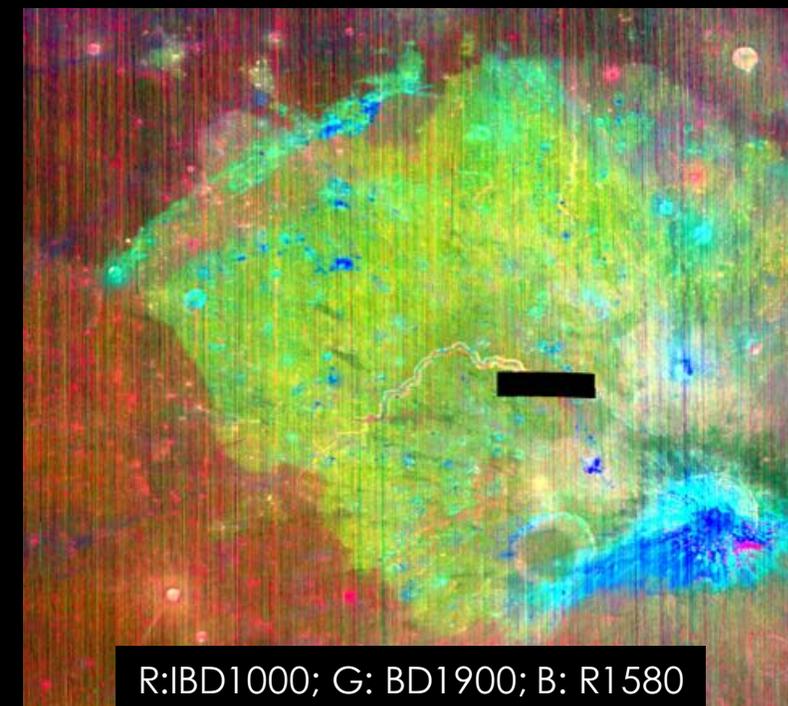
Low slopes

[Arecibo Observatory]



Fine-grained
Block-free
Thick deposit

[M³]



Spectrally homogeneous

Example Exploration Zones: EZ1, Pyroclastic deposit

Volatiles:

- Most hydrated region on plateau [Milliken and Li, 2017]

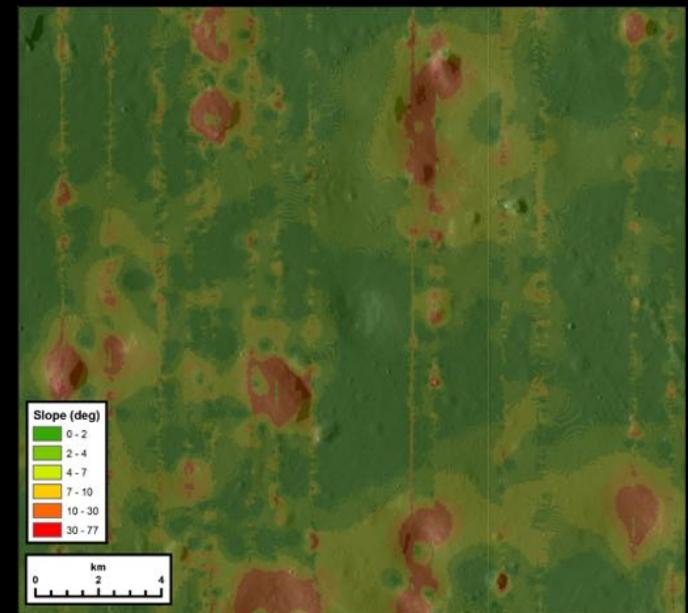
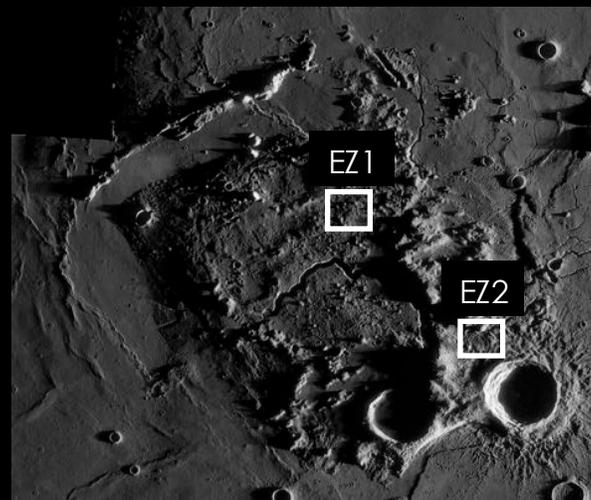
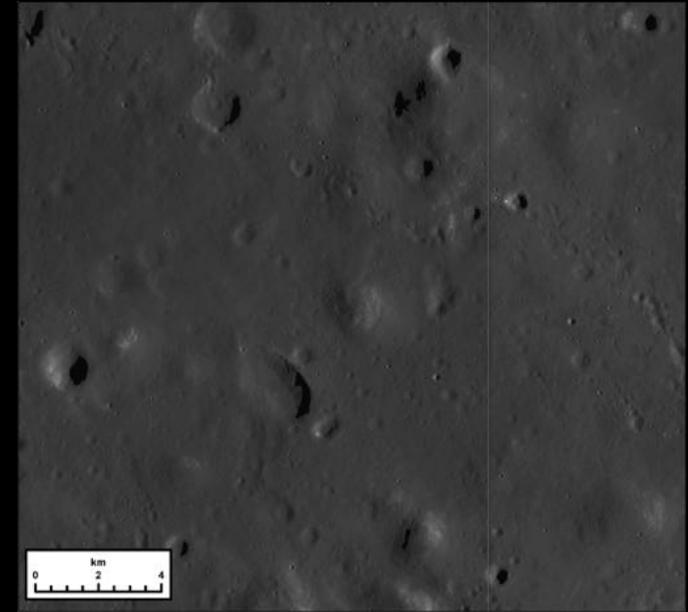
Volcanism:

- Deep region of pyroclastic deposit [Campbell et al., 2008]
- Near sinuous rille

Impacts:

- Kipukas expose local plateau material
- Distal Aristarchus crater ejecta
- Small impacts near landing site

SKGs: All



Example Exploration Zones: EZ2, Aristarchus Ejecta Deposit

Impacts:

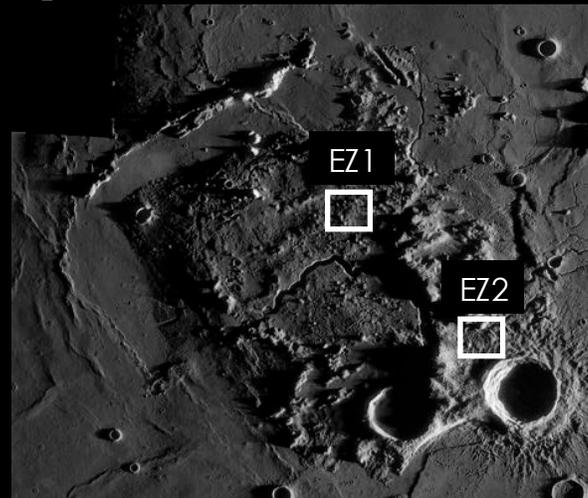
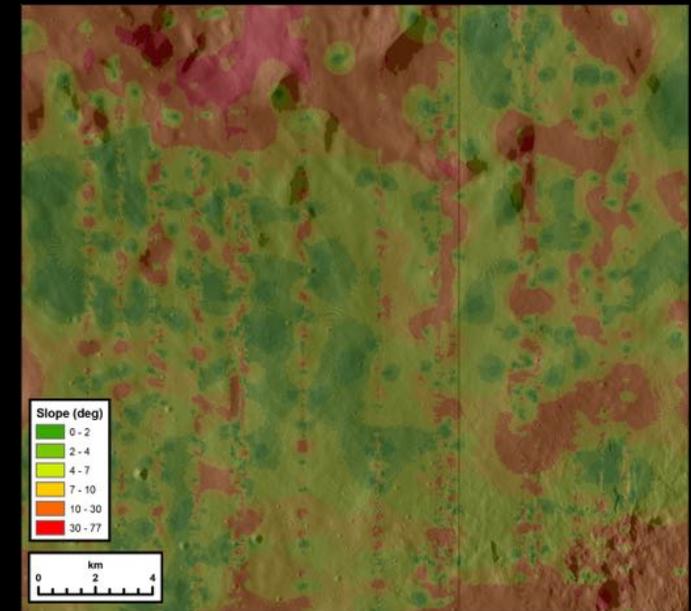
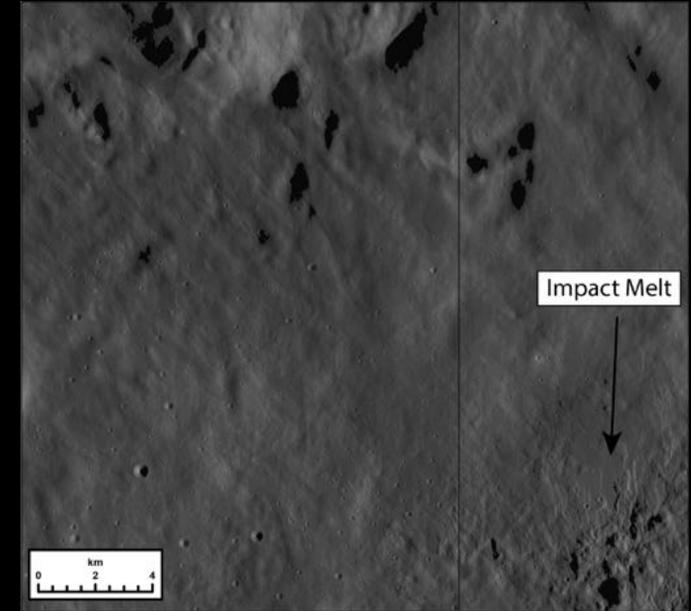
- Impact melt present
- Crater ejecta includes pyroclastic deposit, plateau, surrounding mare basalts, lunar crust
- Crater exposures (OL) could be sourced from depth

Volcanism:

- Pyroclastic deposit
- Access to sinuous rille via Cobra Head
- Silic volcanic units [Tim Glotch talk]

SKGs:

- The lunar environment and effects on human life
- How to live and work on the lunar surface



Mission Requirements: Mobility, Sample Return

Mobility, sample return not required to answer fundamental scientific and exploration questions

- Homogeneous pyroclastic deposit
- Dispersed Aristarchus crater ejecta, plateau kipukas
- Small impacts provide local stratigraphy without traversing or drilling

Mobility, sample return would enable insights not possible using stationary, *in situ* analyses alone

- Saal et al. [2008] discovered water in quenched lunar glass in quantities not detectable with in-situ capabilities.

Conclusions

- Fundamental questions about lunar volcanism, impacts, and volatiles can be answered by exploring the Aristarchus plateau.
- The pyroclastic deposit on Aristarchus provides a rich testing ground for engineering capabilities and for closing SKGs.
- Several mission designs are feasible in the region, not requiring mobility or sample return. But these capabilities would greatly enhance scientific and engineering discoveries.
- The location, safety, and scientific and exploration opportunities present on the Aristarchus plateau make it critical for future landed exploration. Multiple missions deployed to various locations on the Aristarchus plateau would provide insights into several fundamental lunar questions.