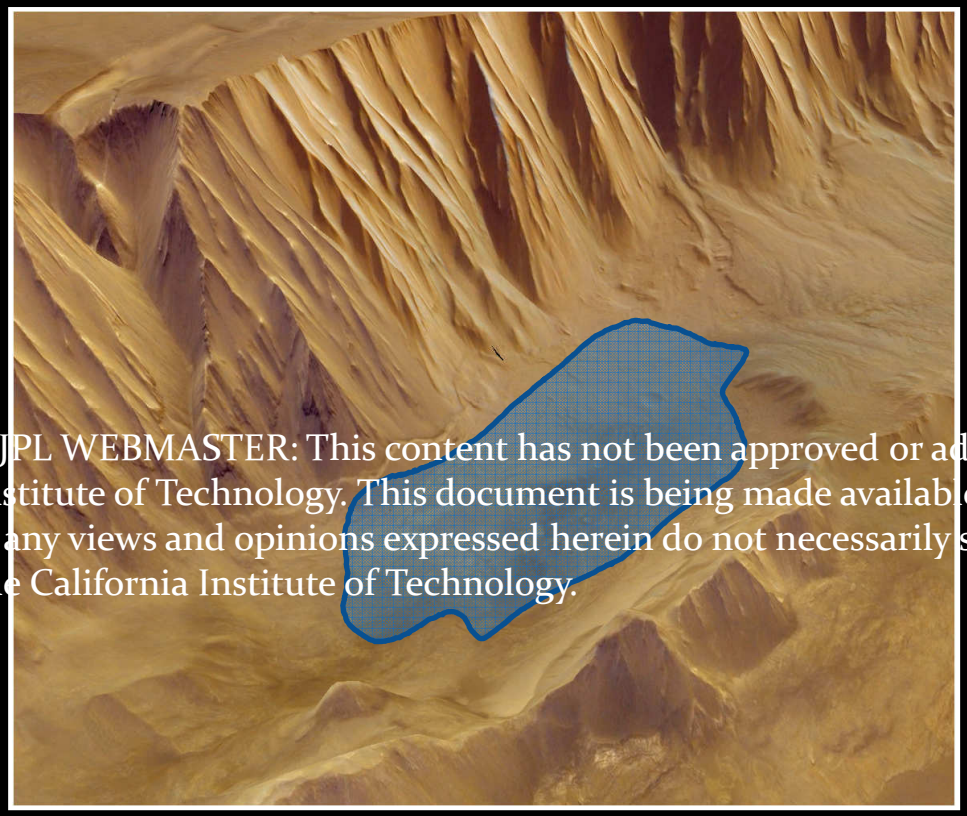
In Situ investigation of the Southwestern Melas Basin



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Seeking Signs of Life

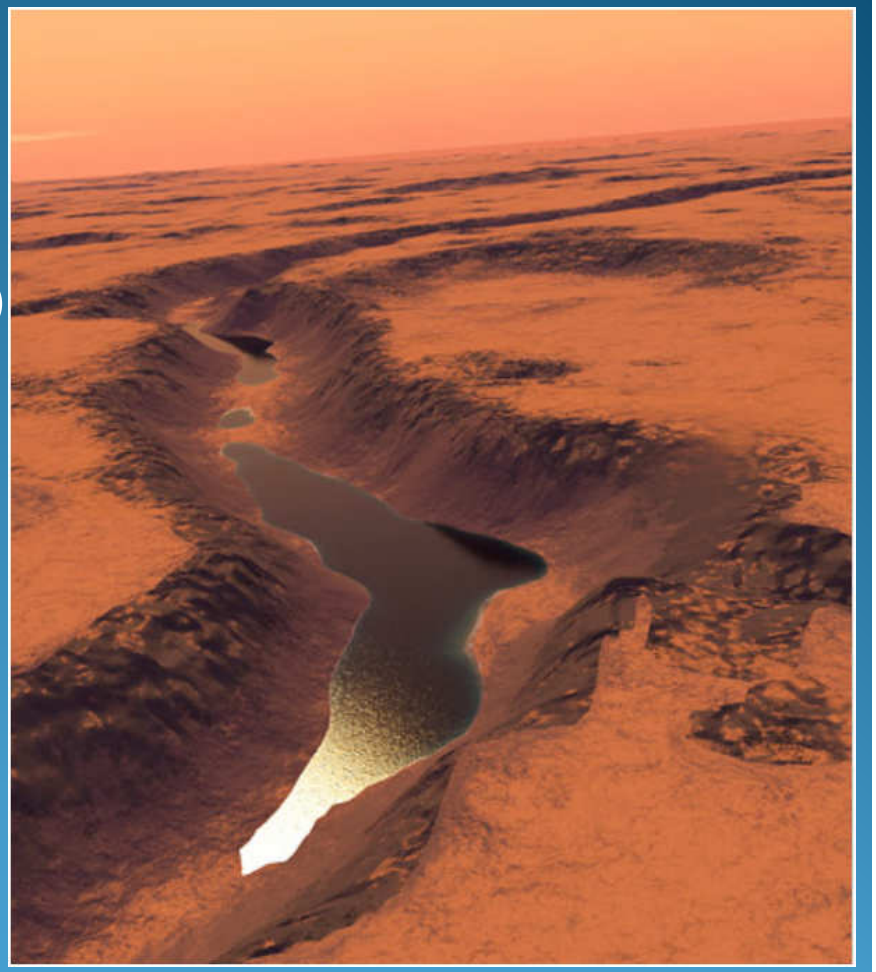
2020 Mars Rover Science Objectives

A. Habitable ancient environment
→ Evidence of aqueous activity

B. Biosignature preservation potential (BPP)
→Depositional environment (preferably lacustrine)

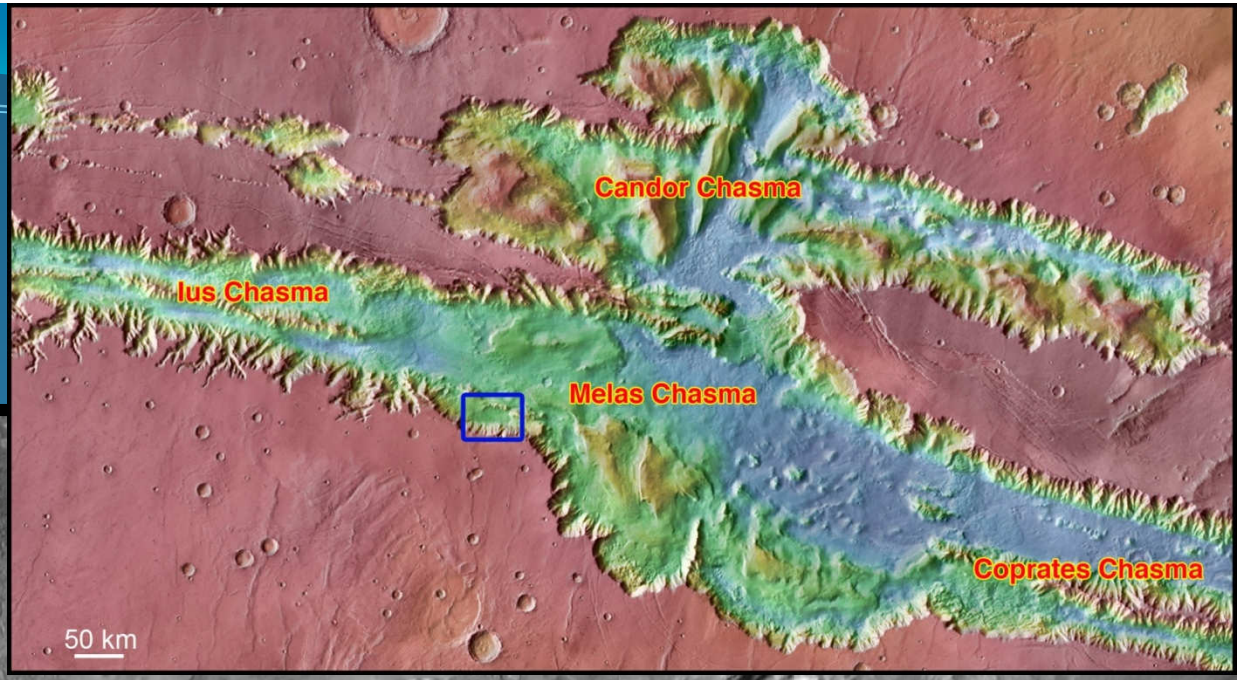
C. Scientifically selected, well-documented samples
→ Geologic and stratigraphic context
→ Accessibility

D. Pave the way for human exploration
→ Achievable at all landing sites



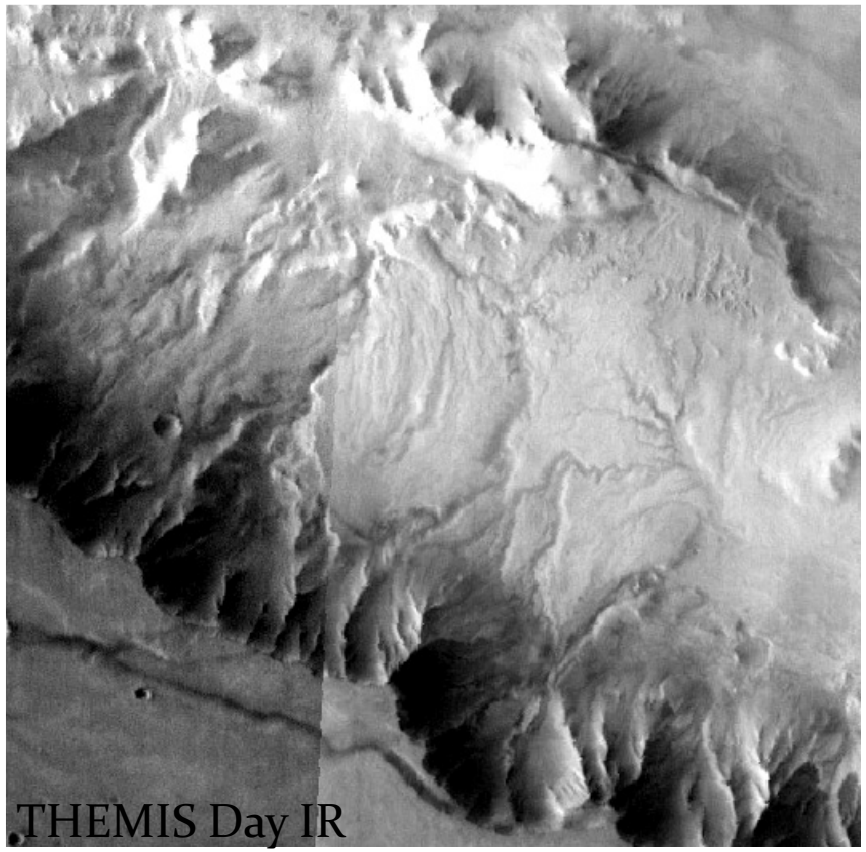
(National Geographic)

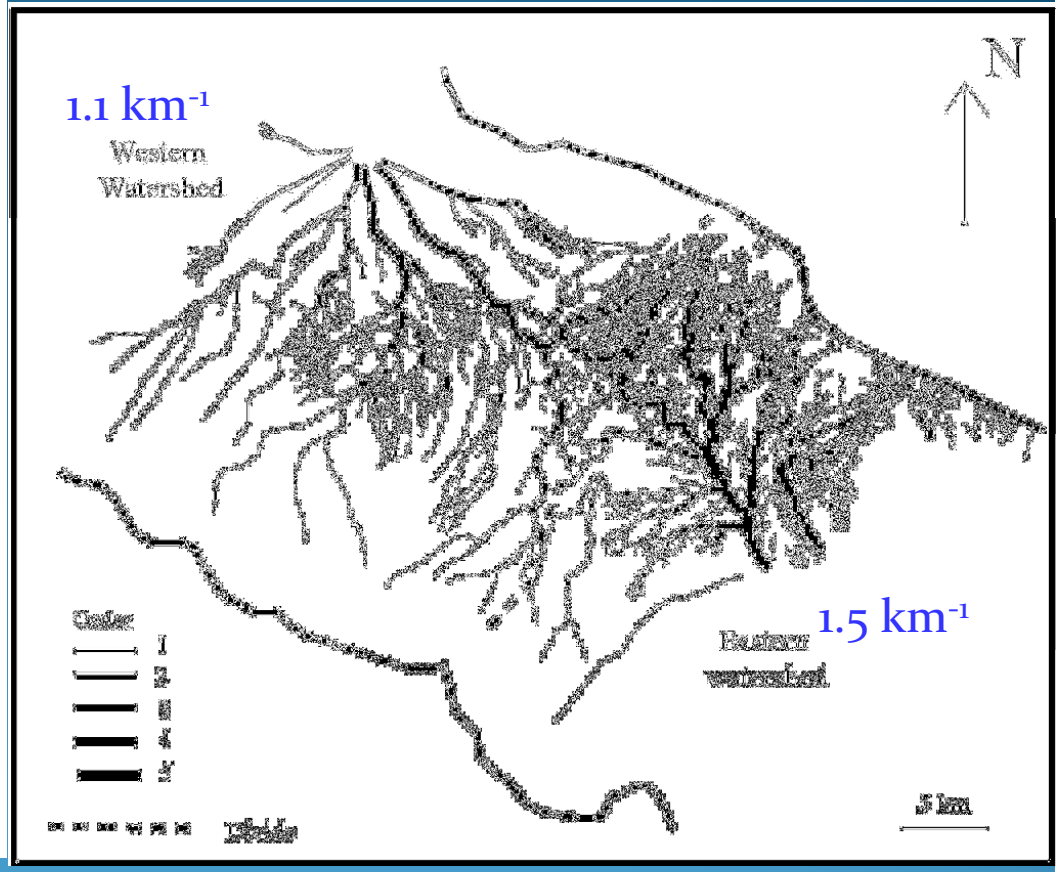
Regional Setting



10 km

Western Drainage Basin





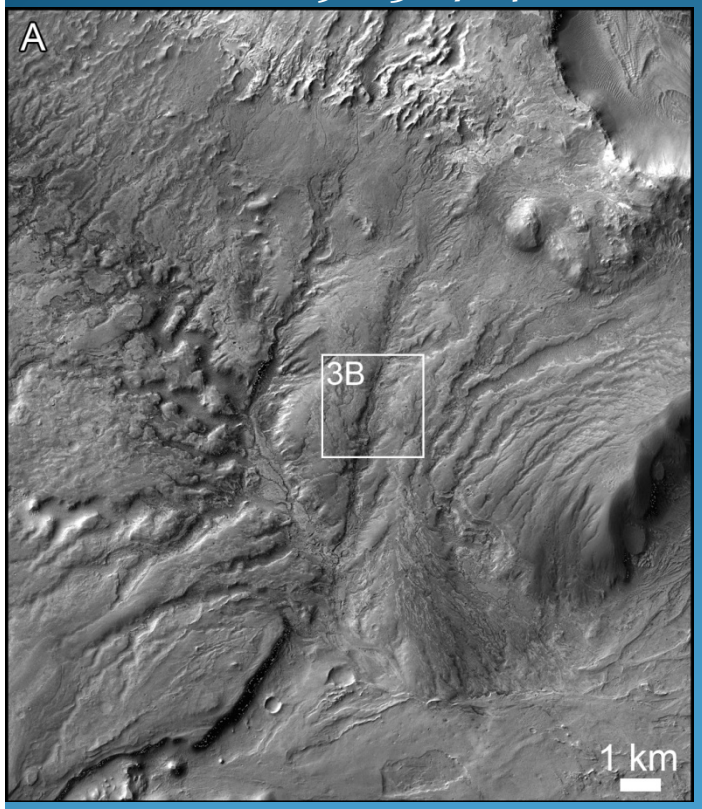
(Quantin et al., *JGR*, 2005)

Maximum VN Drainage Density 0.14 km^{-1} (Hynek et al., 2010)

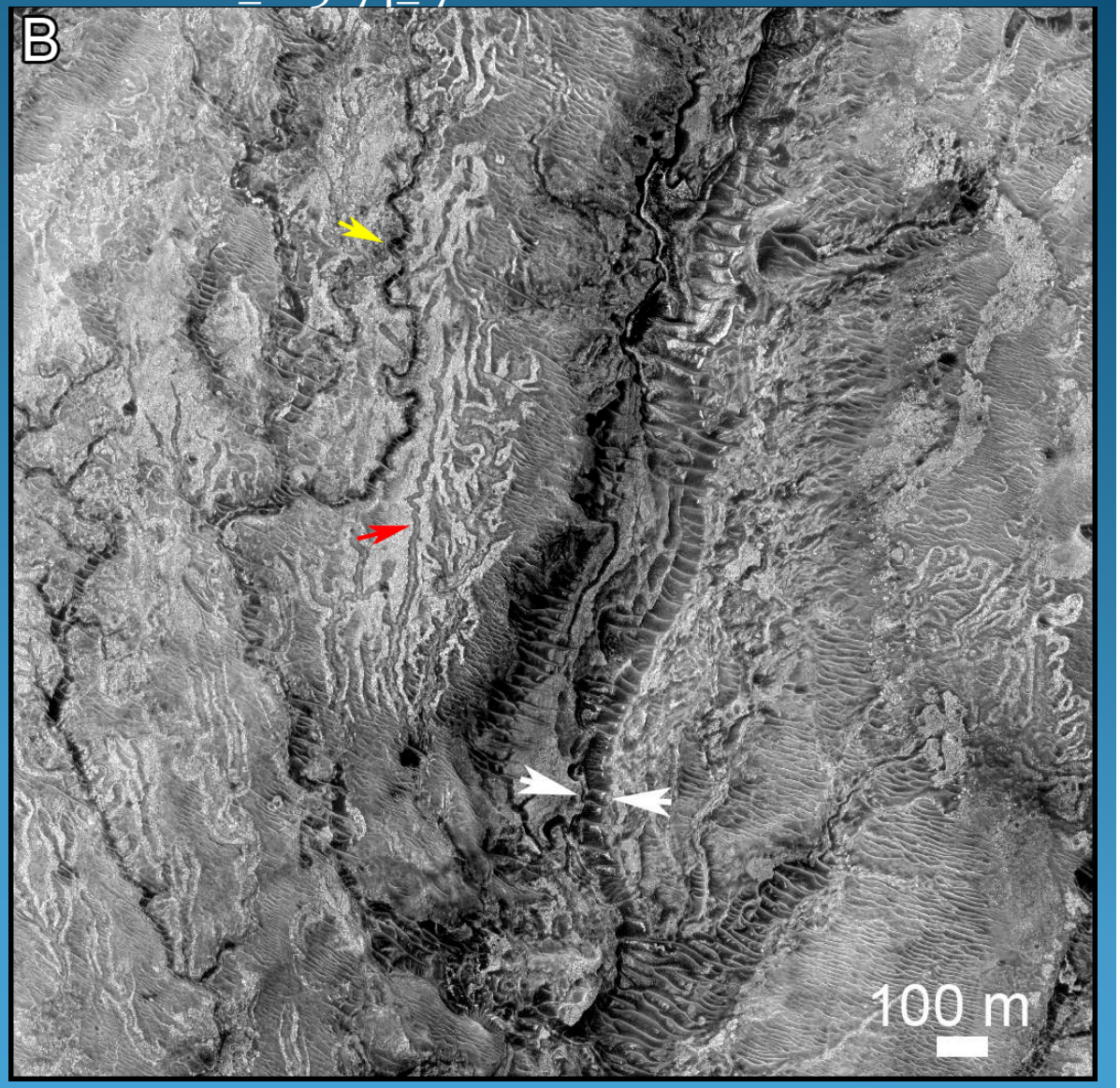
VN Maturity implies formation timescales of thousands of years.

Western Drainage Basin

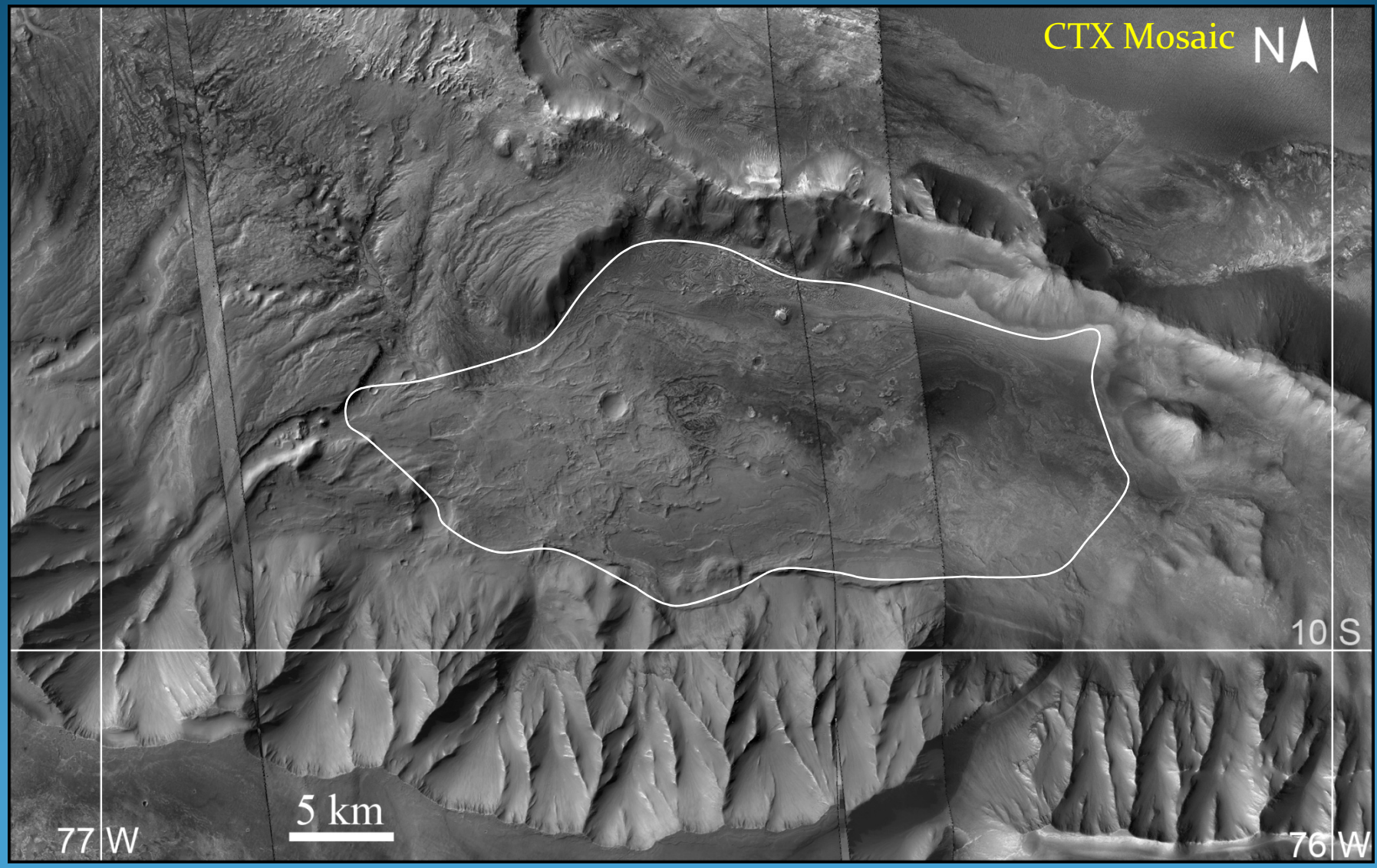
CTX P20_009025_1704



HiRISE PSP_005874_1700

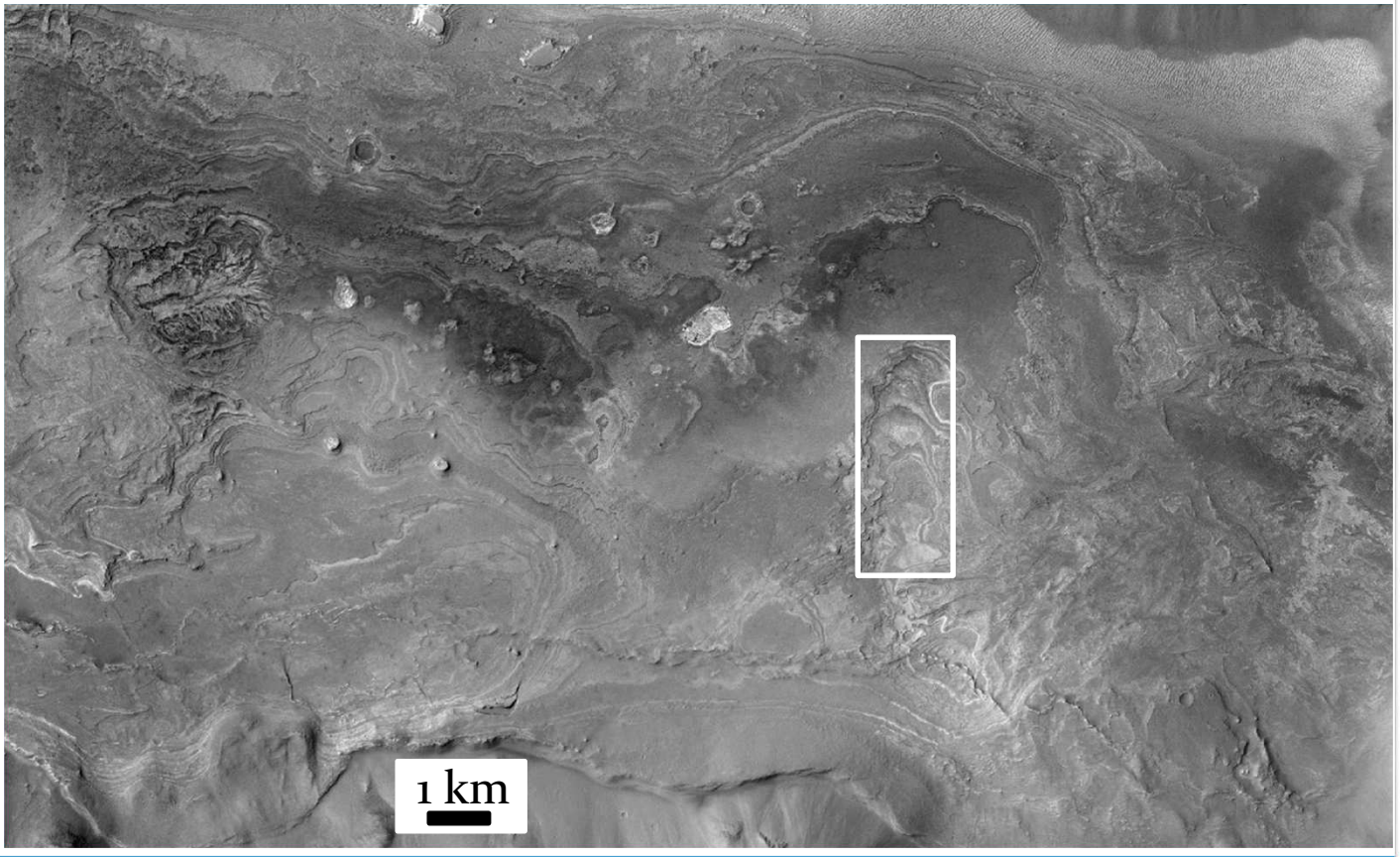


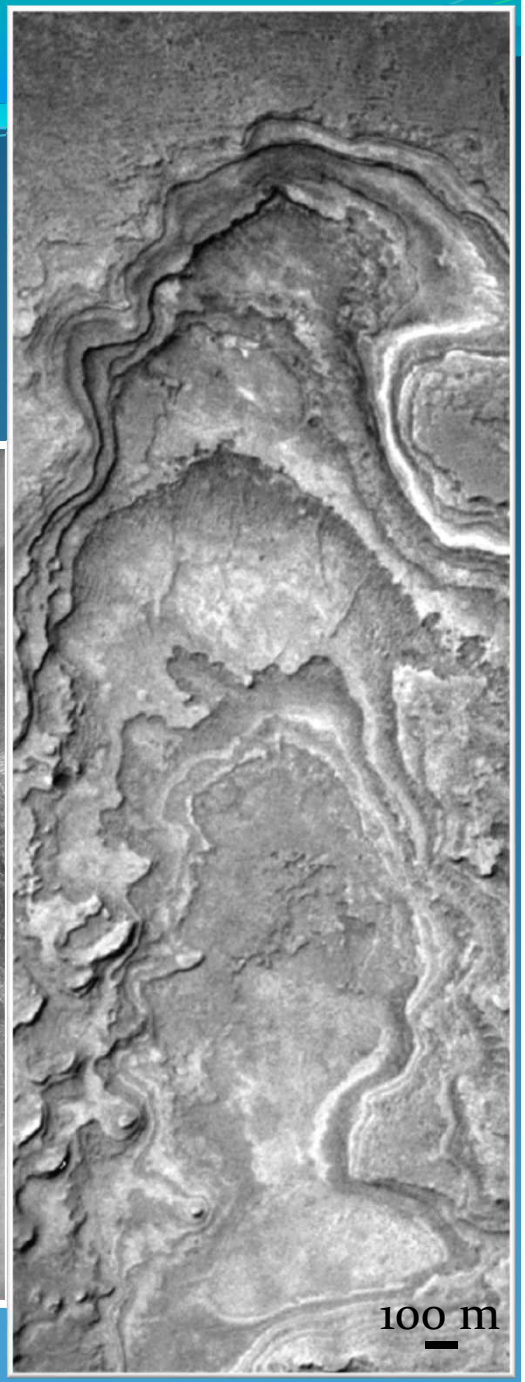
Early parallel drainage
Later: Sinuous incision


CTX Mosaic
N
10 S
5 km
77 W
76 W

Layered Beds

Hypotheses: lacustrine, aeolian, volcanic

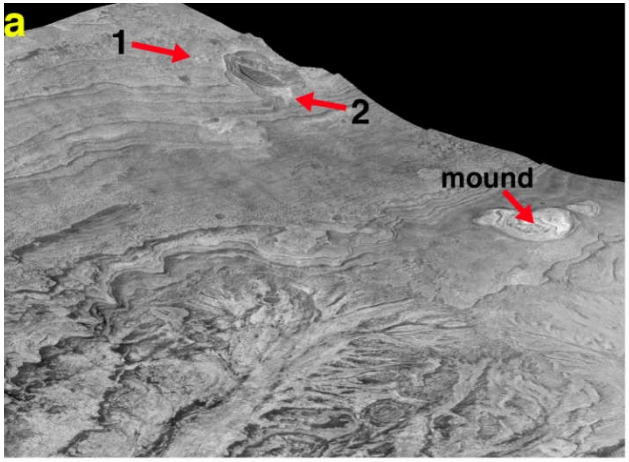


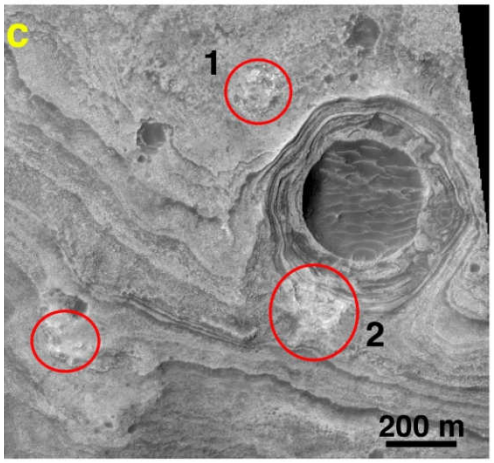


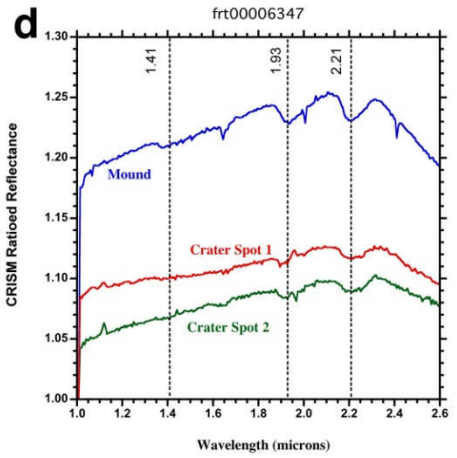
Hydrated Silica/Opal

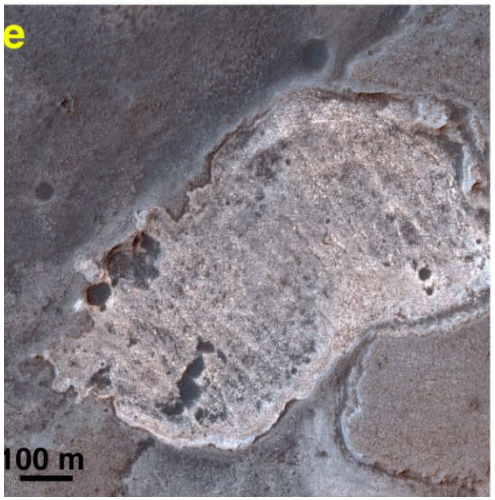
- Associated with fresher, brighter exposures of pre-existing beds
- Not tied to one bed or elevation
- Alteration of sediments by unknown processes

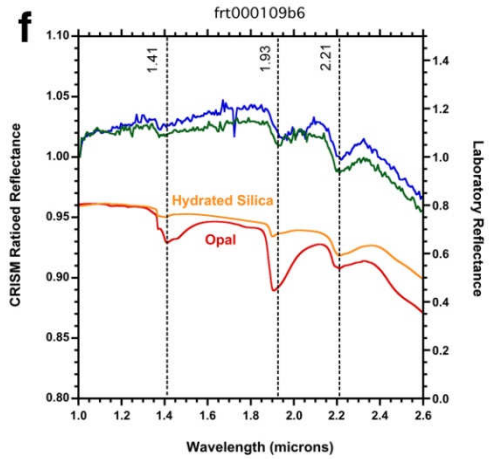
(Weitz et al., 2014)

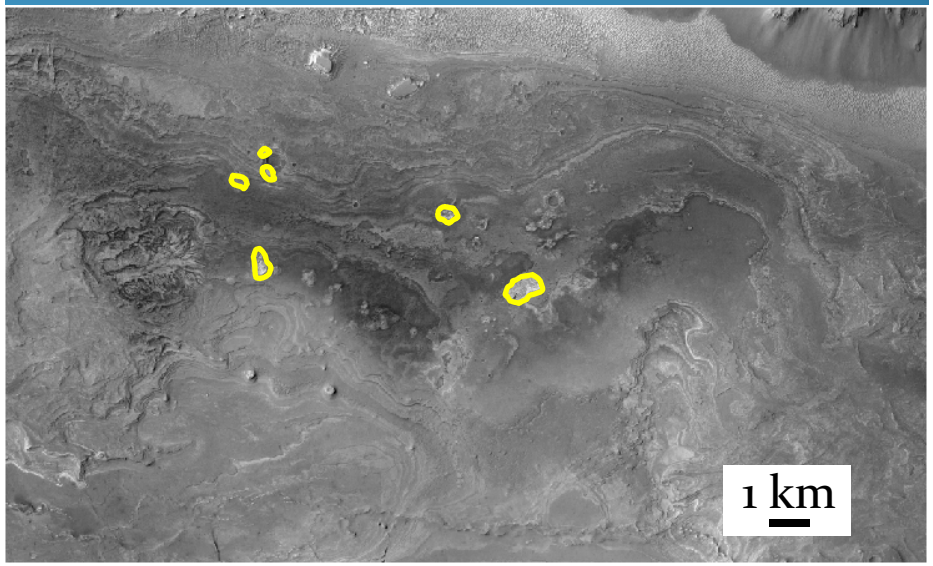




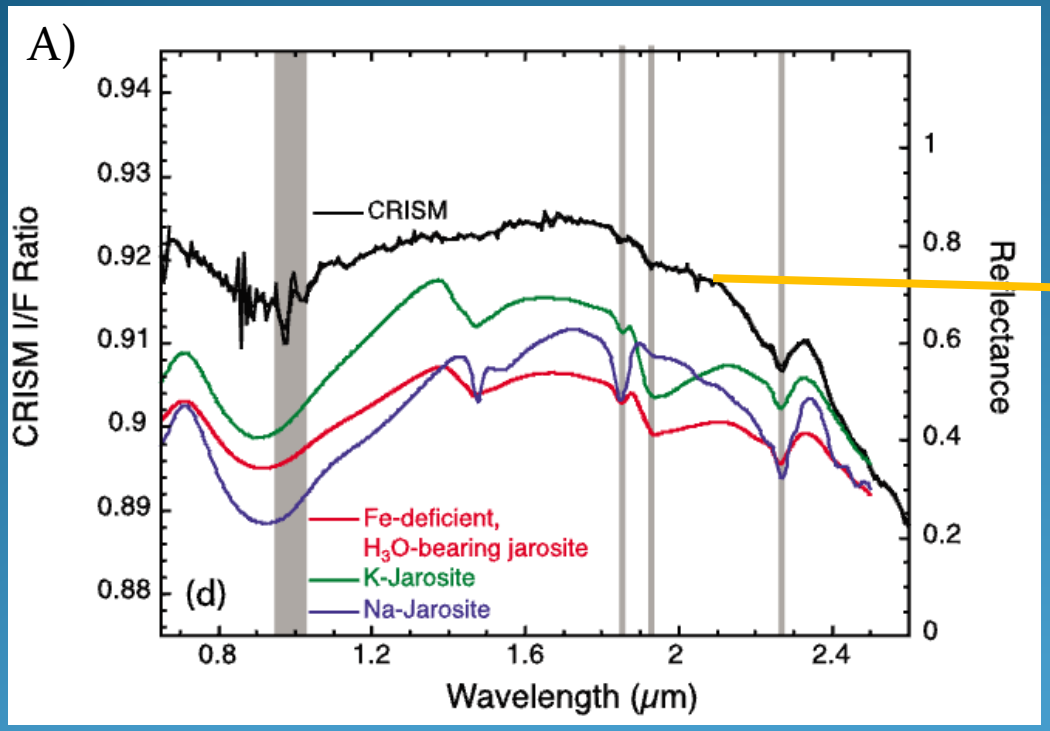




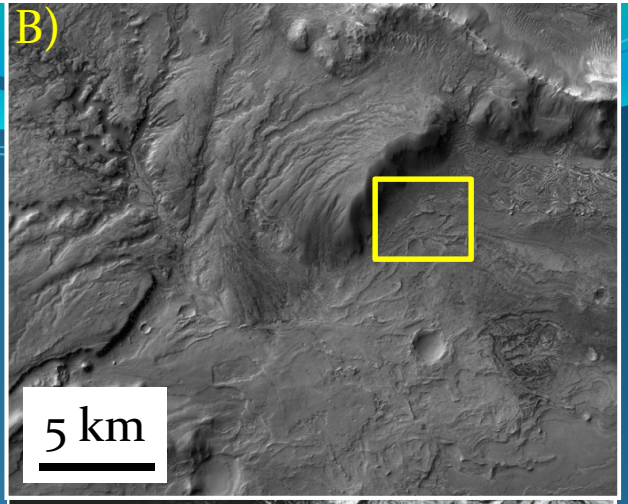


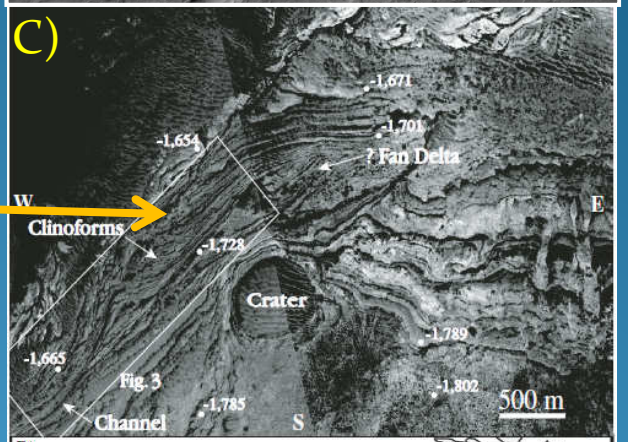


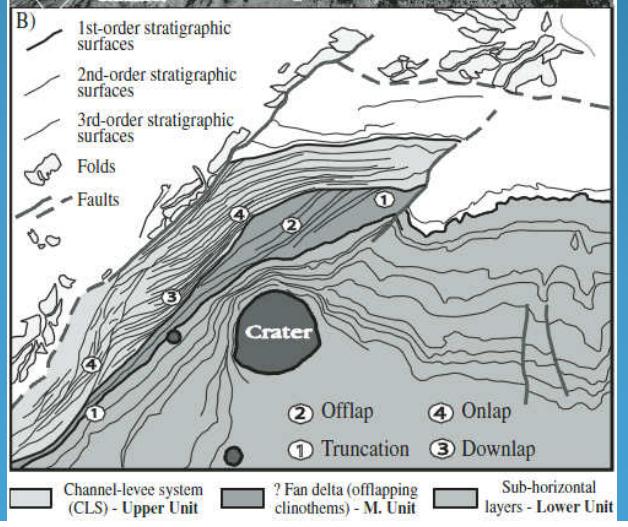
Sulfates—Jarosite



(Metz et al., 2009)







(Dromart et al., 2007)

Depositional Environments

Subaerial

Brown = Debris flows

Blue = Landslides

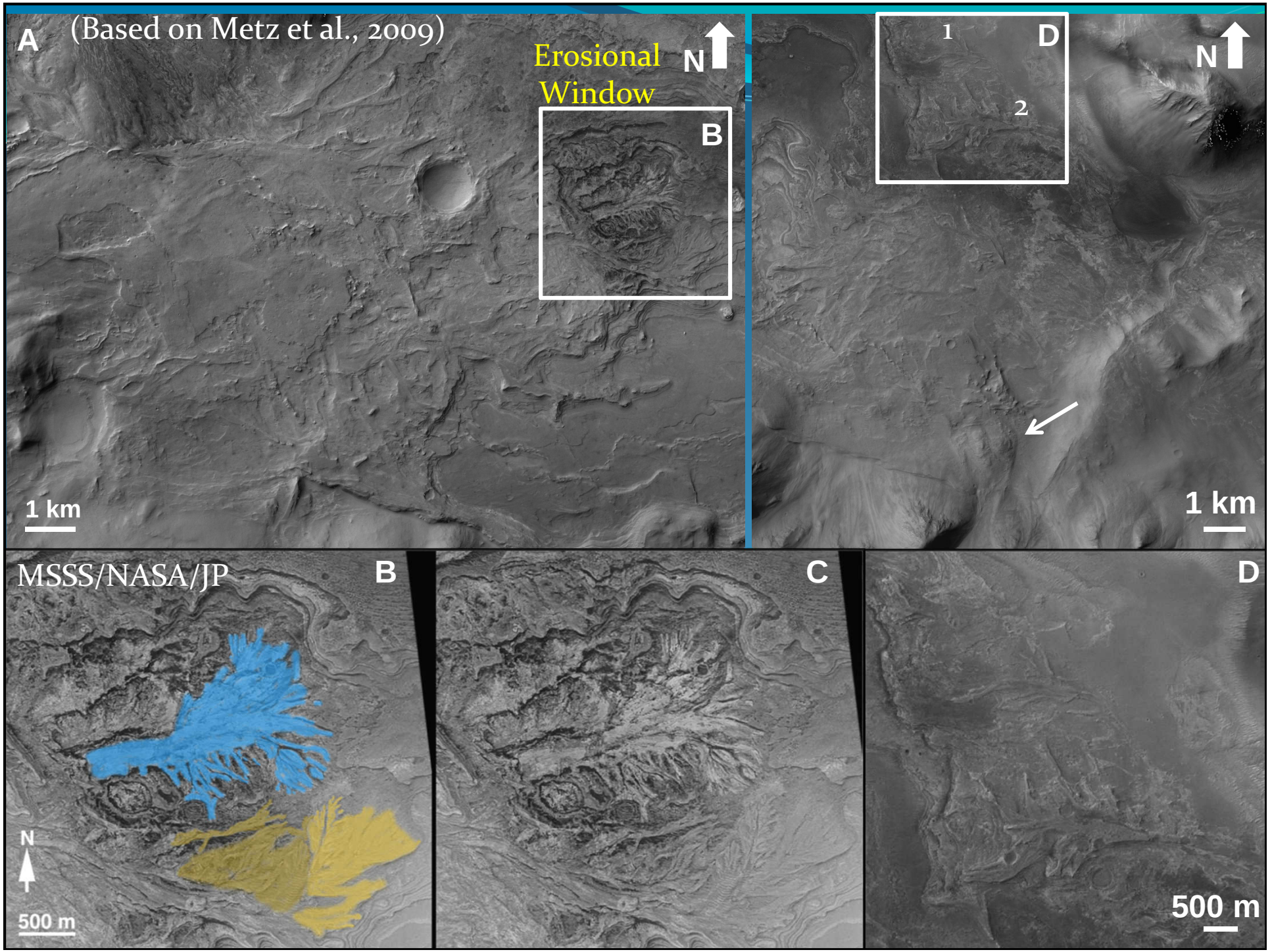
Subaqueous

Purple = Fan/deltas

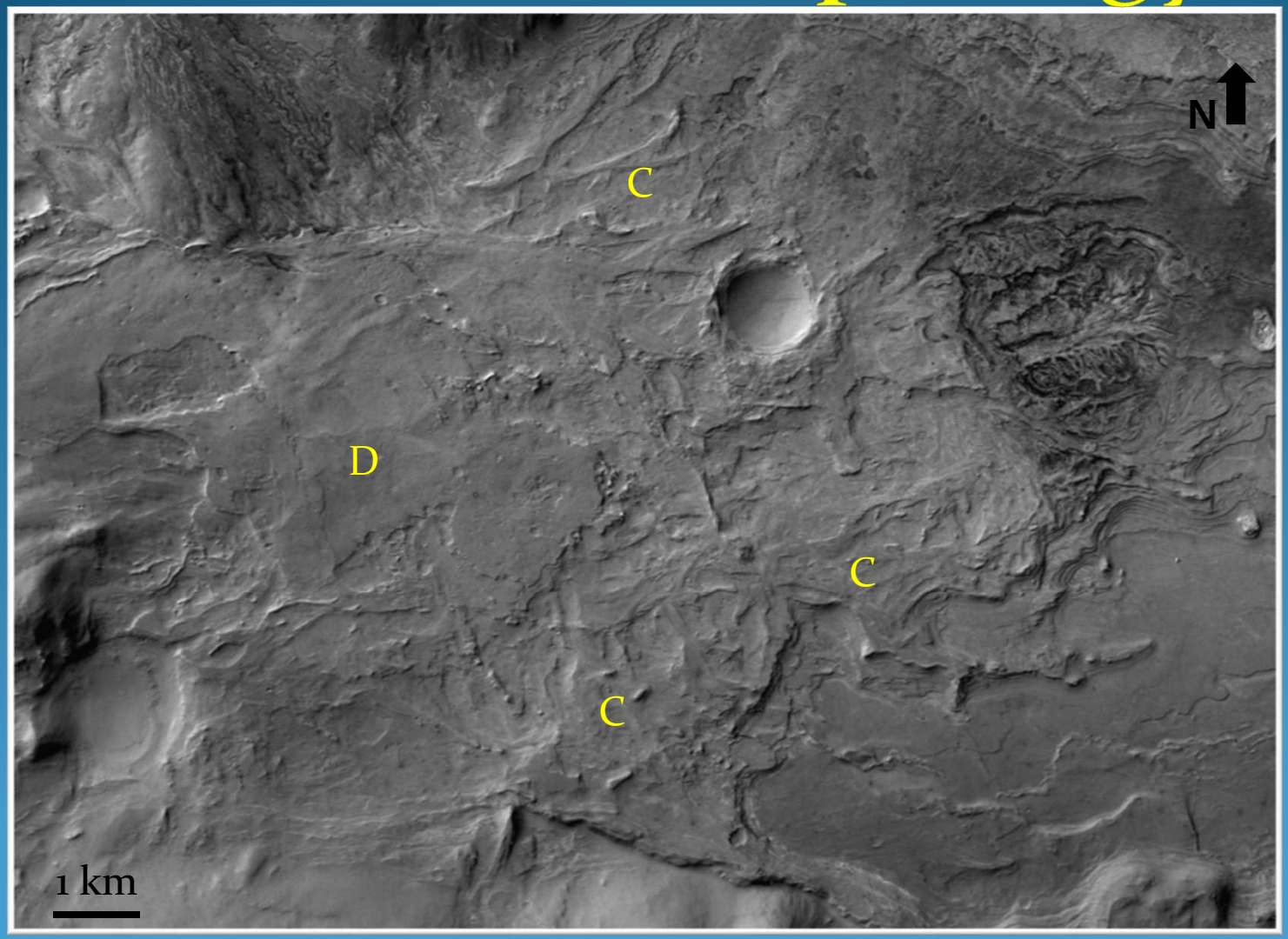
Yellow = Deltas

Orange = Deep sublacustrine fans

(Williams and Weitz, *in review*)

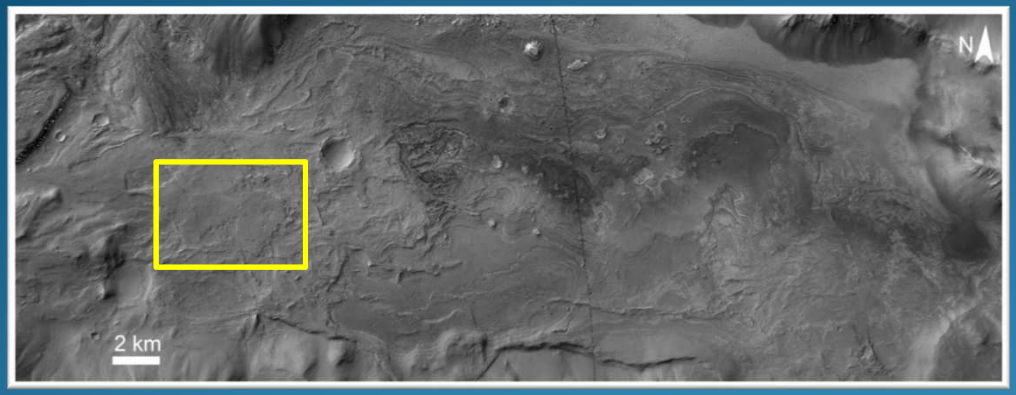

A
(Based on Metz et al., 2009)
Erosional Window
N
B
1 km
1
2
D
N
1 km
MSSS/NASA/JP
B
C
D
N
500 m
500 m

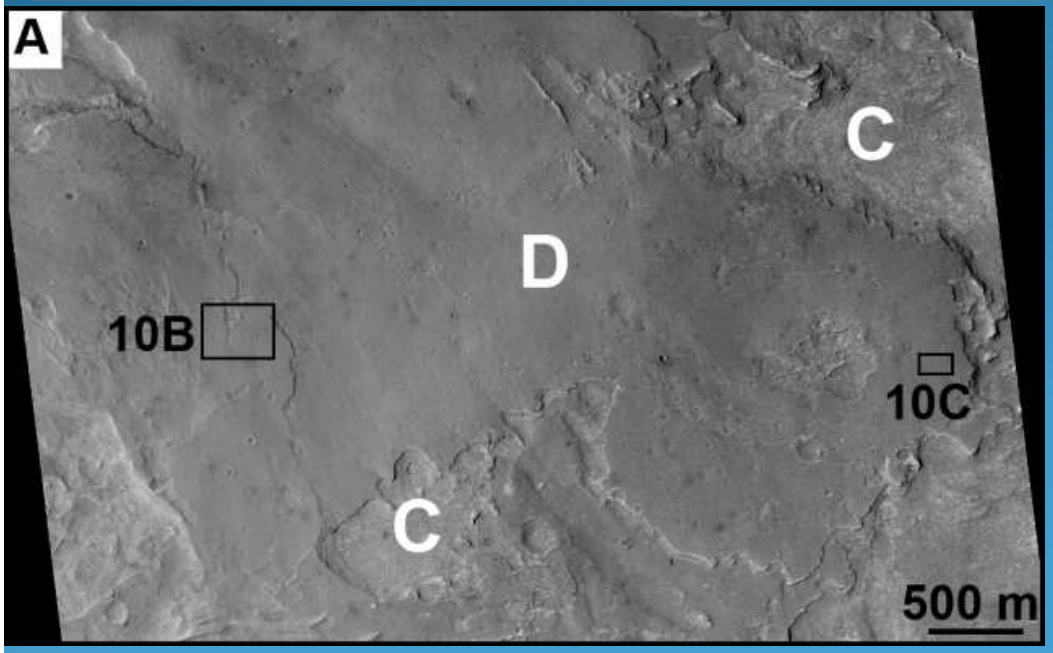
Fans C & D: Morphology

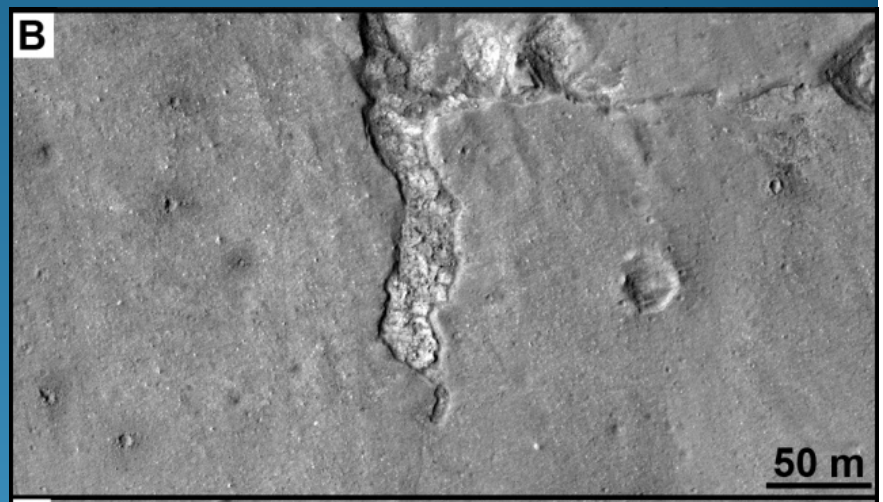


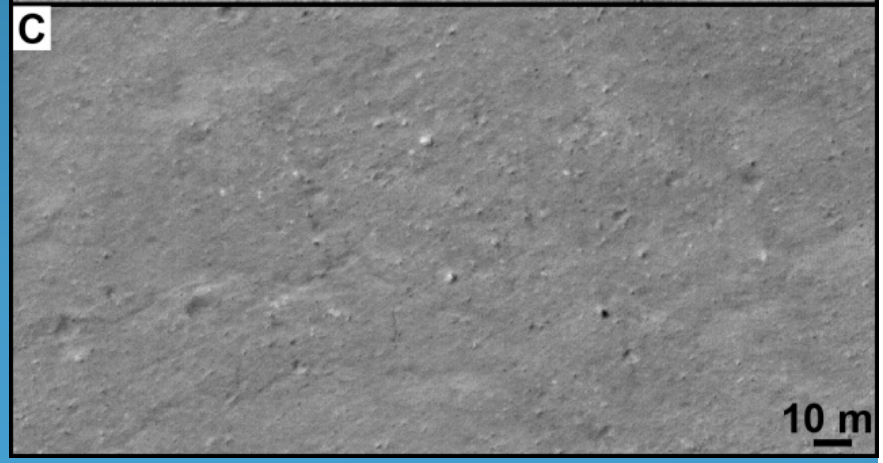
(Williams and Weitz, *in review*)

Fans D: Morphology



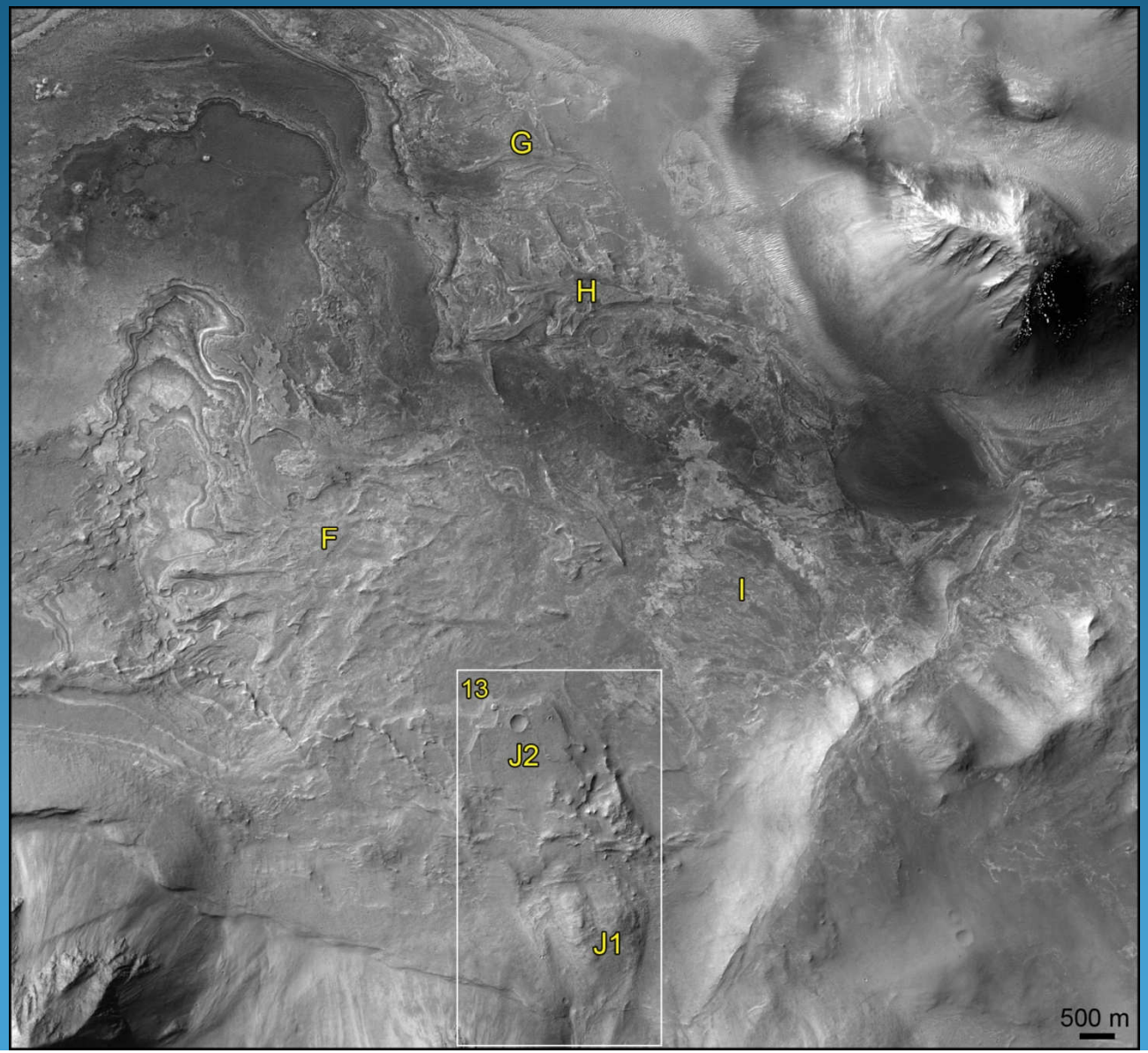




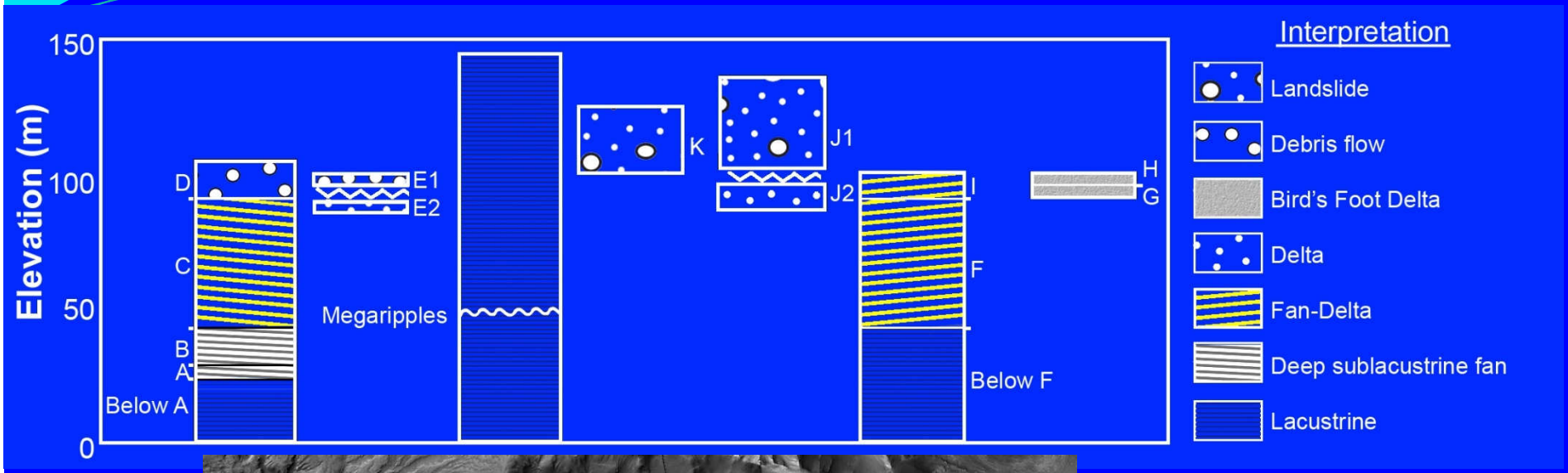


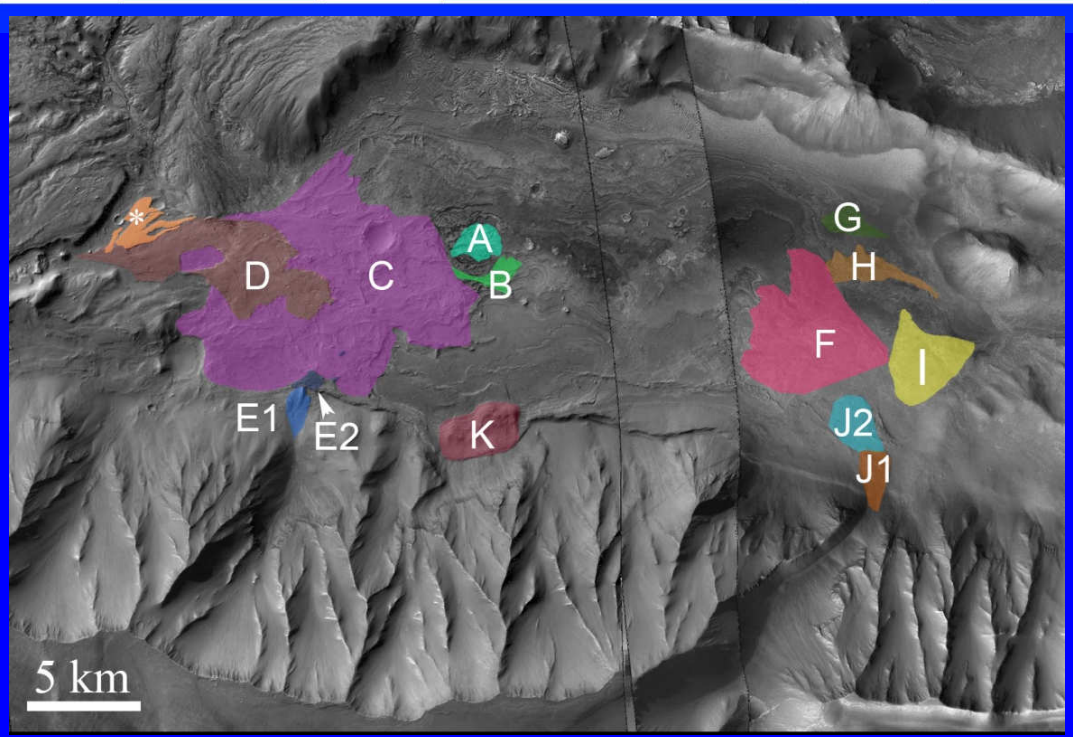
(Williams and Weitz, *in review*)

Eastern Fan Complex



Stratigraphic Relationships





(Williams and Weitz, *in review*)

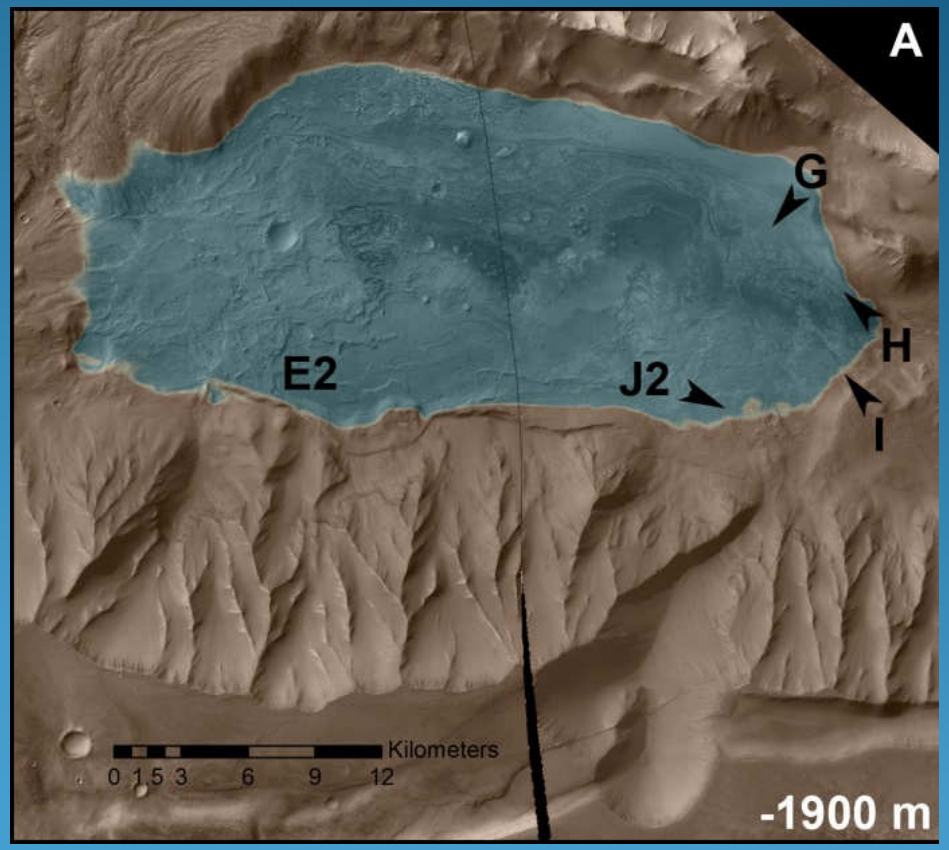
Timescales

1) Use average discharge (~30 m^3/s), representative of persistent flow conditions
→100-250 years basin fill time
Only western inflow

2) Use large delta deposition rates (~0.001 km^3/yr)

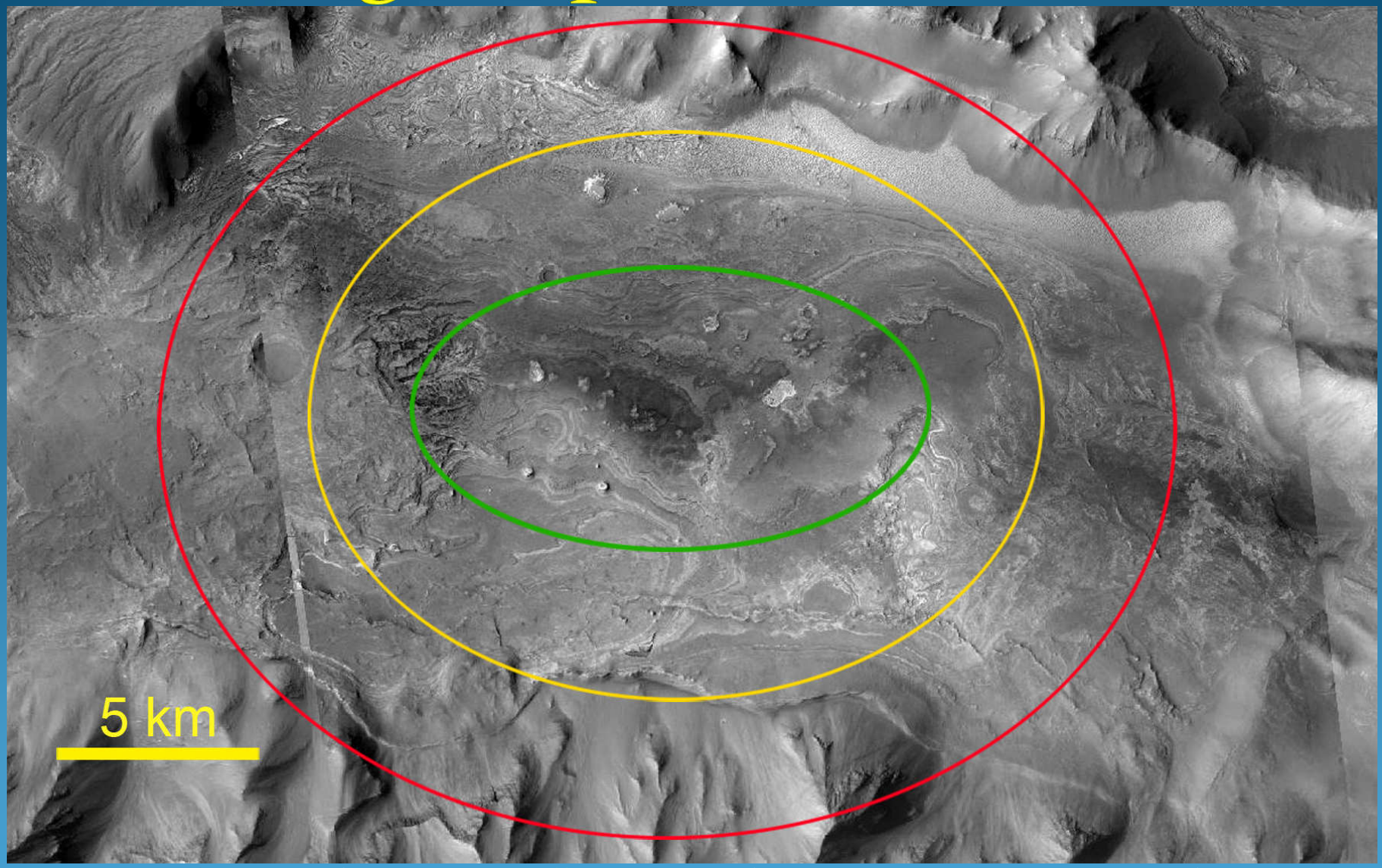
Fan C Volume 0.1 km^3
→~100 years Fan C formation time

3) Use lacustrine deposition rates (0.02 -1 cm/year)
→ for 25 m layered beds below fan A
10^3 – 10^5 years



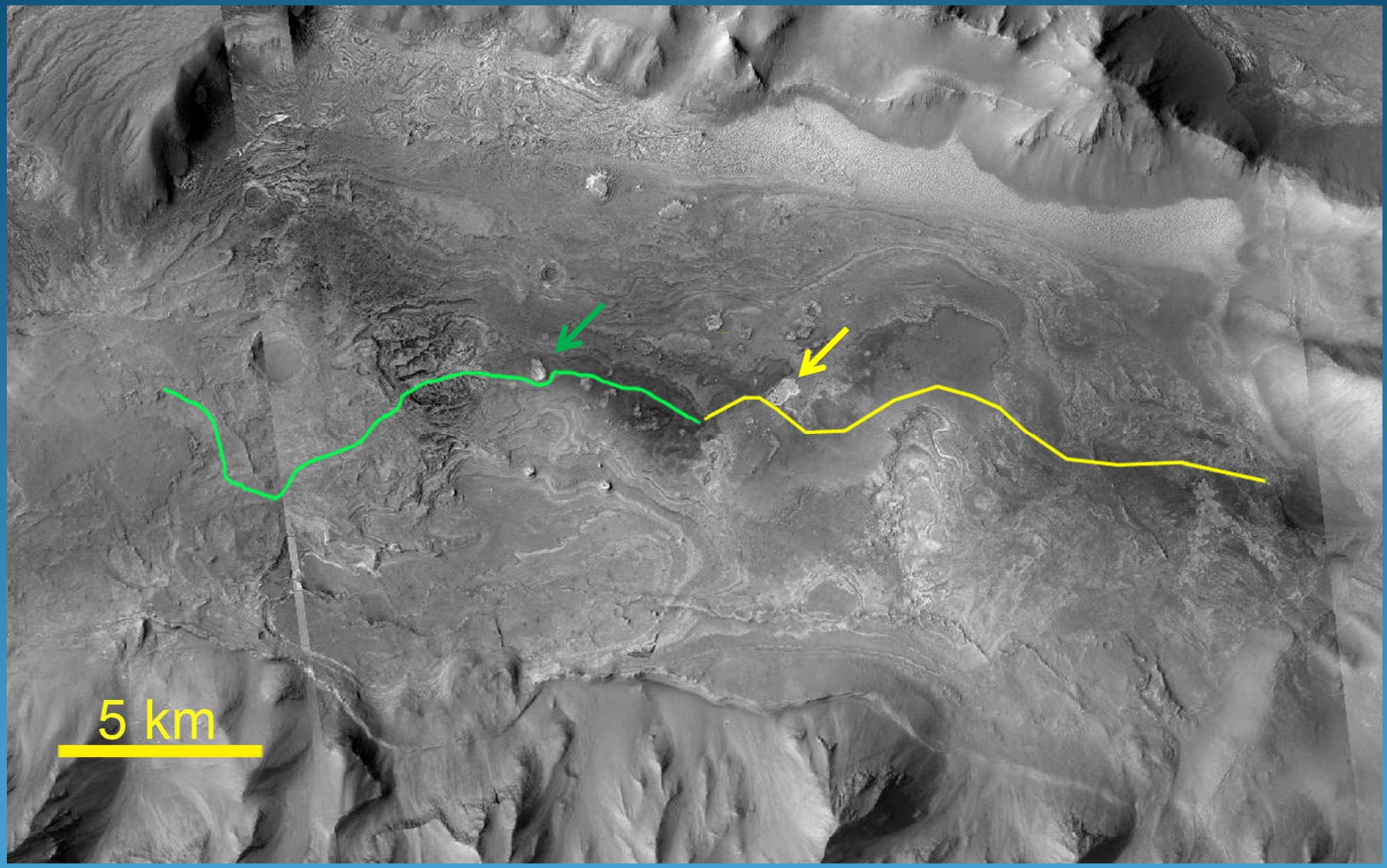
(Williams and Weitz, *in review*)

Landing Ellipses



Red: 25 x 20 km Yellow: 18 x 14 km Green: 13 x 7 km

Potential Routes



Red: 25 x 20 km Yellow: 18 x 14 km Green: 13 x 7 km

Engineering Constraints

Parameter	Criteria	Compliance
Elevation	Below 0.5 km	√ -1.850 +/- 0.100 km
Latitude	Within ±30° of the equator	√ 9.84°S, 283.63°E
Slope	<20° over 2-10 km	√
	<25° over 2-5 m	√ >98% for smallest ellipse
Relief	<100 m over 1-1,000 m	Few locations within ellipse exceed relief constraint.
Rock Abundance	Probability of rock 0.55 m tall in area of 4 m^2 is <0.5%	HiRISE verification needed
Thermal inertia	> 100 J m^{-2} $s^{-0.5}$ K^{-1}	√
Albedo	<0.25	√

See supplemental slides for more details

Scientific Rationale for SW Melas

- Well defined geologic and stratigraphic context
- Long-lived lacustrine history exposed
- Scientific targets are distributed across entire ellipse
- Exhumed terrain means young exposure age
  → protection from irradiation
- Diversity of sample targets within landing ellipse
  - Lacustrine deposits
  - Deltaic deposits
  - Alluvial fans
  - Debris flows
  - Hydrated silica
  - Sulfates

Potential Rock Targets

- Volcanic ash deposit
- Transported materials from uplands
  - Impact breccia
  - Igneous rocks

Challenges for SW Melas

- Requires range trigger to shrink ellipse size; would benefit from TRN
- Minor violation of relief constraints
- No *in situ* lava flow
- Detailed examination of rock abundance and traversibility is needed

Supplemental Slides

Threshhold Geological Criteria

	SW Melas
1. Presence of subaqueous sediments or hydrothermal sediments (equal 1st priority),	√ Deltaic & lacustrine
OR	
hydrothermally altered rocks or low-T fluid-altered rocks (equal 2nd priority)	√ Hydrated silica
2. Presence of minerals indicative of aqueous phases (e.g., phyllosilicates, carbonates, sulfates, etc.) in outcrop	√ Hydrated silica
3. Noachian/Early Hesperian age based on stratigraphic relations and/or crater counts	√ Noachian/Early Hesperian Age
4. Access to unaltered igneous rocks as float	Uncertain

Potential Qualifying Geological Criteria

	SW Melas
1. Morphological criteria for standing bodies of water and/or fluvial activity	√ Deltaic & lacustrine deposits
2. Assemblages of secondary minerals of any age.	√ Hydrated silica
3. Presence of former water ice, glacial activity or its deposits.	Not recognized.
4. Igneous rocks of Noachian age, of known stratigraphic relation, better if including exhumed megabreccia.	Inferred volcanic layers in wall rock.
5. Volcanic unit of Hesperian or Amazonian age well-defined by crater counts and well-identified by morphology and/or mineralogy.	Not recongized.
6. Probability of samples of opportunity (ejecta breccia, mantle xenoliths, etc.).	Ejecta breccia, 'grab bag' of catchment lithogies
7. Potential for resources for future human mission	Uncertain.

Other Noteworthy Attributes

- Excellent image and spectral dataset for further assessment of landing site

- Preliminary analysis demonstrates that most engineering constraints are met.

→ Detailed route planning needed to ensure rover trafficability over layered terrain.

- Ground-based observations will constrain timing and duration of aqueous history.

→Ellipse is located on primary target of interest (layered materials)

- Geologic diversity of site enables exploration of a number of scientific questions

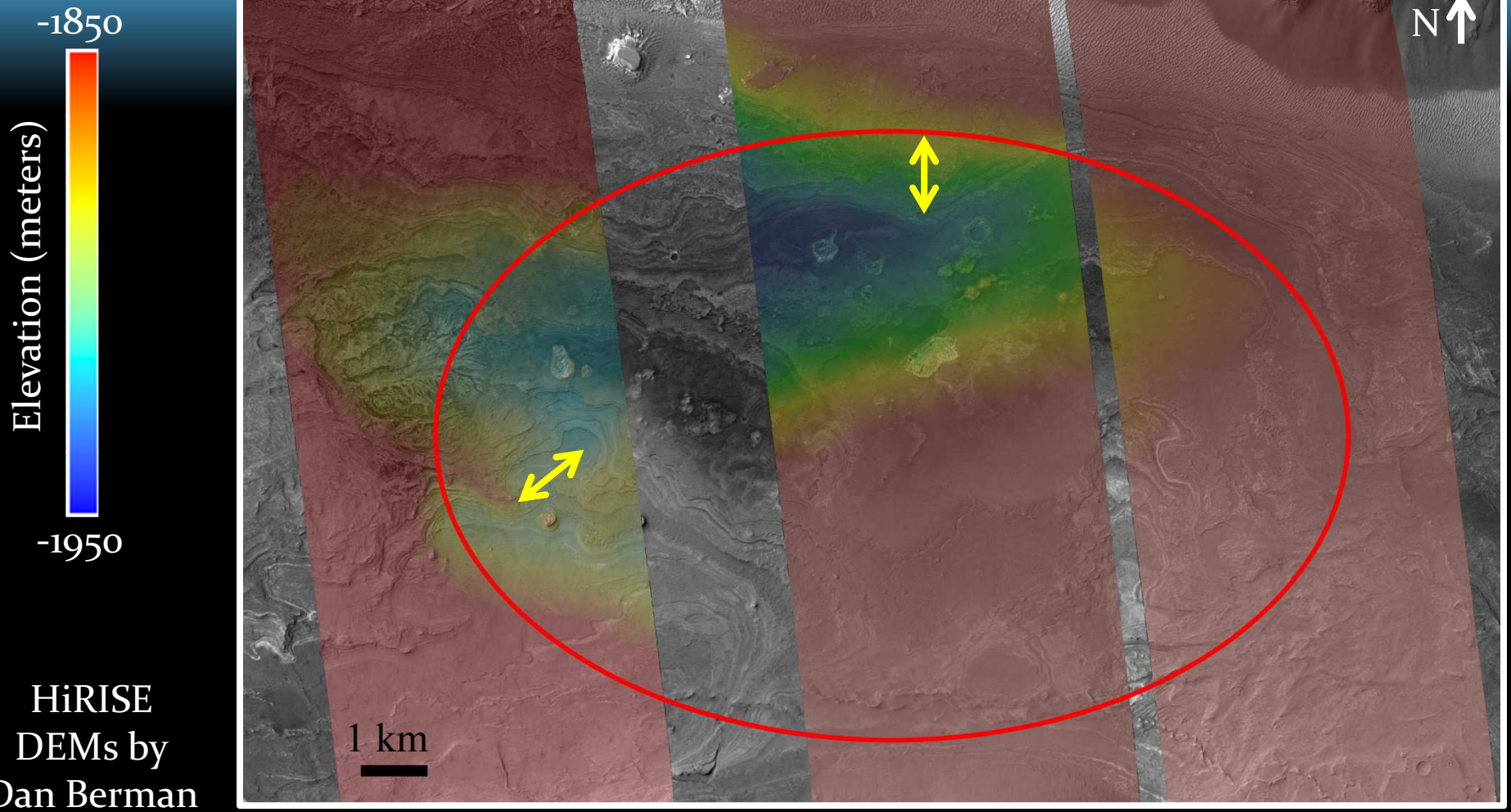
→ application to understand similar landforms elsewhere on Mars.

  - How did light-toned layered unit formed?
  - What caused blocky deposits?
  - What is wallrock?

- Spectacular views from a descent imager inside Valles Marineris.

Relief Criteria <100 m relief over 1-1000 m

(proper control authority and fuel consumption during powered descent)
Assessment: few locales with relief in excess of desired range.



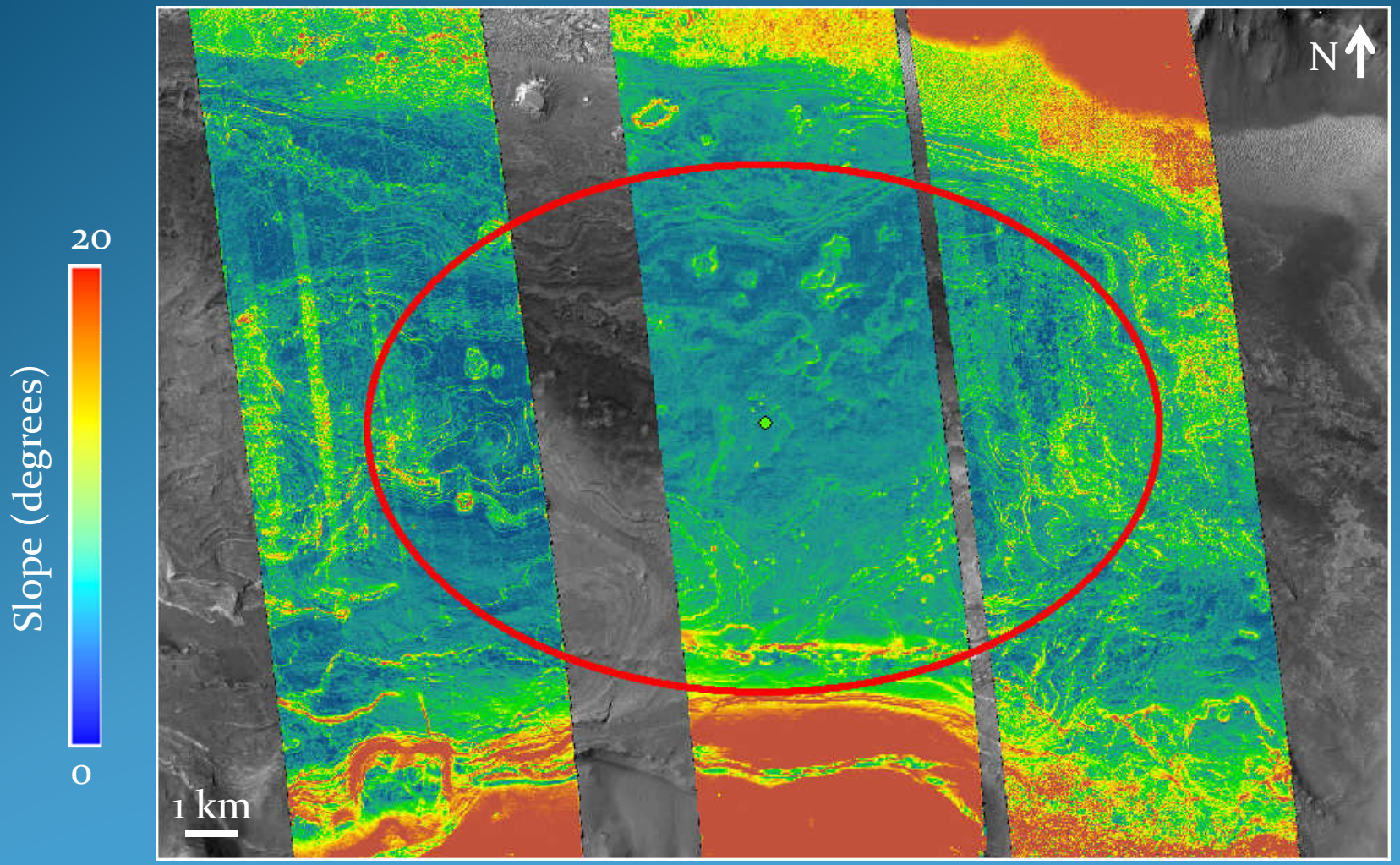
HiRISE DEMs by Dan Berman

Note: Ellipse is 15 x 10 km

Slope Criteria: <25° over 2-5 m

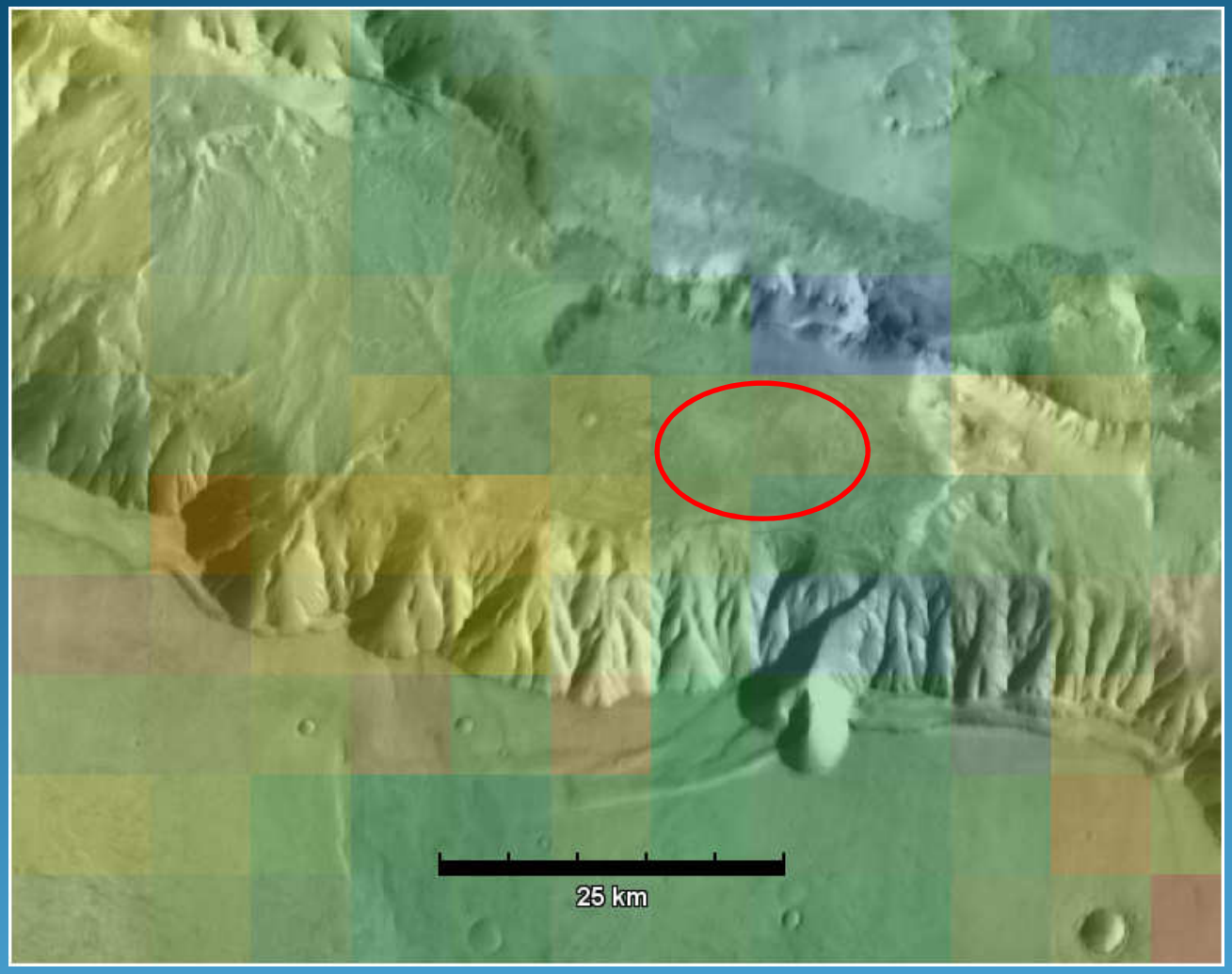
Slope Maps derived from HiRISE DTMs

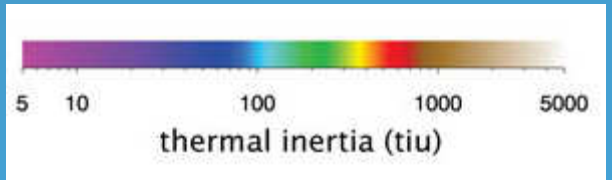
Assessment: Navigable paths exist, but not all science targets may be accessible.



Note: Ellipse is 15 x 10 km

Daytime Thermal Inertia

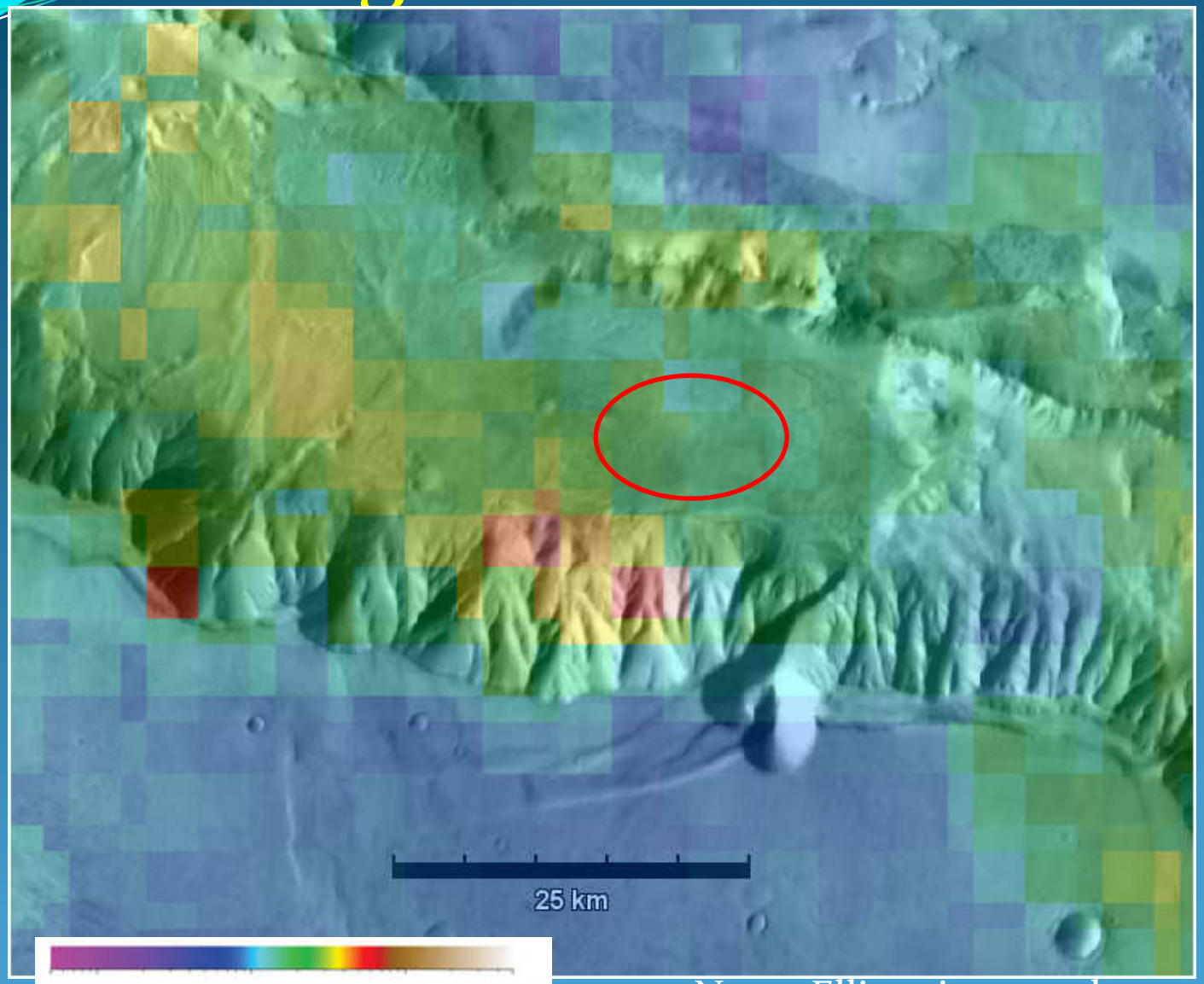




Meets criteria.

Note: Ellipse is 15 x 10 km (Putzig and Mellon, 2007)

Nighttime Thermal Inertia



Meets criteria.

Note: Ellipse is 15 x 10 km
(Putzig and Mellon, 2007)