

# Hadriacus Palus as 2020 Mars Mission Landing Site: Massif-Bound Intercrater Basin on the Northern Hellas Rim

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First Landing Site Workshop for the Mars 2020 Rover Mission  
May 14-16, 2014

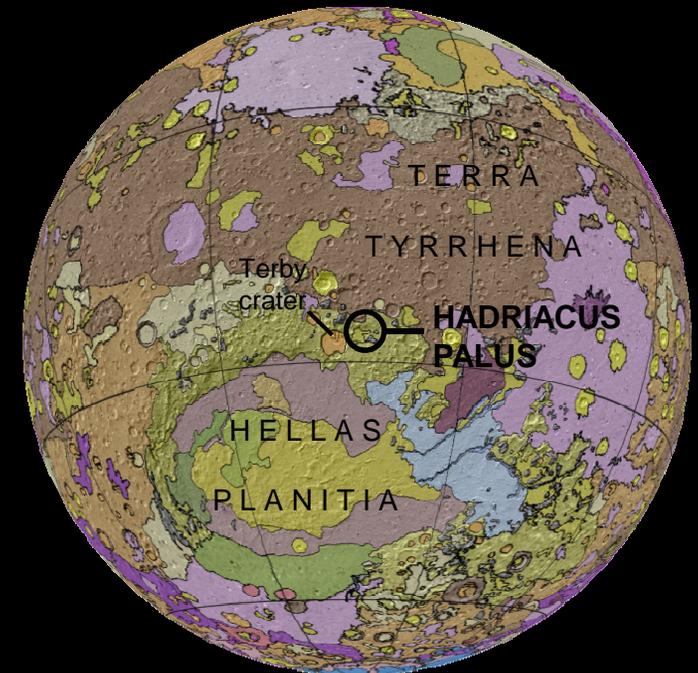
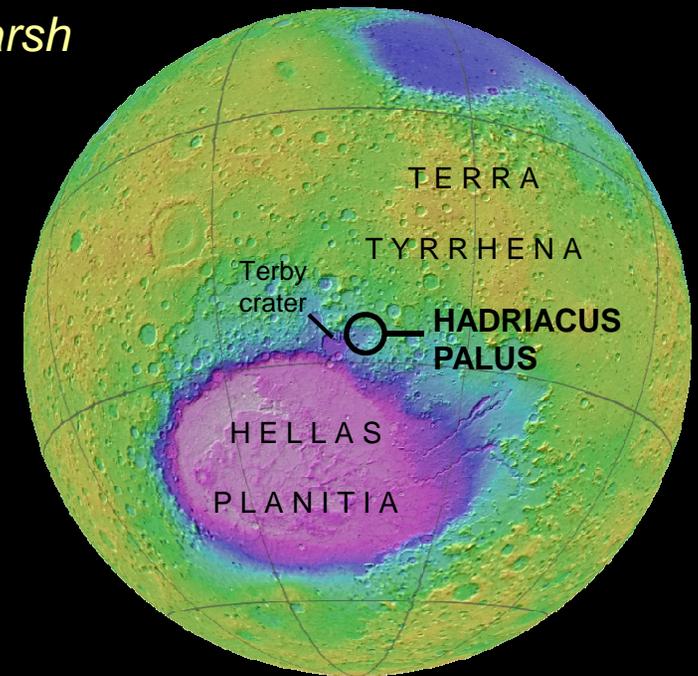
J. A. Skinner, Jr.<sup>1</sup>, C. M. Fortezzo<sup>1</sup>, T. M. Hare<sup>1</sup>, K. L. Tanaka<sup>1</sup>, and T. Platz<sup>2,3</sup>

<sup>1</sup>USGS Astrogeology Science Center; <sup>2</sup>Freie Universität Berlin, Planetary Science Institute<sup>3</sup>

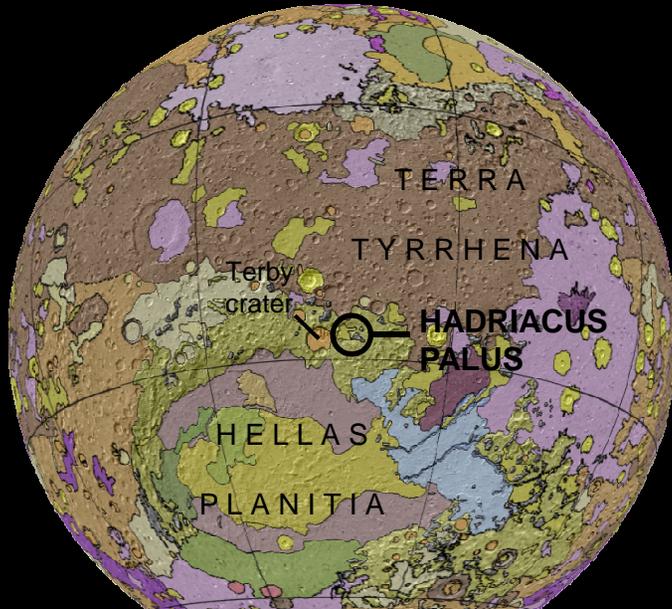
# Why Hadriacus Palus? *Hadrian's Marsh*

- Land on science
- Exhumed Noachian extensional basin sequence
- Lacustrine, fluvial, and volcanic outcrops
- Representative highland plains units
- 2 channel systems, different provenance
- 30 m - >100 m exposed and accessible strata
- High likelihood basement and volcanic rock
- Mineralized fractures pervasive
- Hydrated minerals in section

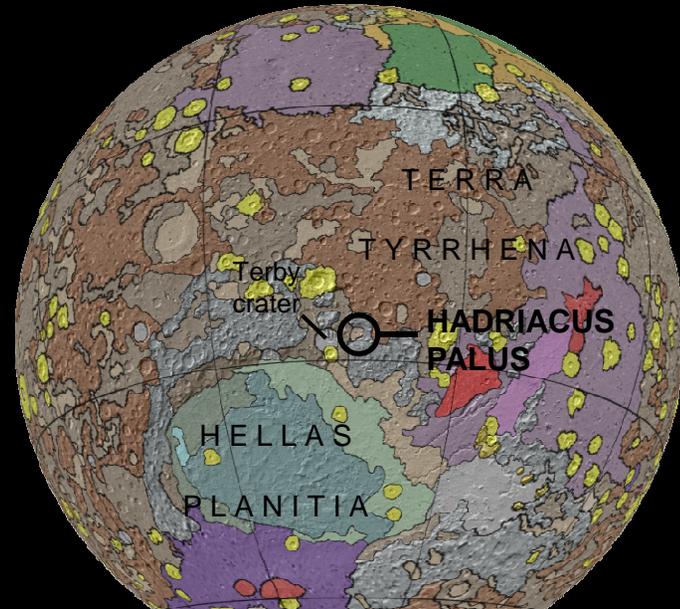
Site Name	Hadriacus Palus
Center Coordinates	26.919°S, 77.971°E
Elevation (MOLA)	-2623.1 ± 50.4 m
Slope (MOLA)	0.60 ± 0.58°
Ellipse size	25 x 20 (nominal)
Prime Science Targets	Subaqueous sediments Stratified units Channels Volcanics



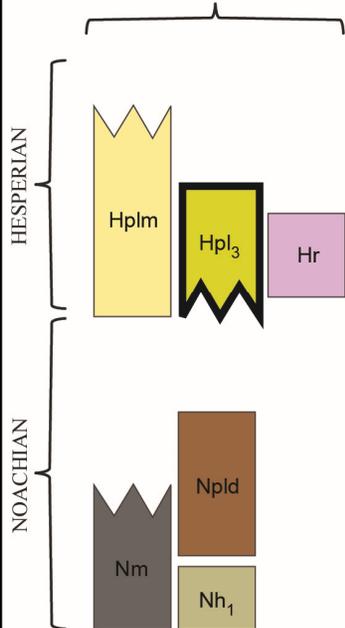
USGS I-1802  
Greeley and Guest, 1987



USGS SIM 3292  
Tanaka et al., in press



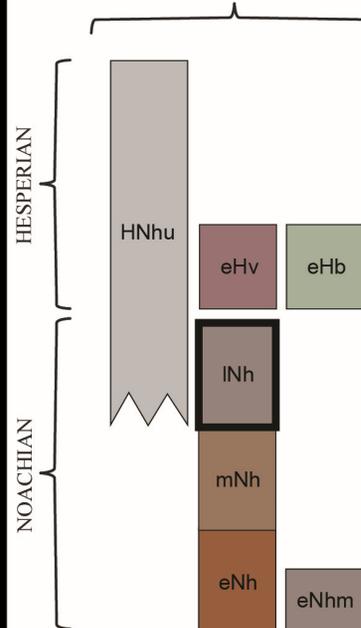
HIGHLAND AND CIRCUM-HELLAS GEOLOGIC PROVINCE



USGS I-1802 (VIKING ORBITER) INTERPRETATIONS

- Hpl<sub>3</sub>** Smooth unit - Interbedded lava flows and sedimentary units of eolian or fluvial origin
- Hr** Ridged plains material - Extensive lava flows erupted with low effective viscosity from many sources
- Hplm** Mottled smooth plains material - Interbedded lava flows and eolian and/or fluvial sedimentary deposits.
- Npld** Dissected unit - Cratered unit that has been highly dissected by fluvial activity
- Nm** Mountainous material - Mostly ancient crustal material uplifted during formation of impact basins.
- Nh<sub>1</sub>** Basin rim unit - Impact generated unit of ancient Martian crust; breccias and interbedded volcanic materials.

HIGHLAND AND CIRCUM-HELLAS GEOLOGIC PROVINCE

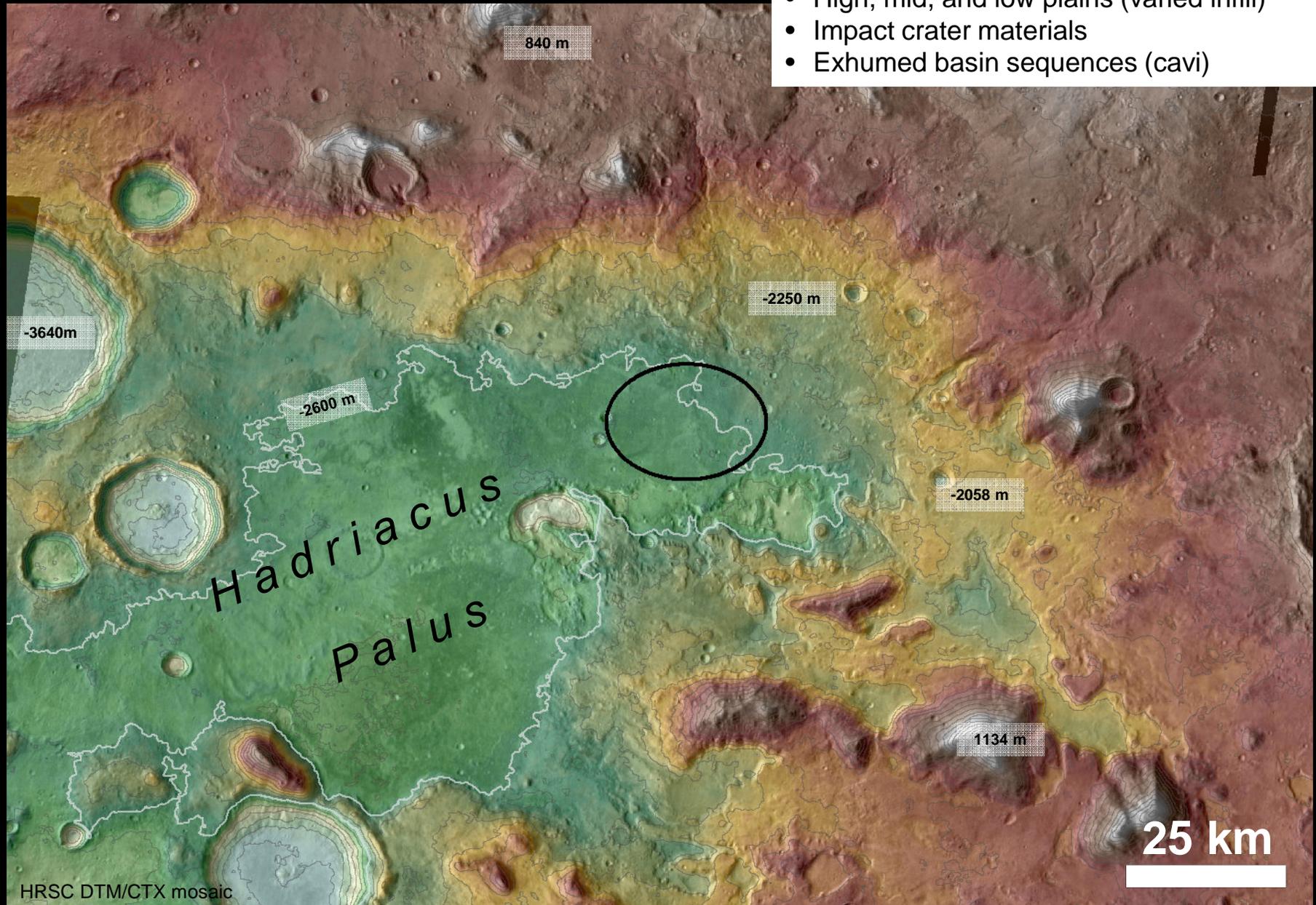


USGS SIM 3292 (POST VIKING ORBITER) INTERPRETATIONS

- HNhu** HN highland undivided - Undifferentiated, friable sedimentary, volcanic, and impact rocks. Locally altered.
- eHv** Early Hesperian volcanic unit - Undifferentiated, locally contracted, fissure and vent flood lavas.
- eHb** Early Hesperian basin unit - Basin fill of eolian, lacustrine, and (or) volcanic origin. Dissected and (or) contracted.
- INh** Late Noachian highland unit - Undifferentiated impact, volcanic, fluvial, and basin fill material.
- mNh** Middle Noachian highland unit - Moderate degraded, undifferentiated impact, volcanic, and basin material.
- eNh** Early Noachian highland unit - Heavily degraded, undifferentiated impact, volcanic, and basin material.
- eNhm** Early Noachian highland massif unit - Primitive, degraded crustal rocks uplifted by basin forming impact.

# Physiographic Setting

- Ovoid basin 160 km x 80 km
- Massifs (crustal blocks, volcanic edifice)
- High, mid, and low plains (varied infill)
- Impact crater materials
- Exhumed basin sequences (cavi)

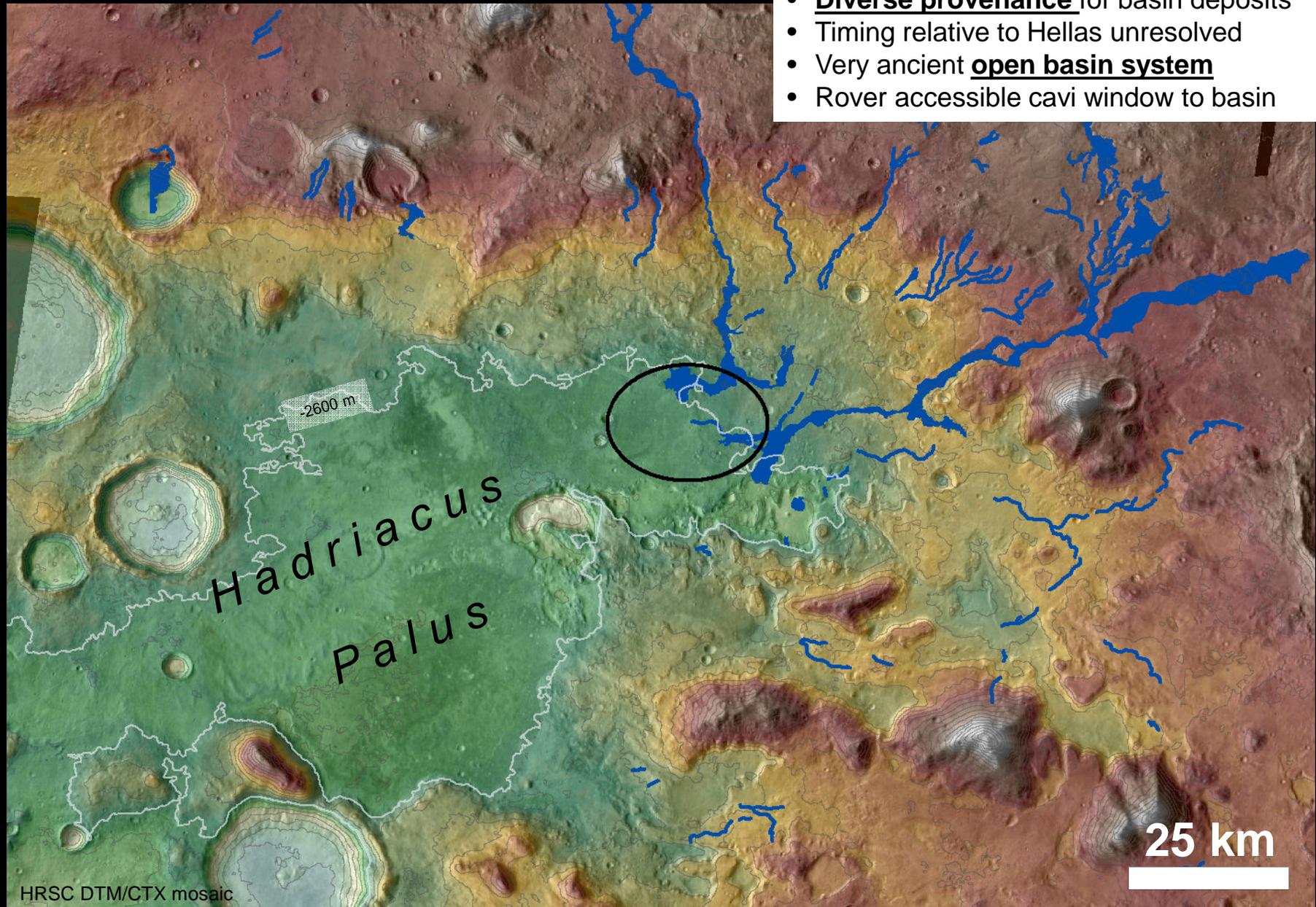


HRSC DTM/CTX mosaïc

25 km

# Physiographic Setting

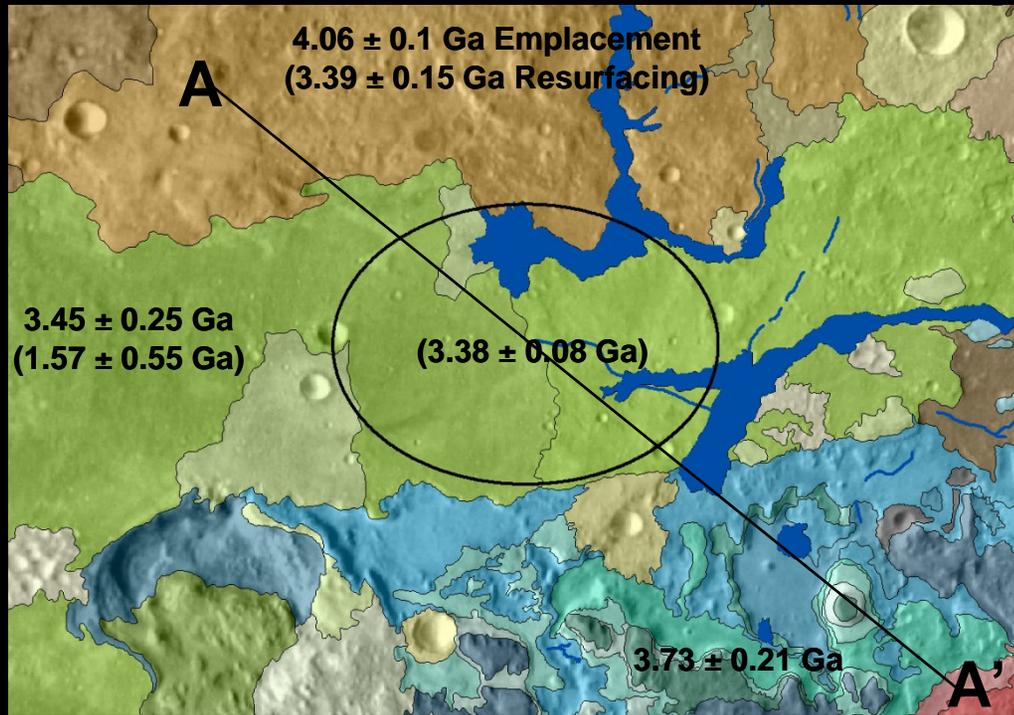
- Noachian to Hesperian terrains dominate
- Major drainage from multiple directions
- **Diverse provenance** for basin deposits
- Timing relative to Hellas unresolved
- Very ancient **open basin system**
- Rover accessible cavi window to basin



25 km

HRSC DTM/CTX mosaic

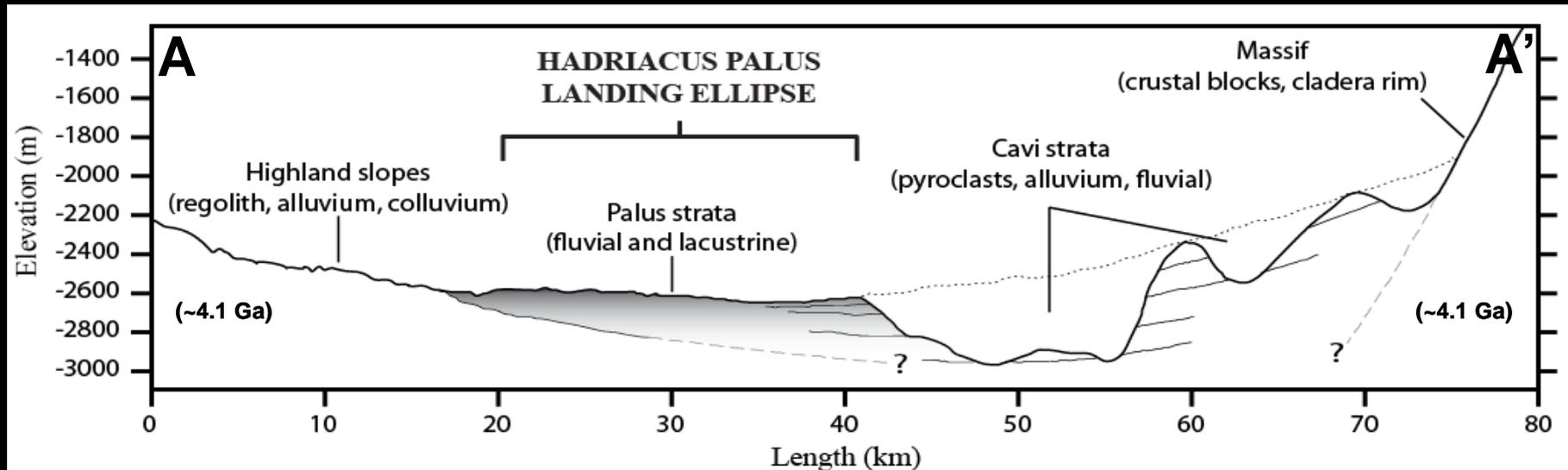
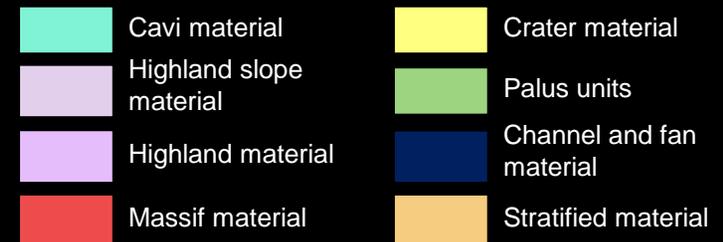
# Geologic Setting (1:250K, 75K, 20K)



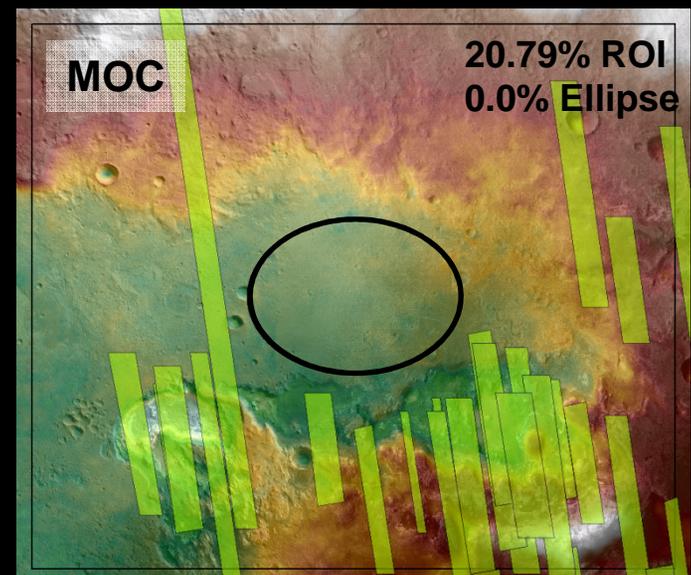
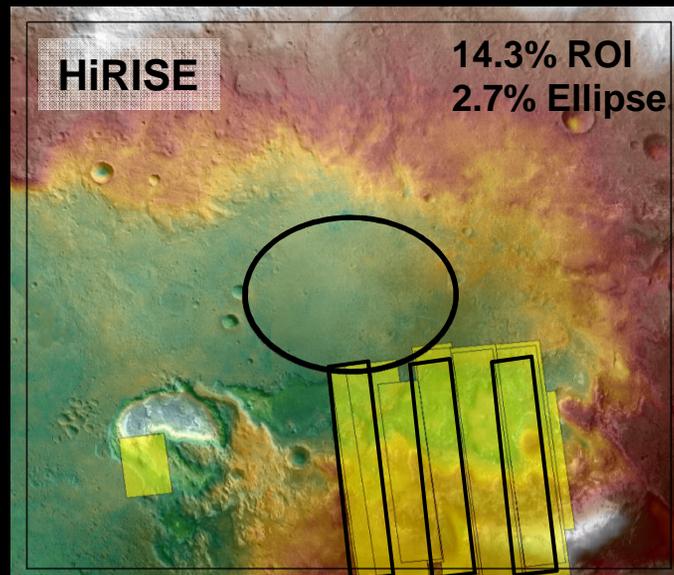
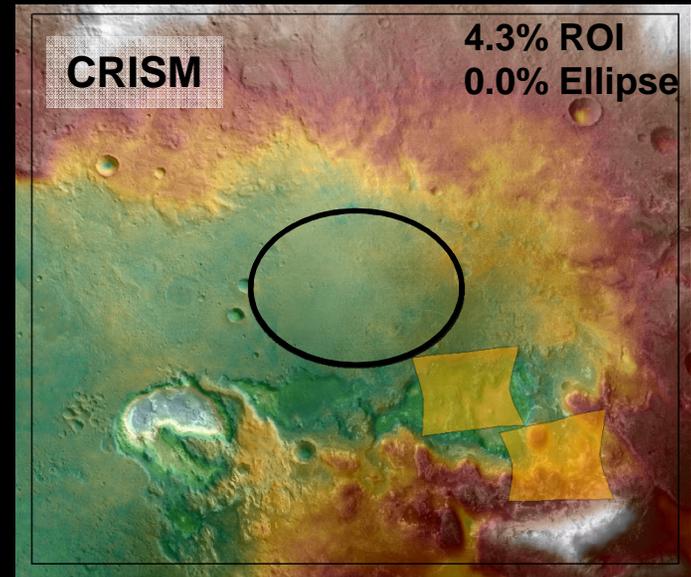
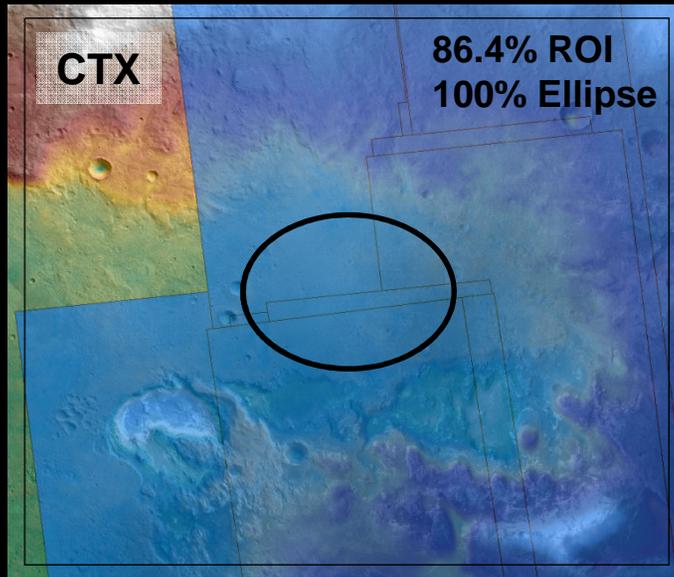
Basin sequences thickening southward

- Pre-Noachian (?) massifs
- E. Noachian highland slopes
- Cavi strata spans Noachian
- M. Noachian to E. Hesperian (?) channels
- Emplacement and exhumation

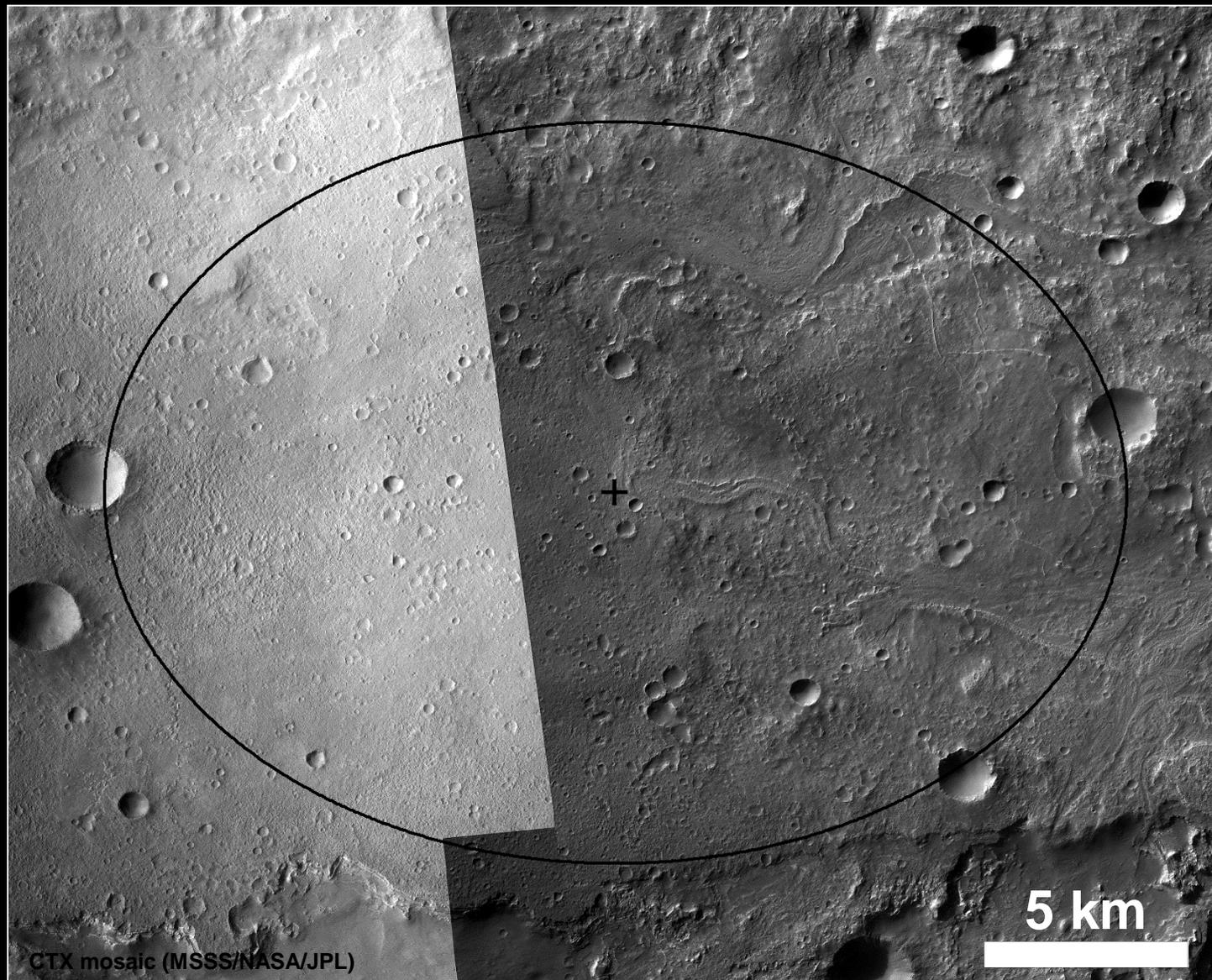
Record of representative highland basin



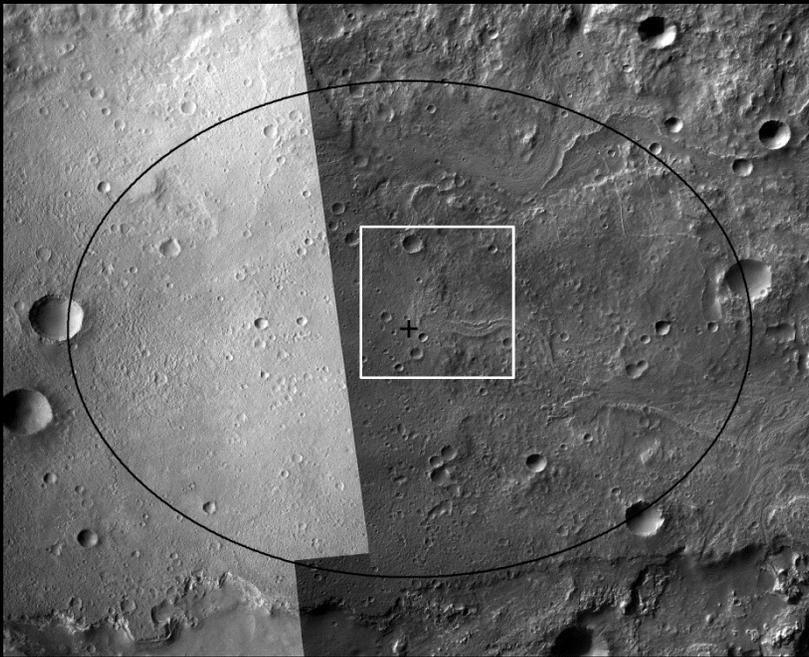
# Existing Data (*High Resolution*)



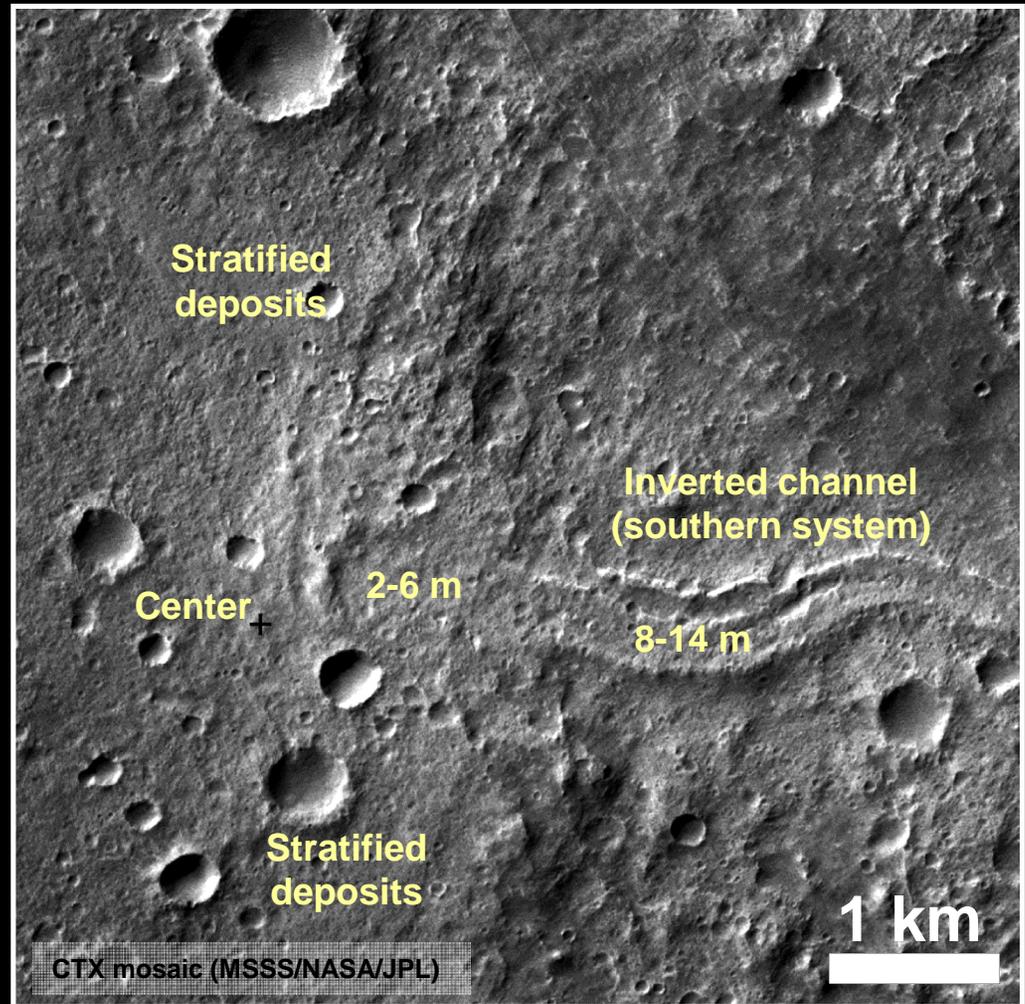
# Priority Science Observations



# Ellipse Center



- Late Noachian to Early Hesperian
- Subdued sinuous scarp N-S
  - *Stratified deposits*
- Raised sinuous ridges E-W
- Raised ▲ landform at termination
- Environment (exhumed)
  - *Lake bed deposits (~4 m)*
  - *Fluvial deposits (~12 m)*
  - *Terminal fan (~10 m)*



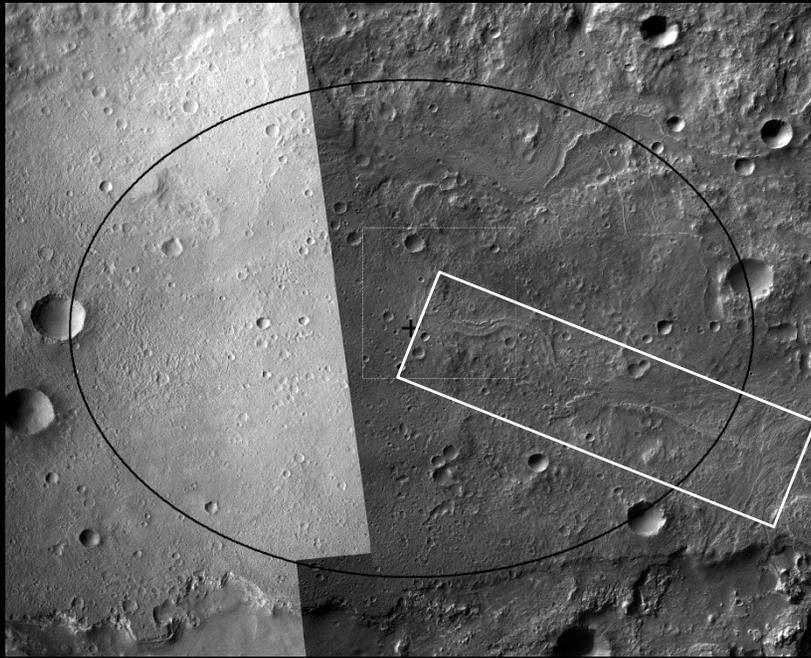
## Key Observations

*Exhumed strata, Basin-fan contact*

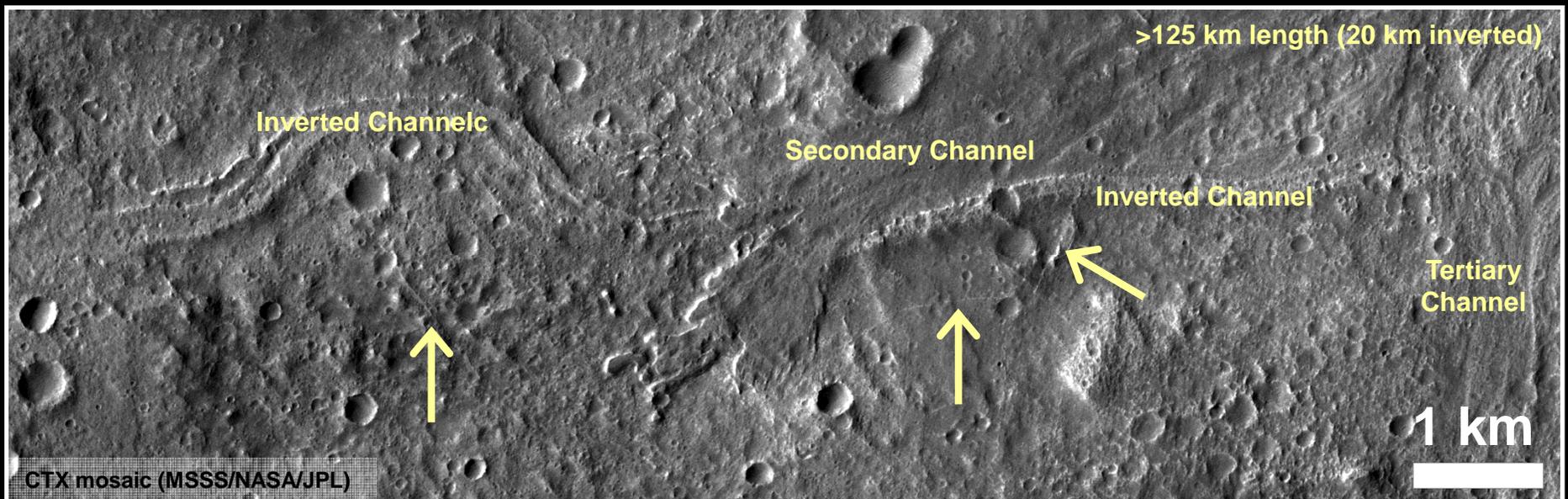
*Fluvial strata*

*Channel surface*

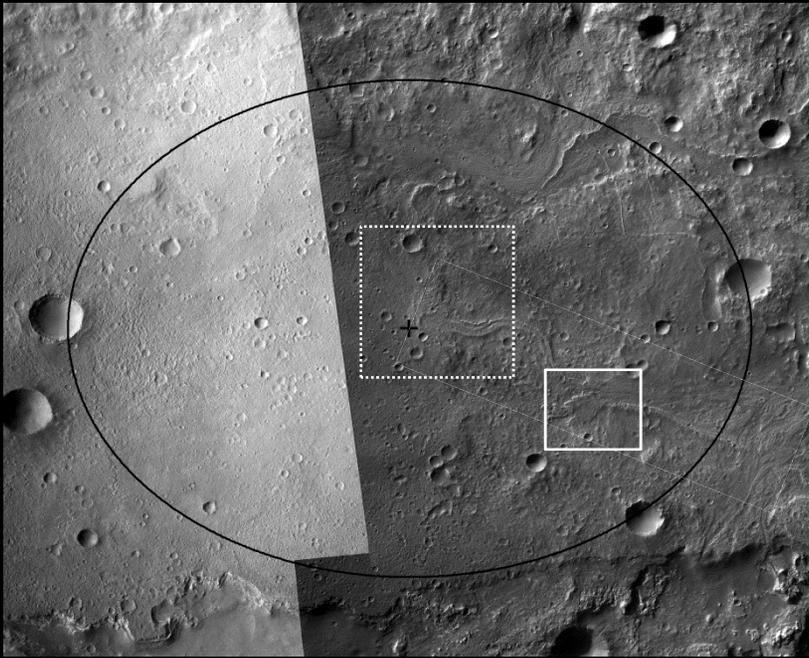
# Southern Channel System



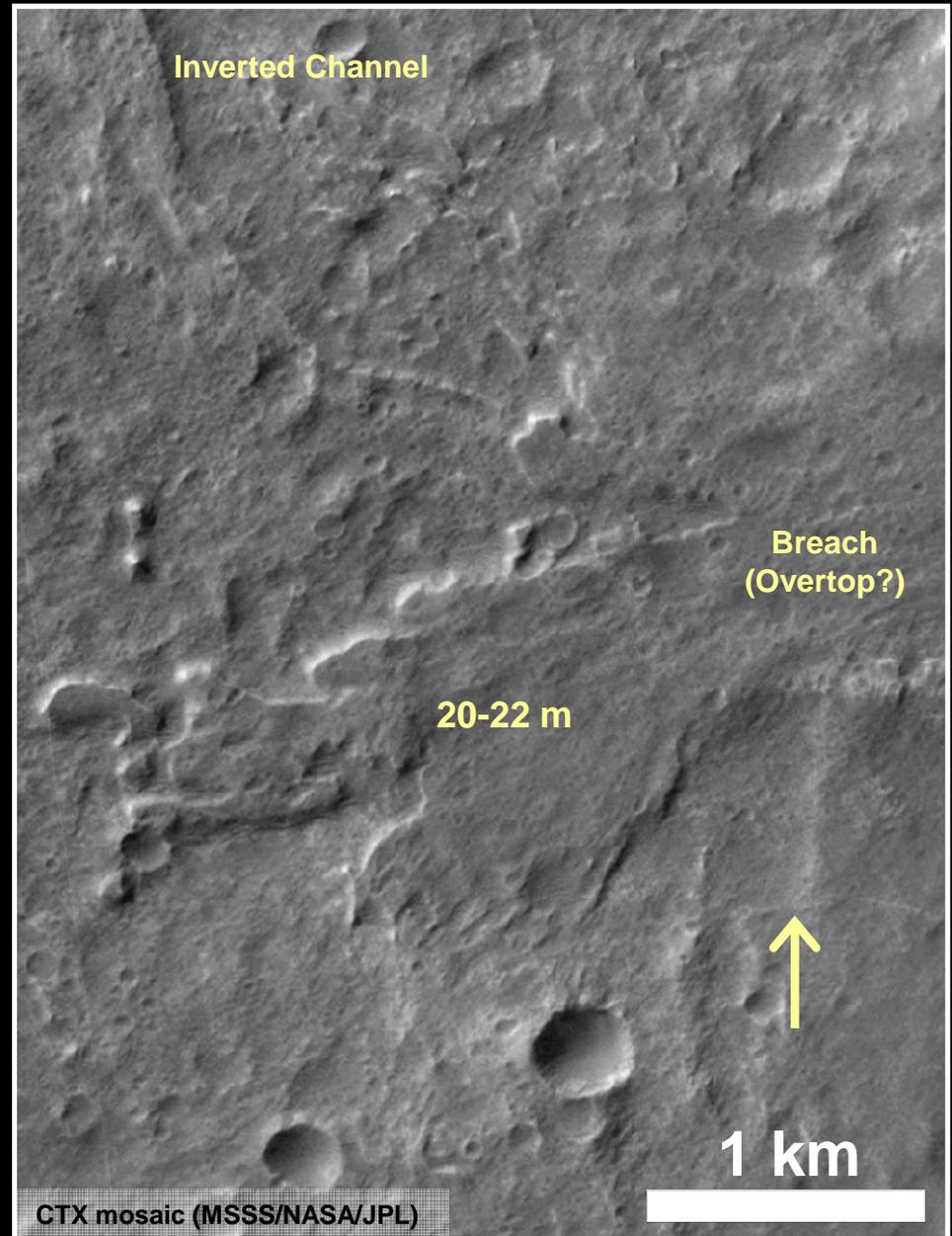
- Sheds Nm and Nh<sub>1</sub> (EN basin rim)
- Channel system
  - *Multiple fluvial events*
  - *Abuts and breaches inverted channel*
- Linear ridges (mineralized fractures)
- Key Observations
  - *Lithologic gradation in channel surface (>10 m)*
  - *Breach and secondary channel (>20 m)*
  - *Mineralized fractures in basin floor (arrows)*



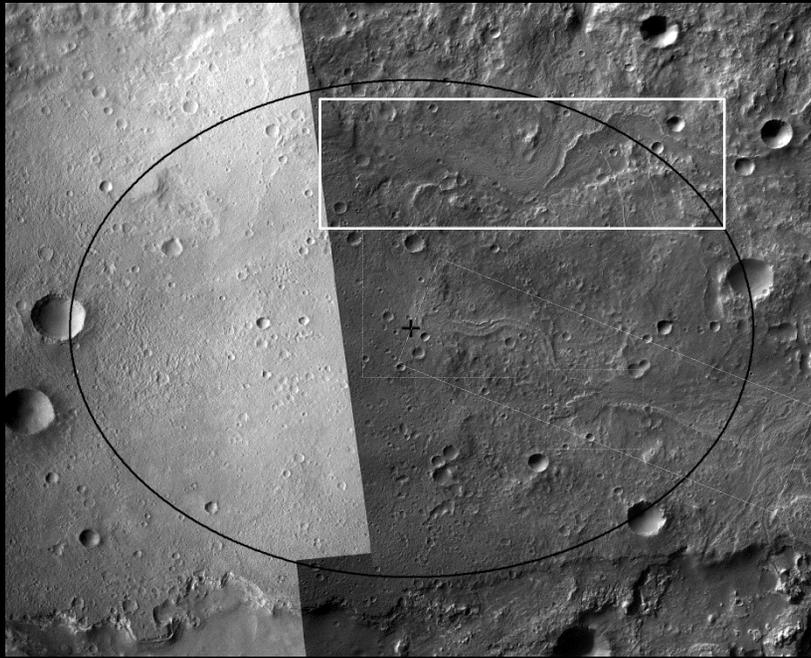
# Southern Channel System



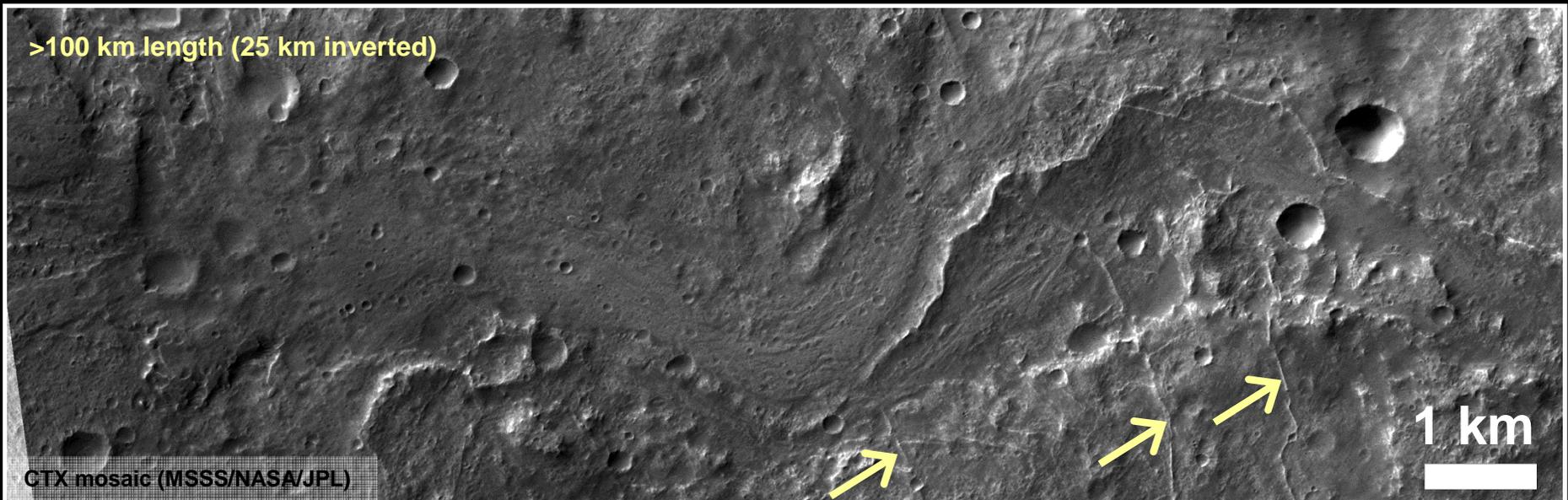
- Hesperian exhumation
- Southern channel system
  - *Second fluvial event*
  - *Abuts and breaches inverted channel*
- Key Observations
  - *Inverted channel surface (>10 m)*
  - *Breach and secondary channel (>20 m)*
  - *Lineaments in basin floor (arrow)*
- Track M-LN change in provenance



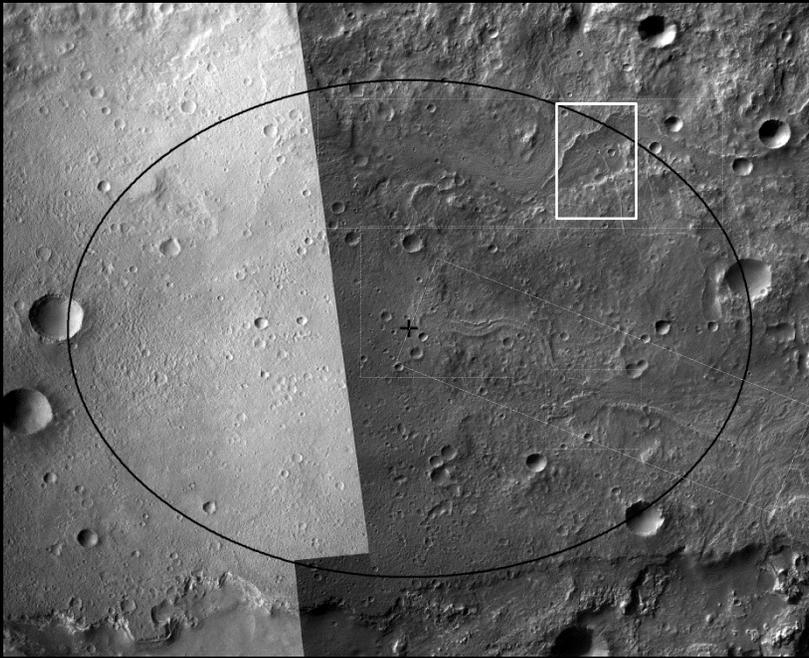
# Northern Channel System



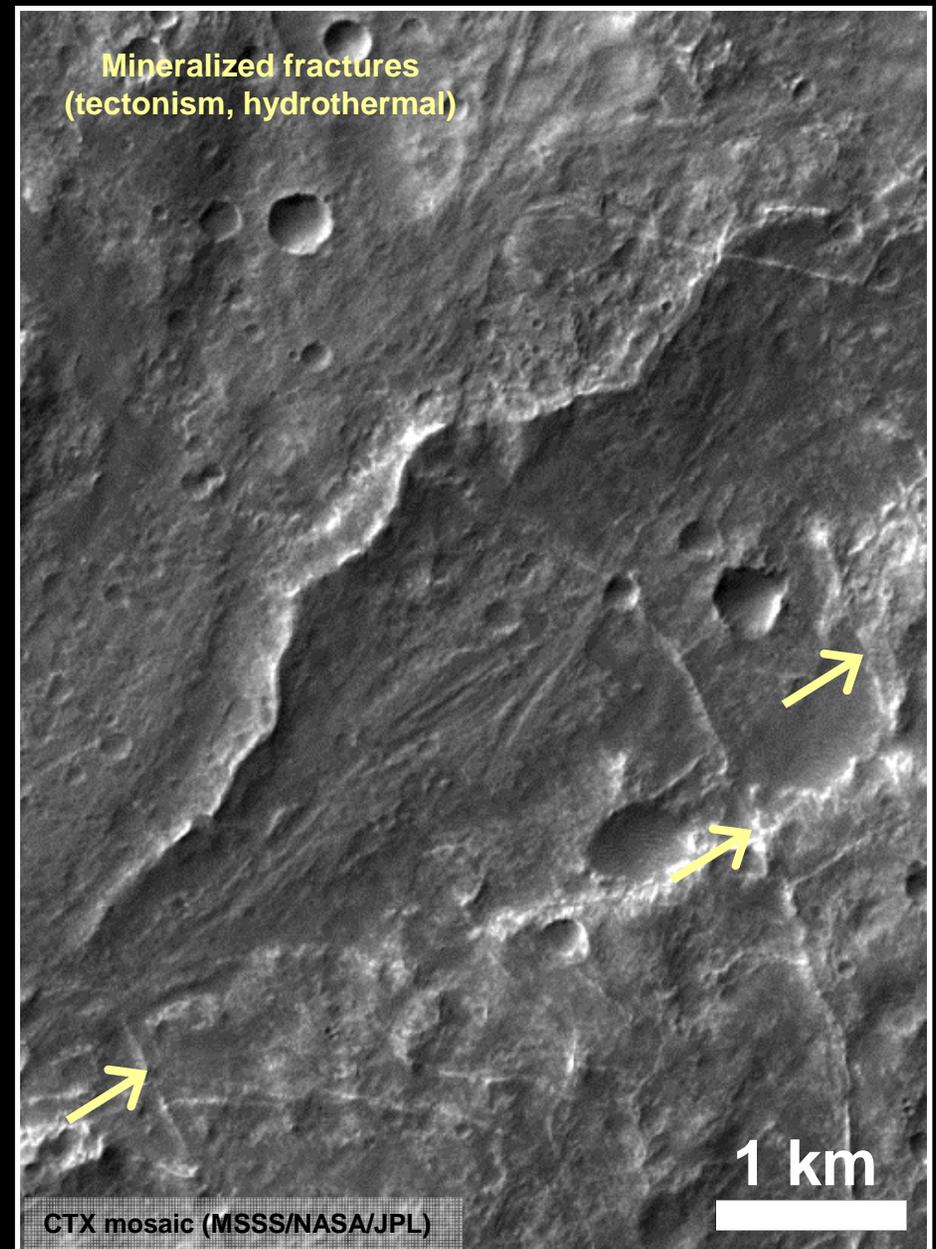
- Noachian (~M-L?) emplacement
- Sheds Npld (dissected regolith)
- Northern channel system
  - *Drains upper highland surfaces (Npld)*
  - *Abuts inverted channel*
  - *Multiple fluvial events*
- Key Observations
  - *Inverted channel surface (>10 m)*
  - *Secondary channel (>20 m)*
  - *Mineralized ridges in basin floor (arrows)*



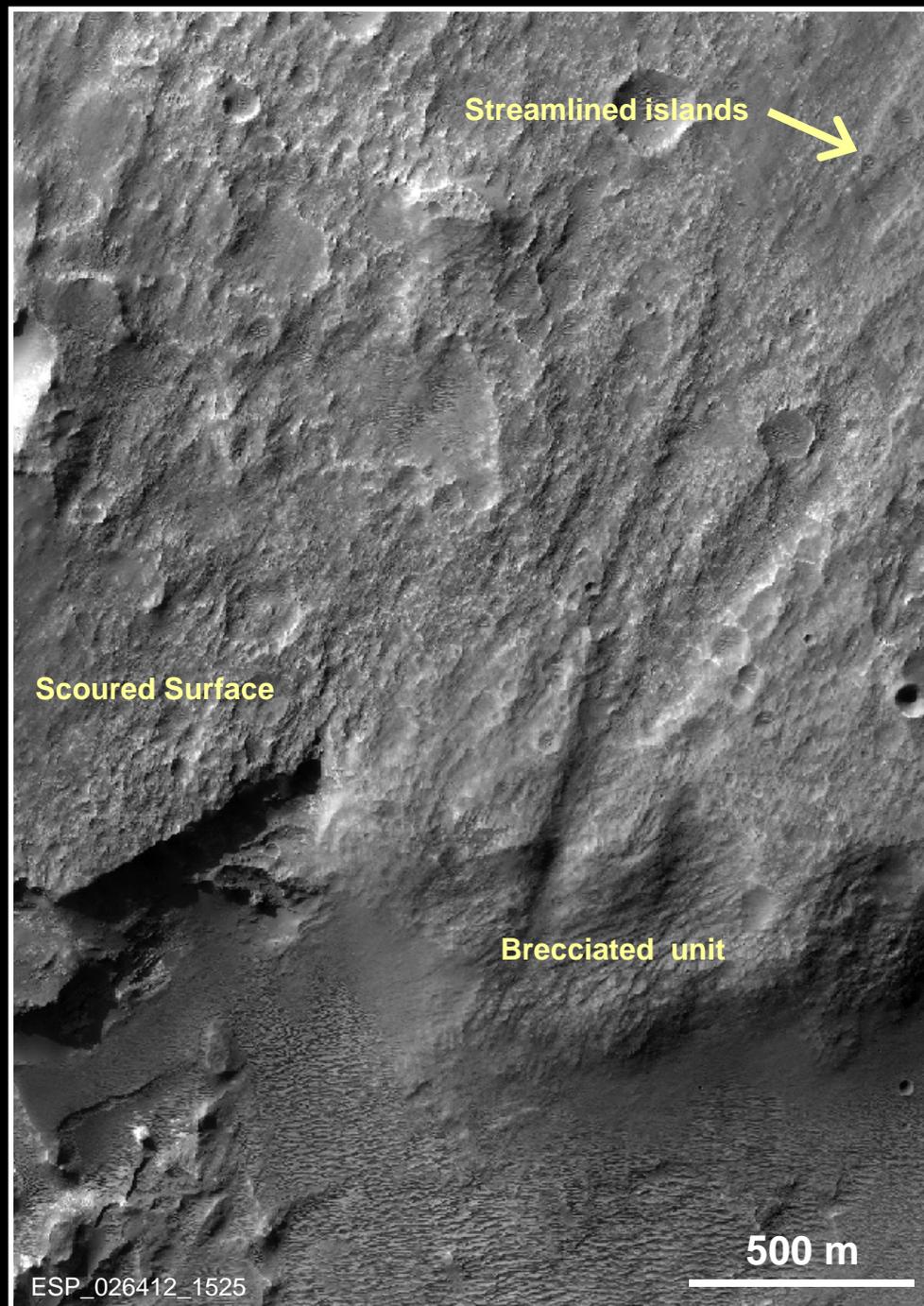
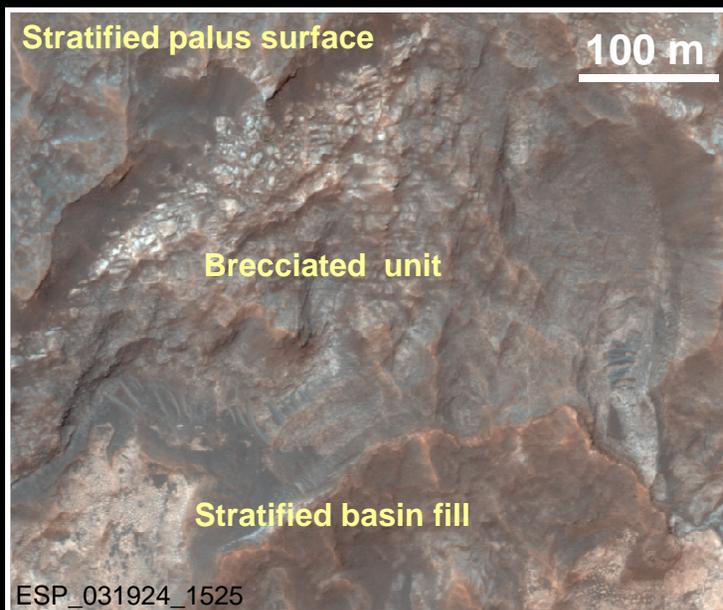
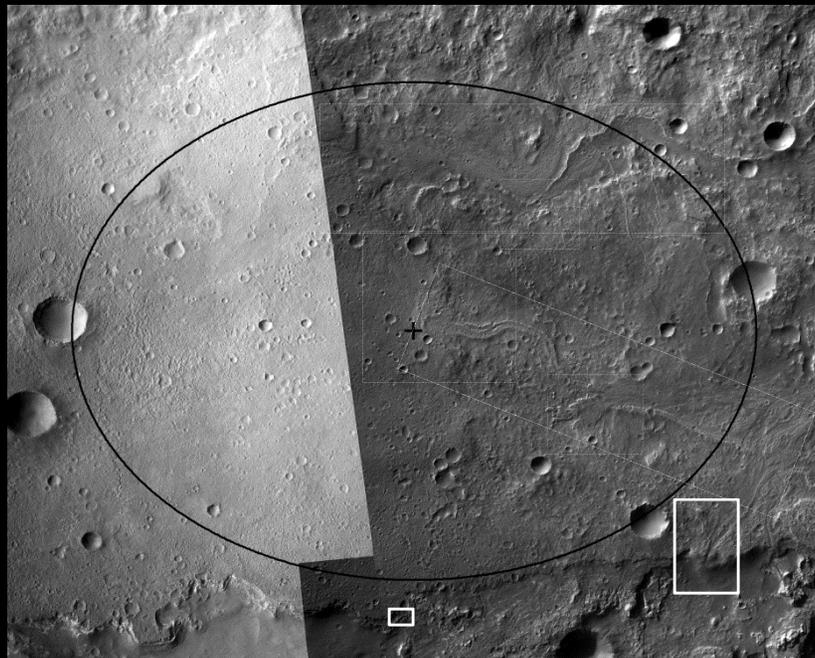
# Northern Channel System



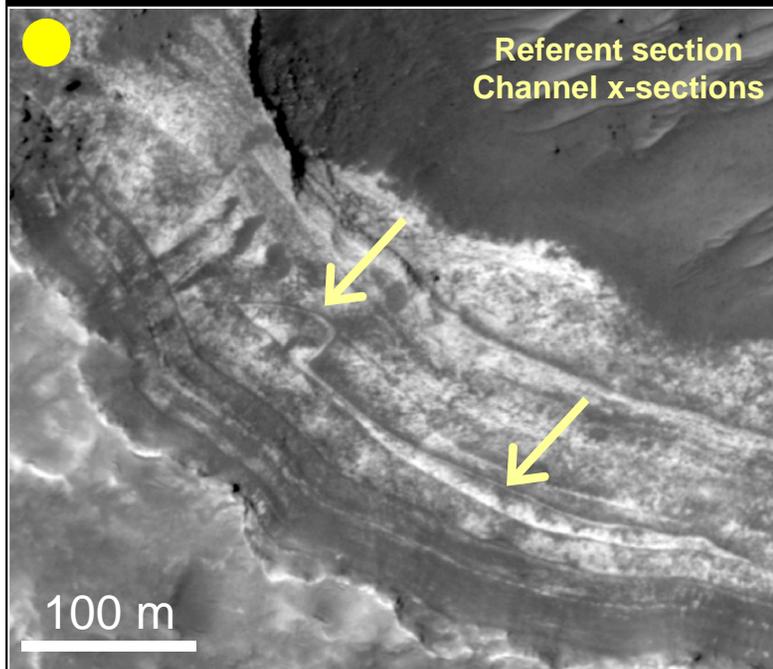
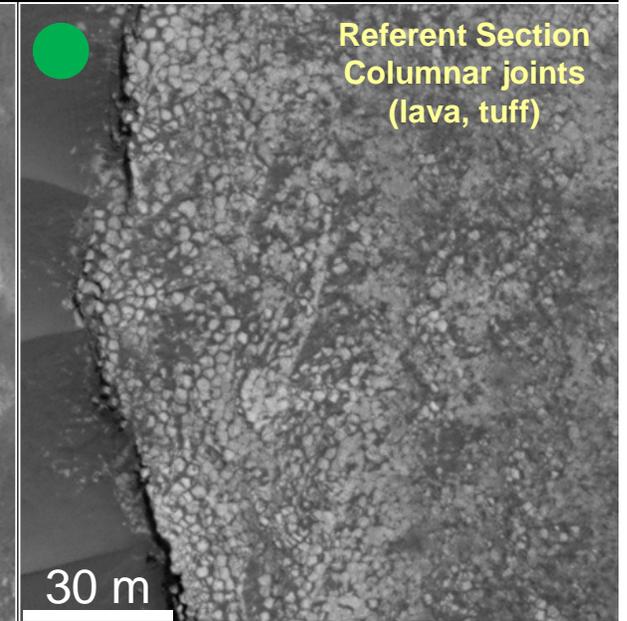
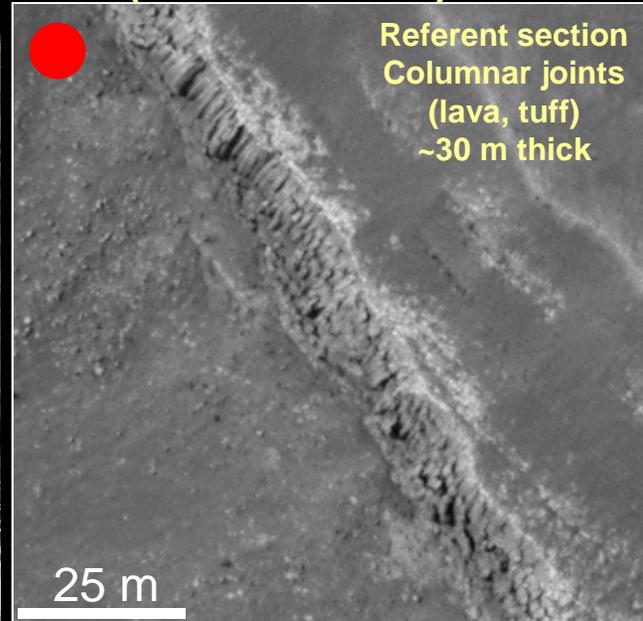
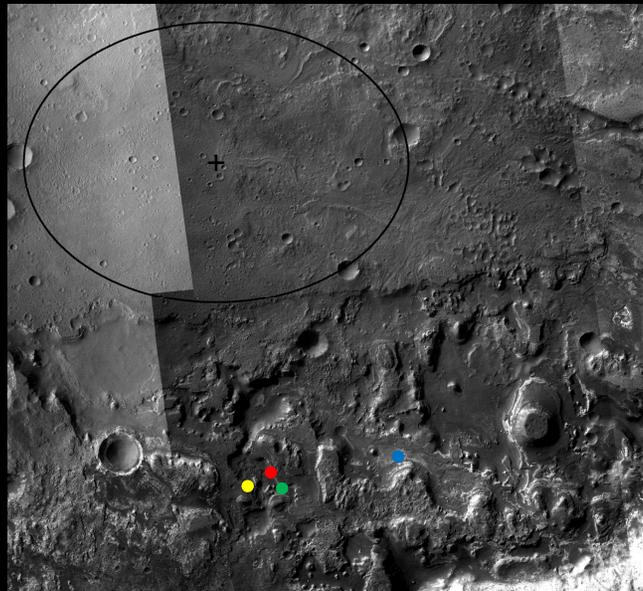
- Hesperian(?) exhumation
- Channel-exhumed basin contact
- Well-exposed mineralized fractures
- Track M-LN change in provenance
- Inverted channel tracks to NE



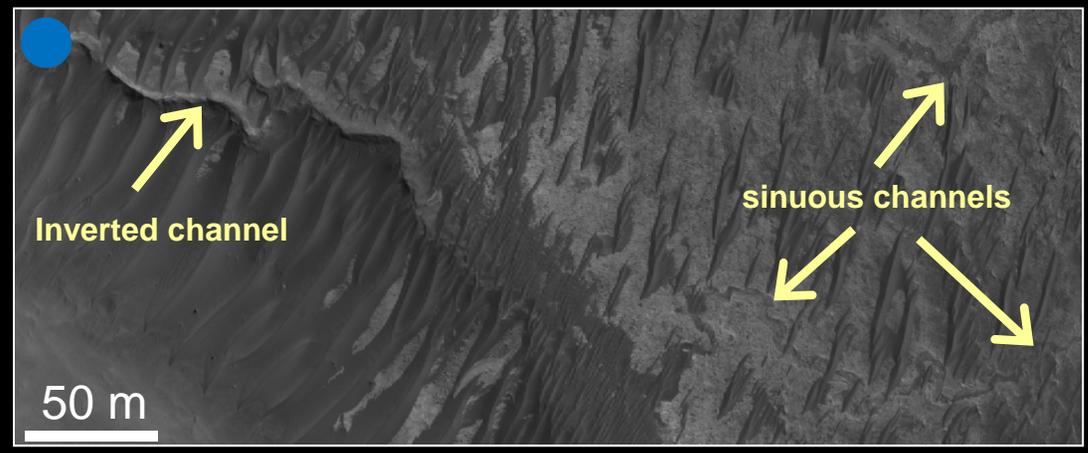
# Cavi Margin



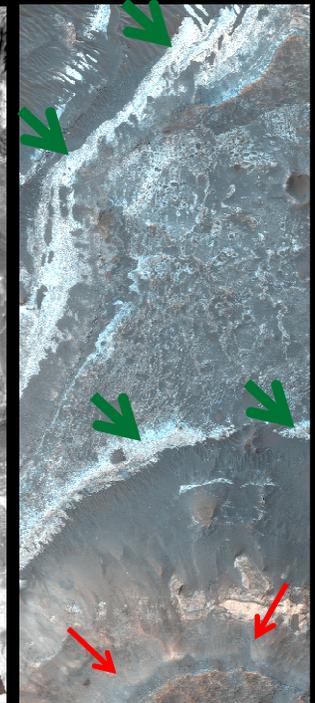
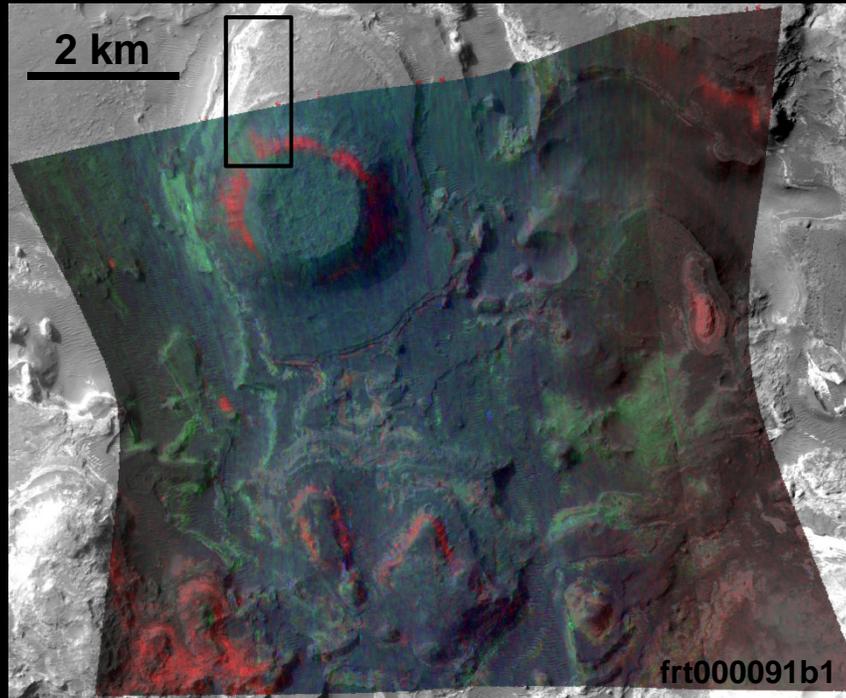
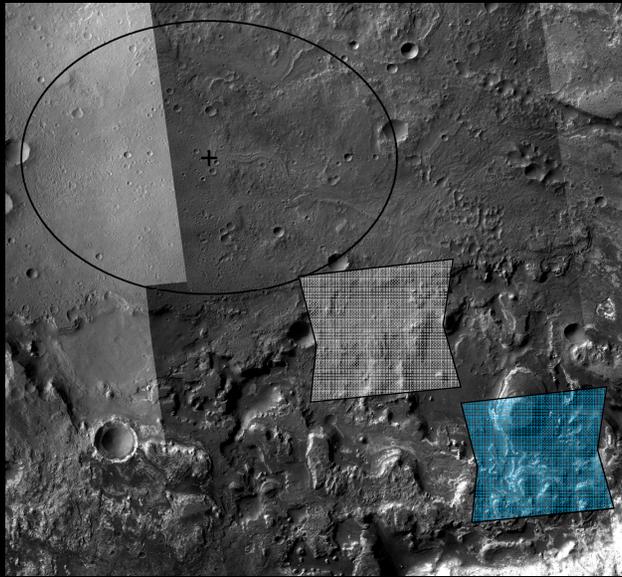
# Beyond the Ellipse (Drive to)



- Key exposures of Noachian geological record
- Details true basin filling strata
- Deposition and exhumation

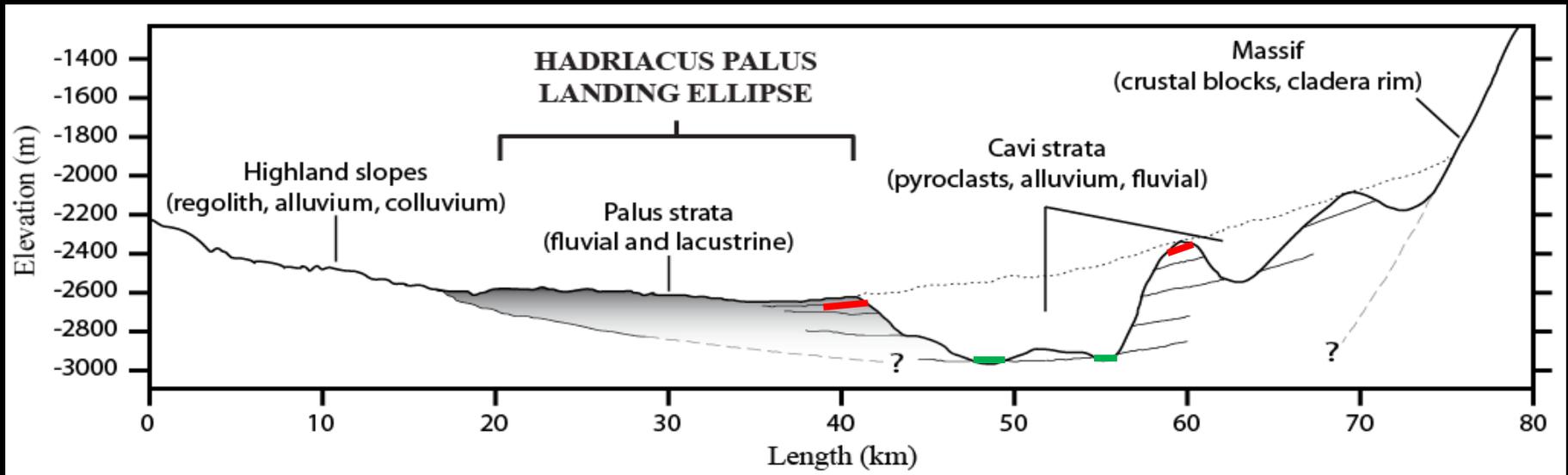


# Mineralogy

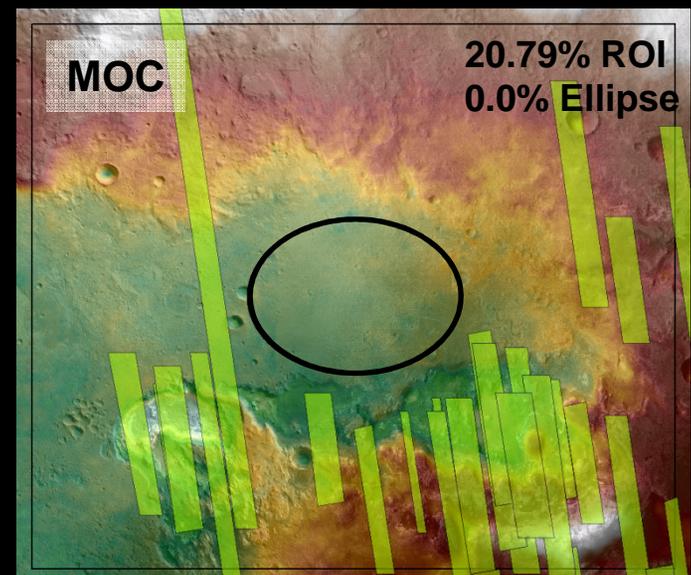
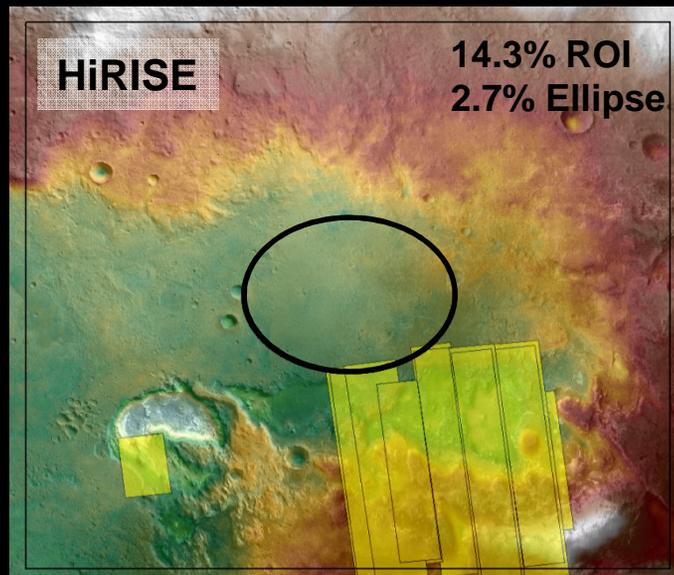
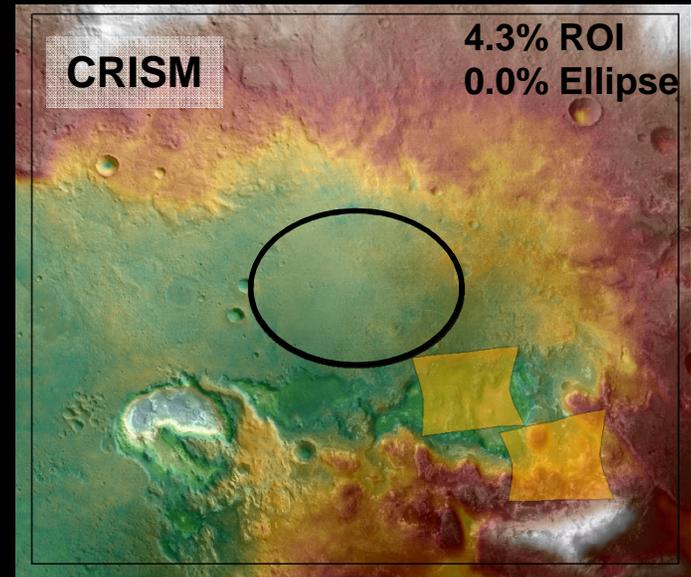
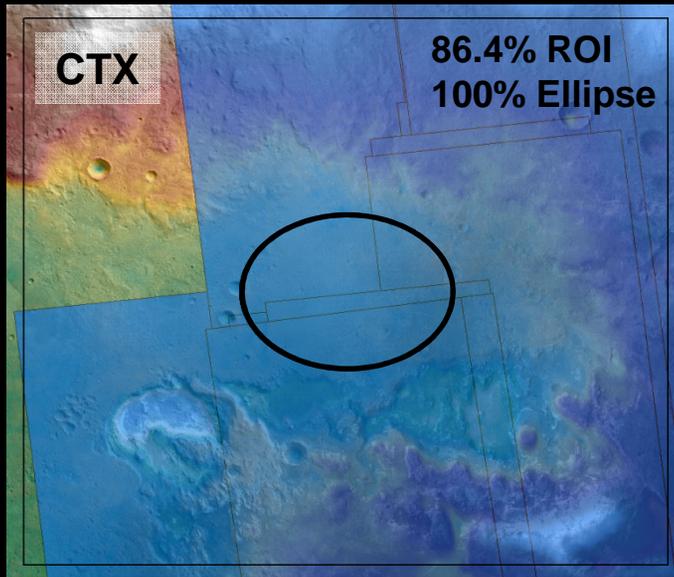


Red = Phyllosilicates BD2300  
 Green = Sulfates BD2400 (SINDEX)  
 Blue = Monohydrated Minerals BD2100

ESP\_032425\_1525  
 1 km across image

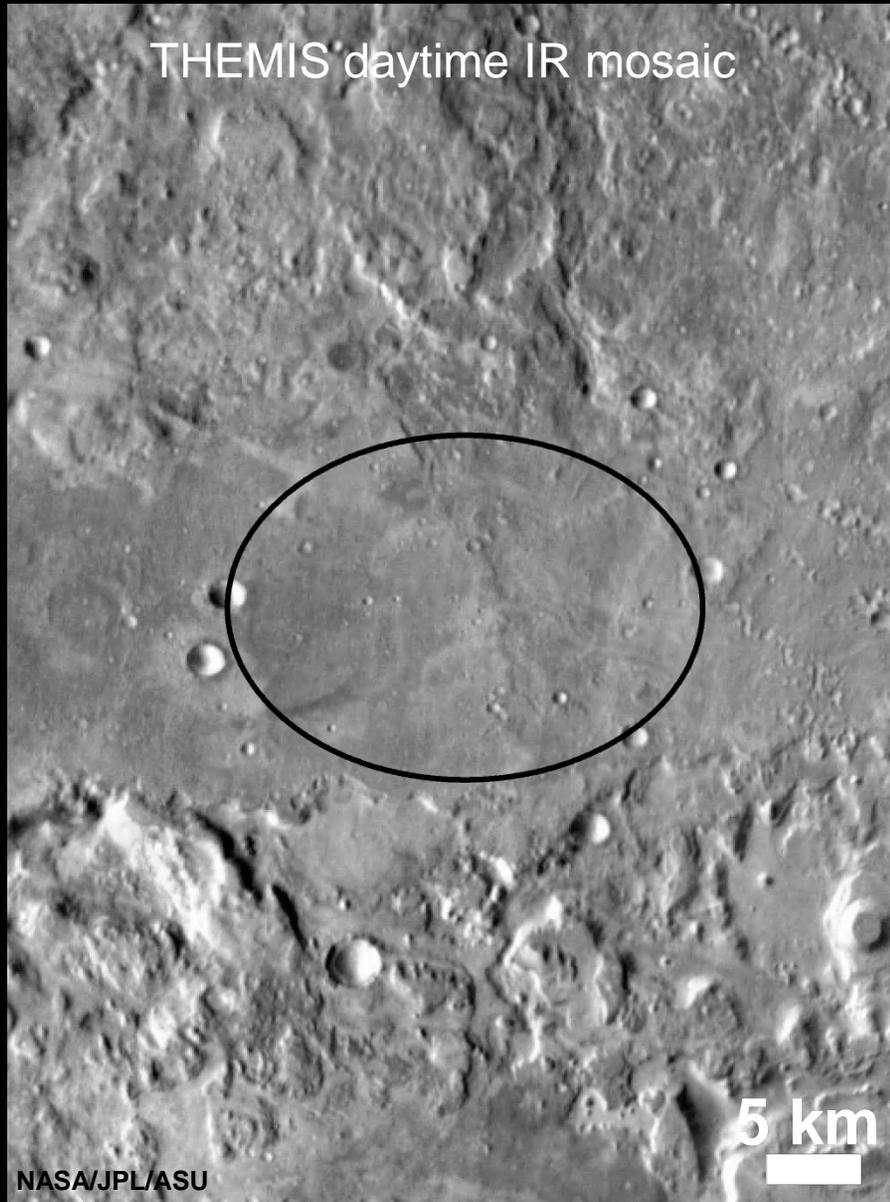


# Existing Data (*High Resolution*)



# Thermal Character

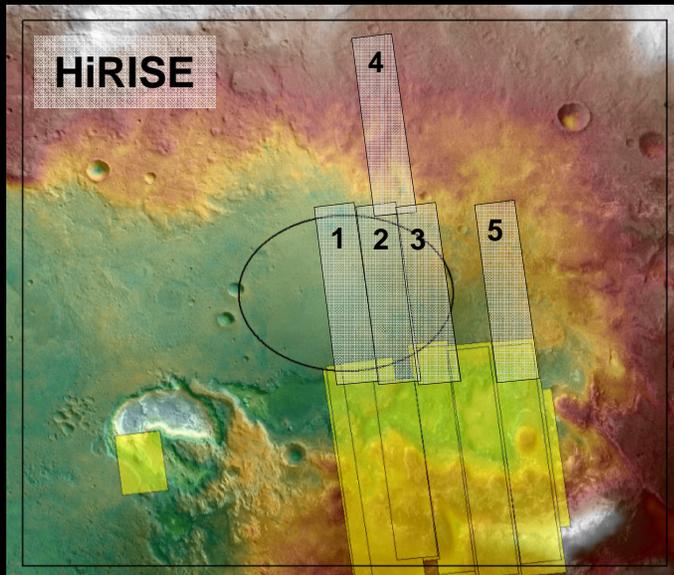
THEMIS daytime IR mosaic



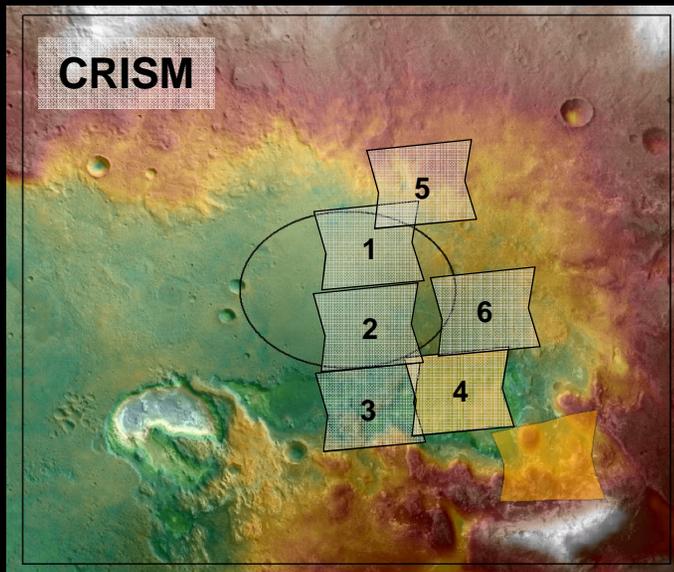
THEMIS nighttime IR mosaic



# Required Data Coverage



Number	Location	Science Rationale
1-3	Ellipse center	<ul style="list-style-type: none"> <li>• Stratified lake bed units</li> <li>• Inverted channels, terminations</li> <li>• Fracture and ridge unit</li> </ul>
4	Northern channel system	<ul style="list-style-type: none"> <li>• Channel surface, canyon walls</li> <li>• Palus marginal contact</li> <li>• Dissected highlands</li> </ul>
5	Eastern channel system	<ul style="list-style-type: none"> <li>• Stratified basin upper units</li> <li>• Eastern channel and highlands</li> <li>• Eastern palus margin</li> </ul>



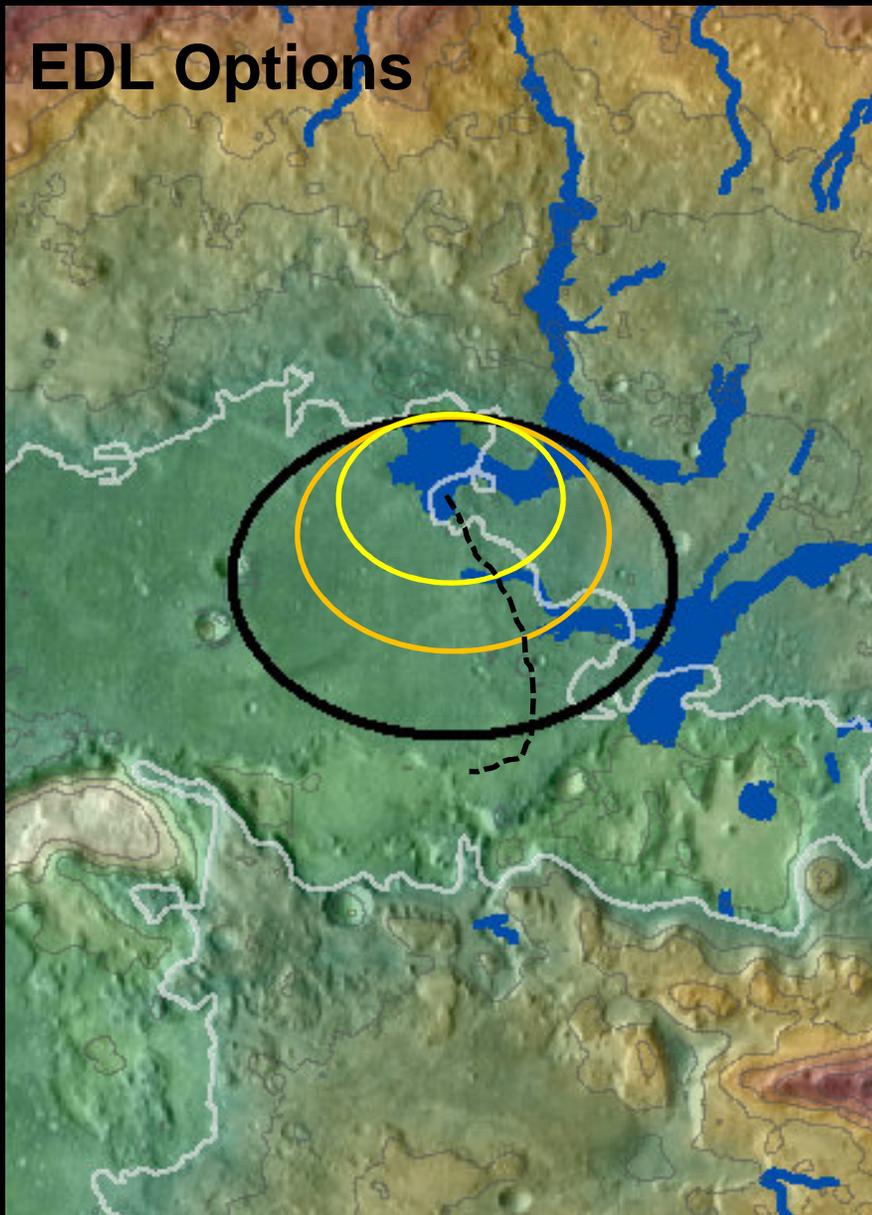
Number	Location	Science Rationale
1-2	Ellipse center	<ul style="list-style-type: none"> <li>• Stratified basin surface units</li> <li>• Inverted channels and fans</li> </ul>
3-4	Cavi	<ul style="list-style-type: none"> <li>• Southern palus margin</li> <li>• Correlate exposures</li> <li>• Fractured deep basin units</li> </ul>
5-6	Bounding highland slopes	<ul style="list-style-type: none"> <li>• Channel walls and margins</li> <li>• Dissected highland source</li> </ul>

# Geological Criteria *(Qualified and Surpassed)*

Threshold Geological Criteria		Notes
<b><u>Subaqueous sediments</u></b> or hydrothermal sediments	✓	Stratified deposits (fluvial and lacustrine)
<u>Hydrothermally altered rocks</u> or low-T fluid-altered rocks	?	Additional CRISM FRT required
Presence of <b><u>aqueous phase minerals</u></b> in outcrop	✓	Hydrated phases present in outcrop
<b><u>Noachian/Early Hesperian</u></b> age units	✓	Pervasive throughout
Access to unaltered <b><u>igneous rocks as float</u></b>	✓	Two major channel systems; impact ejecta
Not a special region	✓	Lies north of modeled 5 m ice depth

Potentially Qualifying Geological Criteria		Notes
Morphologic evidence for <b><u>standing bodies of water</u></b> and/or <b><u>fluvial activity</u></b>	✓	Two major channel systems
<u>Assemblages of secondary minerals</u> of any age	?	Additional CRISM FRT required
Presence of former water ice	X	None identified
<u>Igneous rocks</u> of Noachian age, of known stratigraphic relation ... including exhumed megabreccia	?	Palus bounding intermediate highland units; likely in basal sections of stratigraphic sequence
Volcanic unit of Hesperian or Amazonian age	?	Hesperian pyroclastics; no Amazonian identified
High probability of <b><u>“opportunistic” samples</u></b> (e.g., ejecta, mantle, xenoliths)	✓	Ejecta and secondary craters accessible; mantle and xenoliths possible as float
Potential for resources for future human missions	?	TBD

# Engineering Constraints



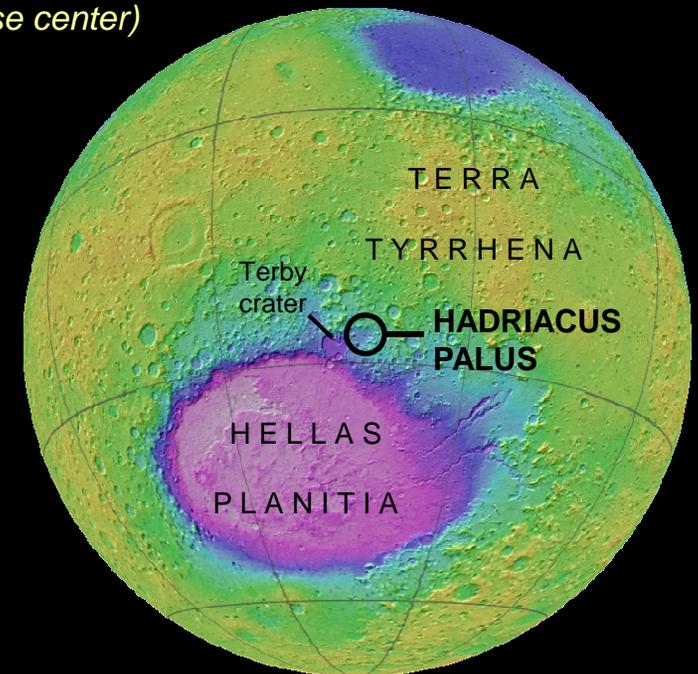
- Land on site
- 25 x 20 km ellipse location nominal (can shift)
- RT and +TRN (useful, not critical)
  - *Avoid local impact craters*
  - *More specified target*
  - *Hazard avoidance*
  - *Efficient pre-plan of traverse envelope*
- Traverse conditions favorable, unknown

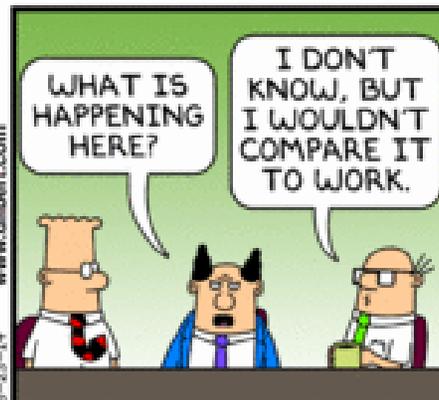
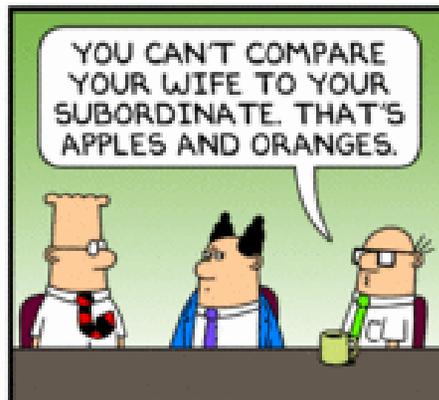
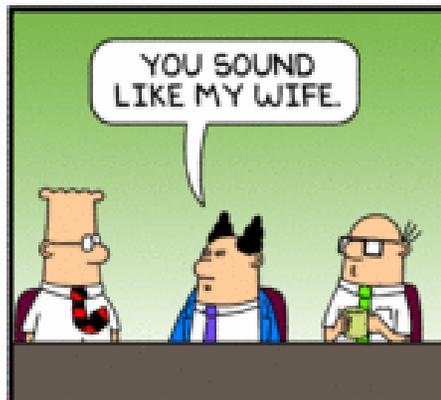
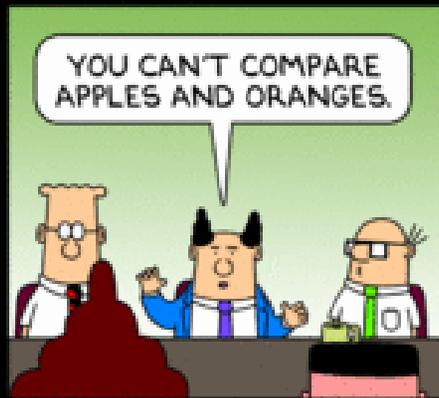
Constraint	
Elevation below +0.5 km MOLA	✓
Latitude $\pm 30^\circ$ of the equator	✓
Landing ellipse, nominal (25 km x 20 km)	✓
Landing ellipse, range trigger (18 km x 14 km)	✓
<100 m relief at 1 to 1,000 m baseline lengths	✓
<25 – 30 slopes at 2-5 m baseline lengths	?
Rock abundance and height/occurrence probability	?
Radar reflectivity $> -20$ dB and $< +15$ dB at Ka band	?
Load bearing surface: $TI > 100 \text{ J m}^{-2} \text{ K}^{-1} \text{ s}^{-1/2}$	✓
Load bearing surface: Albedo $< 0.25$	✓

# Summary - Hadriacus Palus

## *Excellent and Accessible Geological Terrains*

- **Representative section** of Martian intercrater plains
  - *Regional and local geology fairly well constrained (evolving)*
- **Land on Science**
  - *Basin formation and filling processes*
  - *Fluvial and lacustrine infill (up to 30 m <10 km from ellipse center)*
  - *Diverse provenance (EN Hellas massifs, dissected regolith)*
  - *Exhumation and infill (multiple times)*
  - *Mineralized fractures*
- **Go to Science**
  - *Traverse across Noachian-Hesperian boundary*
  - *Down basin → Down traverse (100 m section <15 km from ellipse center)*
- **Important science issues to be resolved**
  - *Lacustrine and fluvial environment (MN → H)*
  - *Crustal formation (bounding massifs)*
  - *Igneous processes (?)*
  - *Basin filling processes*
  - *Channel sequencing and inversion*
  - *Alteration processes (filled fractures)*
  - *Syn- and post-tectonic sedimentation*
- **Satisfies Science and Engineering**
- **Remaining work**
  - *Mineralogic character and diversity from orbit*
  - *Correlate with exposed stratigraphy*
  - *Tighten stratigraphic bounds*





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