

**SOUTHERN NECTARIS FOSSAE:  
A MICROCOSM OF MARTIAN GEOLOGY**  
Workshop Abstract #1005

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# Exploration Zone Map

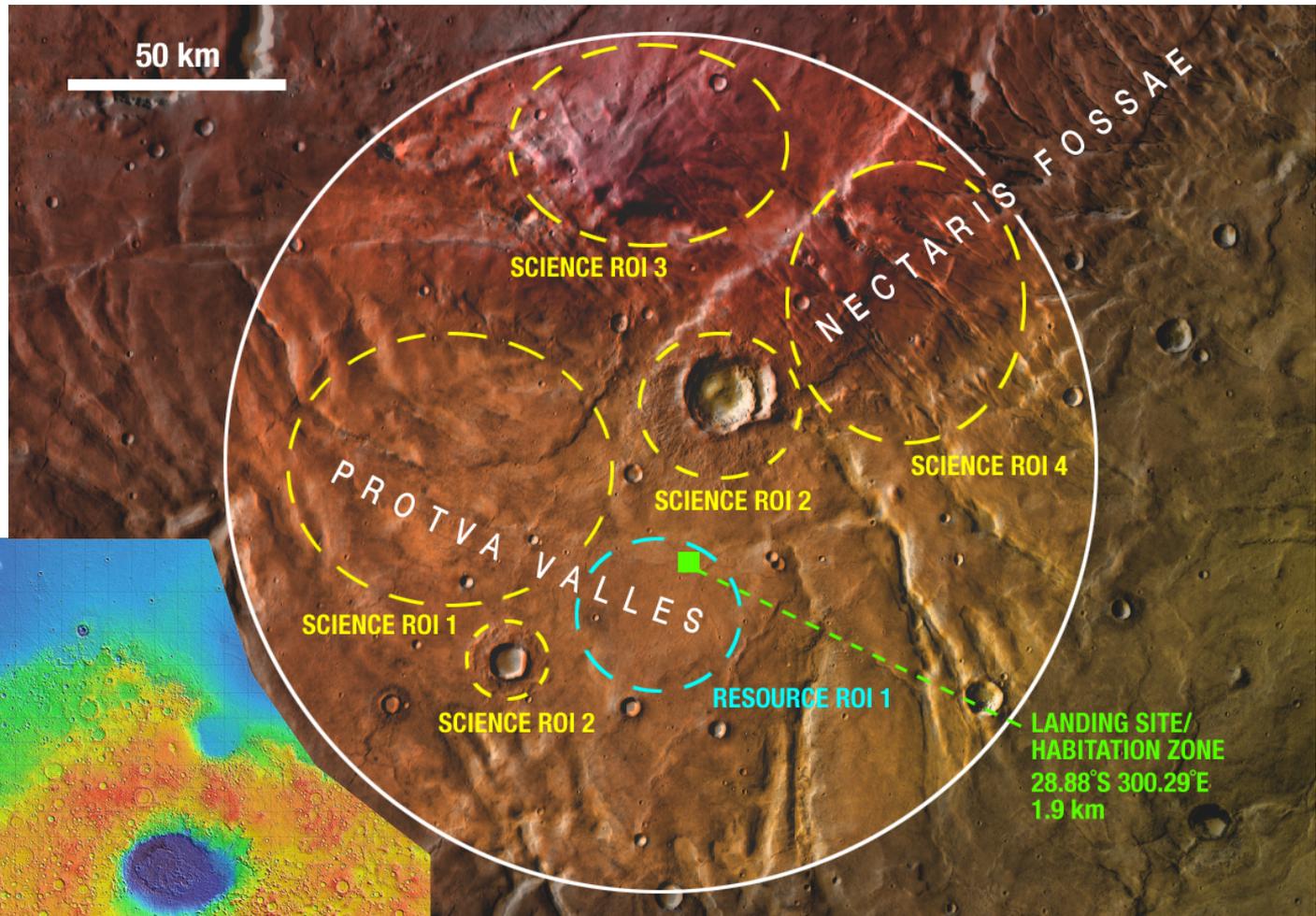
1<sup>st</sup> EZ Workshop for Human Missions to Mars

## Science ROIs:

1. Fluvial
2. Ice & Impacts
3. Volcanic
4. Tectonic

## Resource ROI:

1. Hydrated minerals

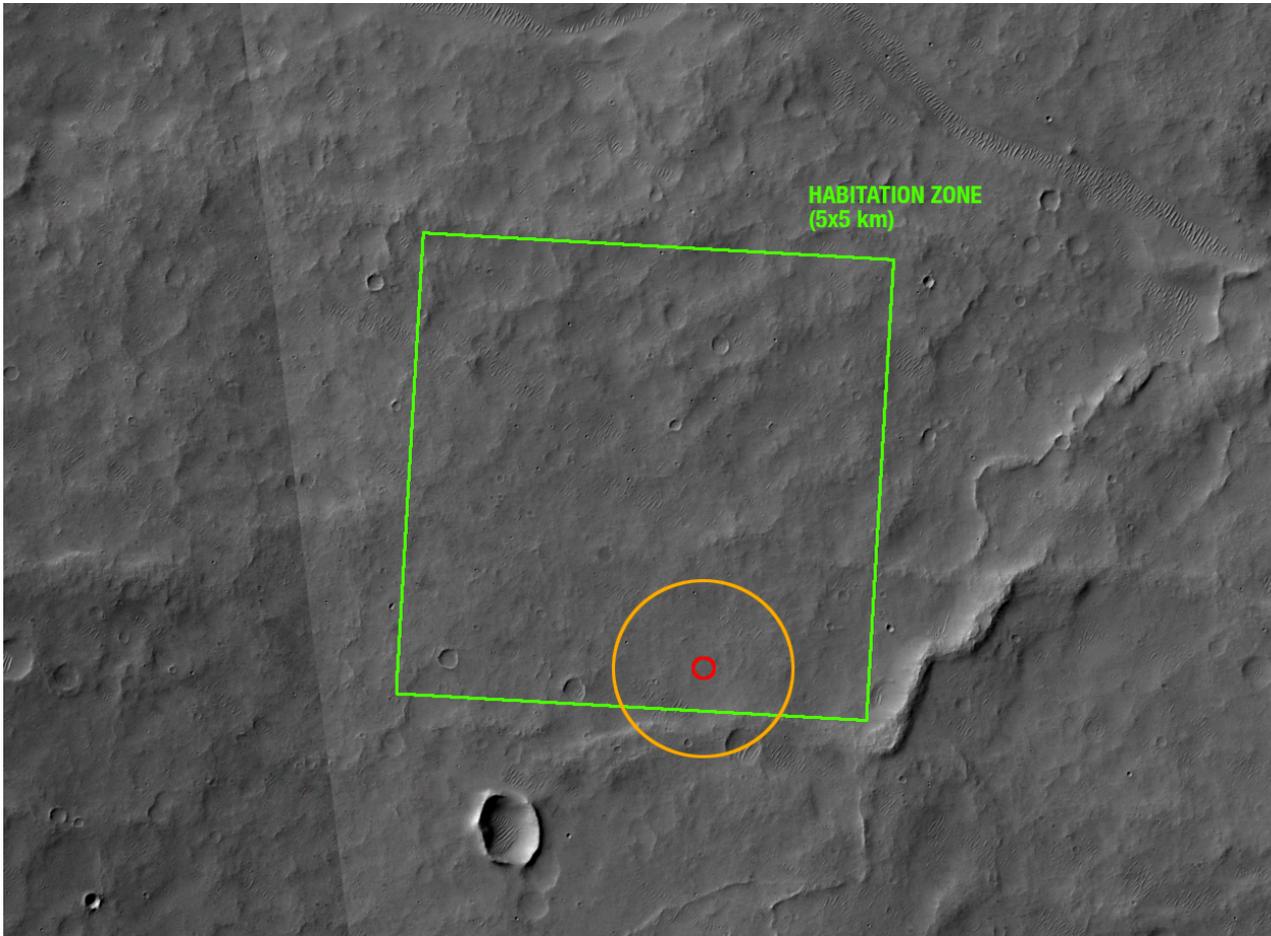


THEMIS Daytime IR w/MOLA color overlay

# Landing Site/Habitation Zone



1<sup>st</sup> EZ Workshop for Human Missions to Mars



Lat/Lon	28.88° S 300.29° E
Altitude	1.9 km
Imagery	CTX, HRSC

- Ancient floodplain; smooth, sandy terrain
- Sparse 100 m-scale dunes, small craters, low hills
- Ample space for infrastructure development
- Traverse paths available to all ROIs
- Resource utilization potential in the immediate area

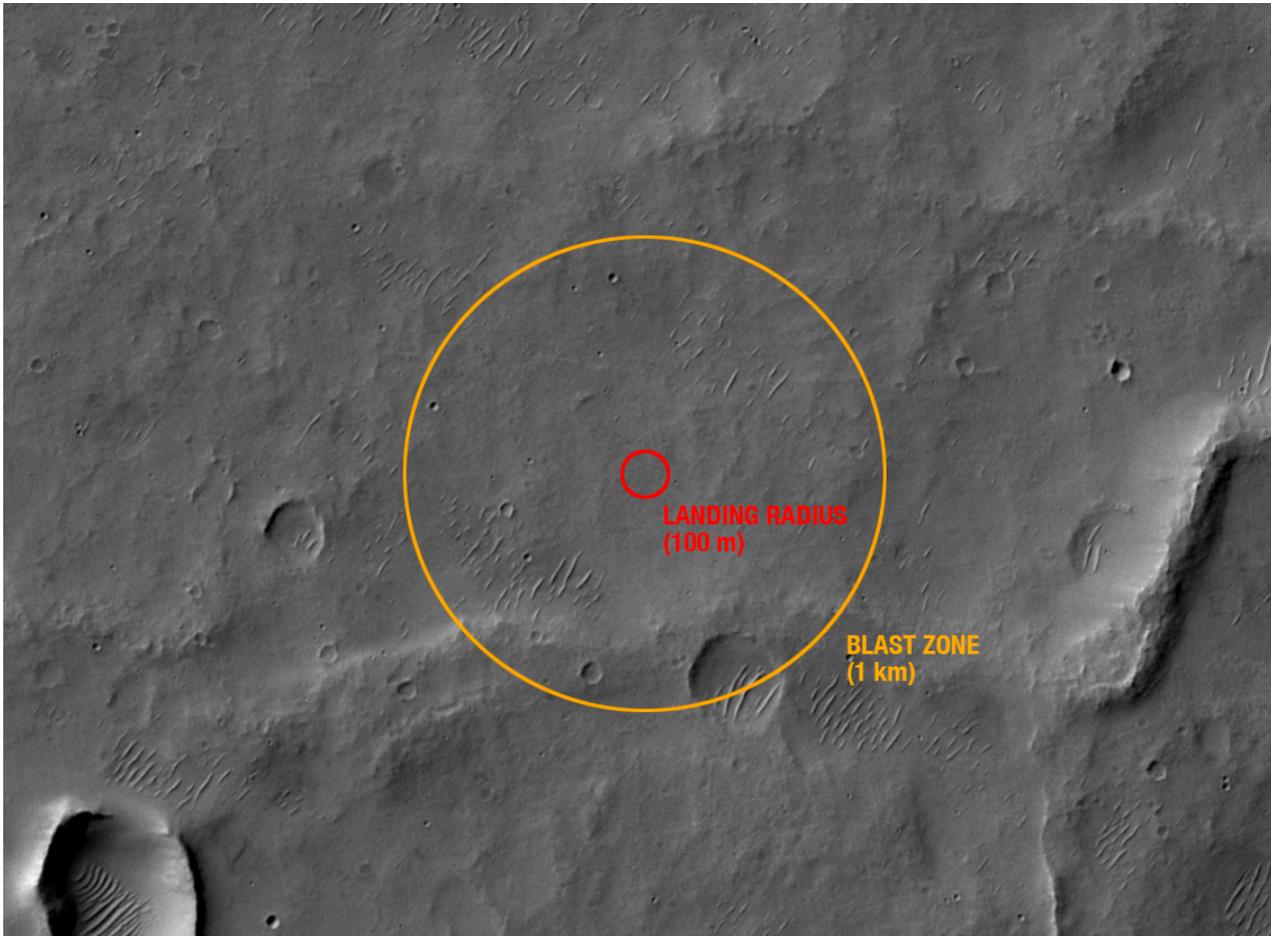
CTX Visible

Southern Nectaris Fossae

# Landing Site/Habitation Zone



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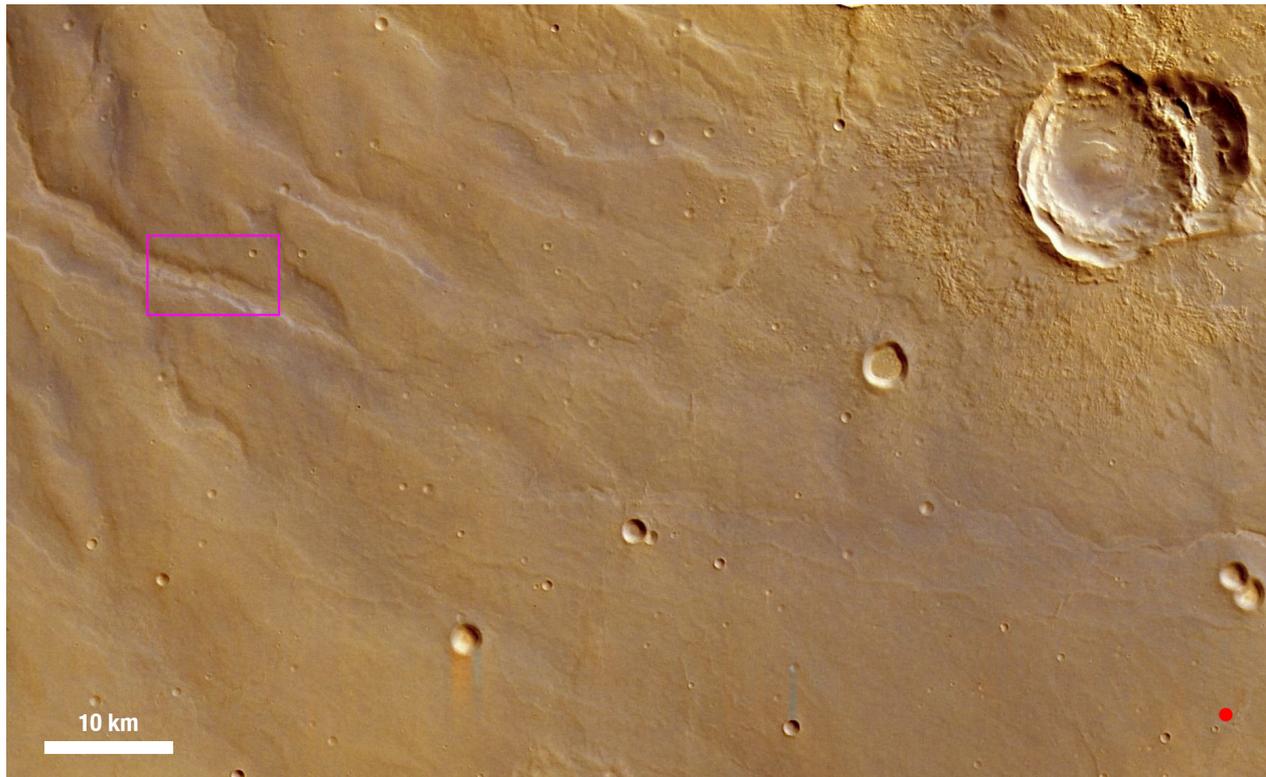
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CTX Visible

Southern Nectaris Fossae

# Science ROI 1: Fluvial

1<sup>st</sup> EZ Workshop for Human Missions to Mars



HRSC Visible

Lat/Lon	28.2–29.3° S 299.1–300.7° E
Altitude	1.8–2.2 km
Imagery	HiRISE, CTX, MOC, HRSC

- Protva Valles: Late Noachian/Early Hesperian valley networks
- Formed by flowing liquid water; **potential for past habitability**
- Geochemical proxies to **constrain past climate states**
- Wide areal extent, incl. near landing site

# Science ROI 1: Fluvial

1<sup>st</sup> EZ Workshop for Human Missions to Mars



CTX Visible

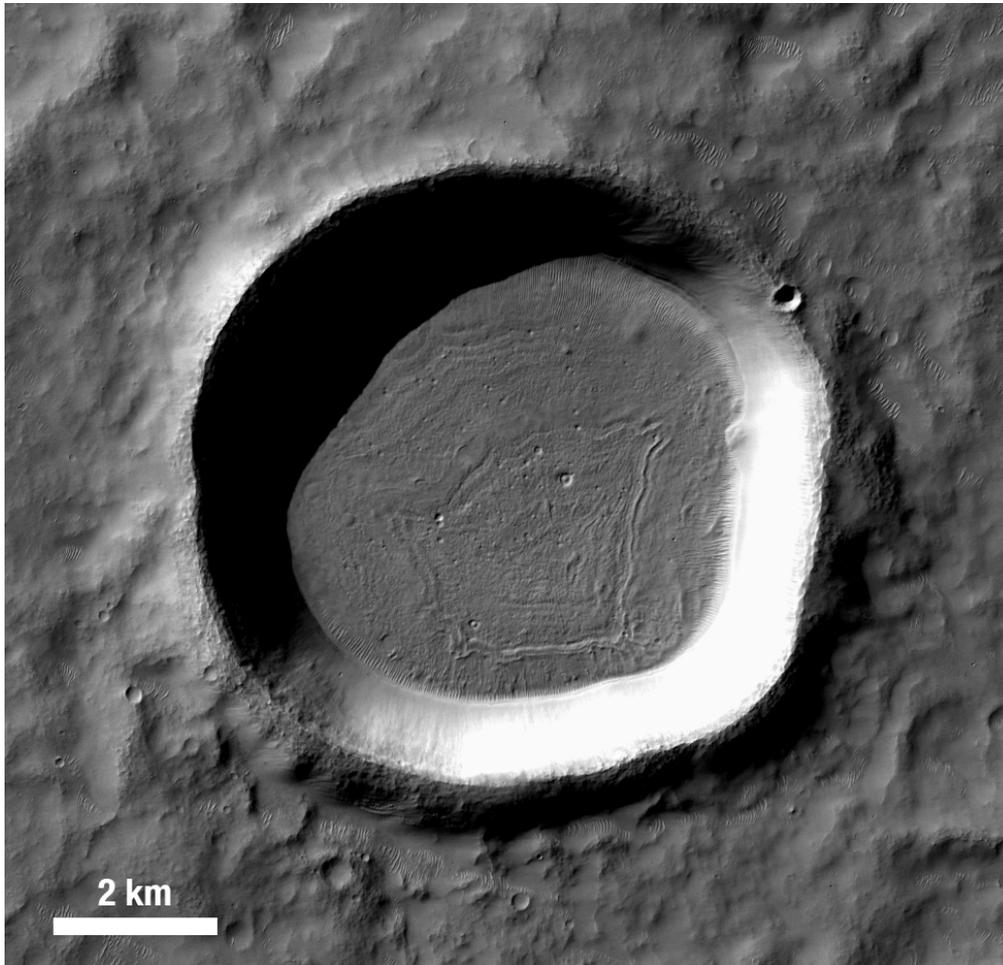
Lat/Lon	28.2–29.3° S 299.1–300.7° E
Altitude	1.8–2.2 km
Imagery	HiRISE, CTX, MOC, HRSC

- Protva Valles: Late Noachian/Early Hesperian valley networks
- Formed by flowing liquid water; **potential for past habitability**
- Geochemical proxies to **constrain past climate states**
- Wide areal extent, incl. near landing site

# Science ROI 2: Ice & Impacts



1<sup>st</sup> EZ Workshop for Human Missions to Mars



Lat/Lon	29.20° S 299.57° E
Altitude	1.7 km (floor) 2.1 km (rim)
Imagery	CTX, HRSC

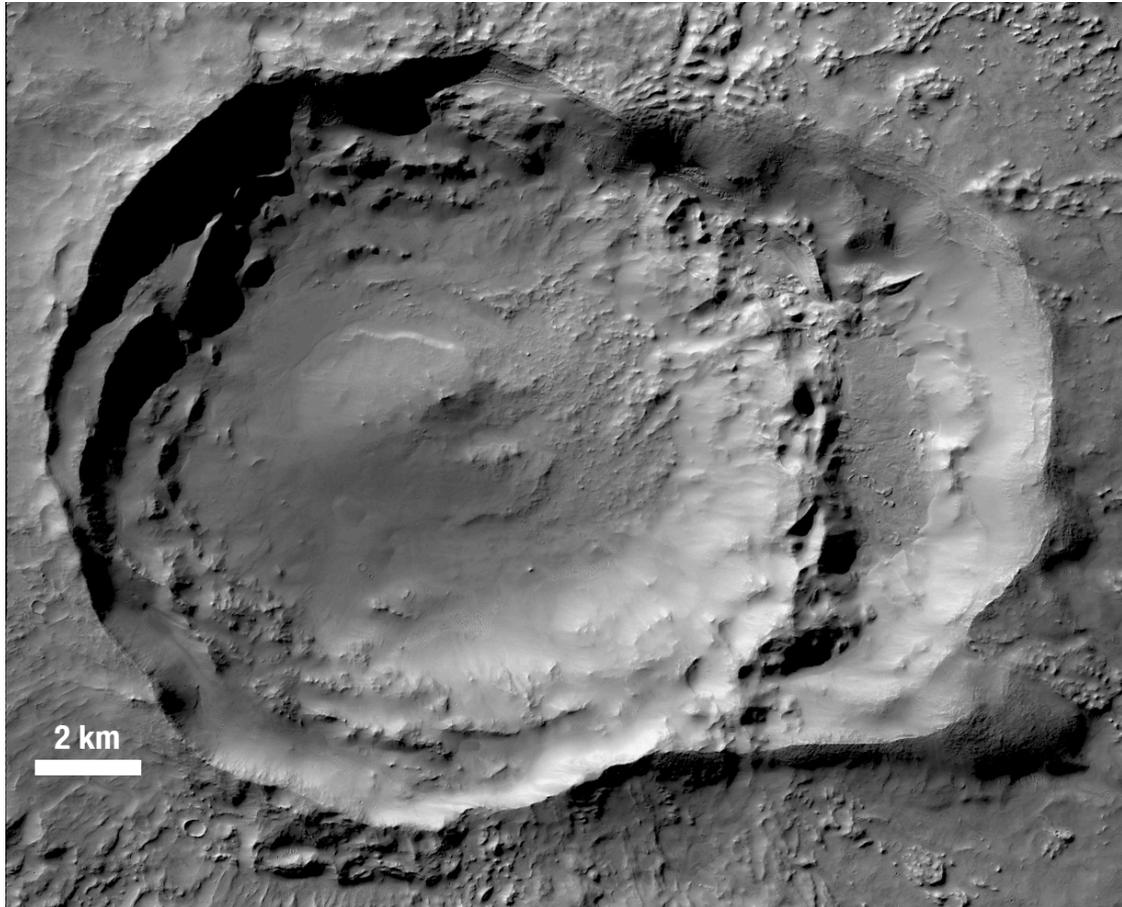
- Concentric crater fill preserves **subsurface Amazonian water ice**
- Potential for past and **present habitability**
- Measurement of **near-surface chemistry, chemical cycling and isotopic signatures**

CTX Visible

# Science ROI 2: Ice & Impacts



1<sup>st</sup> EZ Workshop for Human Missions to Mars



CTX Visible

Lat/Lon	28.26° S 300.40° E
Altitude	1.3 km (floor) 2.4 km (rim)
Imagery	CTX, MOC, HRSC

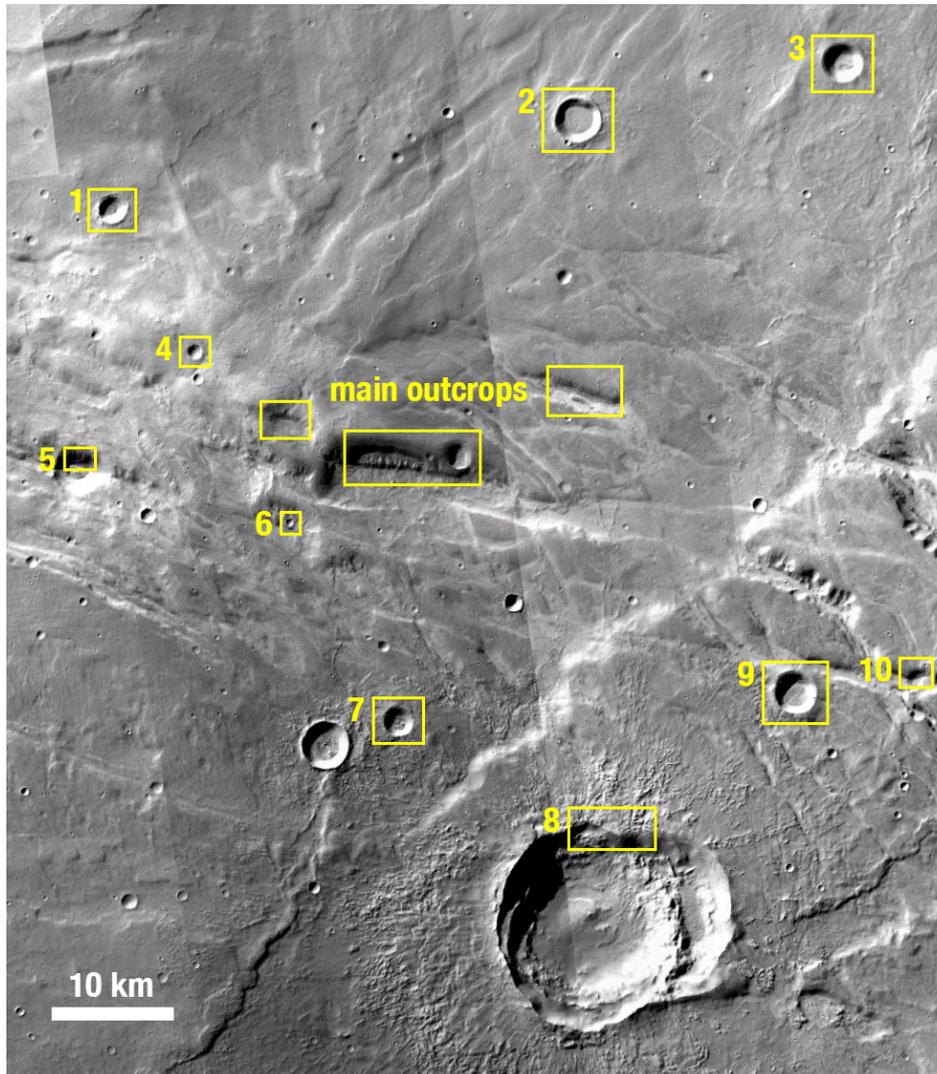
- Variety of **aeolian morphologies and landforms**
- Wide ejecta blanket, **unusual impact structures** and crater overlap
- Evidence of ice/water inconclusive, but worth further investigation

# Science ROI 2: Ice & Impacts



1<sup>st</sup> EZ Workshop for Human Missions to Mars

CTX Visible



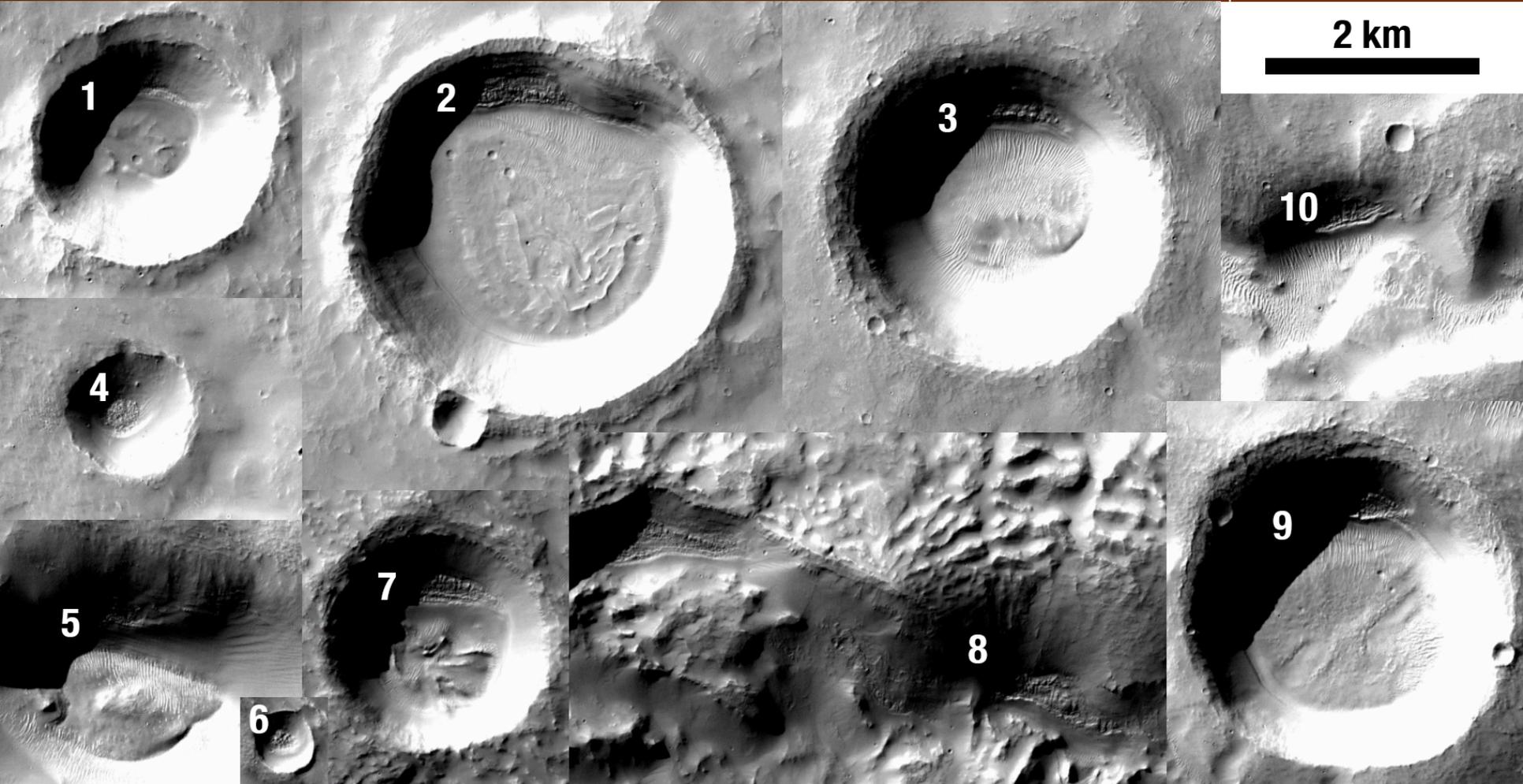
Lat/Lon	27.66 °S 300.07 °E (base of main outcr.)
Altitude	3.3 km
Imagery	HiRISE, CTX, HRSC

- Ice mantles: desiccated ice/dust deposits from recent ice ages (<10 Myr)
- Evidence of **orbital forcings** on past climate
- **Atmosphere, surface, and subsurface interactions**
- Numerous localities throughout the EZ

# Science ROI 2: Ice & Impacts



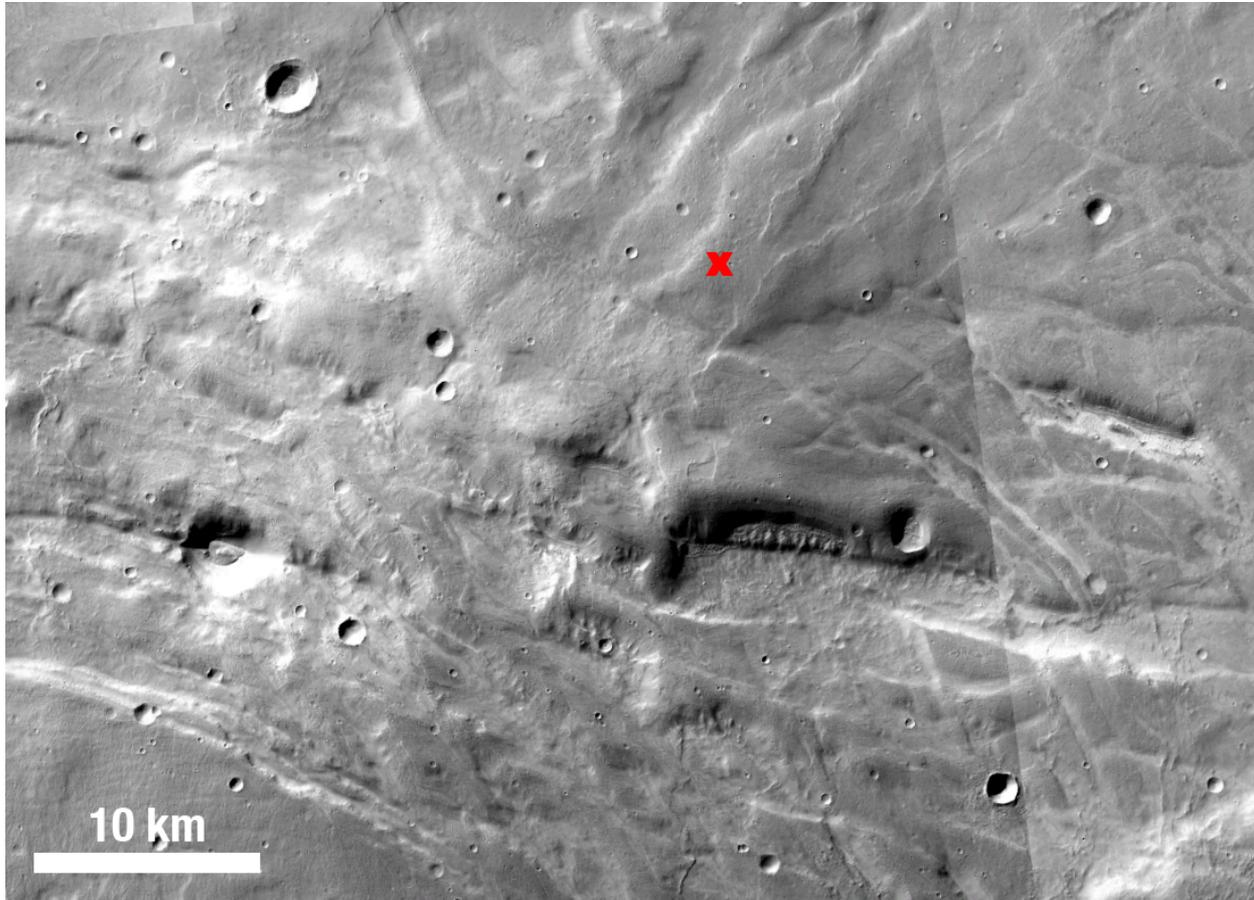
1<sup>st</sup> EZ Workshop for Human Missions to Mars



2 km

# Science ROI 3: Volcanic

1<sup>st</sup> EZ Workshop for Human Missions to Mars



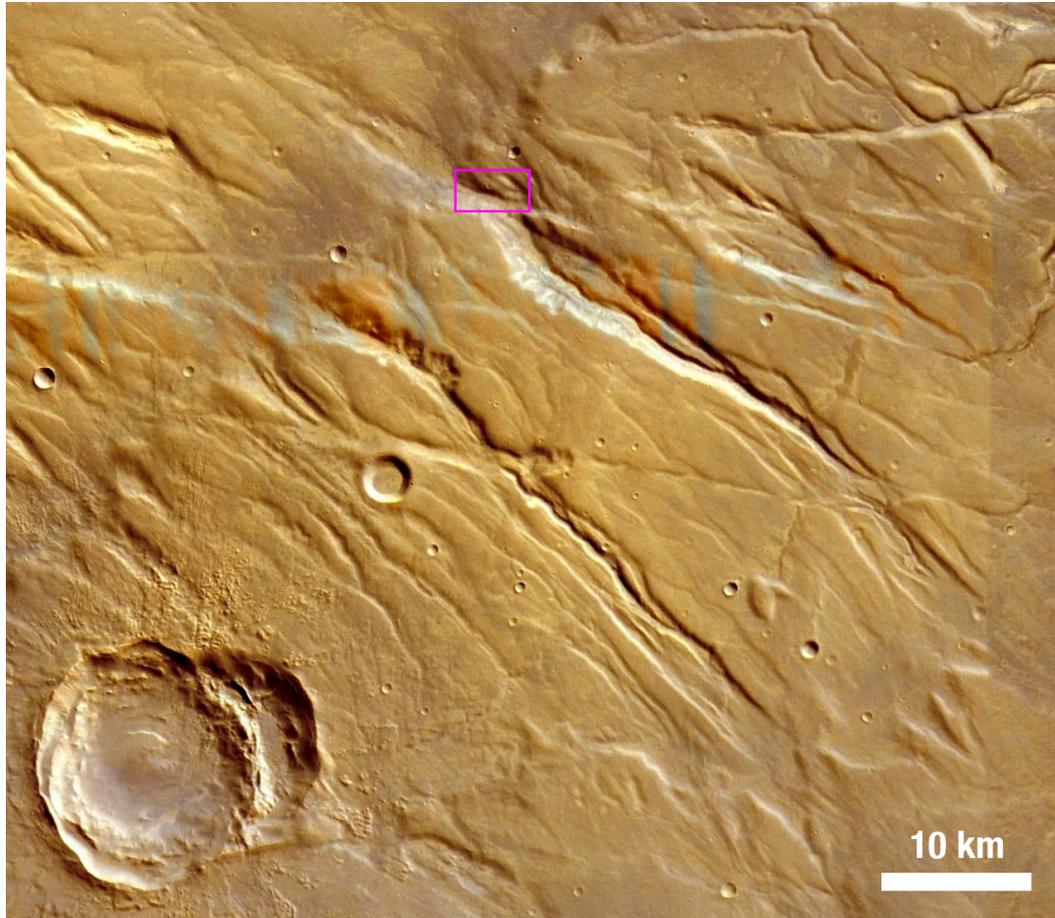
Lat/Lon	27.44 °S 300.06 °E
Altitude	4.3 km (peak)
Imagery	HiRISE, CTX, HRSC

- Thaumasia volcanic province (Noachian)
- Volcanic materials with **trapped gases and inclusions**
- **Ideal for radiometric dating and trace element analysis**
- Primary info source for **thermal, magmatic, tectonic evolution of Martian interior**

CTX Visible

# Science ROI 4: Tectonic

1<sup>st</sup> EZ Workshop for Human Missions to Mars



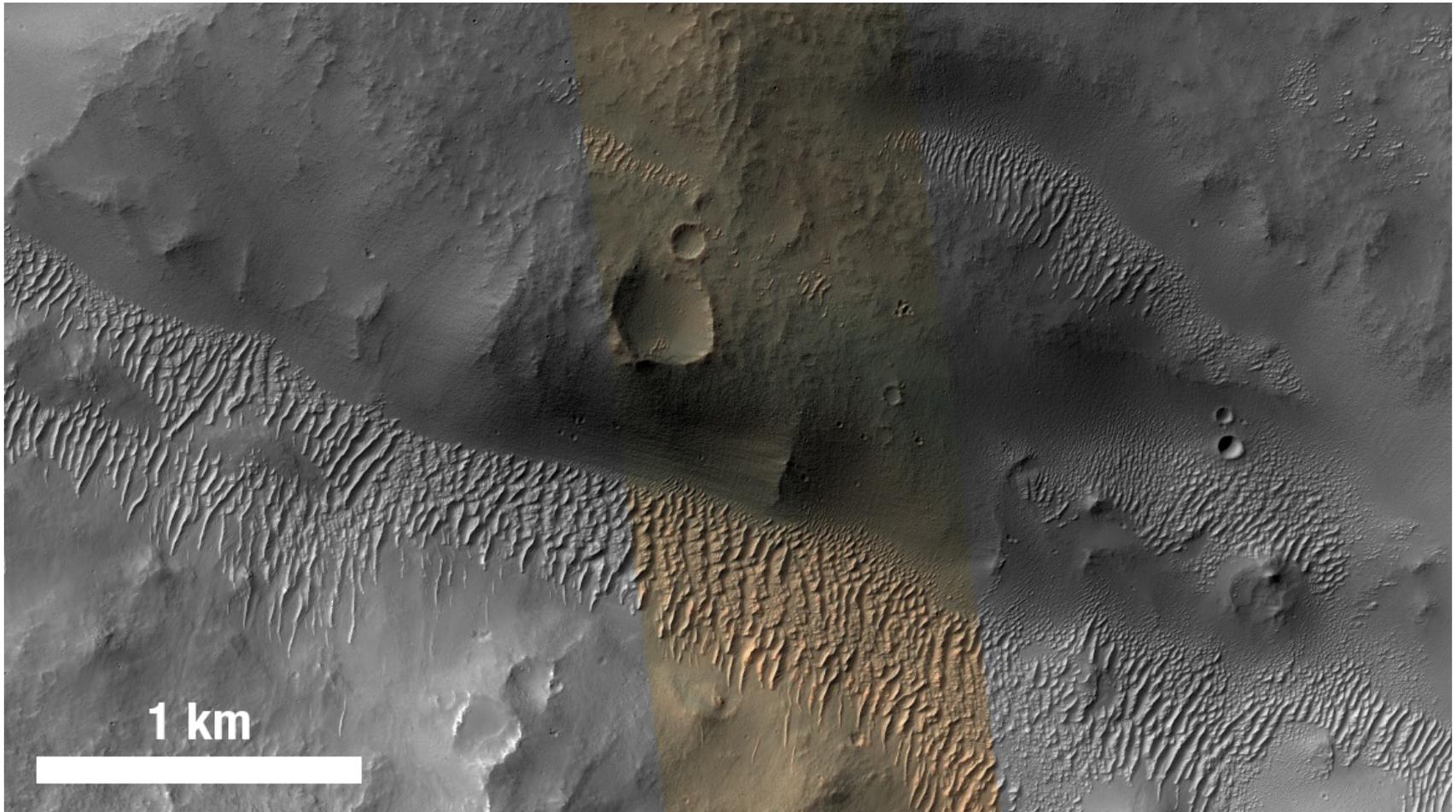
HRSC Visible

Lat/Lon	27.3–28.3° S 300.5–301.7° E
Altitude	1.9–3.3 km
Imagery	HiRISE, CTX, MOC, HRSC, CRISM

- Nectaris Fossae: **structural features with regional context** (Valles Marineris)
- Normal faulting and structural features
- Better preserved **stratigraphic sections of Noachian crust**
- CRISM measurements suggest fluvial activity

# Science ROI 4: Tectonic

1<sup>st</sup> EZ Workshop for Human Missions to Mars



HiRISE Merged RGB

Southern Nectaris Fossae

# Science ROI Summary

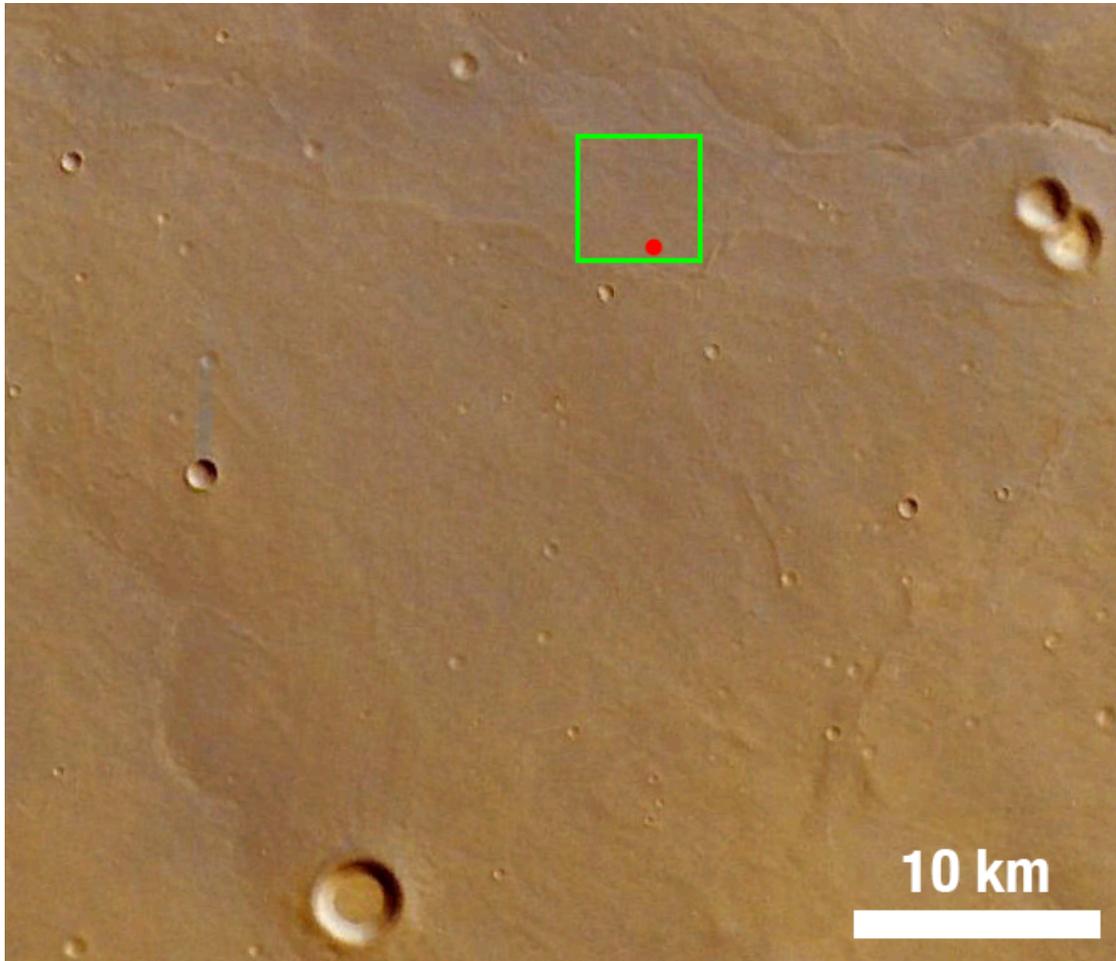
1<sup>st</sup> EZ Workshop for Human Missions to Mars



	Threshold	Qualifying
<b>1. FLUVIAL</b> (Valley networks, e.g. Protva Valles)	<ul style="list-style-type: none"> <li>• Potential for past habitability</li> <li>• Evidence of aqueous processes</li> <li>• Potential for interpreting relative ages</li> </ul>	<ul style="list-style-type: none"> <li>• Noachian bedrock units</li> <li>• Diversity of aeolian landforms</li> </ul>
<b>2. ICE &amp; IMPACTS</b> (Ice-filled craters*, ice mantles†)	<ul style="list-style-type: none"> <li>• Potential for past habitability* † AND</li> <li>• Potential for present habitability/refugia*</li> <li>• Evidence of aqueous processes†</li> </ul>	<ul style="list-style-type: none"> <li>• Surface-atmosphere exchange†</li> <li>• Amazonian subsurface ice* †</li> <li>• Impact deposits*</li> <li>• Diversity of aeolian landforms*</li> </ul>
<b>3. VOLCANIC</b> (Thaumasia igneous province)	<ul style="list-style-type: none"> <li>• Noachian rocks w/trapped gases (?)</li> <li>• Datable surfaces</li> </ul>	<ul style="list-style-type: none"> <li>• Rocks from igneous provinces (Thaumasia)</li> <li>• Noachian bedrock units</li> <li>• Remnant magnetization (?)</li> </ul>
<b>4. TECTONIC</b> (Normal faulting, e.g. Nectaris Fossae)	<ul style="list-style-type: none"> <li>• Potential for interpreting relative ages</li> <li>• Evidence of aqueous processes</li> </ul>	<ul style="list-style-type: none"> <li>• Noachian bedrock units</li> <li>• Structural features with regional context</li> <li>• Diversity of aeolian landforms</li> </ul>

# Resource ROI 1: Hydrated Minerals

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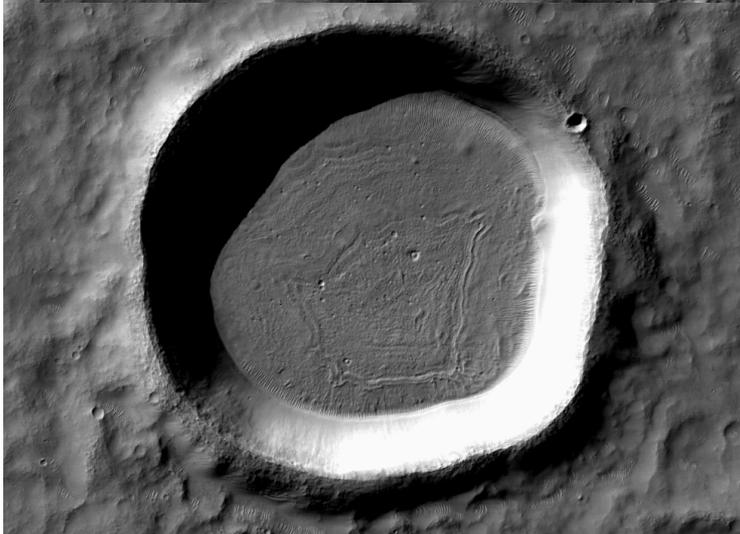
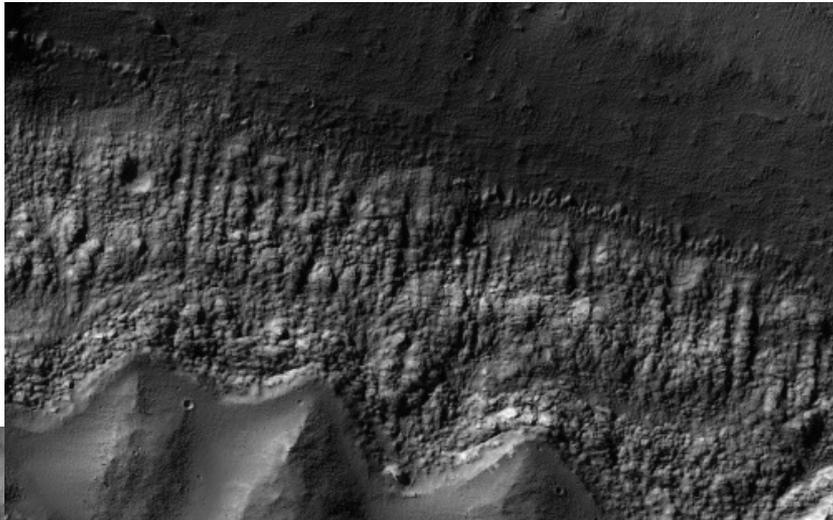


Lat/Lon	28.7–29.3° S 299.8–300.7° E
Altitude	1.7–2.0 km
Imagery	CTX, HRSC

- Protva Valles floodplain: resources available over hundreds of km<sup>2</sup>
- Accessible by automated equipment; level terrain free of large obstacles
- Convenient location: resources could be processed and utilized on-site

# Resources in Other ROIs

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## ADDITIONAL HYDRATED MINERALS

- Protva Valles and Nectaris Fossae

## ICE, ICE/REGOLITH MIX

- Significant water resource, widespread and abundant
- >5 km from the habitation zone
- Difficulty of access for large equipment

## VOLCANIC DEPOSITS

- Source of Fe, Mg, Al and Si
- Similar issues of distance and ease of access; abundance questionable

# Science Criteria

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Site Factors				SROI 1	SROI 2	SROI 3	SROI 4	EZ SUM	
Science Site Criteria	Astrobio	Threshold	AND/OR	Potential for past habitability	●	●		○	2,1
				Potential for present habitability/refugia		●			1,0
		Qualifying		Potential for organic matter, w/surface exposure		○			0,1
	Atmospheric Science	Threshold		Noachian/Hesperian rocks w/trapped atmospheric gases			○		0,1
			Qualifying		Meteorological diversity in space and time	?	?	?	?
				High likelihood of surface-atmosphere exchange		●			1,0
				Amazonian subsurface or high-latitude ice or sediment		●			1,0
			High likelihood of active trace gas sources	?	?	?	?		
	Geoscience	Threshold		Range of martian geologic time; datable surfaces			●	○	1,1
				Evidence of aqueous processes	●	●		●	3,0
				Potential for interpreting relative ages	●	●	●	●	4,0
		Qualifying		Igneous Rocks tied to 1+ provinces or different times	○	○	●	○	1,3
				Near-surface ice, glacial or permafrost		●			1,0
				Noachian or pre-Noachian bedrock units	●	●	●	●	4,0
			Outcrops with remnant magnetization			○		0,1	
			Primary, secondary, and basin-forming impact deposits		●			1,0	
	Structural features with regional or global context				●	1,0			
	Diversity of aeolian sediments and/or landforms	●	●		●	3,0			

Key	
●	Yes
○	Partial Support or Debated
	No
?	Indeterminate

# ISRU/Engineering Criteria

1<sup>st</sup> EZ Workshop for Human Missions to Mars



Site Factors			SROI 1	SROI 2	SROI 3	SROI 4	RROI 1	LS/HZ	EZ SUM	
ISRU and Civil Engineering Criteria	Engineering	Meets First Order Criteria (Latitude, Elevation, Thermal Inertia)						●	1,0	
	Water Resource	Threshold	AND/OR Potential for ice or ice/regolith mix		●					1,0
			Potential for hydrated minerals	●			●	●		3,0
			Quantity for substantial production	●	●			●		3,0
			Potential to be minable by highly automated systems	●	●		●	●		4,0
			Located less than 3 km from processing equipment site					●		1,0
			Located no more than 3 meters below the surface	○	●		○	●		2,2
			Accessible by automated systems	○	○		○	●		1,3
	Qualifying	Potential for multiple sources of ice, ice/regolith mix <b>and</b> hydrated minerals								
		Distance to resource location can be >5 km	●	●		●				3,0
		Route to resource location must be (plausibly) traversable	●	●		●				3,0
	Civil Engineering	Threshold	~50 sq km region of flat and stable terrain with sparse rock distribution						●	1,0
			1–10 km length scale: <10°						●	1,0
			Located within 5 km of landing site location						●	1,0
	Qualifying	Located in the northern hemisphere								
		Evidence of abundant cobble sized or smaller rocks and bulk, loose regolith							●	1,0
		Utilitarian terrain features							○	0,1
	Food Production	Qualifying	Low latitude						●	1,0
			No local terrain feature(s) that could shadow light collection facilities						●	1,0
			Access to water						●	1,0
Access to dark, minimally altered basaltic sands										
Metal/Silicon Resource	Threshold	Potential for metal/silicon			●				1,0	
		Potential to be minable by highly automated systems			●				1,0	
		Located less than 3 km from processing equipment site								
		Located no more than 3 meters below the surface				○				0,1
		Accessible by automated systems				○				0,1
	Qualifying	Potential for multiple sources of metals/silicon			●					1,0
		Distance to resource location can be >5 km			●					1,0
		Route to resource location must be (plausibly) traversable			●				1,0	

Key	
●	Yes
○	Partial Support or Debated
	No
	Not Applicable

# EZ Data Needs

1<sup>st</sup> EZ Workshop for Human Missions to Mars



	Goal	Purpose	Assets
<b>HIGHEST PRIORITY</b>	Obtain high-resolution visible imagery of key science areas	Better knowledge of morphology, geologic history, etc.	HiRISE
	Take initial spectral measurements of potential resources	Determine composition of resource materials (esp. hydrated minerals and water ice)	CRISM
<b>OTHER PRIORITIES</b>	Get on the ground with rovers and landers	Detailed analysis of local conditions and suitability for human habitation	Future rovers/landers
	Full-scale spectral analysis of the EZ	Comprehensive knowledge of EZ geology and resource availability	Future orbital spectrometer(s)
	Long-term atmospheric monitoring, continued site assessment	Is the EZ suitable for long-term human presence?	All of the above

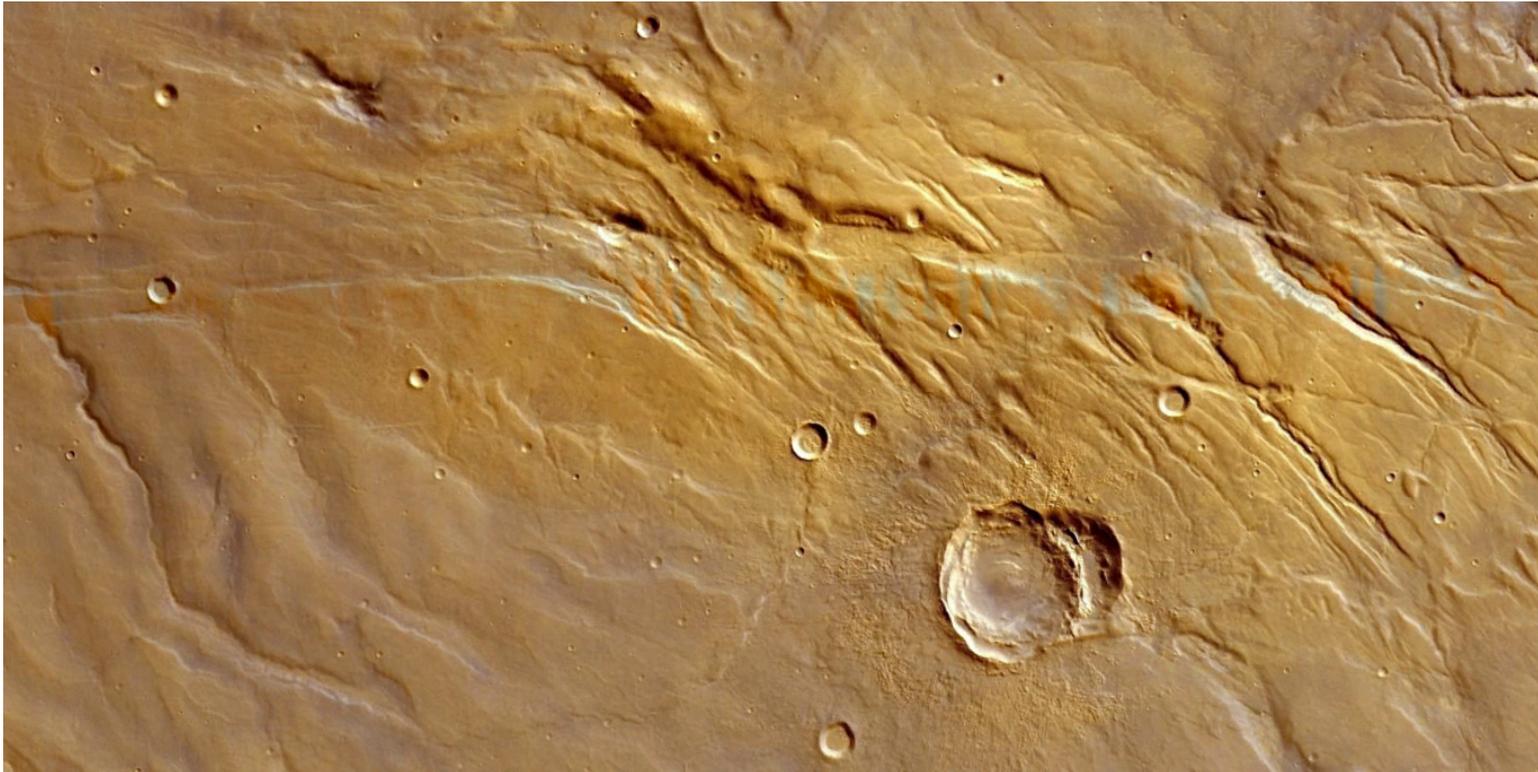
# Why Go Here?

1<sup>st</sup> EZ Workshop for Human Missions to Mars



**mi • cro • cosm** *noun*

a place regarded as encapsulating in miniature the characteristic qualities or features of something much larger (*OED*)

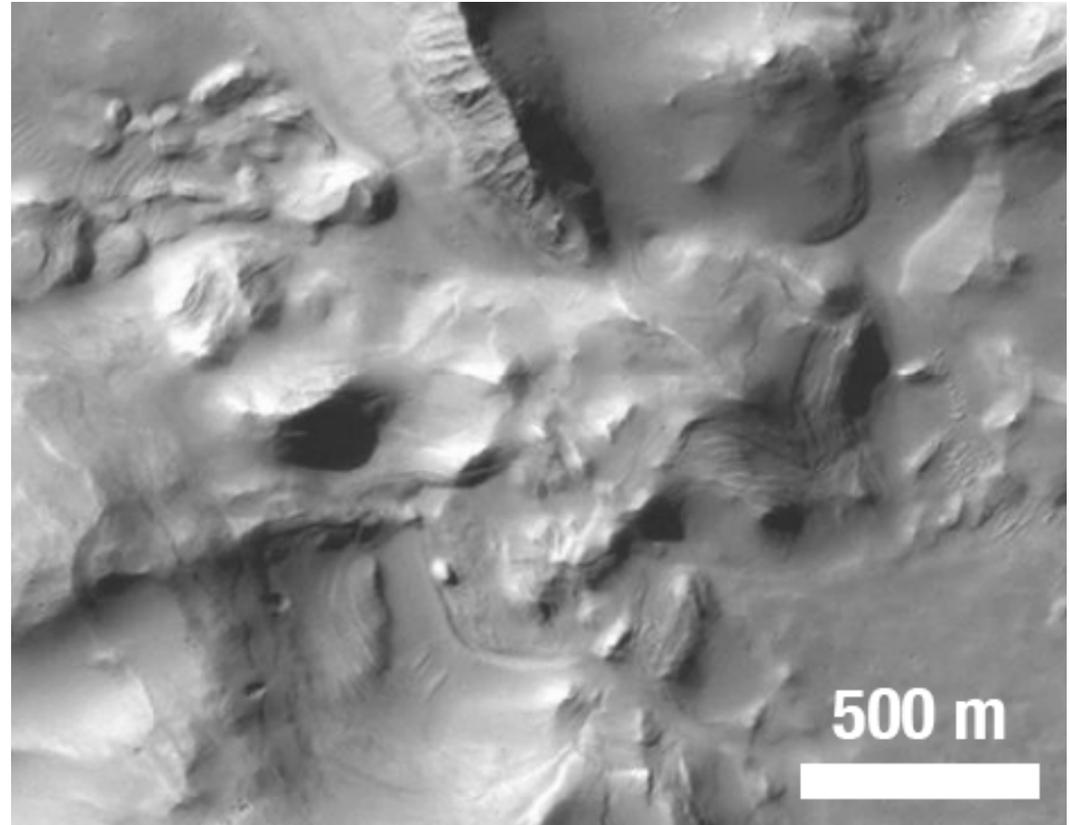
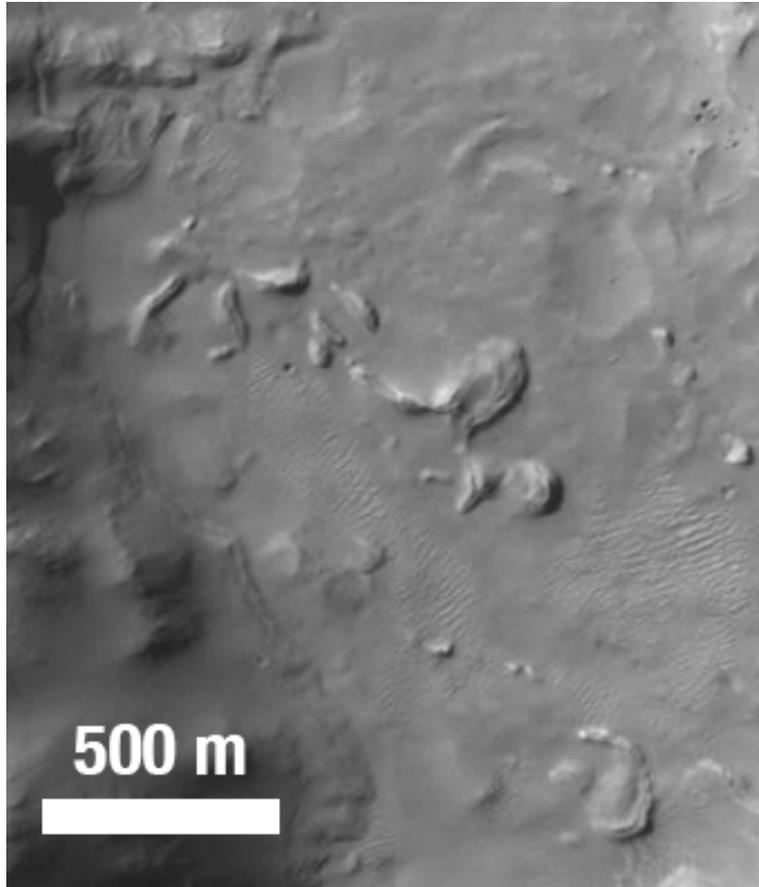


Southern Nectaris Fossae

# Science ROI 2: Ice & Impacts



1<sup>st</sup> EZ Workshop for Human Missions to Mars

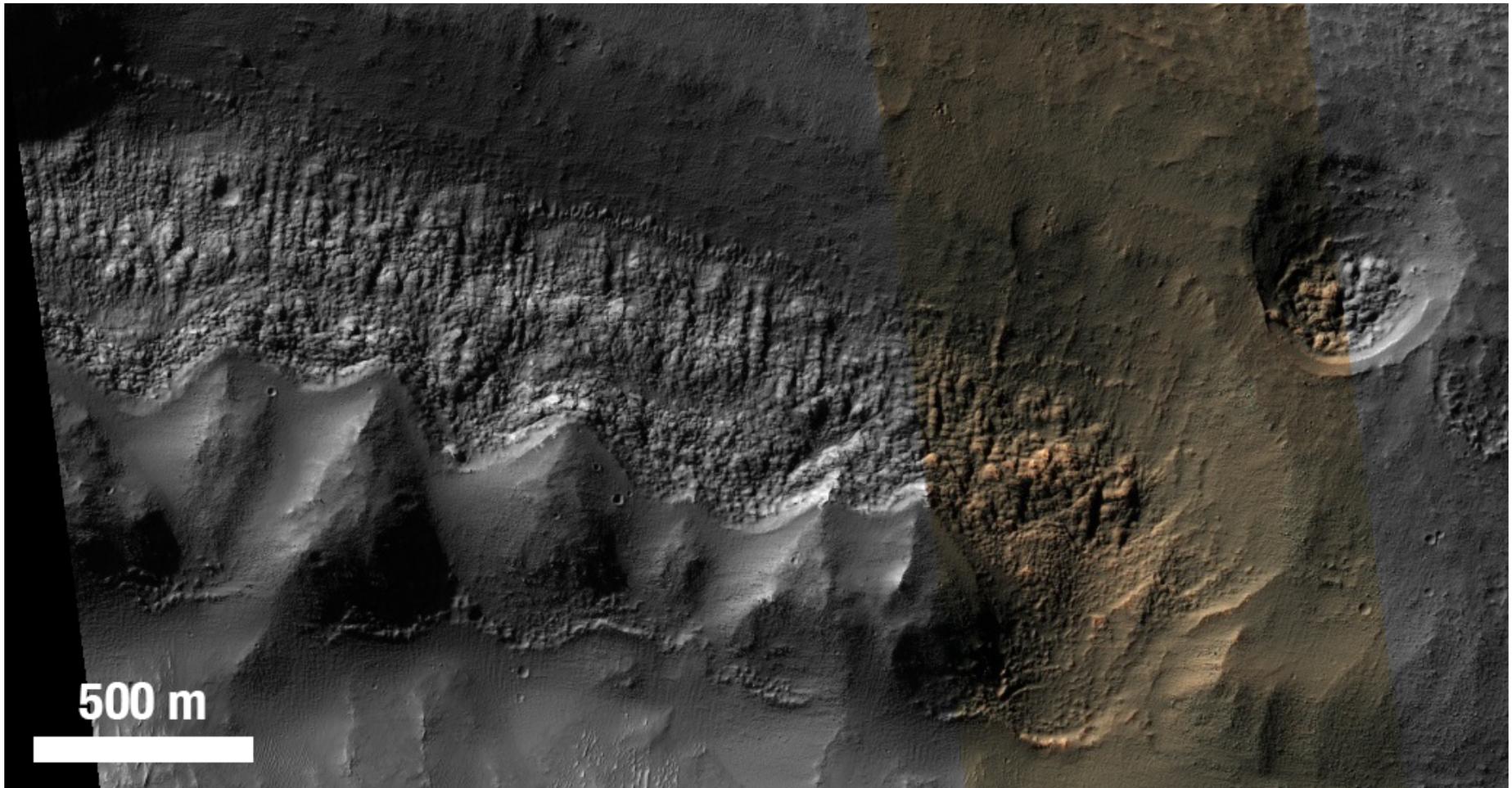


CTX Visible

# Science ROI 2: Ice & Impacts



1<sup>st</sup> EZ Workshop for Human Missions to Mars



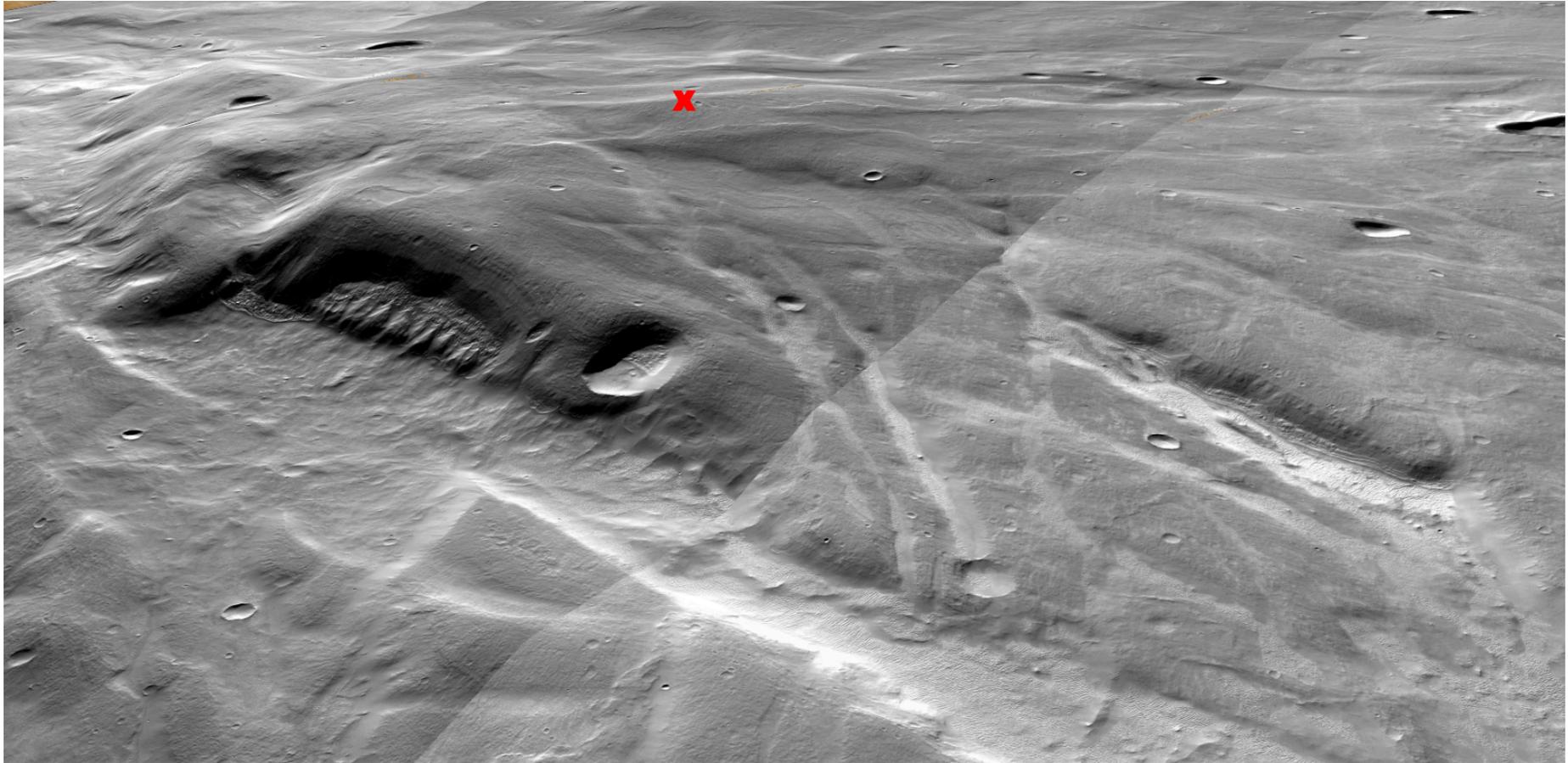
500 m

HiRISE Merged RGB

Southern Nectaris Fossae

# Science 3: Volcanic

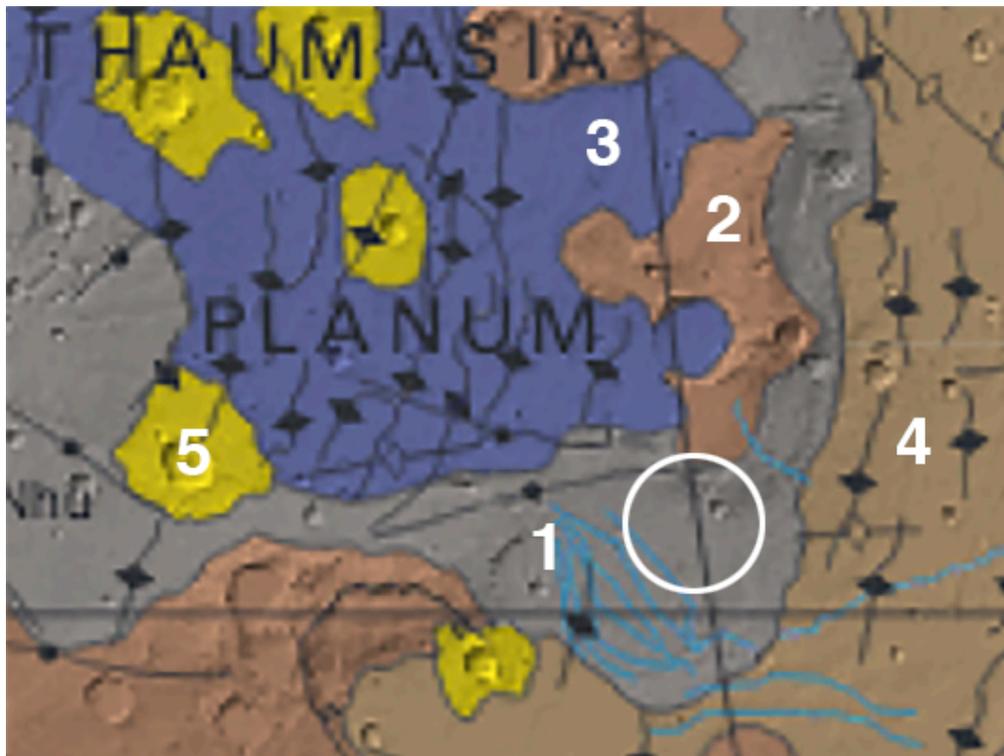
1<sup>st</sup> EZ Workshop for Human Missions to Mars



CTX Visible w/2x elevation exaggeration (Google Earth)

# Geologic Map

1<sup>st</sup> EZ Workshop for Human Missions to Mars



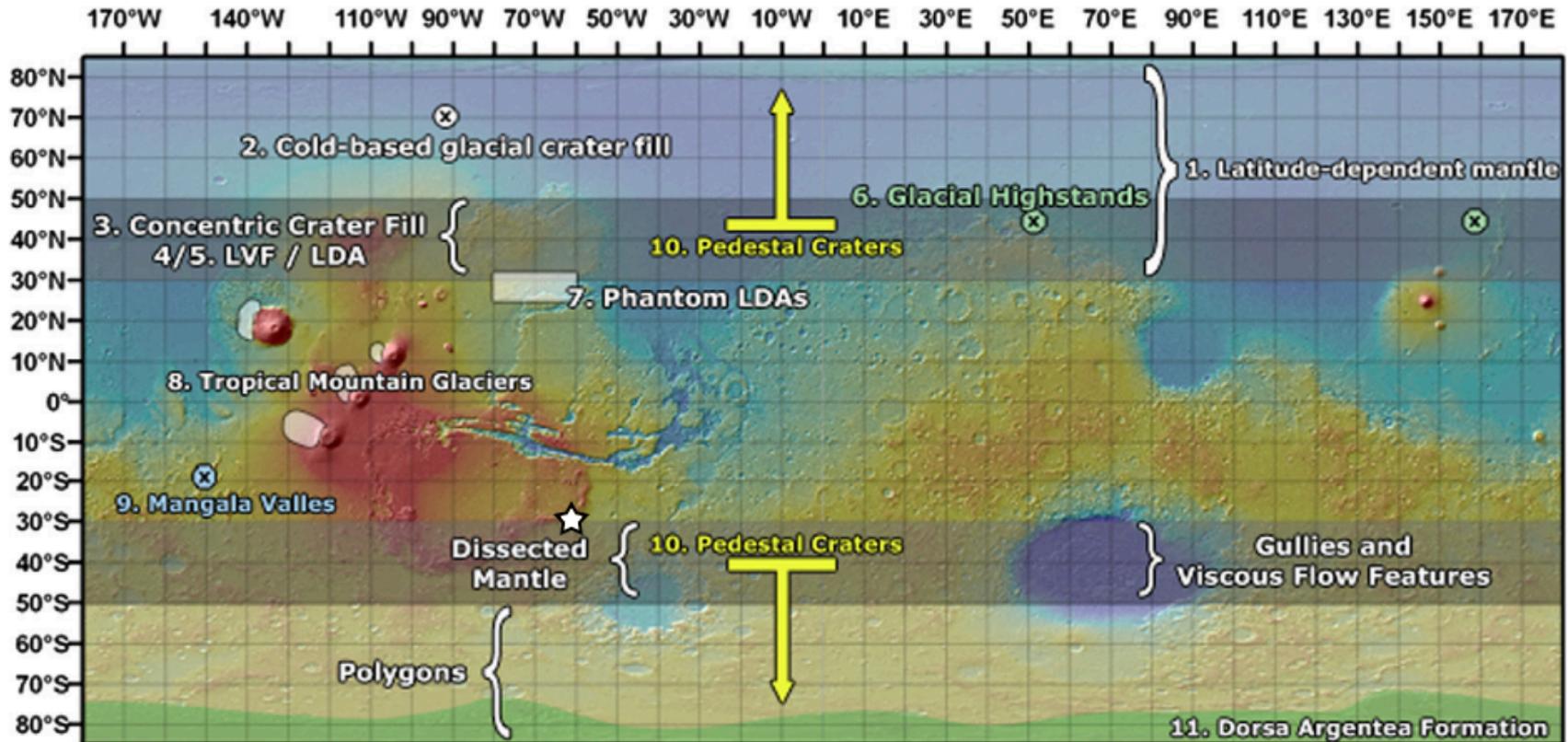
Tanaka et al., 2014

1. Noachian highland undivided
2. Middle Noachian highland
3. Late Noachian volcanic
4. Late Noachian highland
5. Amazonian and Hesperian impact

# Distribution of Non-Polar Ice



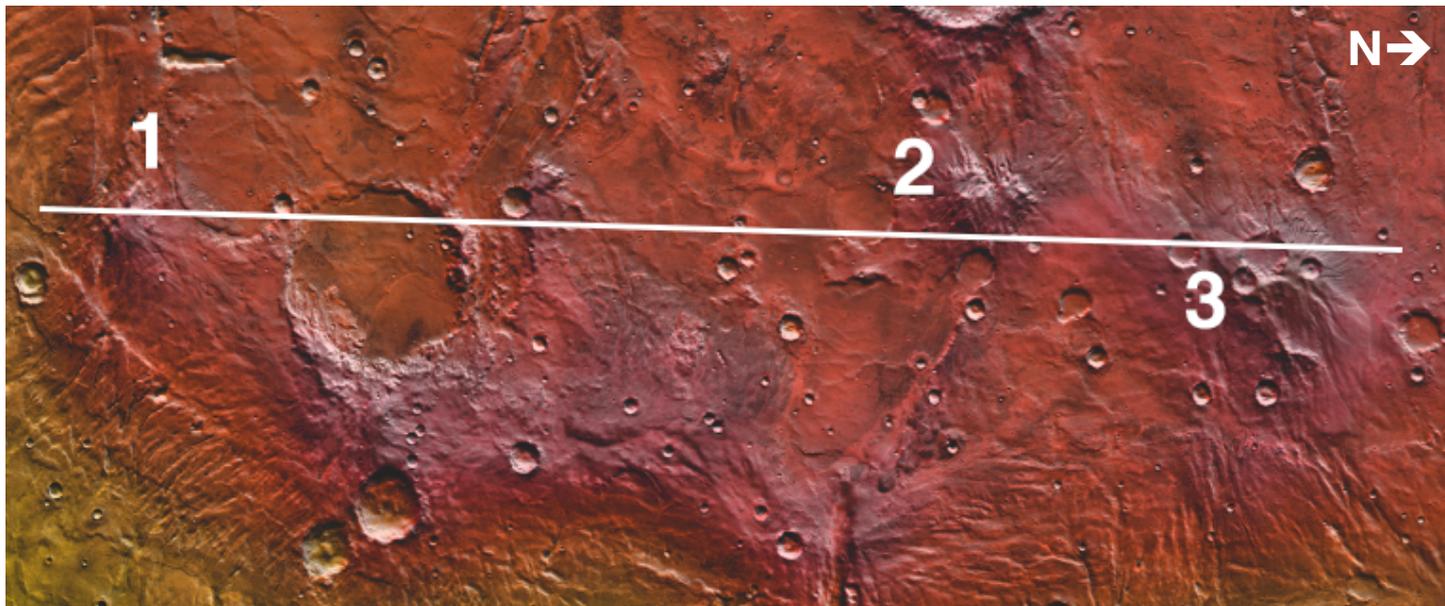
1<sup>st</sup> EZ Workshop for Human Missions to Mars



Head and Marchant, 2008

# Volcanic “Arc”

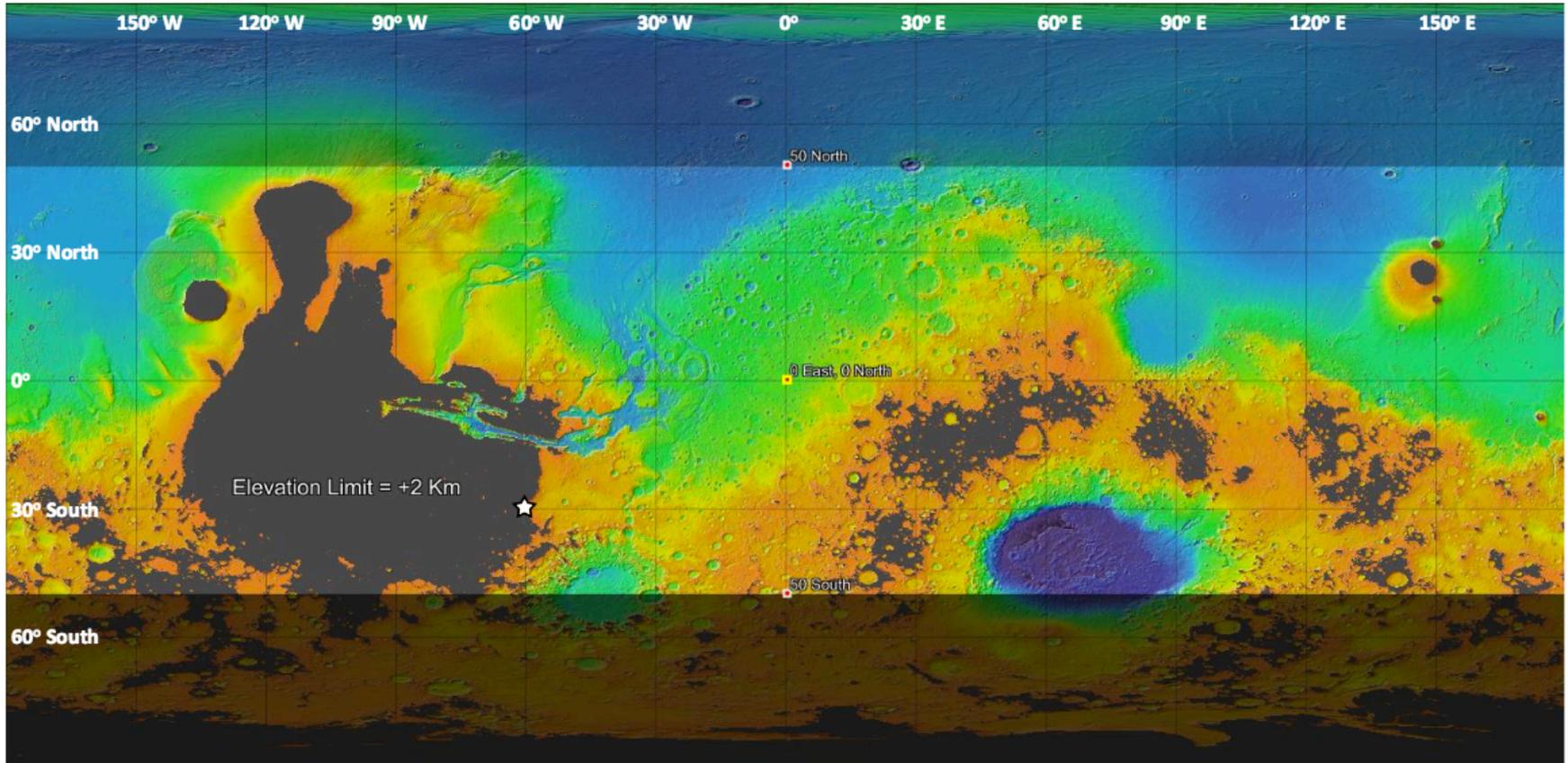
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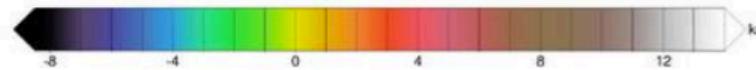
THEMIS Day IR w/MOLA color overlay

# Elevation Limits

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MOLA Color Legend



Southern Nectaris Fossae