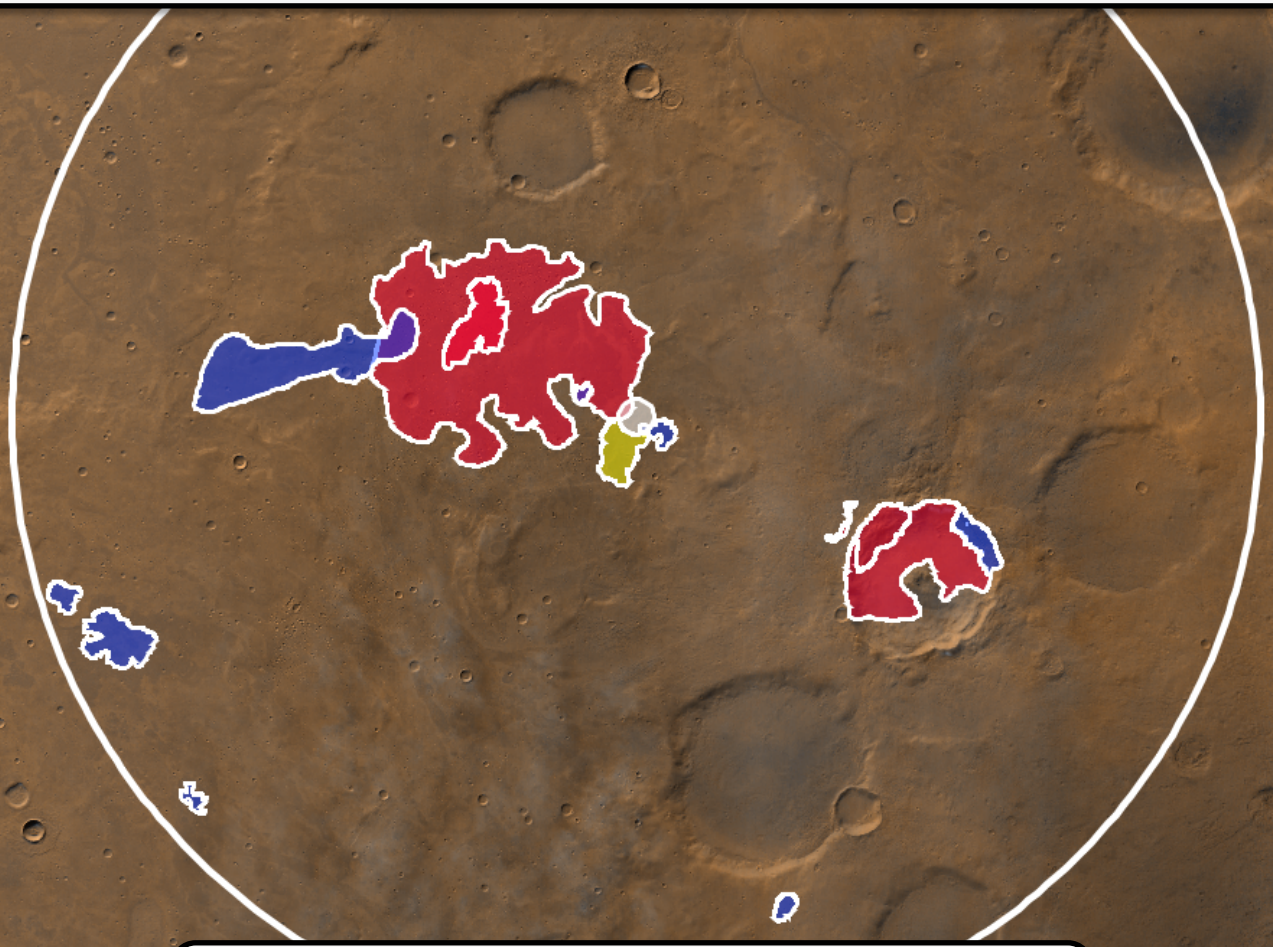
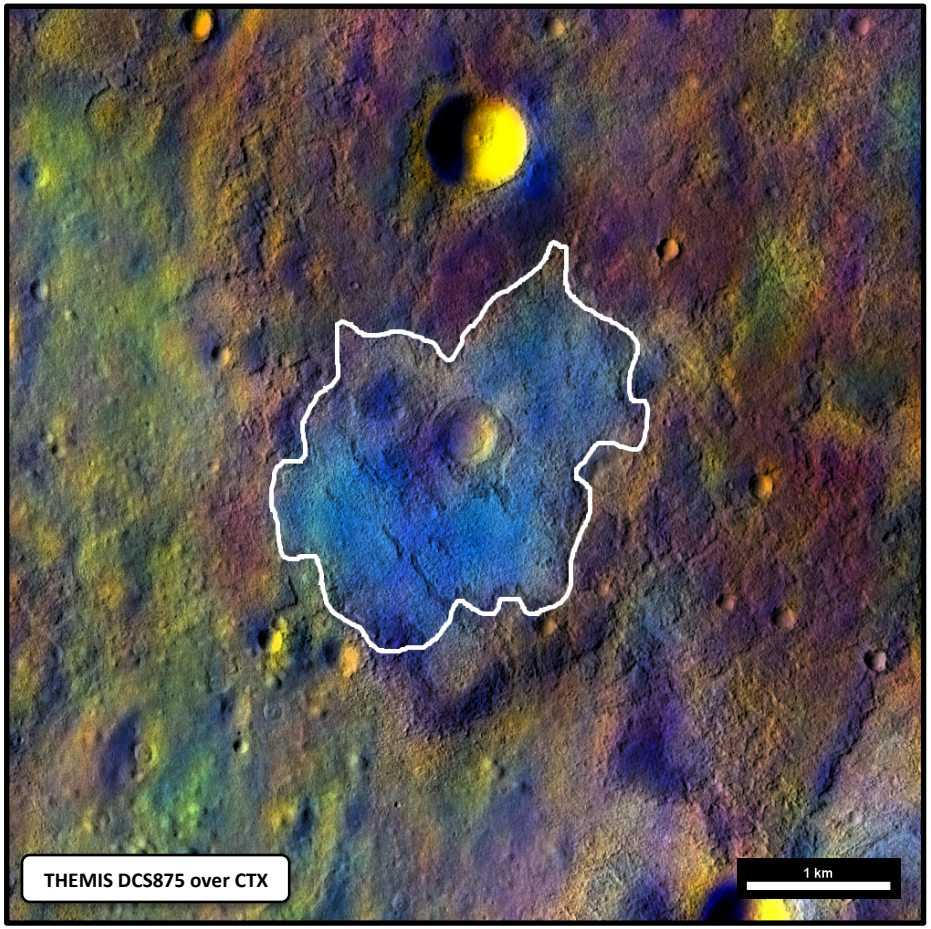
Western Noachis Terra Chloride Deposits

Abstract #1021



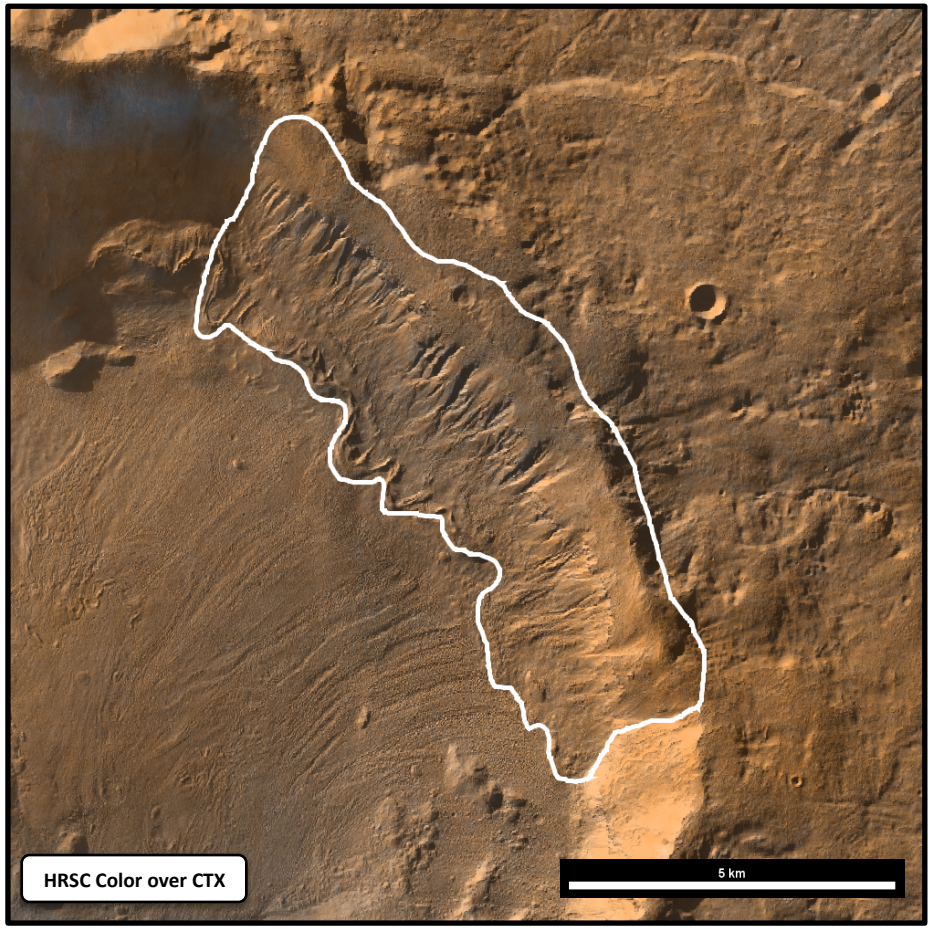
J. R. Hill[1] and P. R. Christensen[1]
[1]Arizona State University, Tempe, AZ 85287

Chlorides & Glacier-Like Forms (GLFs)



Chloride Deposits

Based on *Osterloo et al.*, 2010

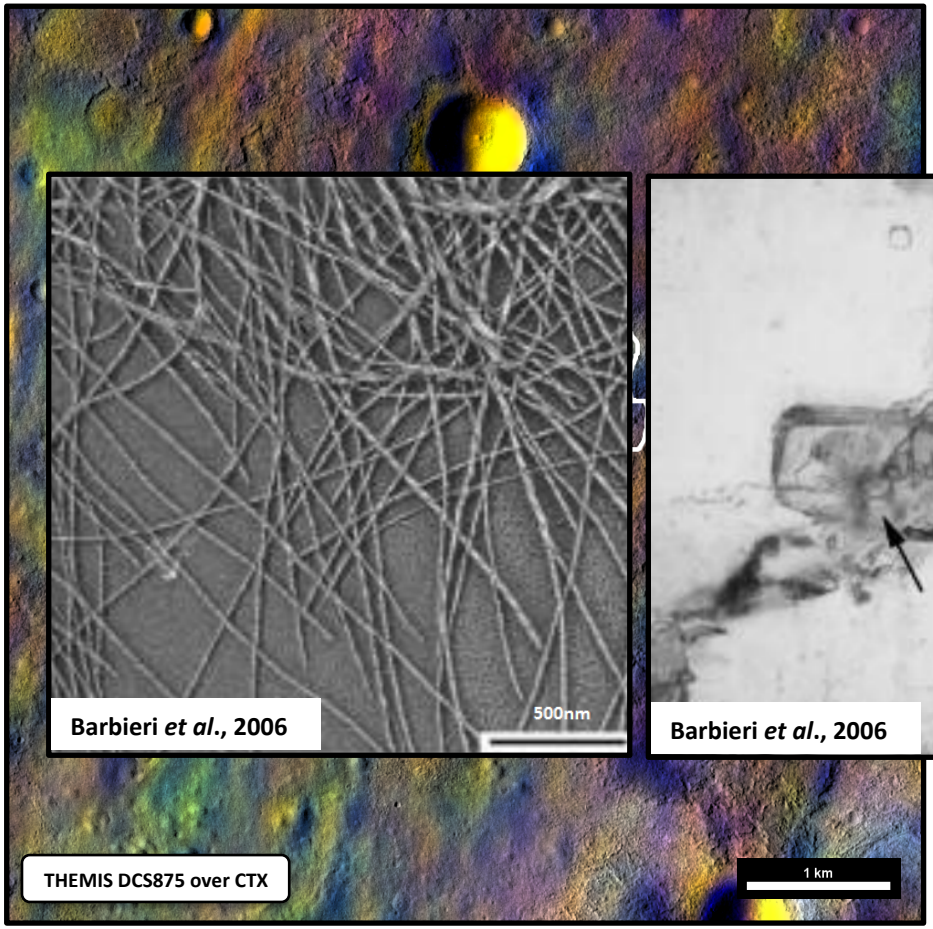


Glacier-Like Forms

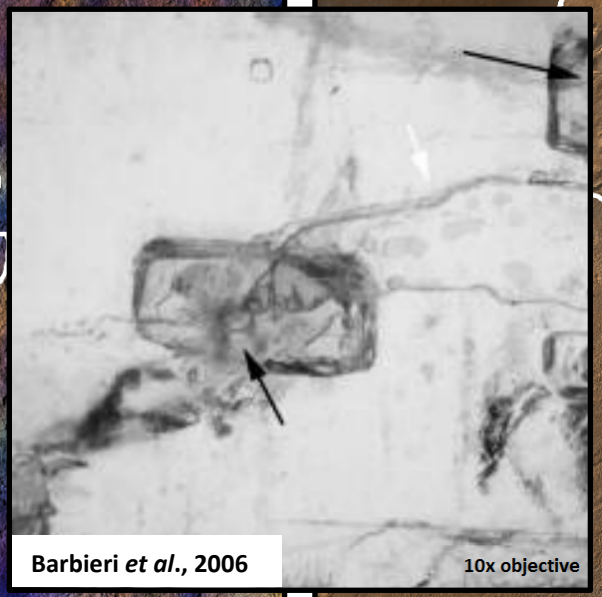
Based on *Souness et al.*, 2012

Western Noachis Terra Chloride Deposits

Chlorides & Glacier-Like Forms (GLFs)



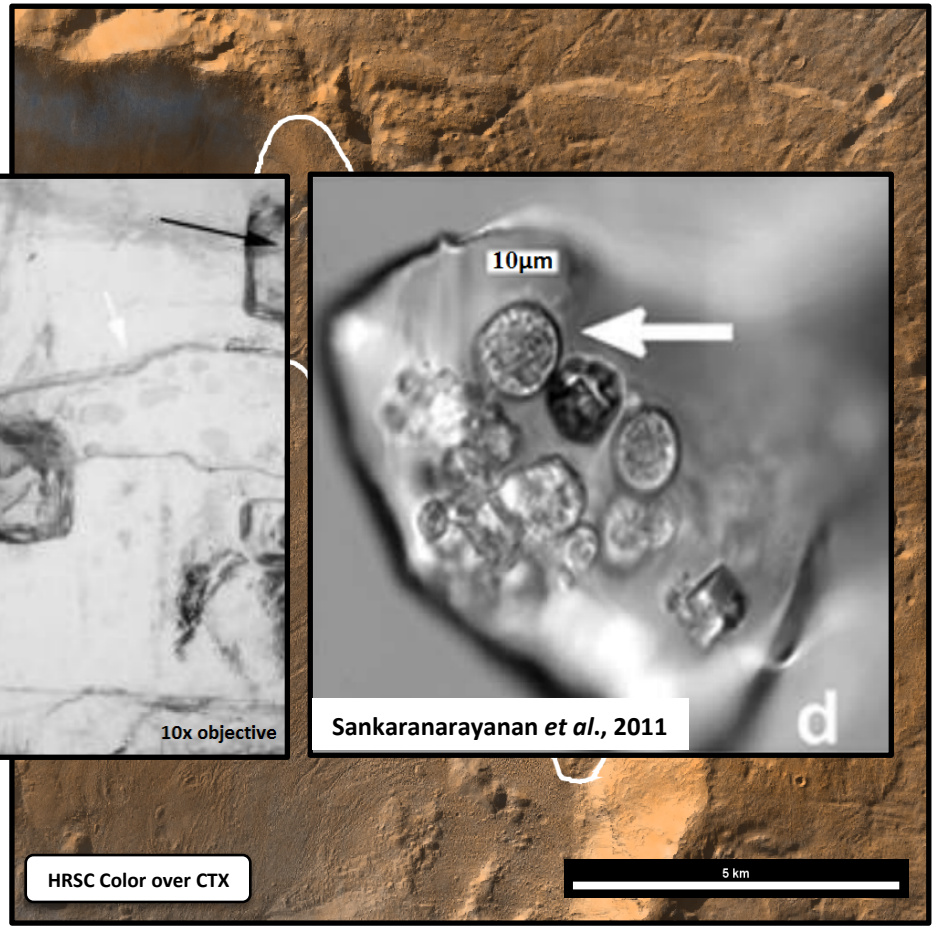
Barbieri *et al.*, 2006



Barbieri *et al.*, 2006

Chloride Deposits

Based on *Osterloo et al.*, 2010



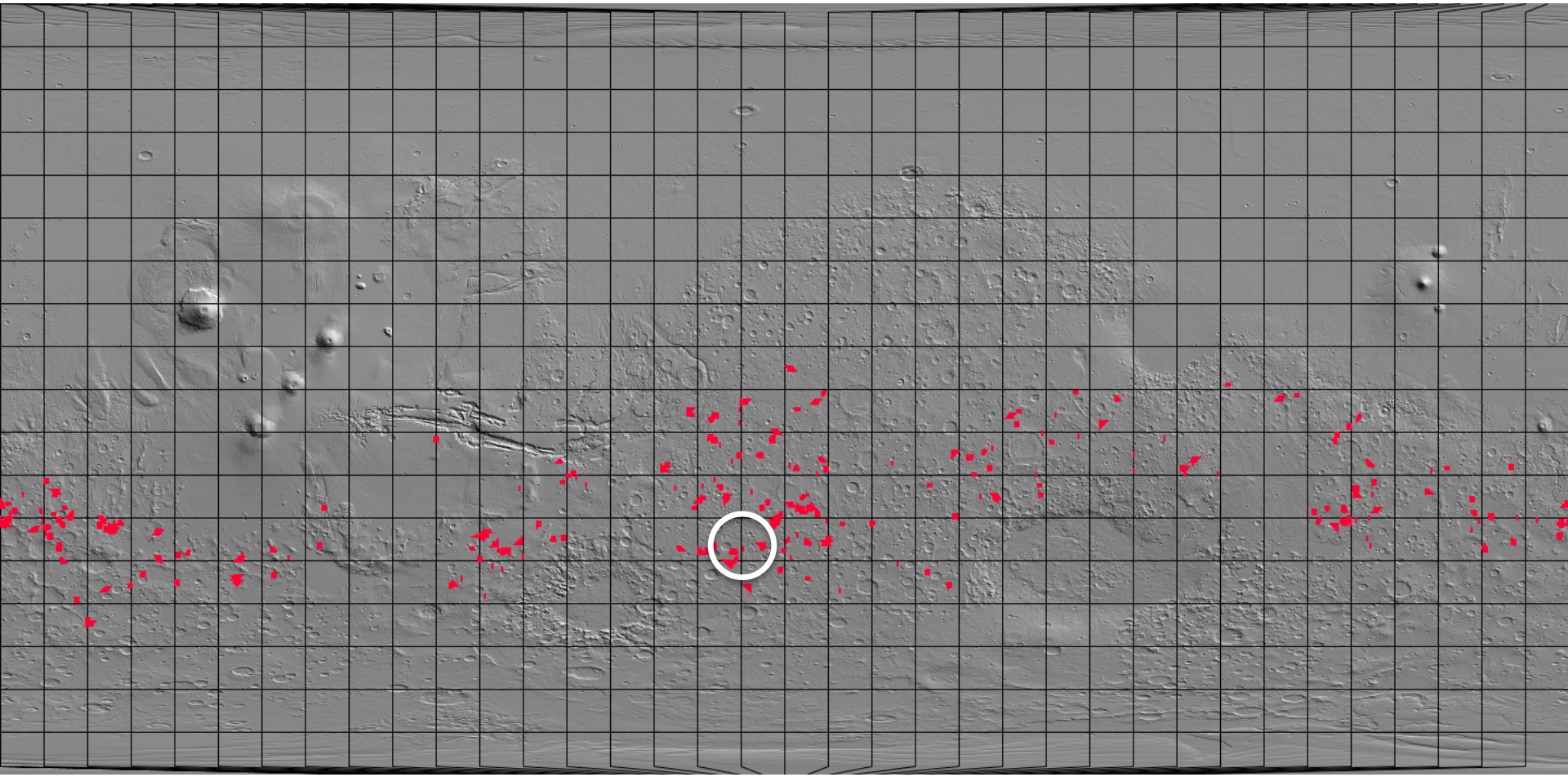
Sankaranarayanan *et al.*, 2011

Glacier-Like Forms

Based on *Souness et al.*, 2012

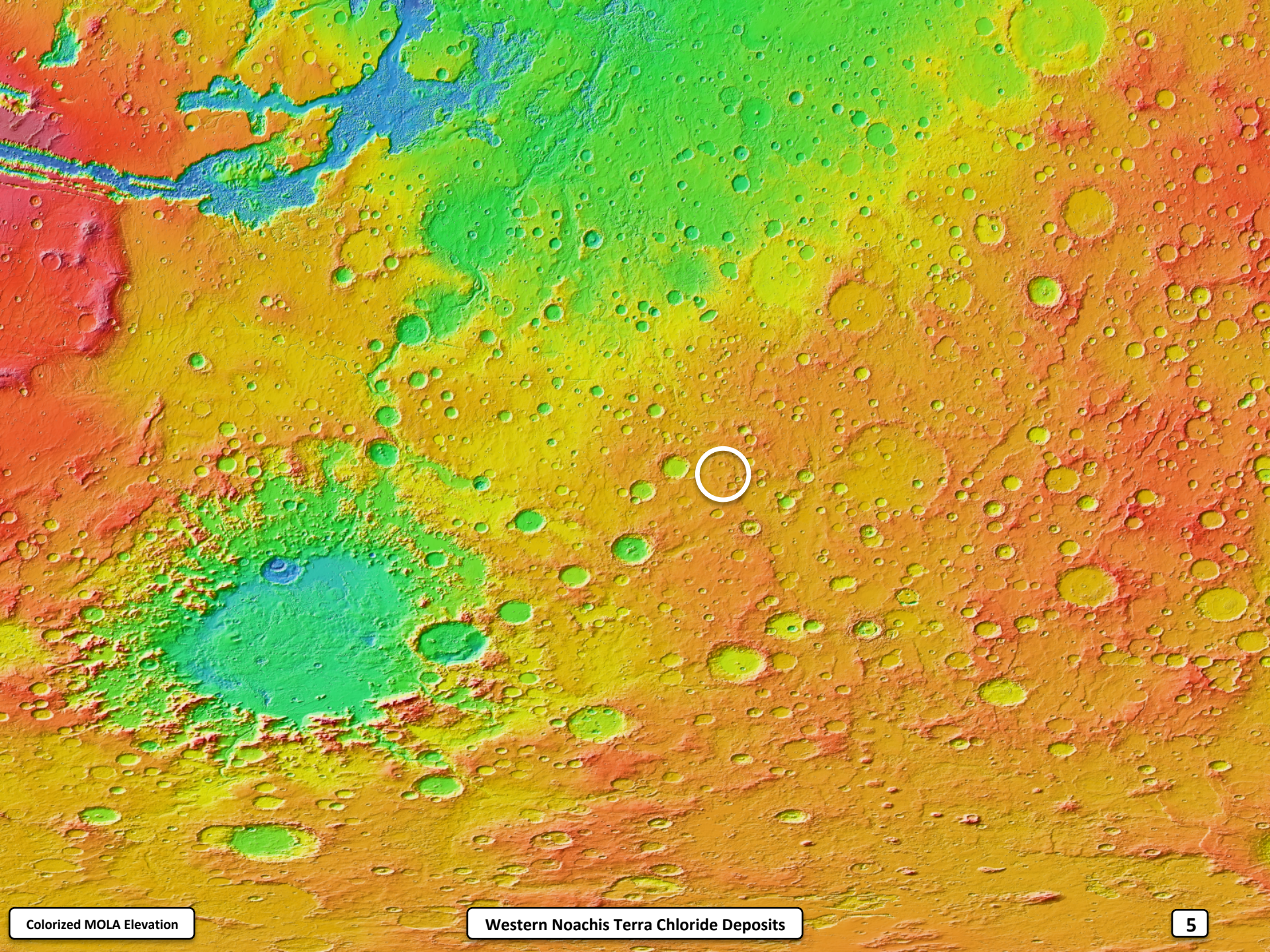
Western Noachis Terra Chloride Deposits

Global Chloride Distribution



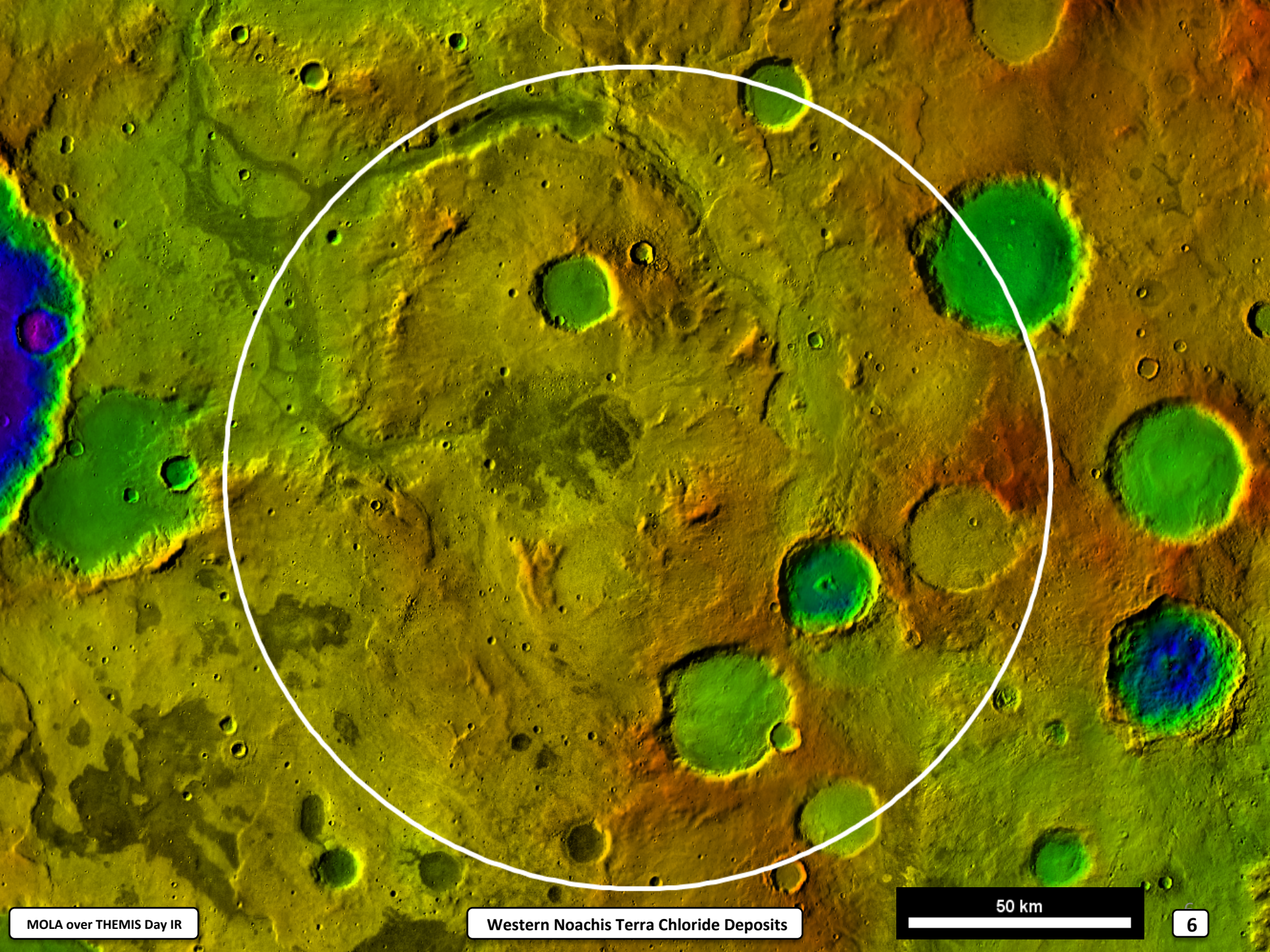
MOLA Shaded Relief

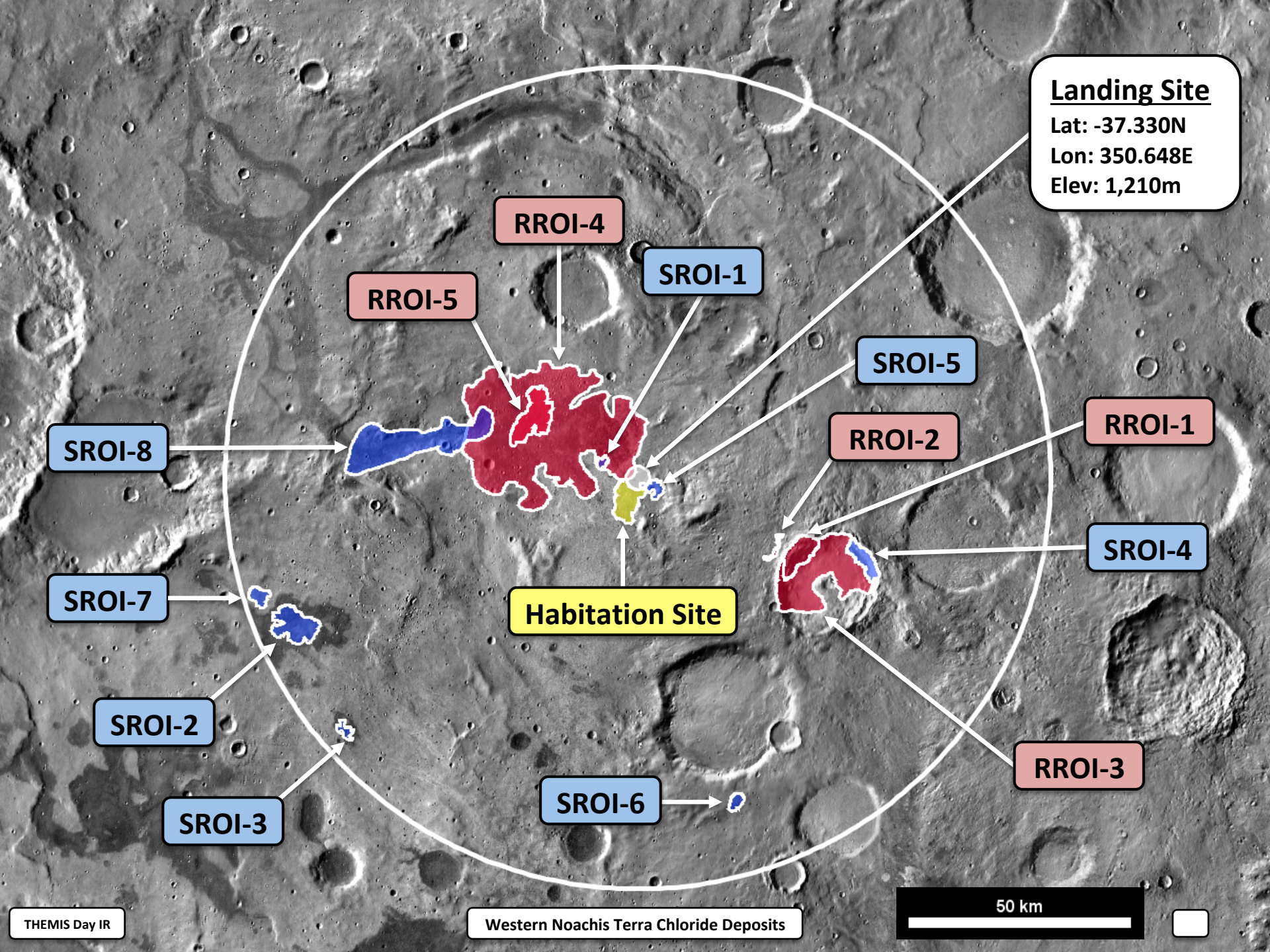
Western Noachis Terra Chloride Deposits



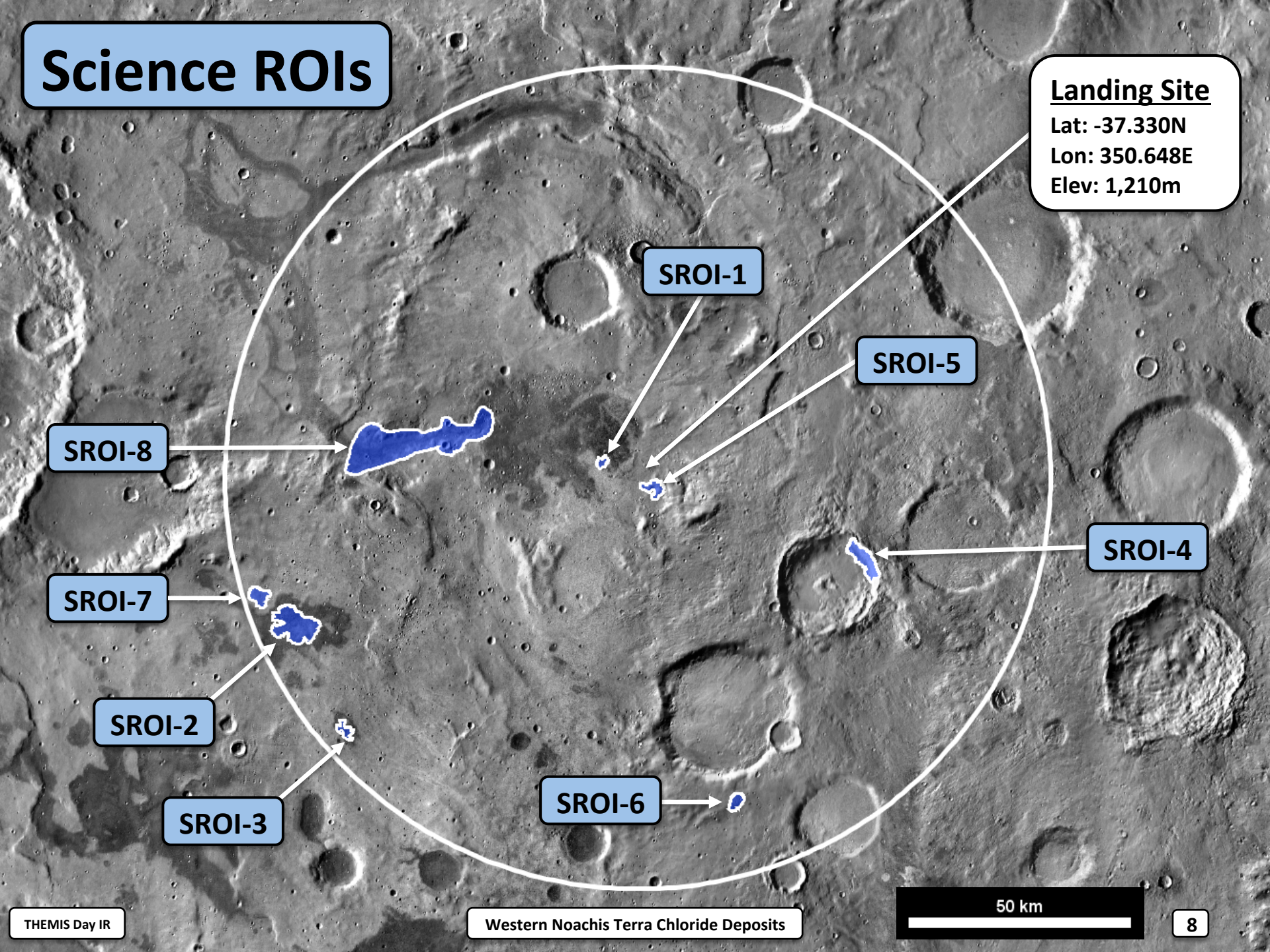
Colorized MOLA Elevation

Western Noachis Terra Chloride Deposits

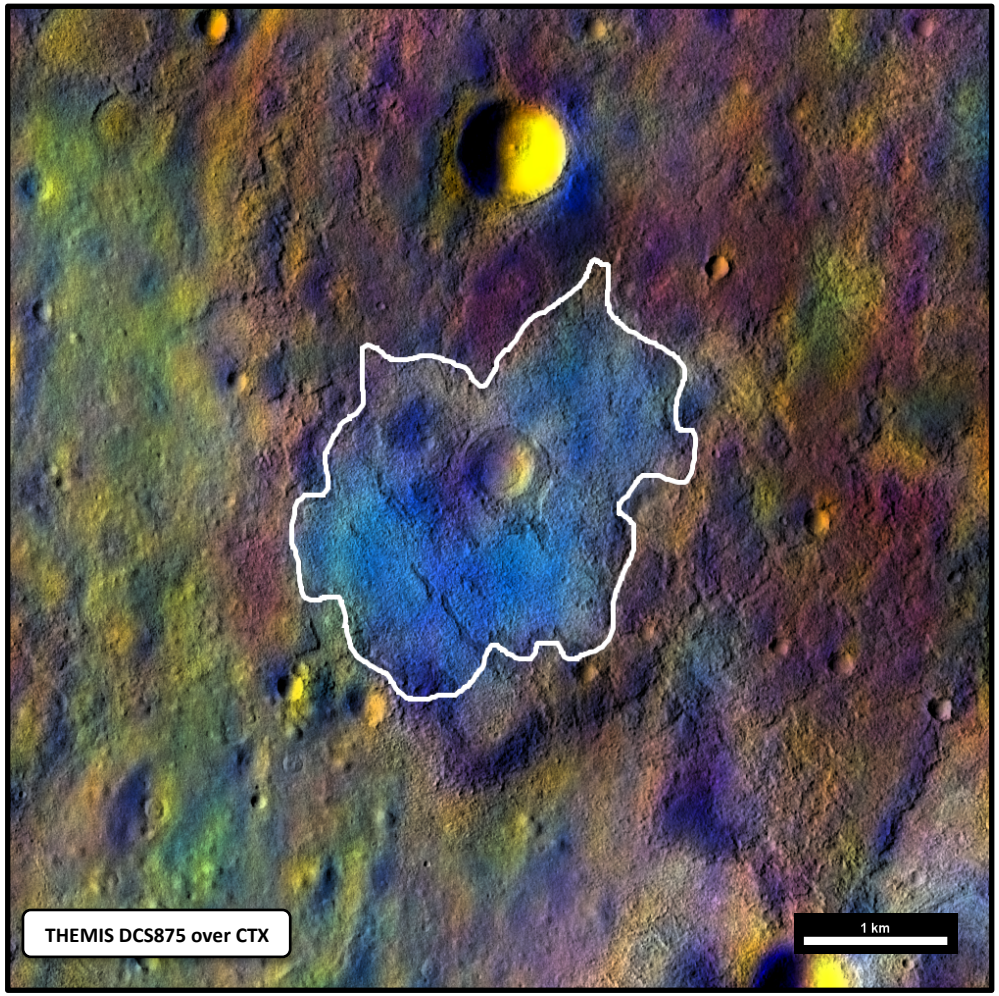

MOLA over THEMIS Day IR
Western Noachis Terra Chloride Deposits
50 km
6


Landing Site
Lat: -37.330N
Lon: 350.648E
Elev: 1,210m
RROI-4
SROI-1
RROI-5
SROI-5
RROI-1
RROI-2
SROI-8
SROI-4
SROI-7
Habitation Site
SROI-2
RROI-3
SROI-6
SROI-3
50 km
THEMIS Day IR
Western Noachis Terra Chloride Deposits

Science ROIs



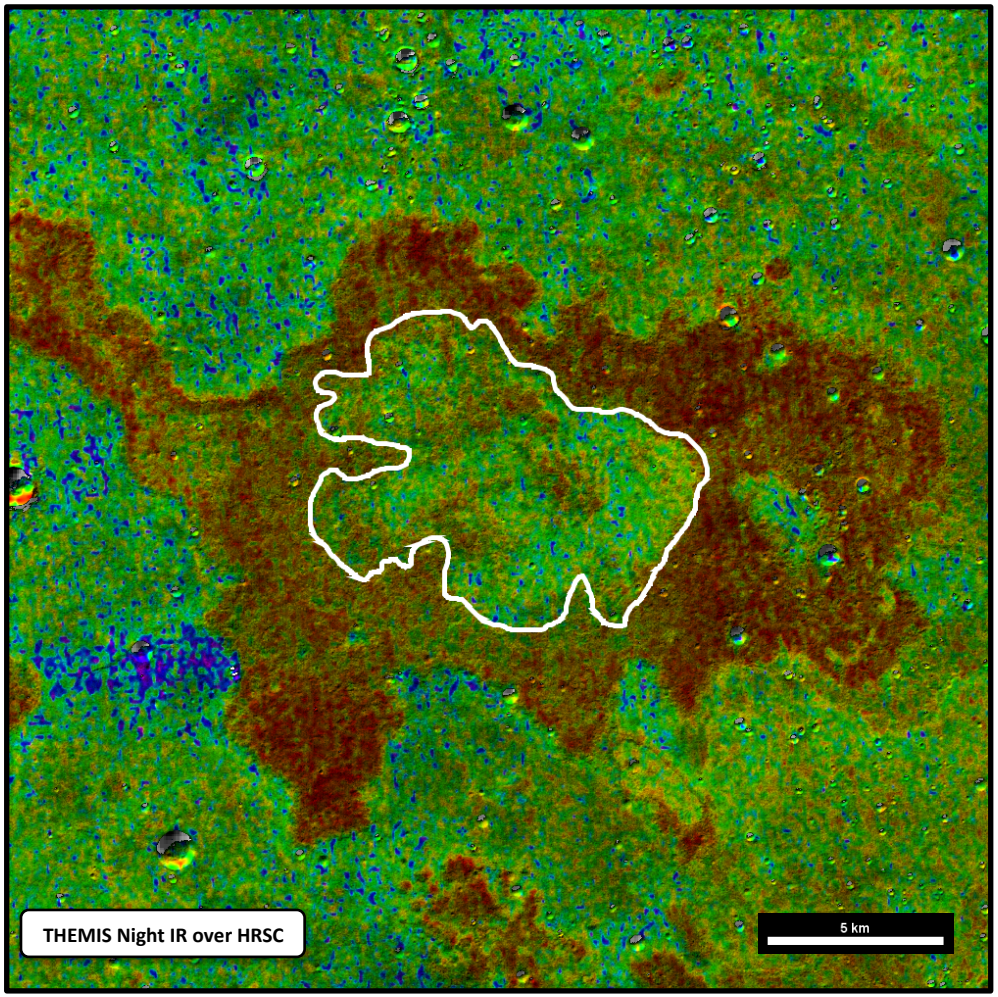
Science ROI 1: Chloride Deposit 1



Location: -37.267N, 350.467E
Elevation: 1,158m
Coverage: THEMIS, CTX

- Chloride mineral(s) deposit with high astrobiological preservation potential
- Basaltic unit with ~15% olivine abundance (TES spectra), likely phyllosilicates, possibly hydrated minerals

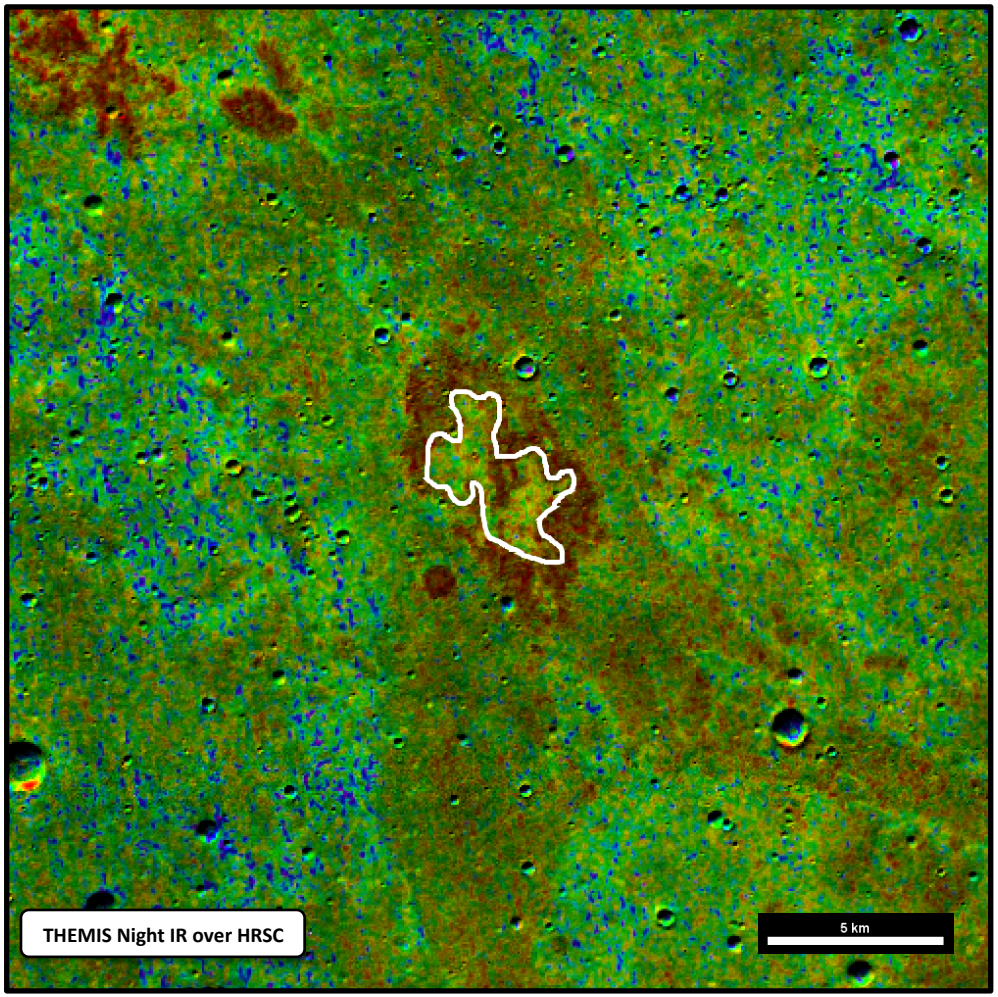
Science ROI 2: Chloride Deposit 2



Location: -37.922N, 348.905E
Elevation: 1,160m
Coverage: THEMIS, CTX, HiRISE, CRISM

- Chloride mineral(s) deposit with high astrobiological preservation potential
- Basaltic unit with ~15% olivine abundance (TES spectra), phyllo-silicates (CRISM) and possibly hydrated minerals (CRISM)

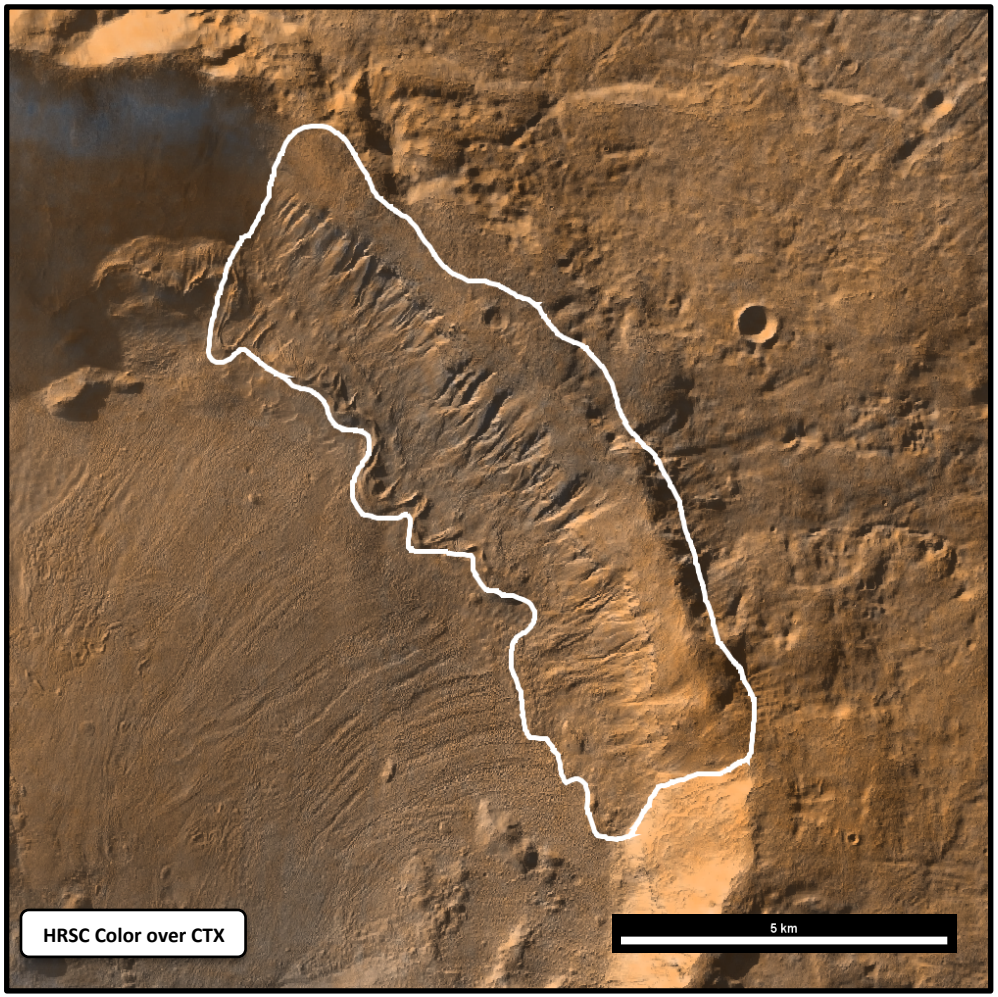
Science ROI 3: Chloride Deposit 3



Location: -38.347N, 349.141E
Elevation: 1,192m
Coverage: THEMIS, CTX

- Chloride mineral(s) deposit with high astrobiological preservation potential
- Basaltic unit with ~15% olivine abundance (TES spectra), likely phyllosilicates, possibly hydrated minerals

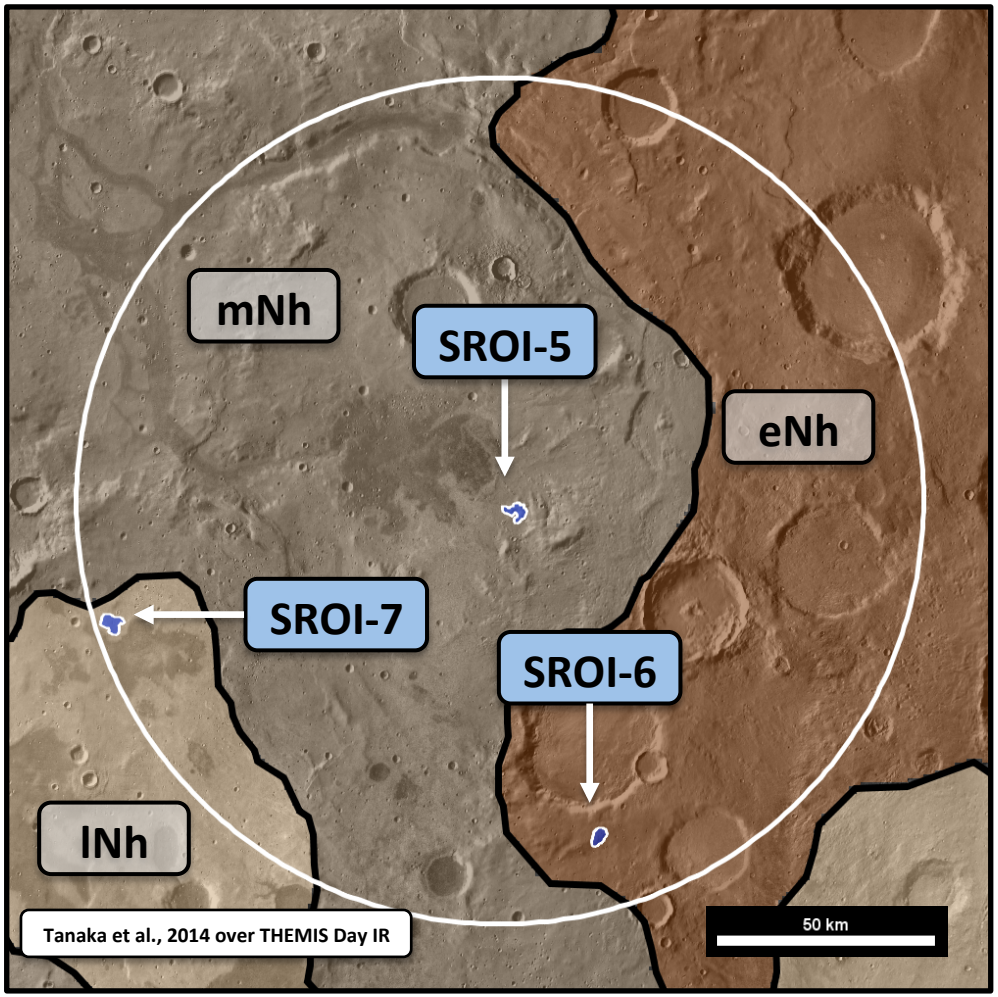
Science ROI 4: Gullies and Potential RSL



Location: -37.823N, 351.823E
Elevation: 668m – 1,711m
Coverage: THEMIS, CTX, HiRISE, CRISM

- Gullies and glacier-like forms on northeastern crater rim
- Morphology similar to RSLf bearing crater rims
  - If RSLs, access to potentially habitable environment
  - If not, access to an RSL analog environment without planetary protection concerns

Science ROIs 5,6, & 7



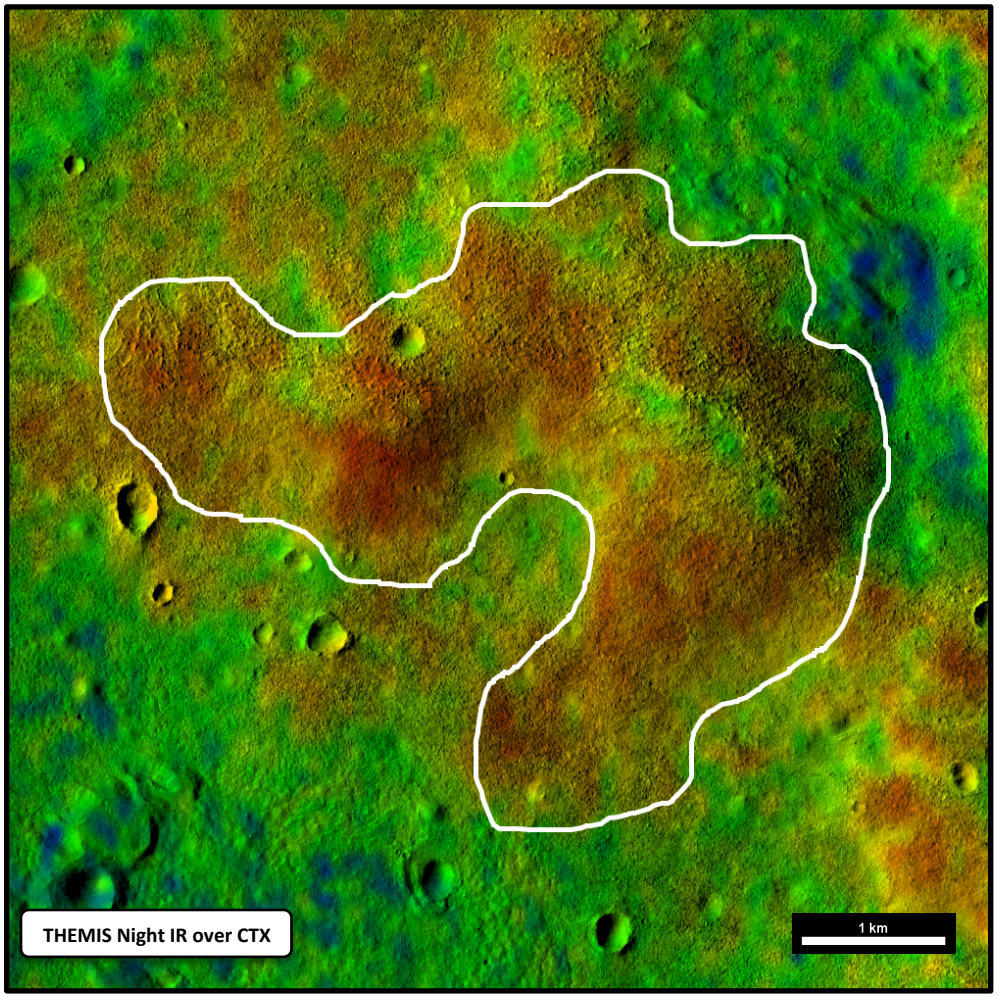
Tanaka et al., 2014 over THEMIS Day IR

eNh = Early Noachian Highlands

mNh = Middle Noachian Highlands

lNH = Late Noachian Highlands

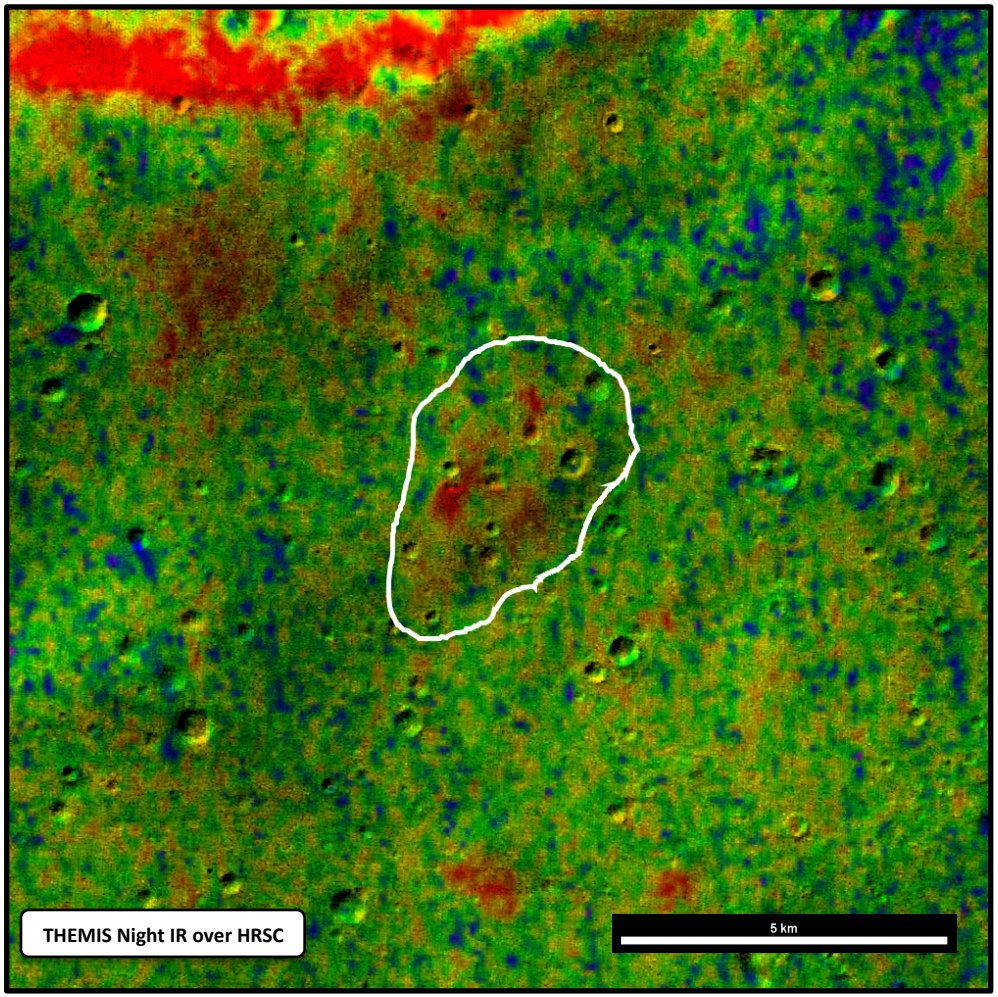
Science ROI 5: Middle Noachian Material



Location: -37.368N, 350.732E
Elevation: 1,231m – 1,389m
Coverage: THEMIS, CTX

- High thermal inertia region with potential outcrops of middle Noachian material
- Lies partially within the proposed landing site

Science ROI 6: Early Noachian Material

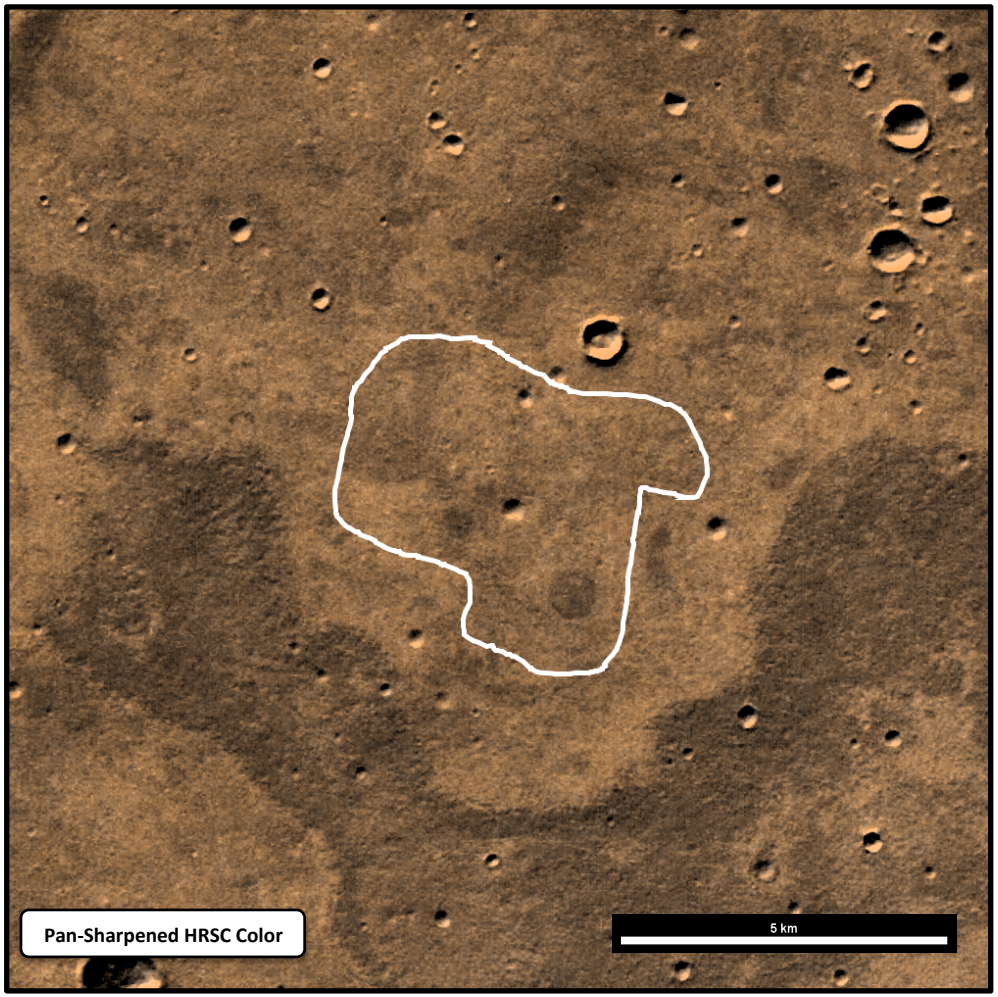


Location: -38.667N, 351.165E
Elevation: 1,546m – 1,655m
Coverage: THEMIS, HRSC

- Slightly higher thermal inertia region with potential outcr ops ofearly Noachian material
- Remnant (negative) magnetic field based on MAG/ER measurements

Western Noachis Terra Chloride Deposits

Science ROI 7: Late Noachian Material

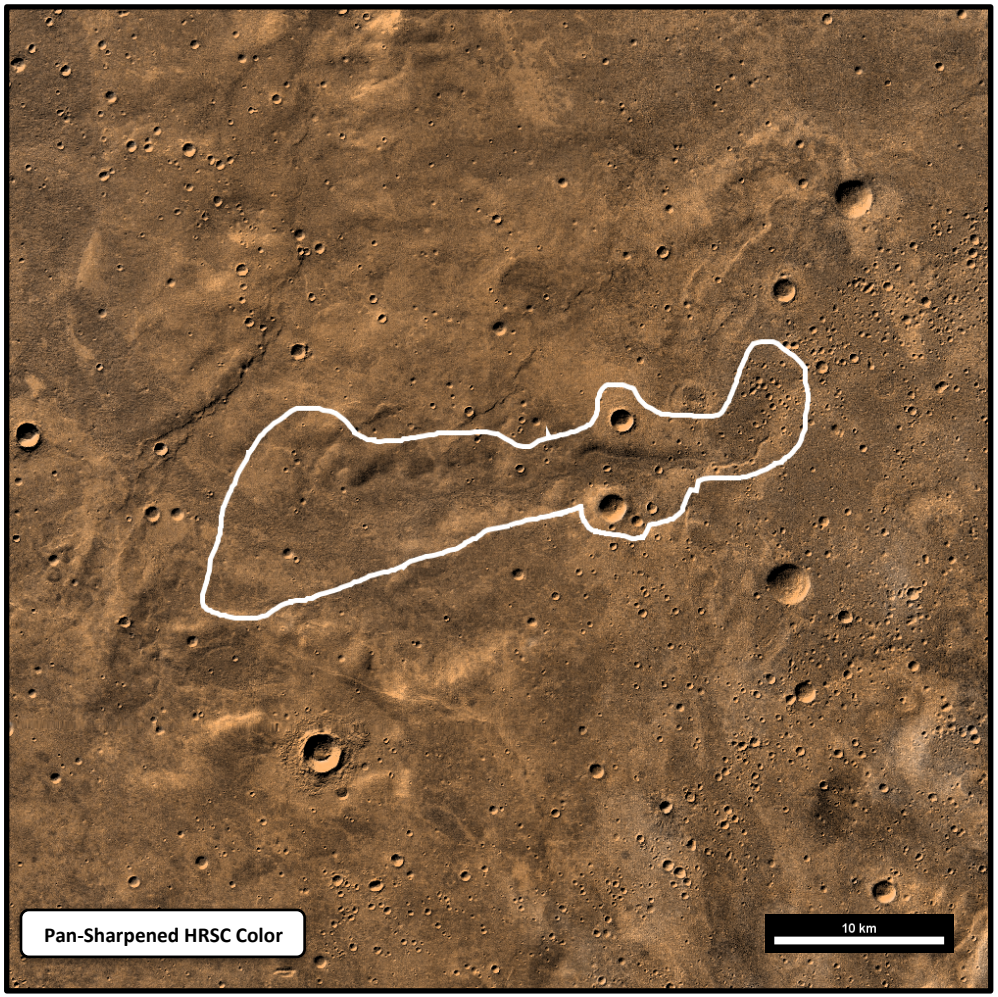


Location: -37.817N, 348.699E
Elevation: 1,192m – 1,217m
Coverage: THEMIS, HRSC

- Slightly higher thermal inertia region with potential outcr ops oflate Noachian material
- Remnant (positive) magnetic field based on MAG/ER measurements

Western Noachis Terra Chloride Deposits

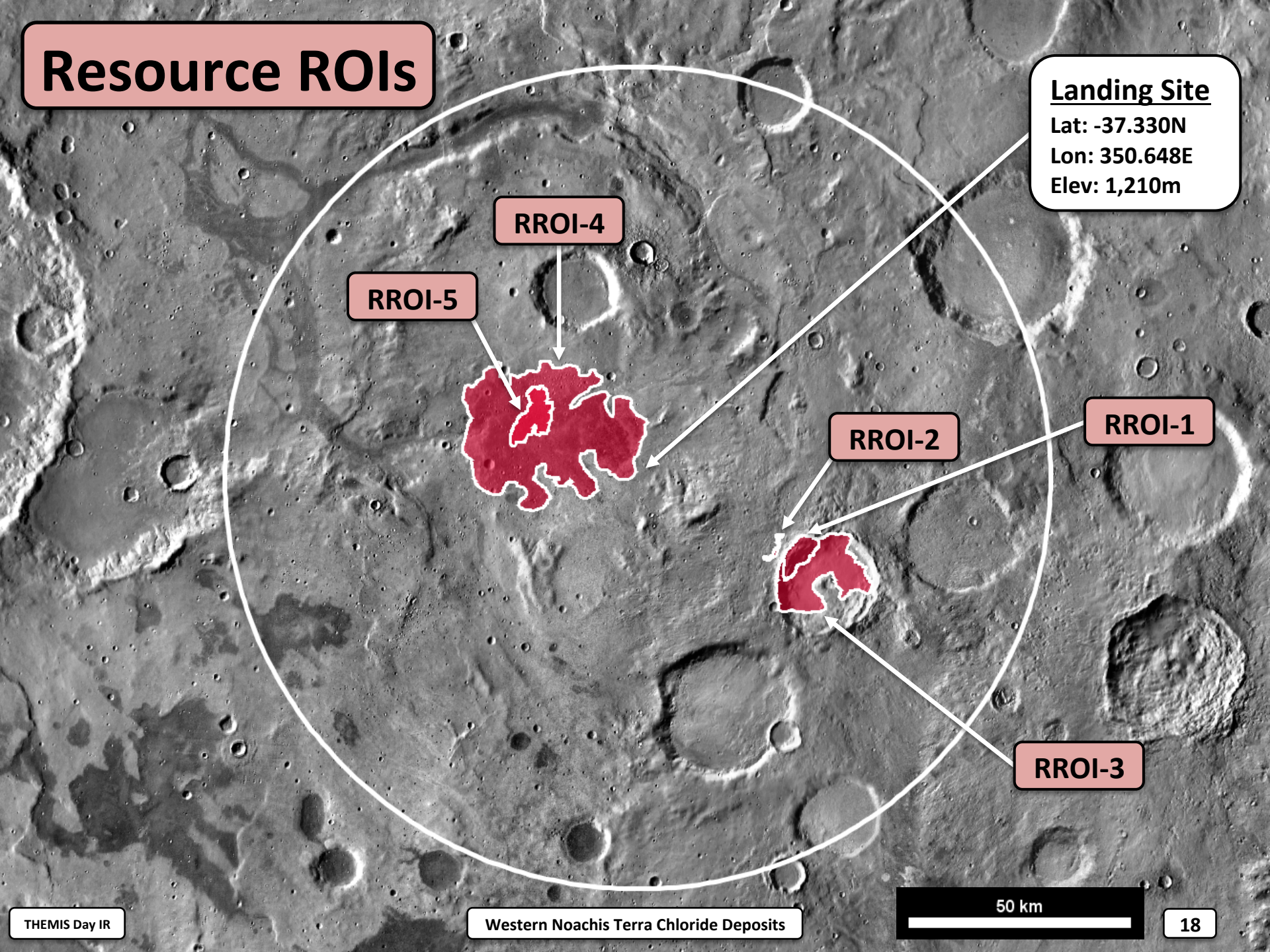
Science ROI 8: Channel with Stratigraphy



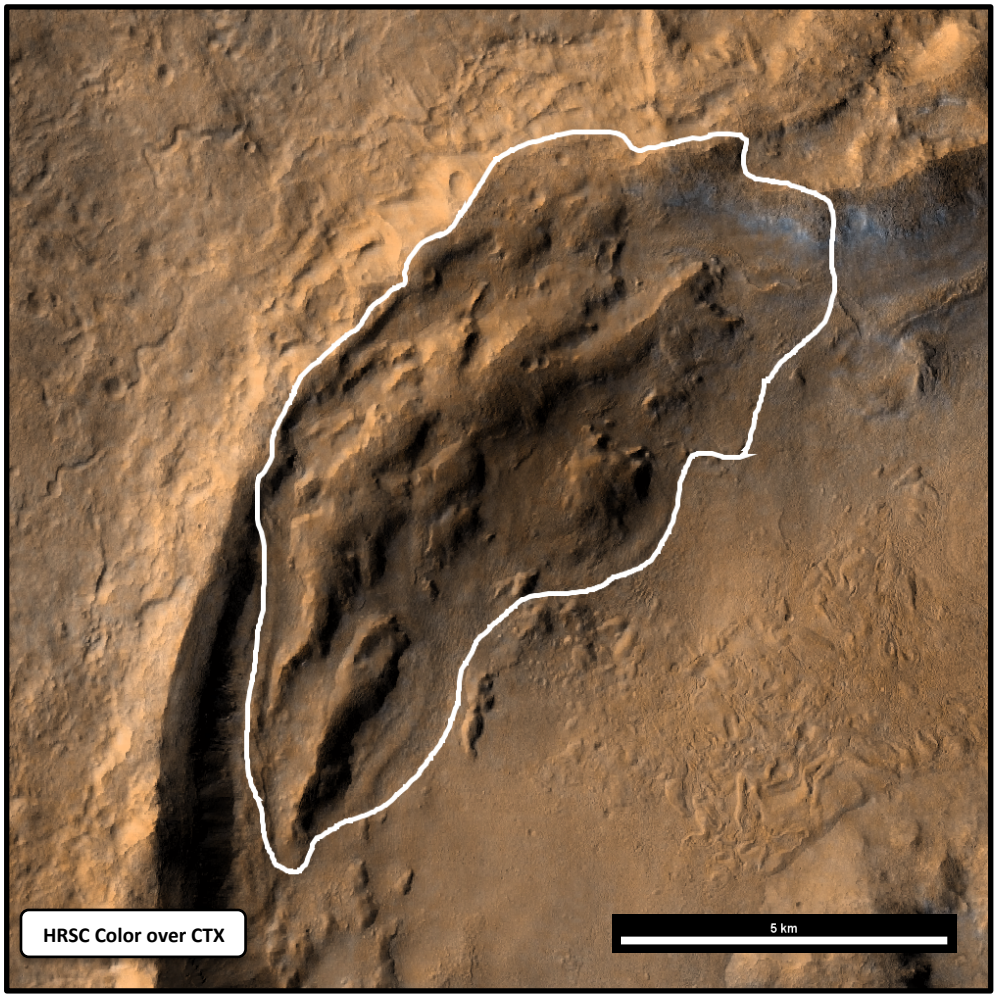
Location: -37.184N, 349.537E
Elevation: 1,105m – 1,204m
Coverage: THEMIS, HRSC

- Outflow channel from the basin containing the primary chloride deposit
- Stratigraphy likely exposed in the steep-walled sections of the channel

Resource ROIs



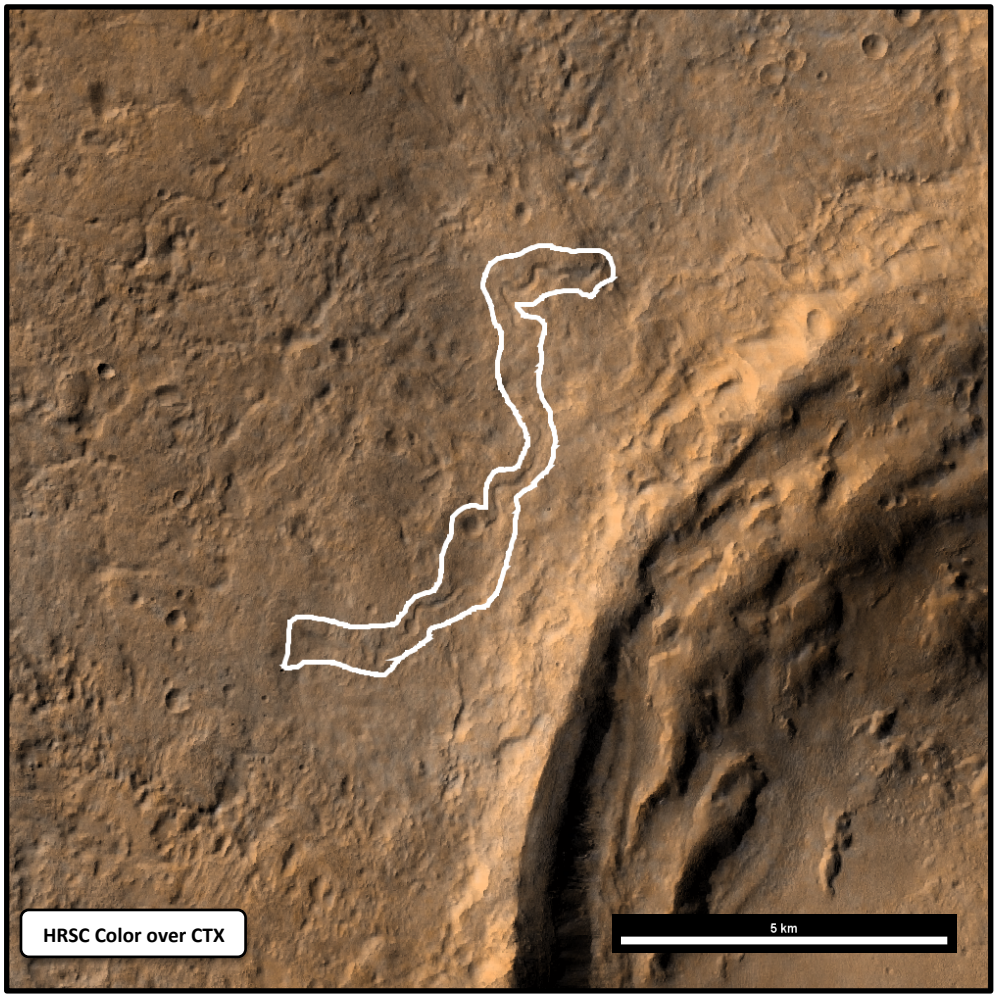
Resource ROI 1: Pasted Terrain



Location: -37.636N, 351.475E
Elevation: 825m – 1,476m
Coverage: THEMIS, HRSC, CTX

- Residual ice under thin armor of dust/regolith on south-facing crater rim
- Patches closer to the rim are more accessible from the landing site

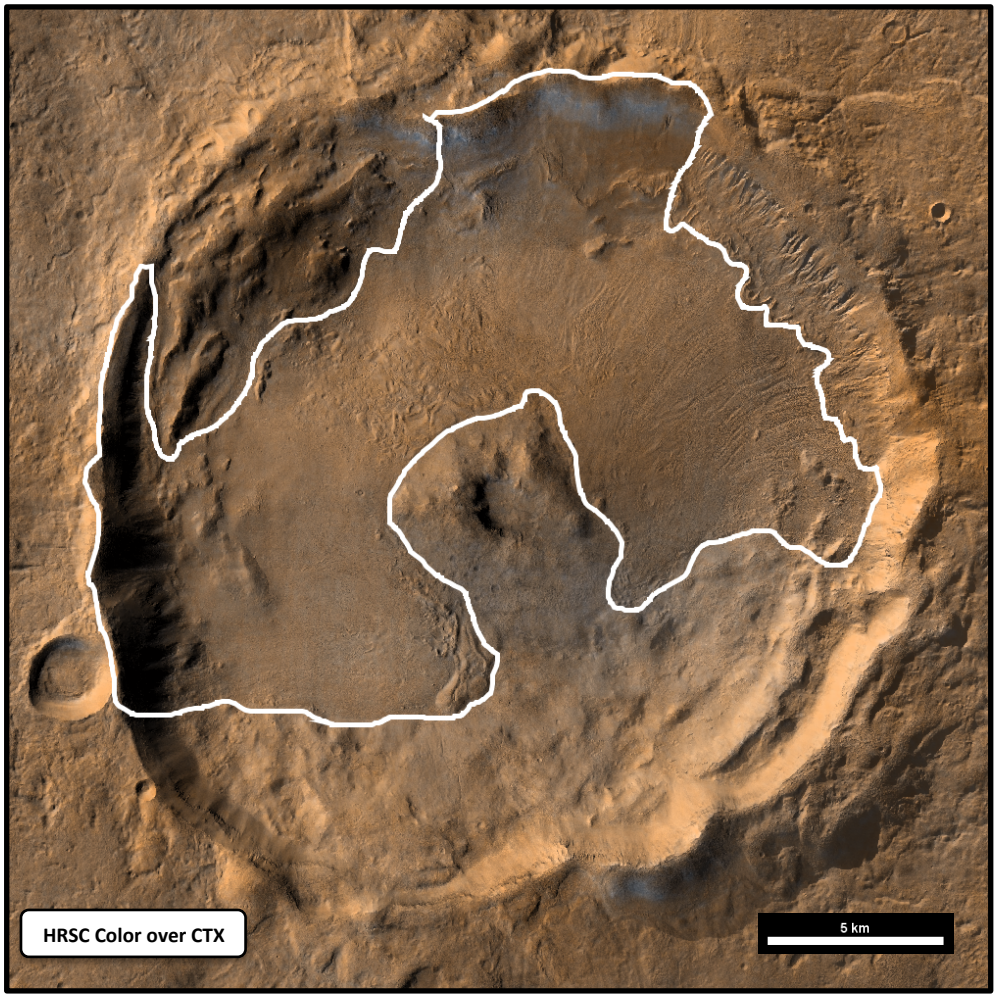
Resource ROI 2: Lineated Valley Fill



Location: -37.616N, 351.367E
Elevation: 1,247m – 1,355m
Coverage: THEMIS, HRSC, CTX

- Potential lineated valley fill in crater ejecta
- Could indicate additional subsurface water ice deposits
- More accessible than RROI-1, but more difficult to confirm due to lack of high resolution data

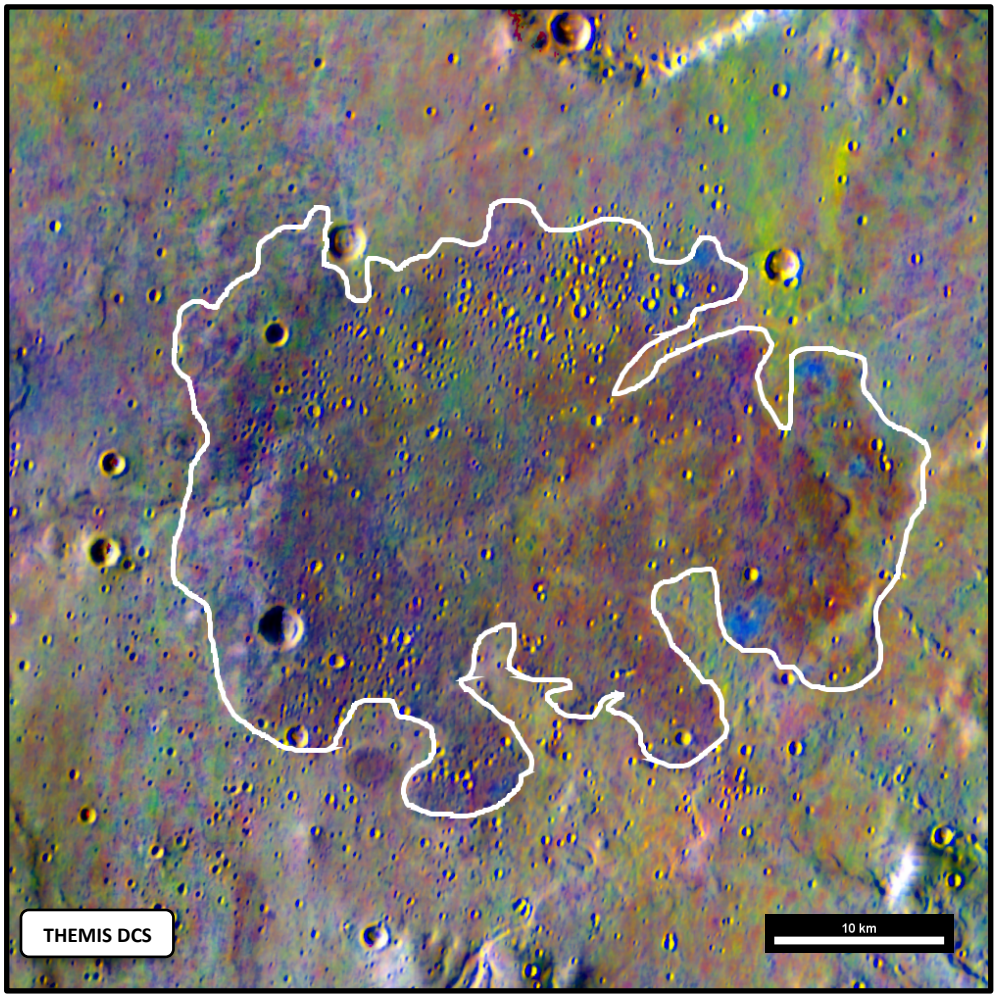
Resource ROI 3: Lineated Crater Fill



Location: -37.753N, 351.625E
Elevation: 273m – 1,731m
Coverage: THEMIS, HRSC, CTX

- Subsurface ice under thin armor of dust/regolith on crater floor
- Appears similar to concentric crater fill, but is not continuous around the crater
- SHARAD profiles have been acquired over this deposit, but need analysis

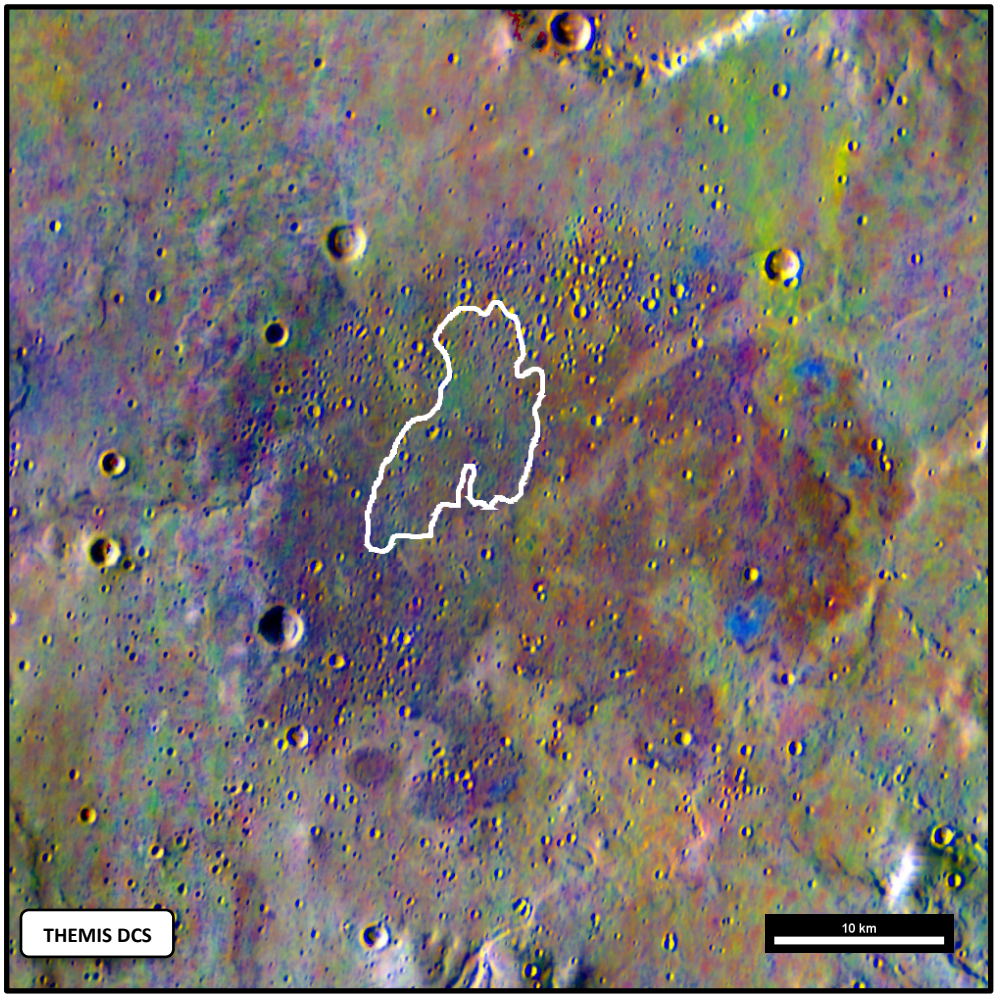
Resource ROI 4: Olivine-Bearing Basalt



Location: -37.141N, 350.188E
Elevation: 1,133m – 1,213m
Coverage: THEMIS, HRSC, CTX

- Basaltic volcanic unit that appears to underlie the primary chloride deposit
- TES spectra show an ~15% olivine abundance, but Fo number not yet determined
- CRISM data expected to confirm presence of hydrated minerals

Resource ROI 5: Silica-Enriched Material



Location: -37.072N, 350.120E
Elevation: 1,130m – 1,157m
Coverage: THEMIS, HRSC, CTX

- Additional region of silica enrichment on the surface
- TES spectra indicate an ~25% abundance of a high-silica material

Western Noachis Terra Chloride Deposits

Science ROIs Rubric

1st EZ Workshop for Human Missions to Mars

				Site Factors	SROI-1	SROI-2	SROI-3	SROI-4	SROI-5	SROI-6	SROI-7	SROI-8	RROI-1	RROI-2	RROI-3	RROI-4	RROI-5	LS	HS	EZ SUM
Science Site Criteria	Astrobio	Threshold	AND/OR	**Potential for past habitability**	●	●	●													3,0
				Potential for present habitability/refugia				○												0,1
		Qualifying		Potential for organic matter, w/ surface exposure	●	●	●													3,0
	Atmospheric Science	Threshold		**Noachian/Hesperian rocks w/ trapped atmospheric gases**	○	○	○		○	○	○	○				○	○	○	○	0,11
		Qualifying		Meteorological diversity in space and time	●	●	●	●				●	●	●	●		○			8,1
				High likelihood of surface-atmosphere exchange				○					○	○	○					0,4
				Amazonian subsurface or high-latitude ice or sediment				●					●	●	●					4,0
				High likelihood of active trace gas sources	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
	Geoscience	Threshold		**Range of martian geologic time; datable surfaces**	○	○	○		●	●	●				○	○	○	●	●	5,6
				Evidence of aqueous processes	●	●	●	●				●		●						6,0
				Potential for interpreting relative ages	●	●	●	●				●				●	●			8,0
		Qualifying		Igneous Rocks tied to 1+ provinces or different times	●	●	●		●	●	●	●				●	●	●	○	10,0
				Near-surface ice, glacial or permafrost				○					●	○	●					2,2
				Noachian or pre-Noachian bedrock units	○	○	○		●	●	●					○	○	●	●	5,5
				Outcrops with remnant magnetization						●	●									2,0
				Primary, secondary, and basin-forming impact deposits	○	○	○							●		○	○			1,5
				Structural features with regional or global context																0,0
				Diversity of aeolian sediments and/or landforms	○	○	○									●				1,3

Resource ROIs Rubric

1st EZ Workshop for Human Missions to Mars

				Site Factors	SROI-1	SROI-2	SROI-3	SROI-4	SROI-5	SROI-6	SROI-7	SROI-8	RROI-1	RROI-2	RROI-3	RROI-4	RROI-5	LS	HS	EZ SUM
ISRU and Civil Engineering Criteria	Engineering			Meets First Order Criteria (Latitude, Elevation, Thermal Inertia)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	15,0
	Water Resource	Threshold	AND/OR	**Potential for ice or ice/regolith mix**				●					●	○	●					3,1
				Potential for hydrated minerals	○	○	○									○	○			0,5
				Quantity for substantial production				●					●	○	●					3,1
				Potential to be minable by highly automated systems				○					●	○	●					2,2
				Located less than 3 km from processing equipment site	○															0,1
				Located no more than 3 meters below the surface				○					○	○	○					0,4
				Accessible by automated systems	●	●	●	○					○	○	○	●	●			5,4
		Qualifying		Potential for multiple sources of ice, ice/regolith mix **and** hydrated minerals	○	●	○	●					●	○	●	○	○			4,5
				Distance to resource location can be >5 km	○	●	●	●					●	●	●	●	●			9,1
				Route to resource location must be (plausibly) traversable	●	●	●	○					●	●	○	●	●			7,2
	Civil Engineering	Threshold		**~50 sq km region of flat and stable terrain with sparse rock distribution**															●	1,0
				1–10 km length scale: <10°														●	●	2,0
				Located within 5 km of landing site location															●	1,0
		Qualifying		Located in the northern hemisphere																0,0
				Evidence of abundant cobble sized or smaller rocks and bulk, loose regolith	●	●	●		○	○	○	○				●	●	○	●	6,5
				Utilitarian terrain features															○	0,1
	Food Production	Qualifying		Low latitude																0,0
				No local terrain feature(s) that could shadow light collection facilities	●	●	●		●	●	●		○	○		●	●	●	●	10,2
				Access to water	○	●	○	●					●	○	●	○	○			4,5
				Access to dark, minimally altered basaltic sands	●	●	●		○	○	○	○				●	●	○		5,5
	Metal/Silicon Resource	Threshold		**Potential for metal/silicon**	●	●	●									●	●			5,0
				Potential to be minable by highly automated systems	●	●	●									●	●			5,0
				Located less than 3 km from processing equipment site	●															1,0
				Located no more than 3 meters below the surface	●	●	●									●	●			5,0
				Accessible by automated systems	●	●	●									○	●			4,1
		Qualifying		Potential for multiple sources of metals/silicon	●	●	●									●	●			5,0
				Distance to resource location can be >5 km	●	●	●									●	●			5,0
				Route to resource location must be (plausibly) traversable	●	●	●									●	○			4,1

Highest Priority EZ Data Needs

Current Assets

- **Science:** HiRISE & CRISM FRT Pair of SROI-1
- **Resource:** CTX Stereo Pair of Traverse Route Between LS & RROI-1/RRO1-2

Potential Future Assets

- **Science:** Thermal IR Spectra >25µm
- **Resource:** Higher Resolution Subsurface Radar

Summary

- **Chloride Deposits**
  - Remnants of potentially habitable environments
  - High astrobiological preservation potential
- **Near-Surface Water Ice**
  - Significant water resources
  - Amazonian climate science
- **Additional ROIs representing a variety of other science and resource targets**

Backup Slides

References

Barbieri, Roberto, et al. "Microbial signatures in sabkha evaporite deposits of Chott el Gharsa (Tunisia) and their astrobiological implications." *Planetary and Space Science* 54.8 (2006): 726-736.

Osterloo, M. M., F. S. Anderson, V. E. Hamilton, and B. M. Hynek (2010), Geologic context of proposed chloride bearing materials on Mars, J. Geophys. Res., 115, E10012, doi: 10.1029/2010JE003613.

Sankaranarayanan K, Timofeeff MN, Spathis R, Lowenstein TK, Lum JK (2011) Ancient Microbes from Halite Fluid Inclusions: Optimized Surface Sterilization and DNA Extraction. PLoS ONE 6(6): e20683. doi:10.1371/journal.pone.0020683.

Souness, Colin, et al. "An inventory and population-scale analysis of martian glacier-like forms." *Icarus* 217.1 (2012): 243-255.

Prioritization List of EZ Data Needs

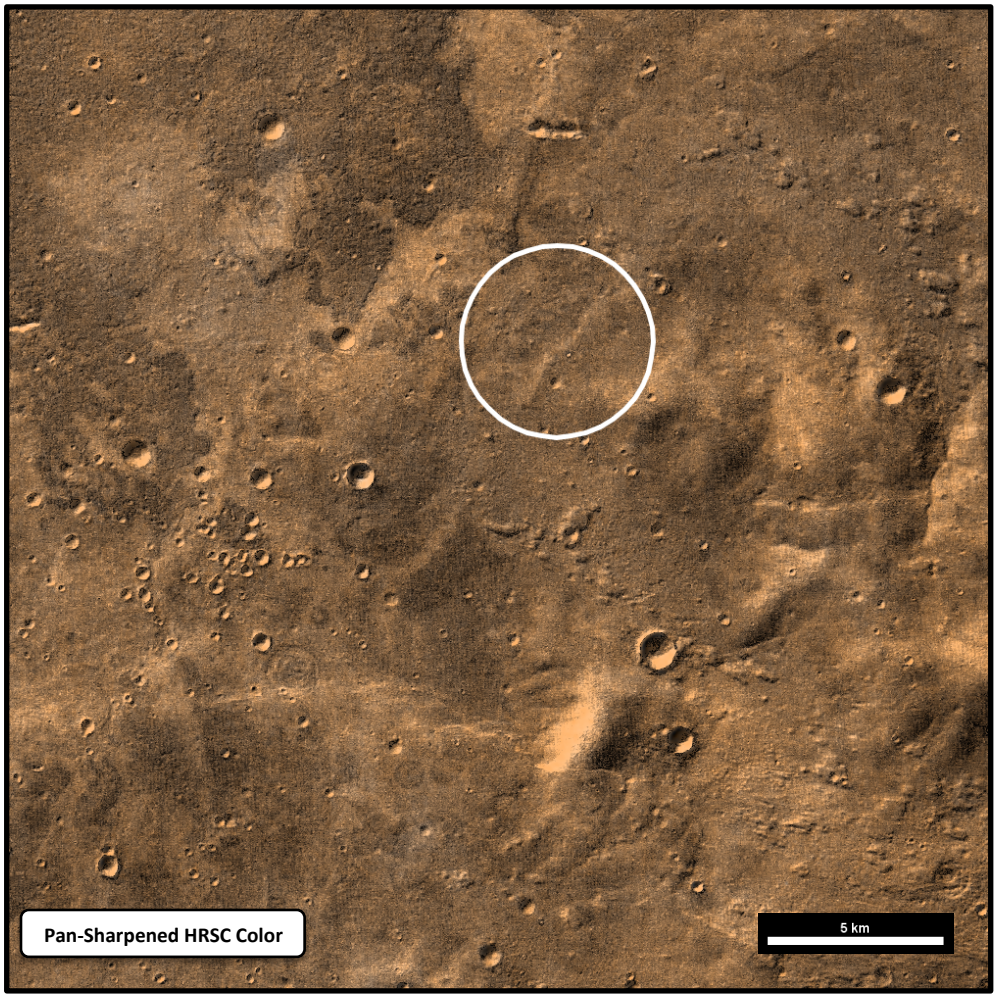
Science

1) HiRISE & CRISM FRT Pair of SROI-1
   - Verify stratigraphic relationship with volcanic unit and confirm co-occurrence of phyllosilicates
2) HiRISE & CRISM FRT Pair of SROI-3
   - Verify stratigraphic relationship with volcanic unit and confirm co-occurrence of phyllosilicates

Resource

1) CTX Stereo Pair of Traverse Route Between LS & RROI-1/2
   - Verify plausible traverse route
2) HiRISE & CRISM FRT Pair of RROI-2
   - Verify presence of lineated valley fill
3) HiRISE image(s) of Traverse Route Between LS & RROI-1/2
   - Plot plausible traverse route

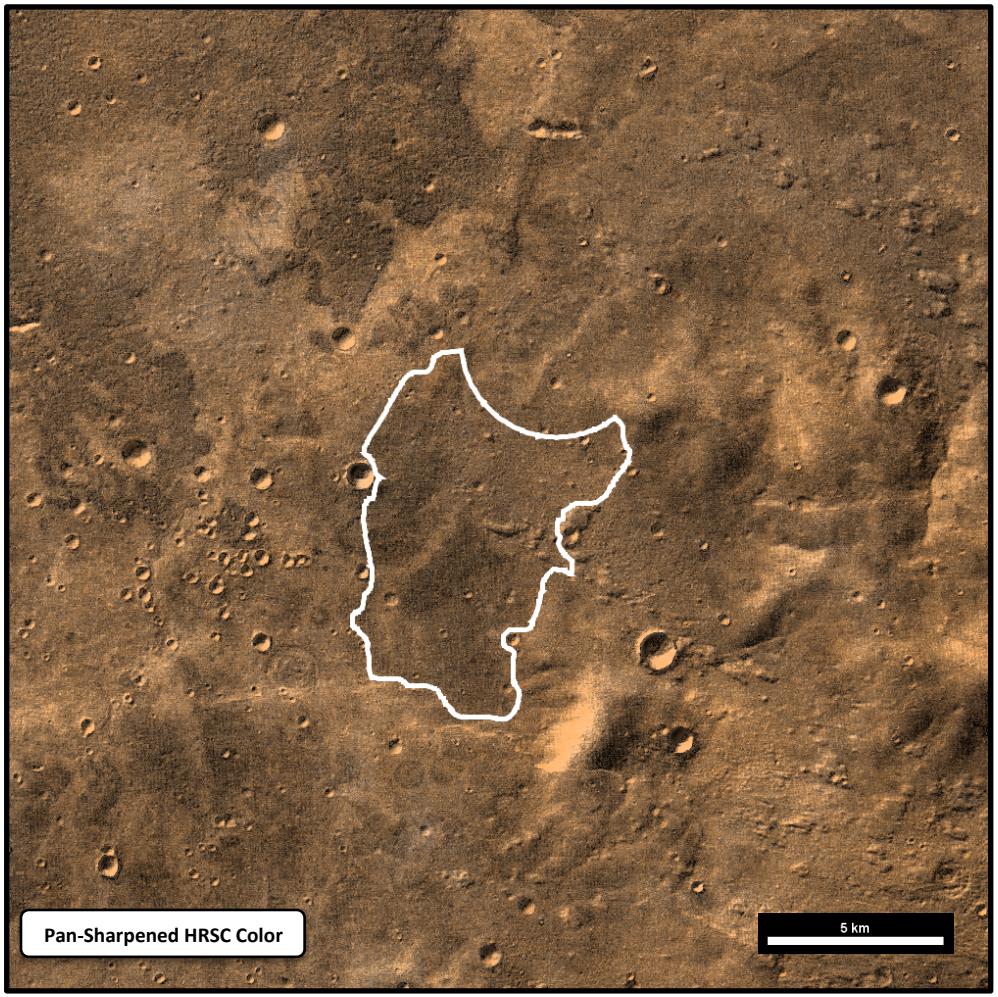
Landing Site



Location: -37.330N, 350.648E
Elevation: 1,210m
Coverage: THEMIS, HRSC, CTX

- Landing site of ~25km^2
- Meets all landing site requirements
- Intersects SROI-5 and RROI-5

Habitation Site



Location: -37.427N, 350.590E
Elevation: 1,189m – 1,246m
Coverage: THEMIS, HRSC, CTX

- Habitation site of ~50km^2
- Meets all habitation site requirements
- Adjacent to landing site