Presentation 1050

Noctis Landing

1st EZ Workshop for Human Missions to Mars

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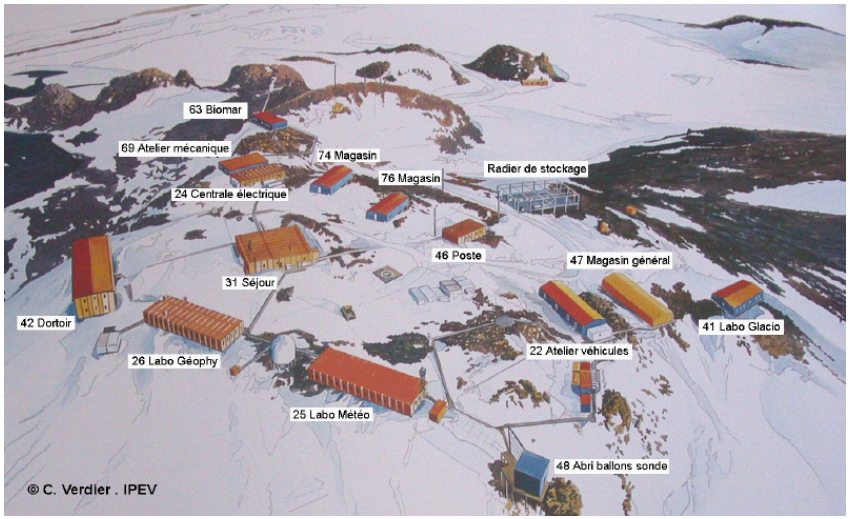
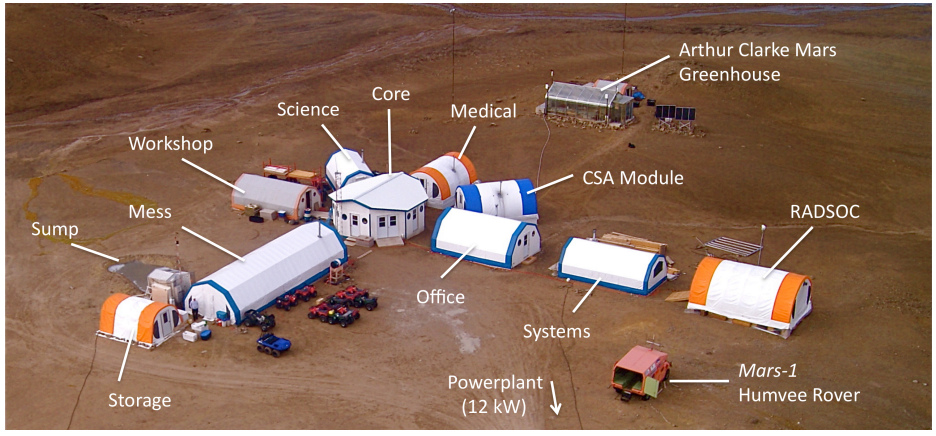
MI	Mars Institute
SETI	SETI Institute
ARC	Ames Research Center
JSC	Johnson Space Center

Experience
Antarctica

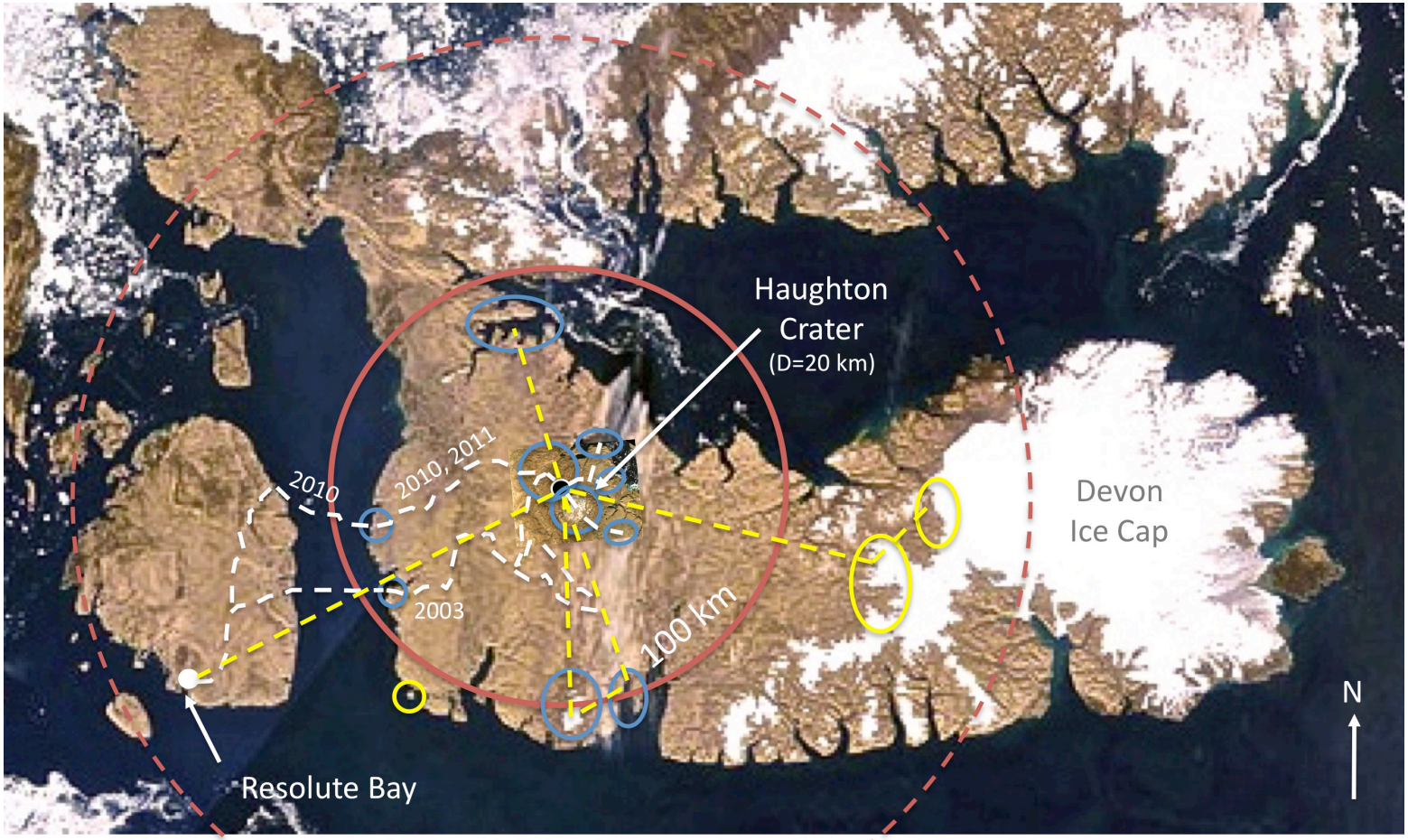


Experience

Haughton-Mars Project



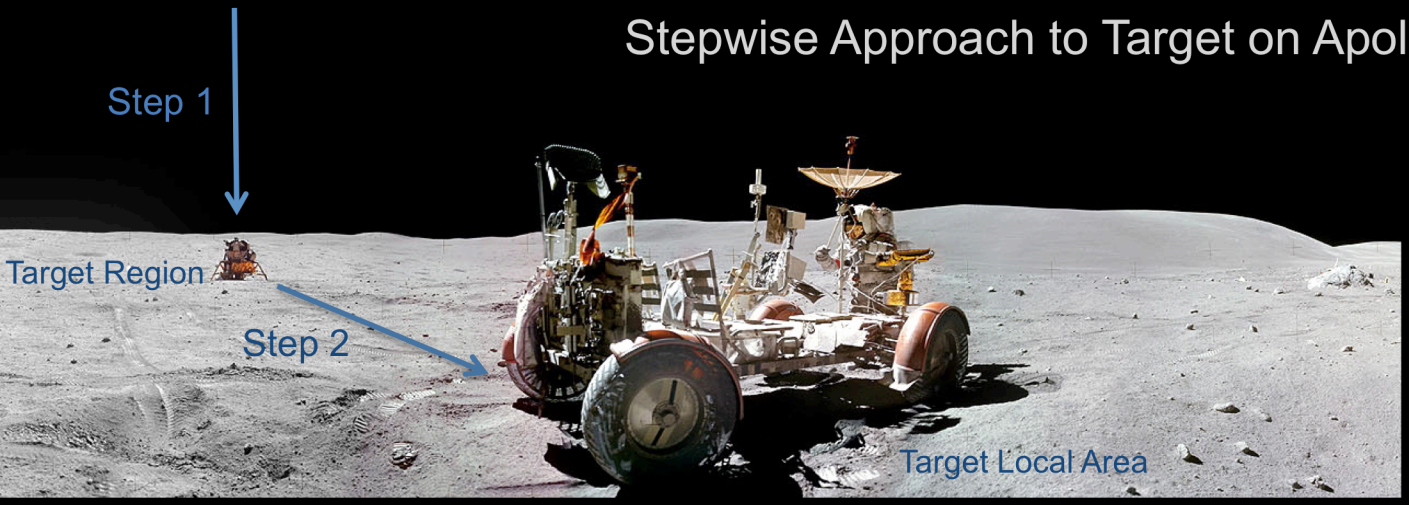
Haughton-Mars Project



HAUGHTON-MARS PROJECT
Devon Island, Arctic
Lee et al. 2015

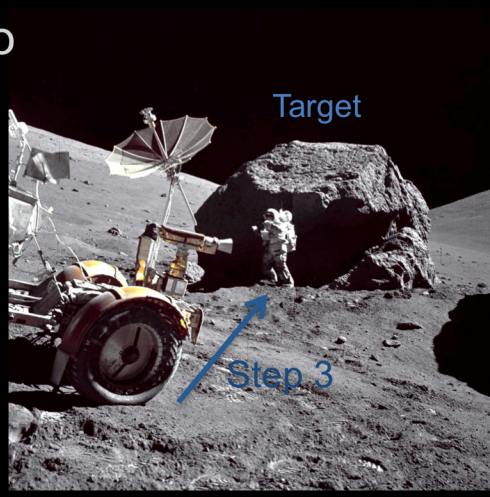
Experience
Apollo

Stepwise Approach to Target on Apollo



Step 1: Reach Target Region using Lunar Module.

Step 2: Reach Target Local Area using Lunar Rover.



Step 3: Reach Target on Foot.

Experience

Haughton-Mars Project

1st EZ Workshop for Human Missions to Mars

Stepwise Approach to Target: General Strategy

Step 1

Step 1: Reach Target Region/Base using Lander.

Step 2

Step 2: Approach Target Local Area using Pressurized Rover(s). ATVs in Escort for Scouting and Logistics Support.

Step 3

Step 3: Reach Target Local Area using ATV.

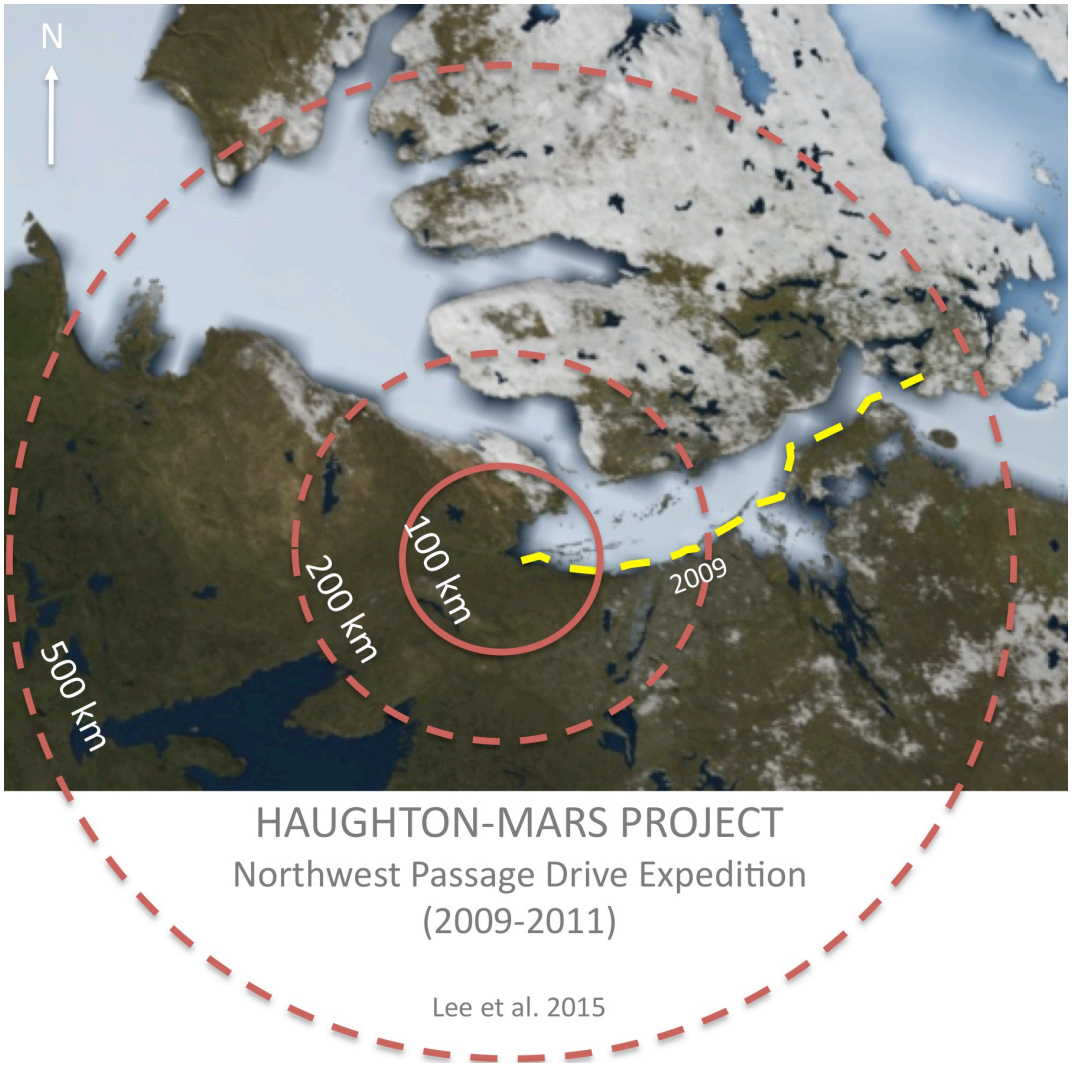
Step 4

Step 4: Reach Target on Foot.

Experience

Haughton-Mars Project

NORTHWEST PASSAGE DRIVE EXPEDITION



Experience

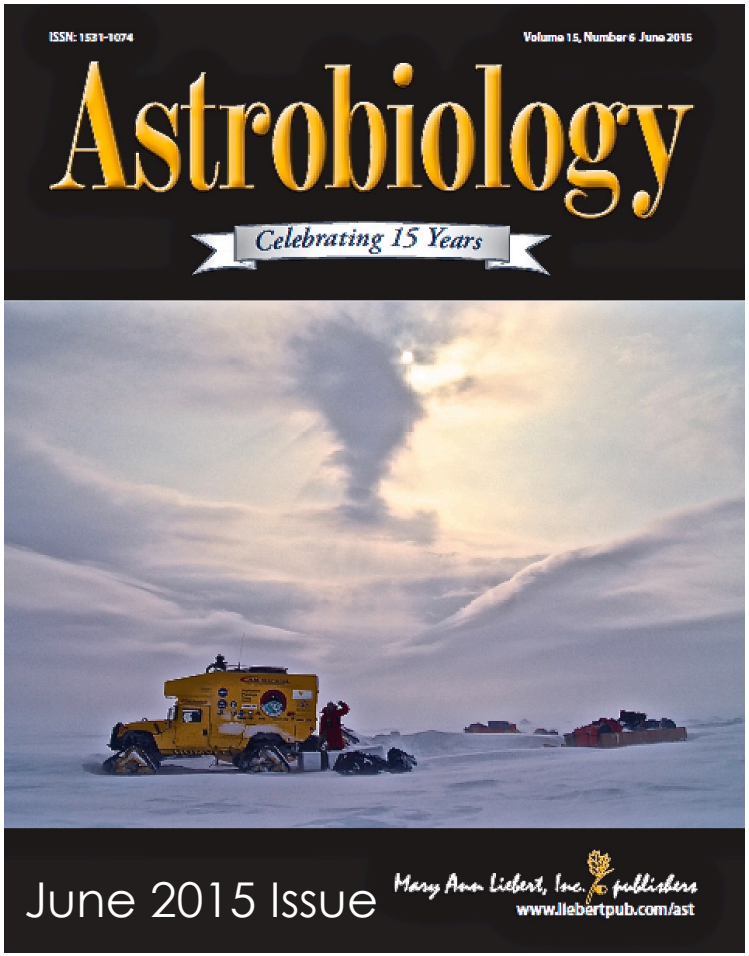
Haughton-Mars Project

1st EZ Workshop for Human Missions to Mars

NORTHWEST PASSAGE DRIVE EXPEDITION

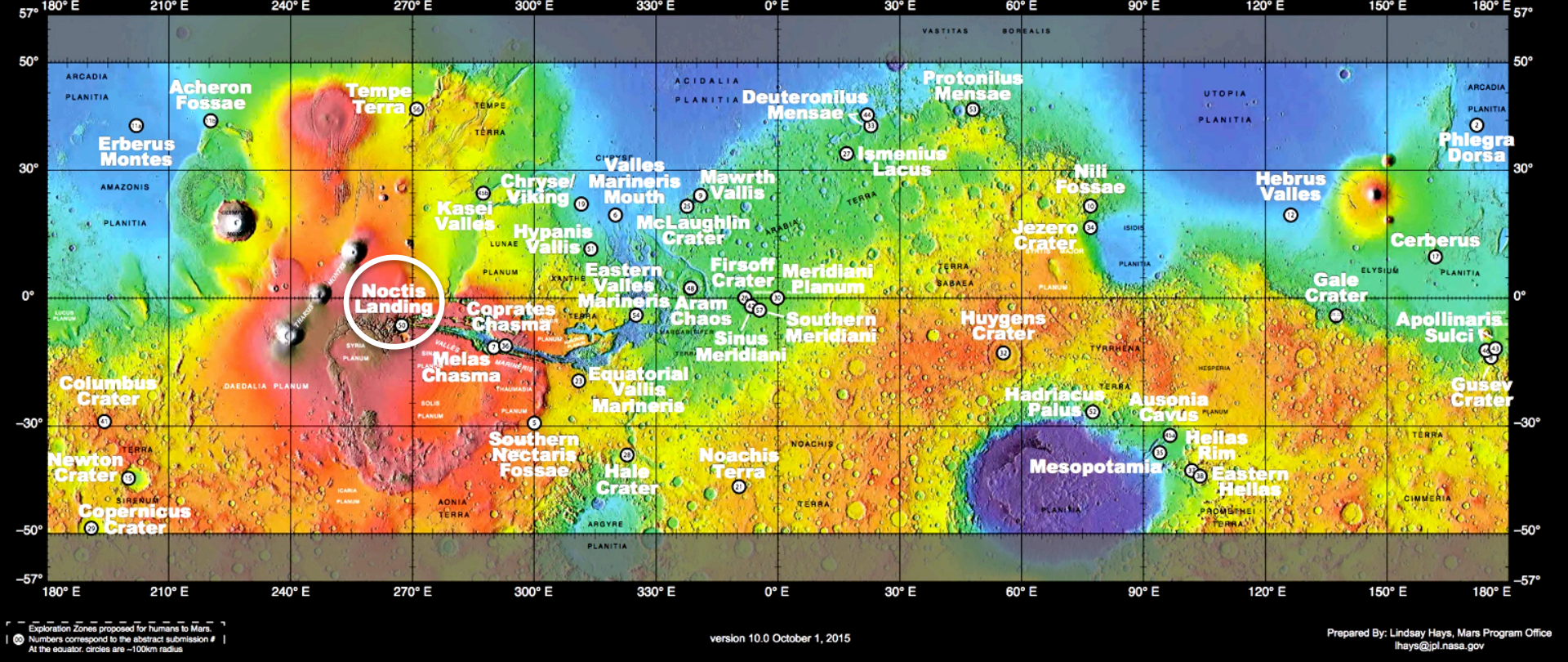
POLAR TREK TO MARS

YouTube.com



Exploration Zone Map

Noctis Landing



Assumptions

1 Strategy: Fixed Base + Mobility Systems (Robotic & Human)

Mobile base is a bad idea: 1) Might get stuck in bad spot.
2) Planetary Protection.

Mobility systems should allow global access pver time. (All Mars is interesting!)

2 First Landing Site = Long Term Base Site

Base Site Scouting will be done by Robots, not Astronauts.

3 Science Driver: Astrobiogeology

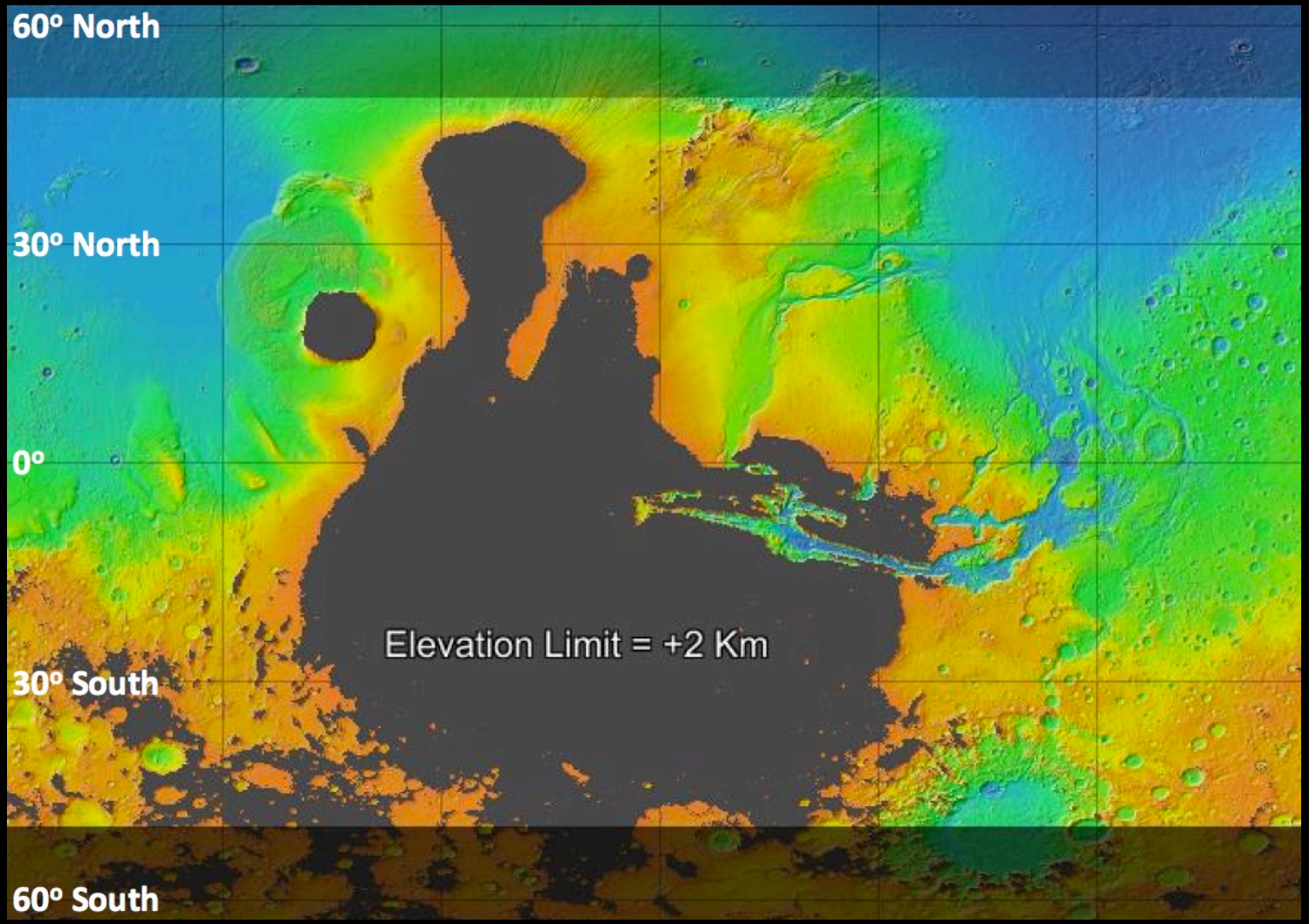
4 Highest Priority Science ROIs:

Valles Marineris : Longest and most comprehensive environmental record.
Tharsis: Longest and most recent high T activity.
Deep Subsurface: Deep drilling to access any liquid aquifer.

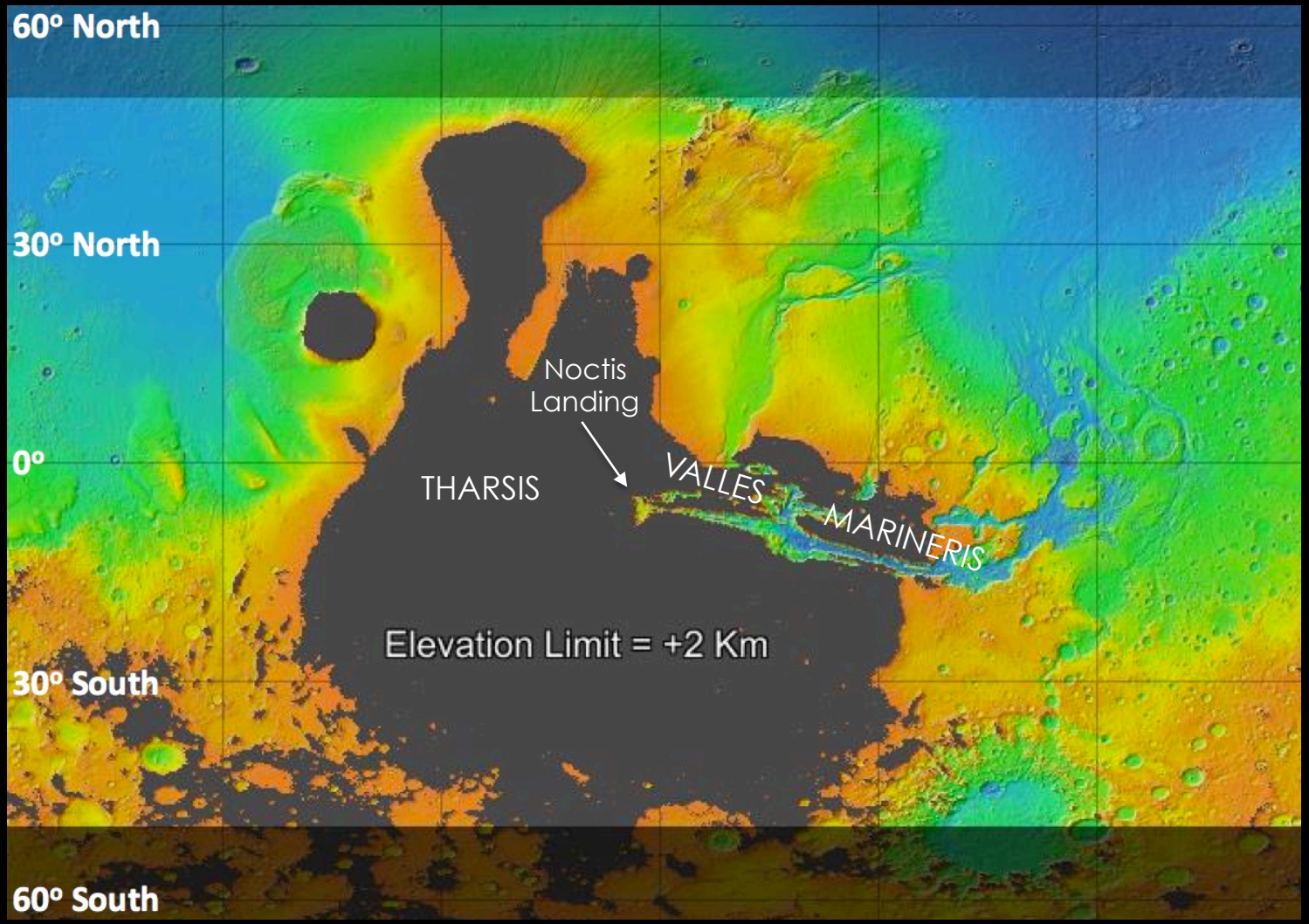
5 Minimal Mobility Systems Required:

Two Pressurized Rovers (PR). **Traverses 10s to 100s of km OK.**
One Drivable Robotic ATV per person for local EVAs and PR escort.

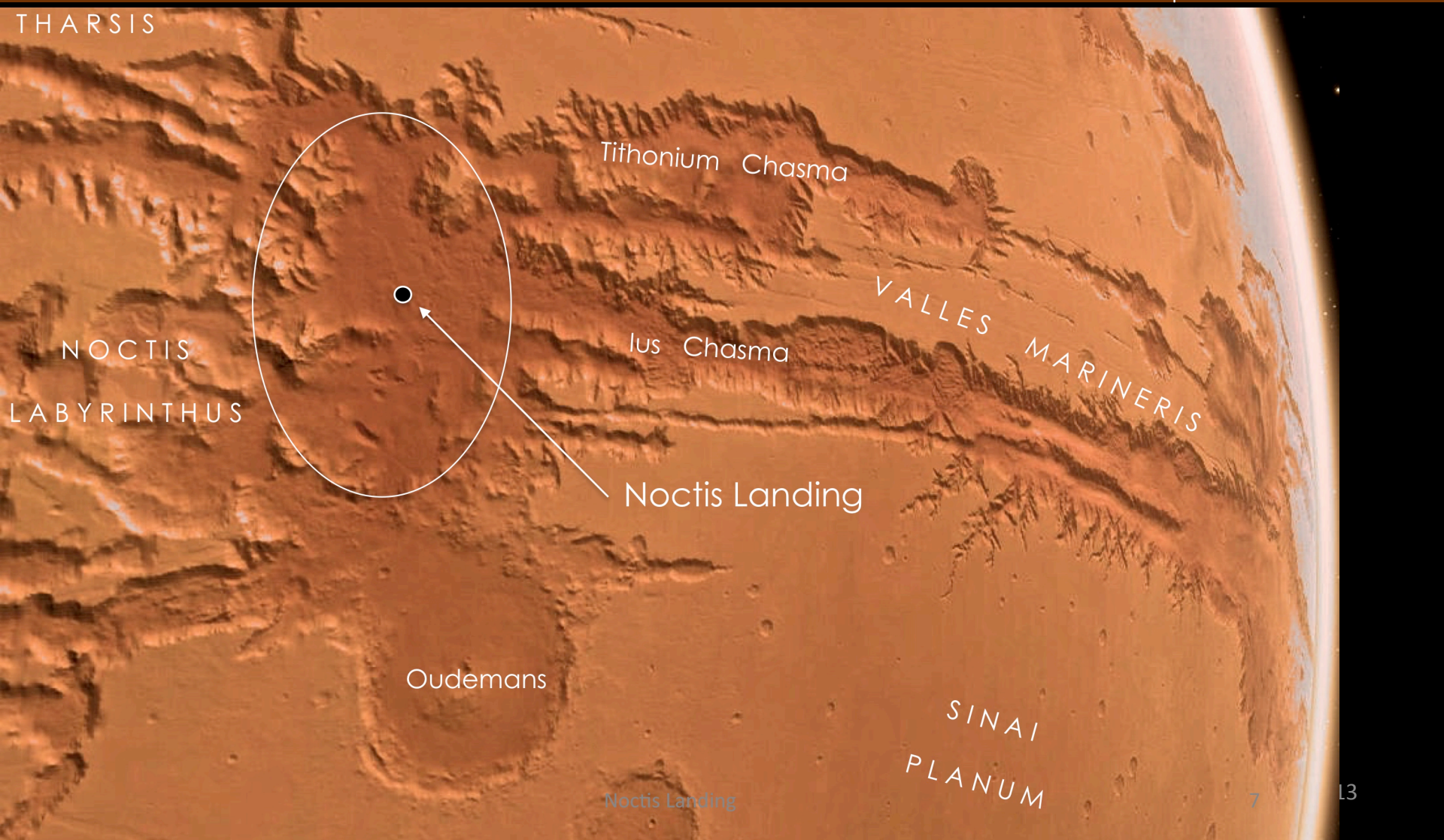
Exploration Zone Map
Noctis Landing



Exploration Zone Map
Noctis Landing

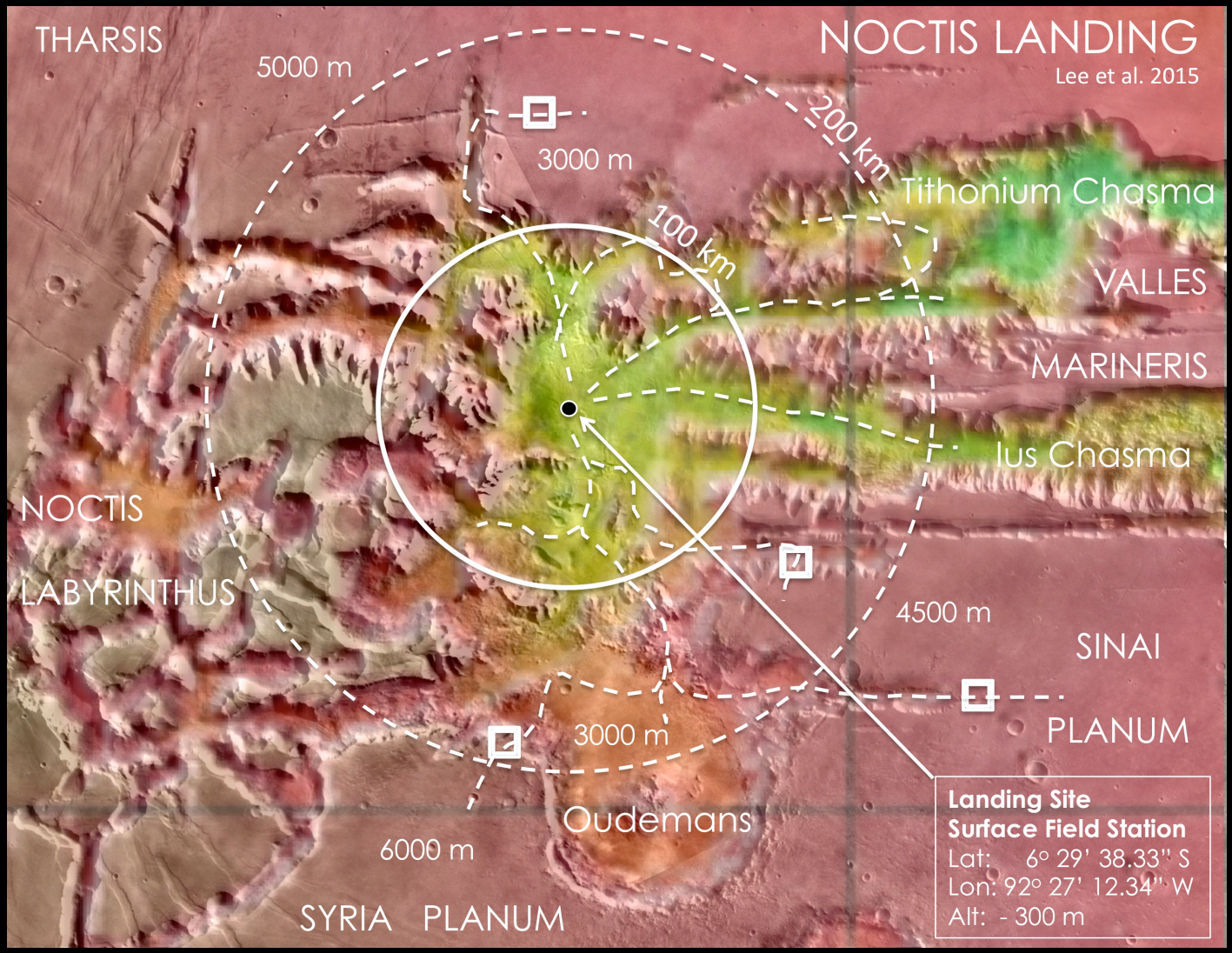


Exploration Zone Map
Noctis Landing

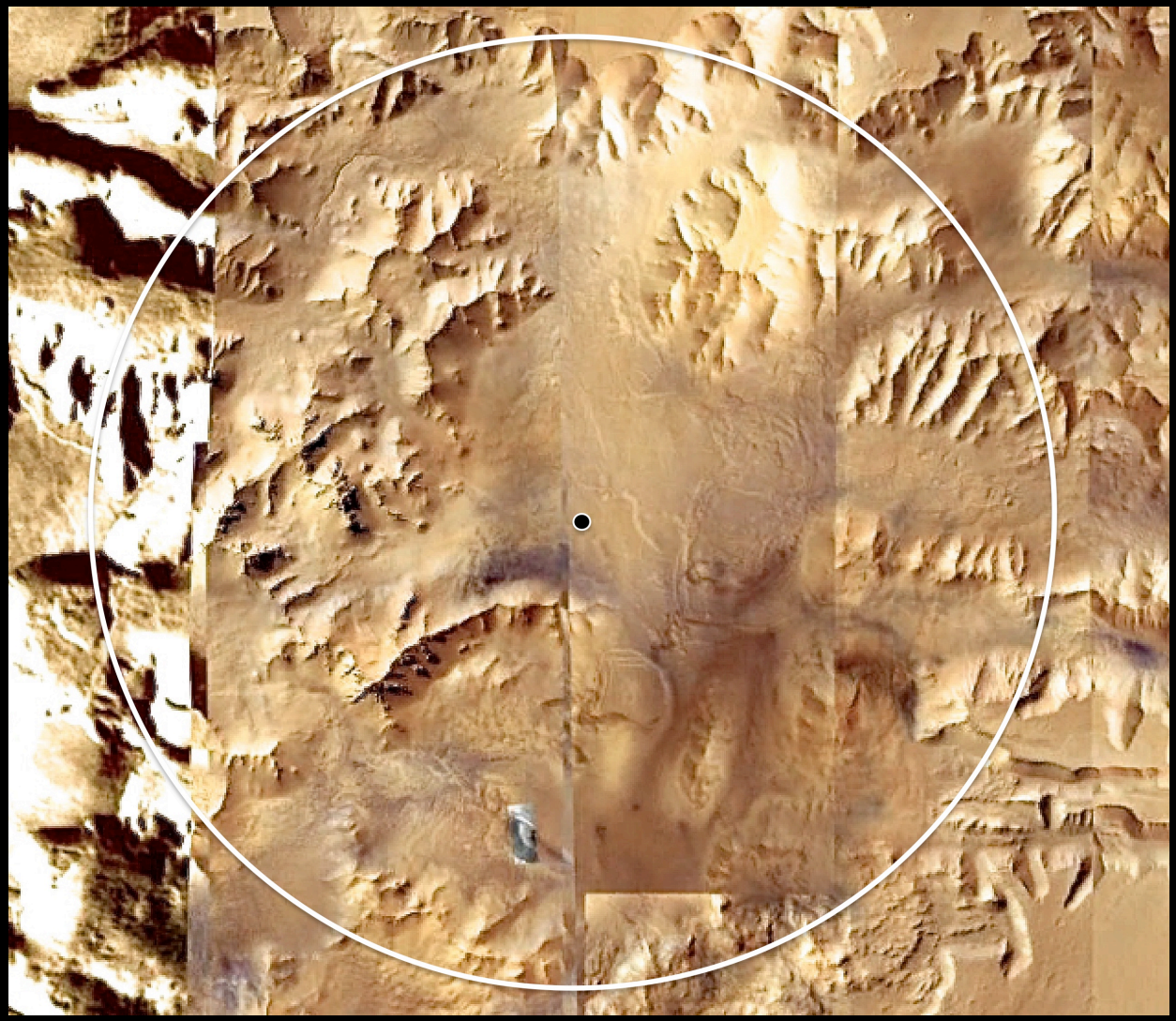


Exploration Zone Map

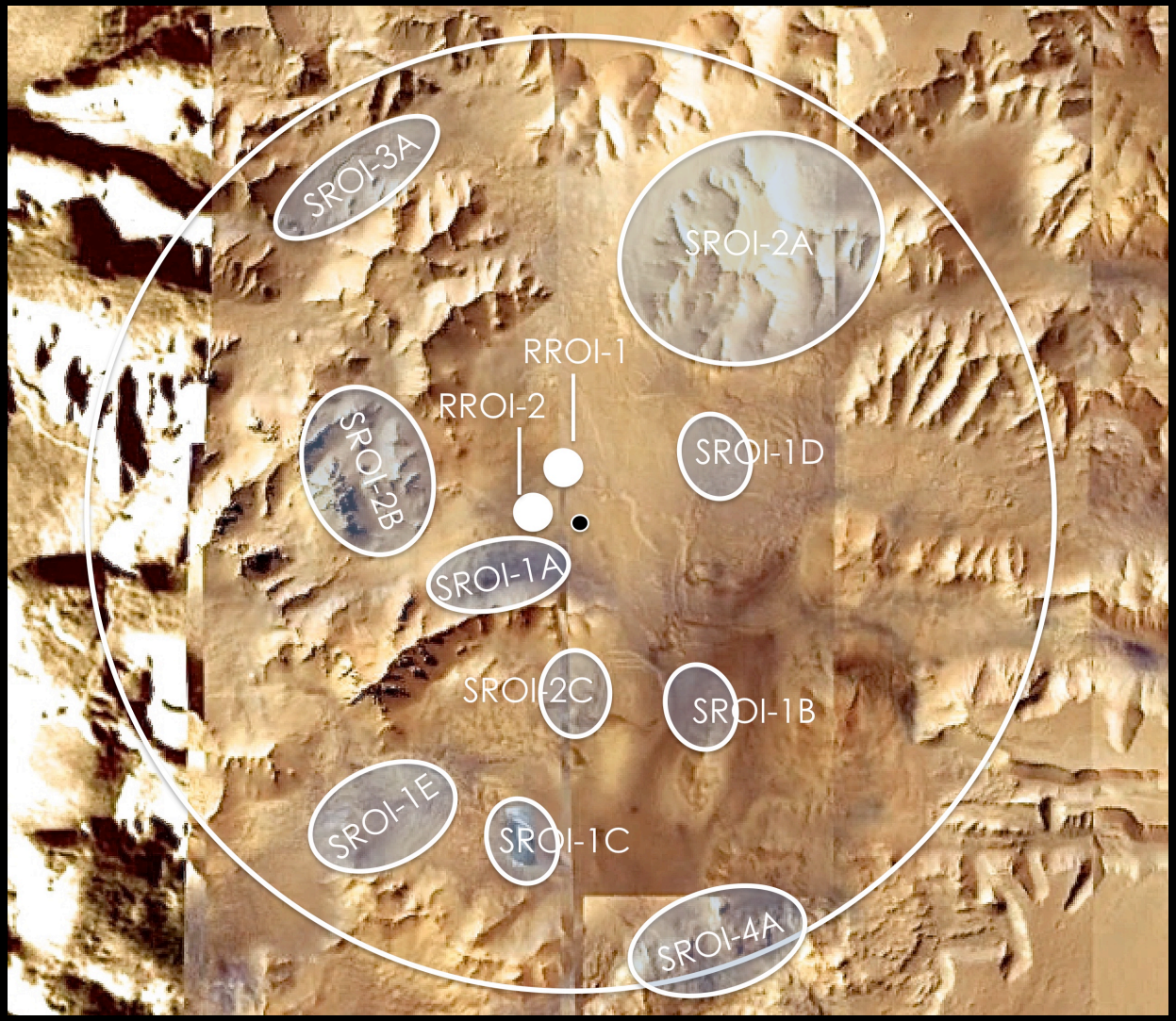
Noctis Landing



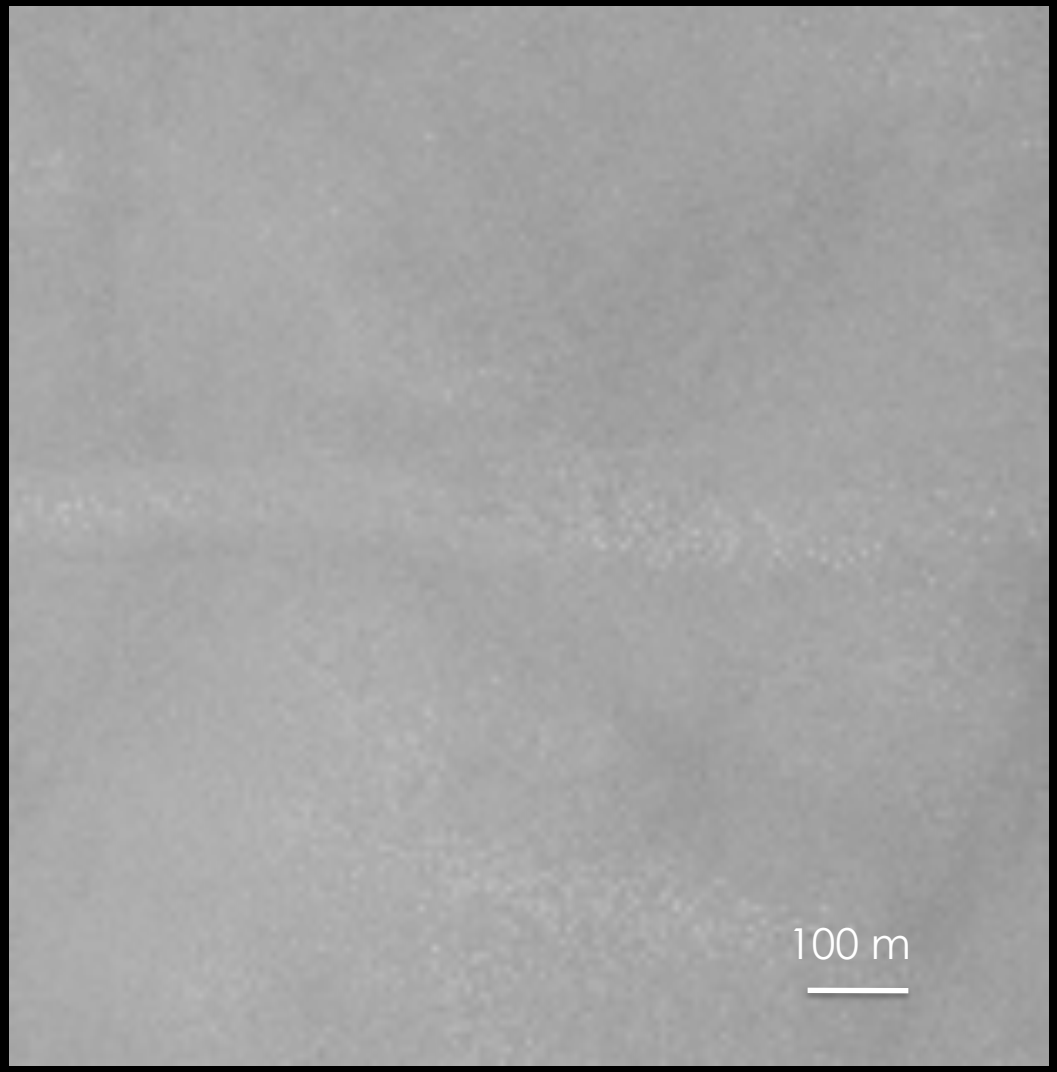
Exploration Zone Map
Noctis Landing



Exploration Zone Map
Noctis Landing



Noctis Landing
Landing Site



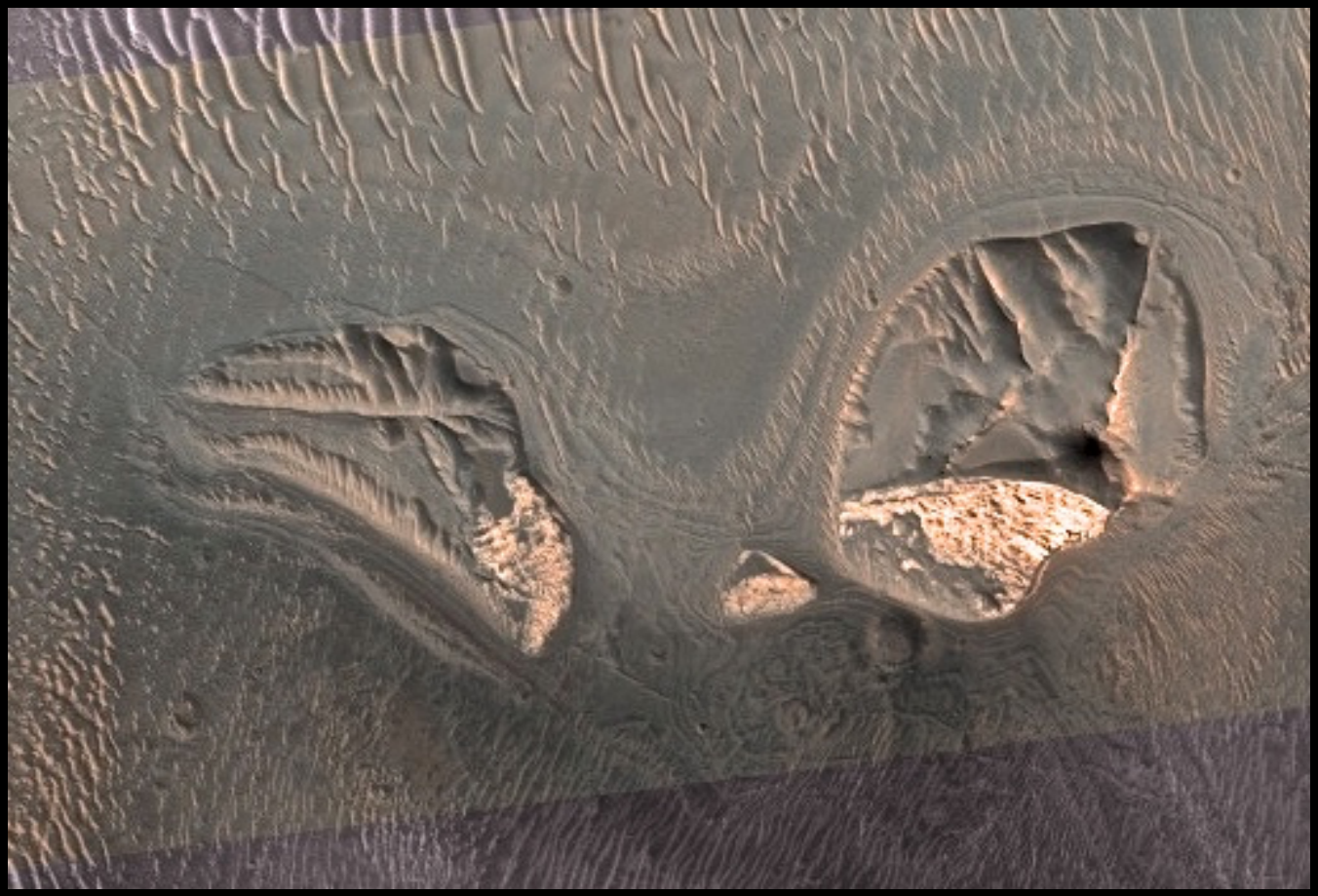
Noctis Landing Science ROI-1A

- **Hydrated Mineral Deposits** (e.g., Sulfates). Discrete outcrops.
- Potential biosignatures protected by volcanic deposits?

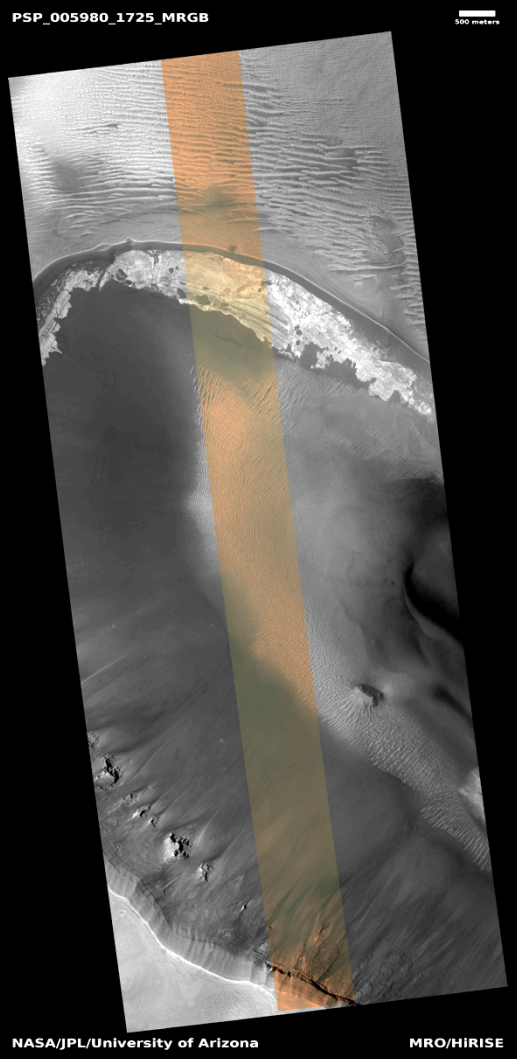
Haughton-Mars Project

Noctis Landing Science ROI-1B

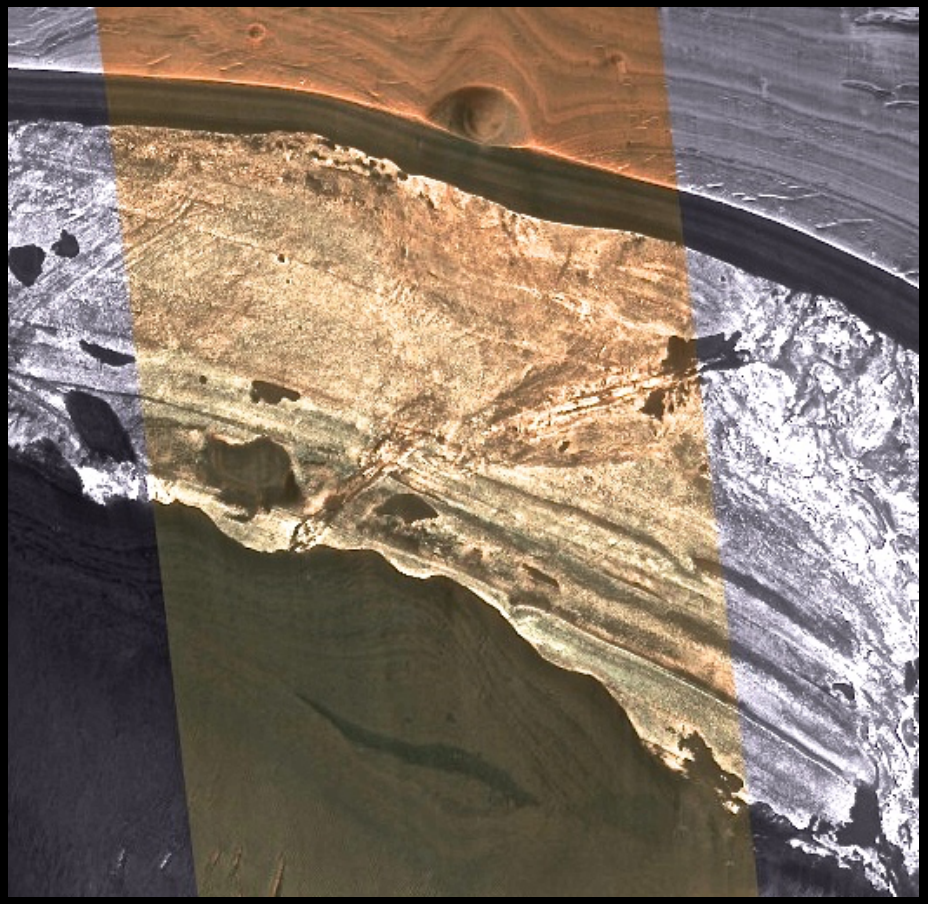
- **Hydrated Mineral Deposits** (e.g., Sulfates). Buried Layers?
- Potential biosignatures protected by volcanic deposits?



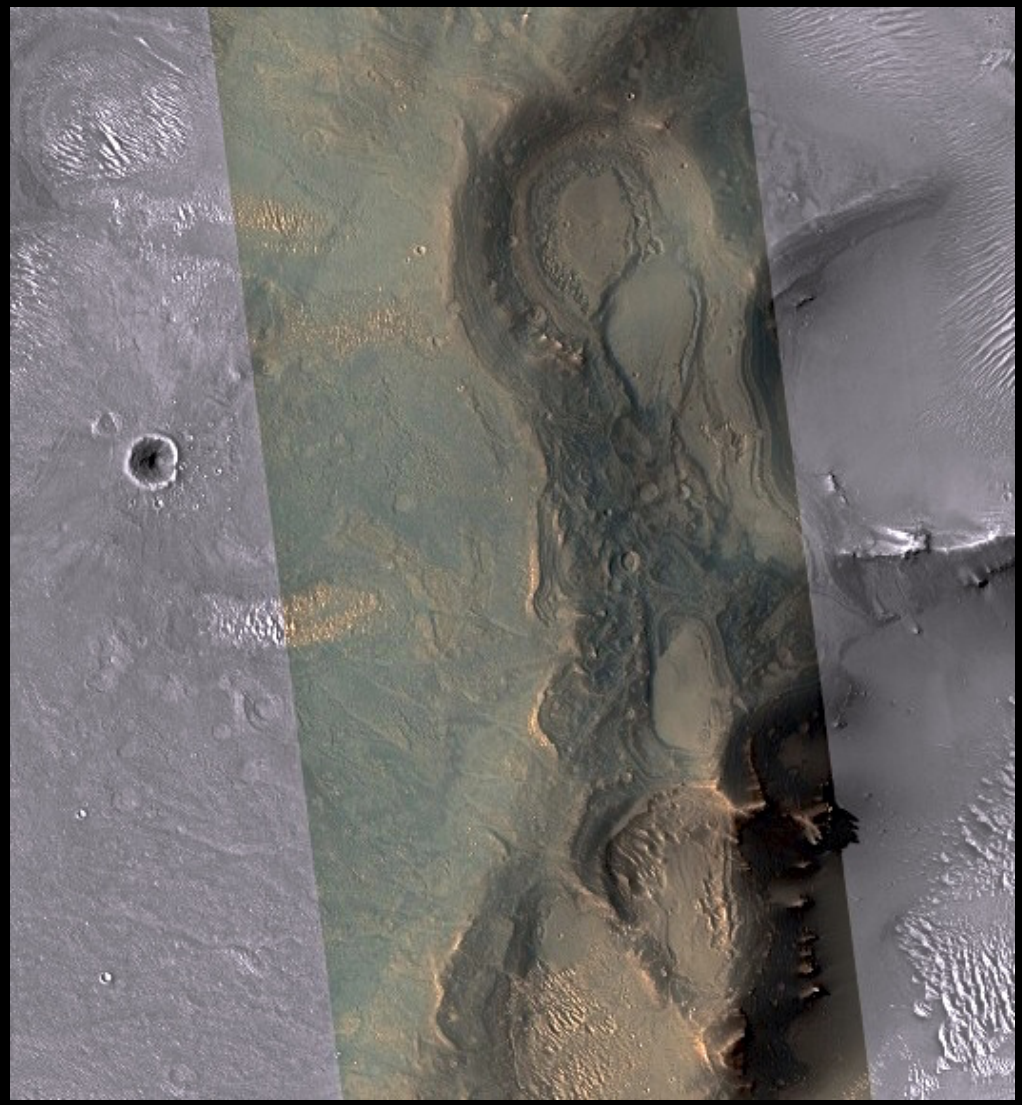
Noctis Landing Science ROI-1C



- **Hydrated Mineral Deposits**. Extensive Layers?
- Potential preserved biosignatures.

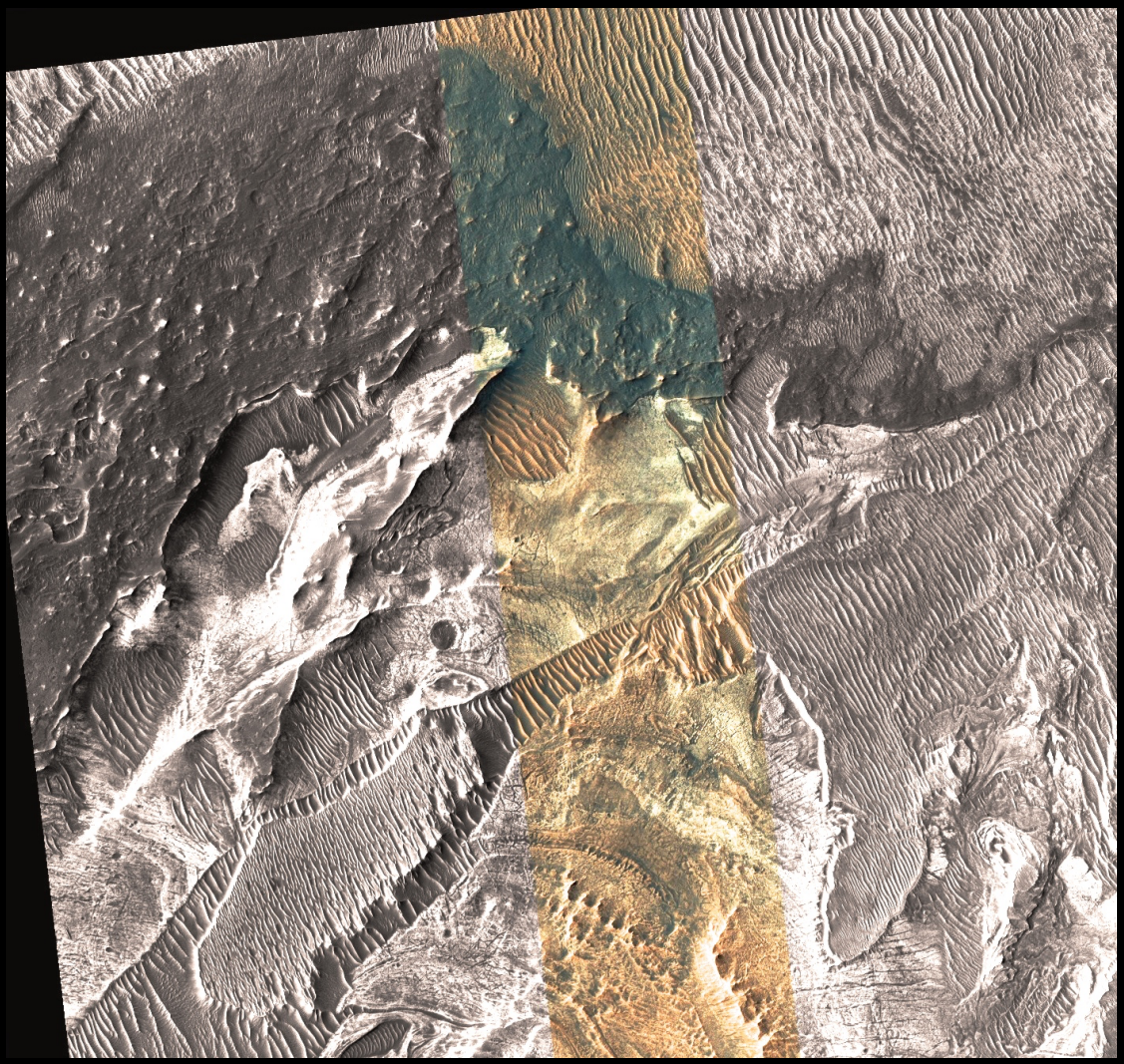


Noctis Landing Science ROI-1D



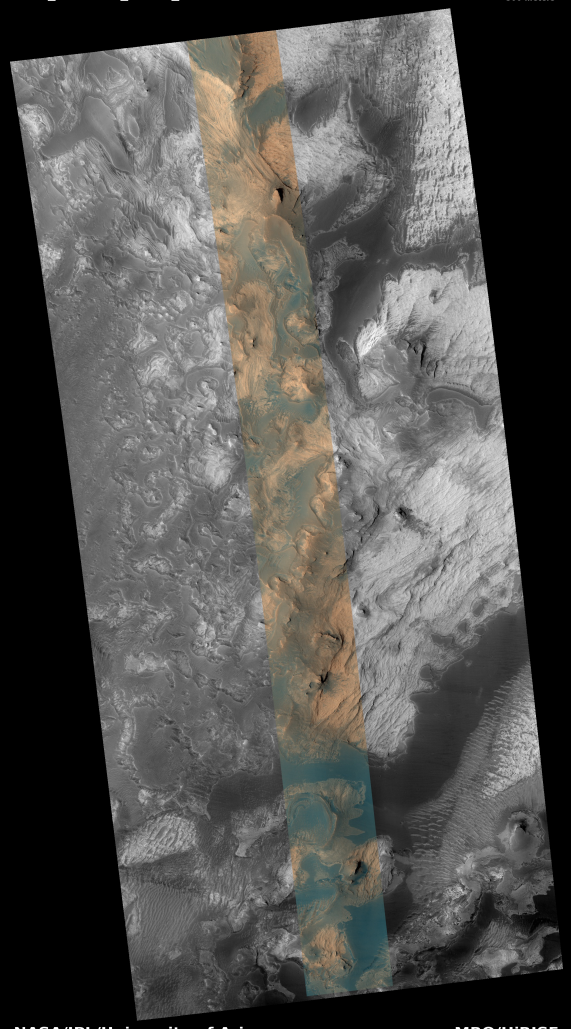
- **Hydrated Mineral Deposits**.
- Shown here: Layered volcanic deposits possibly protecting hydrated mineral deposits?

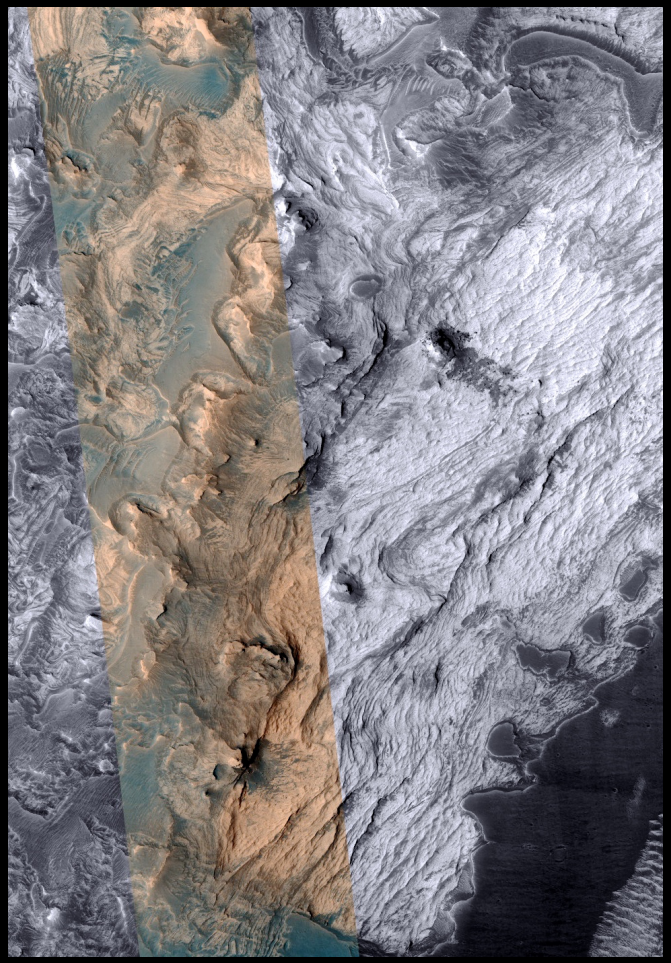
Noctis Landing Science ROI-1E



- **Hydrated Mineral Deposits** (Light toned).
- Darker volcanic deposits.
- Landscape of deposition AND deflation.

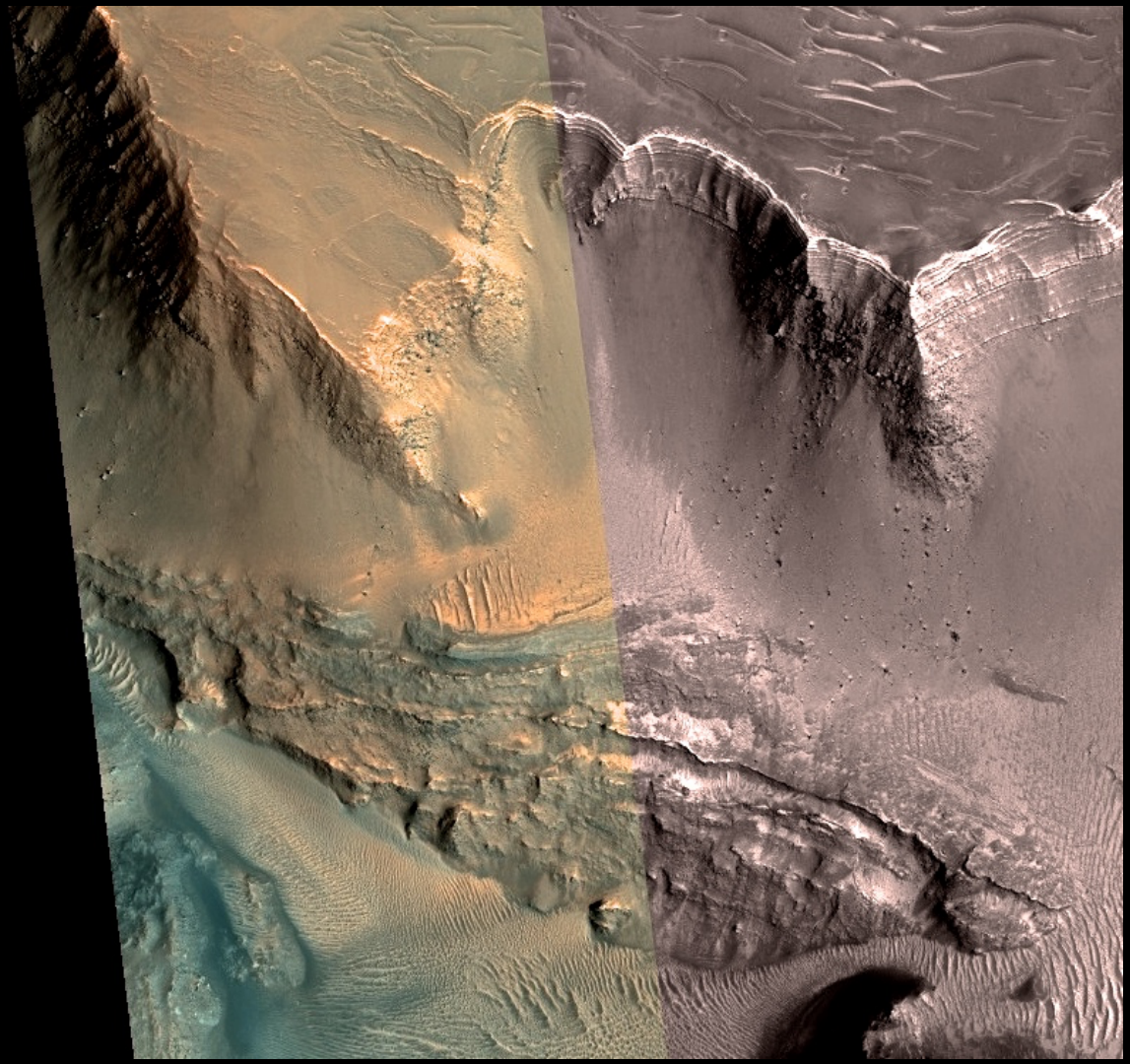
Noctis Landing Science ROI-1F





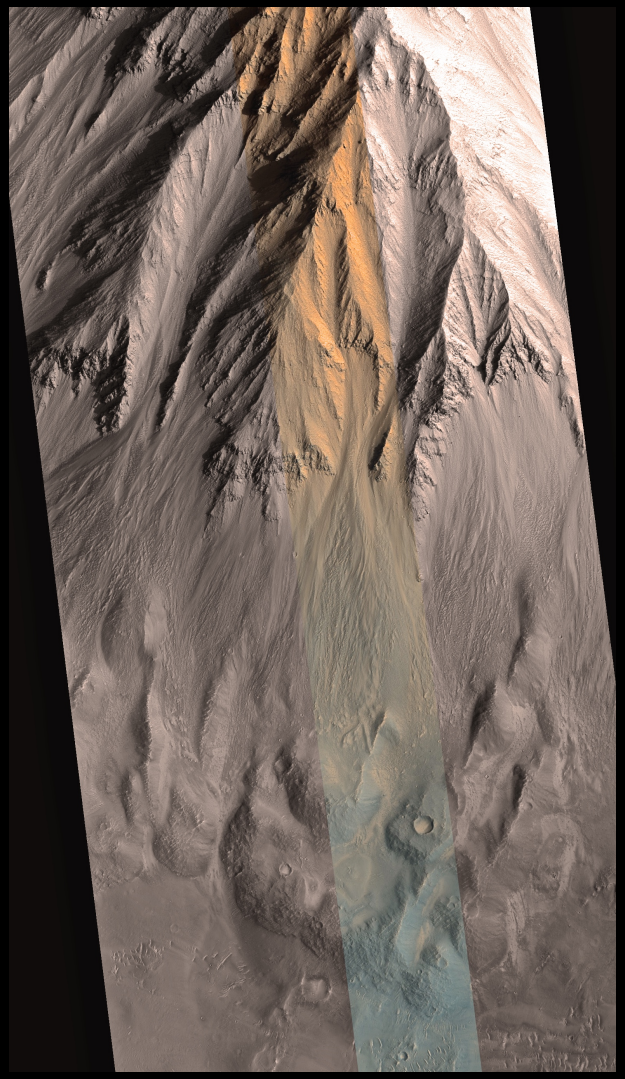
- Tithonium Chasma
- **Hydrated Mineral Deposits**
- Extensive Layers

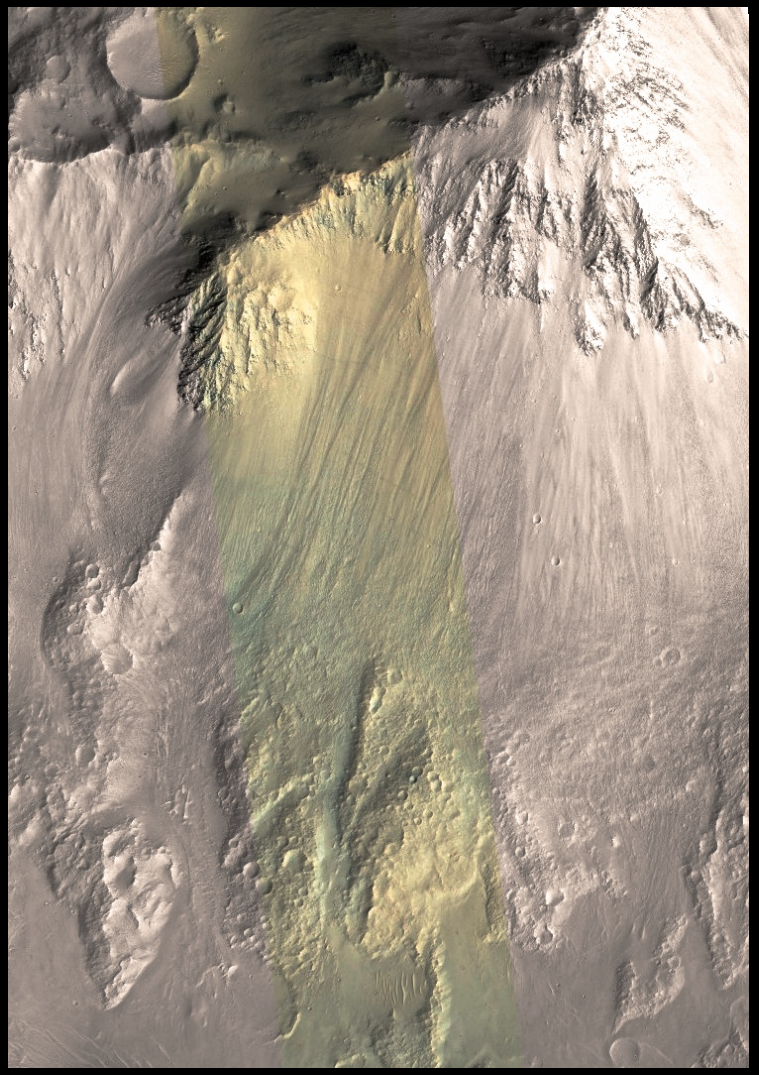
Noctis Landing Science ROI-2A



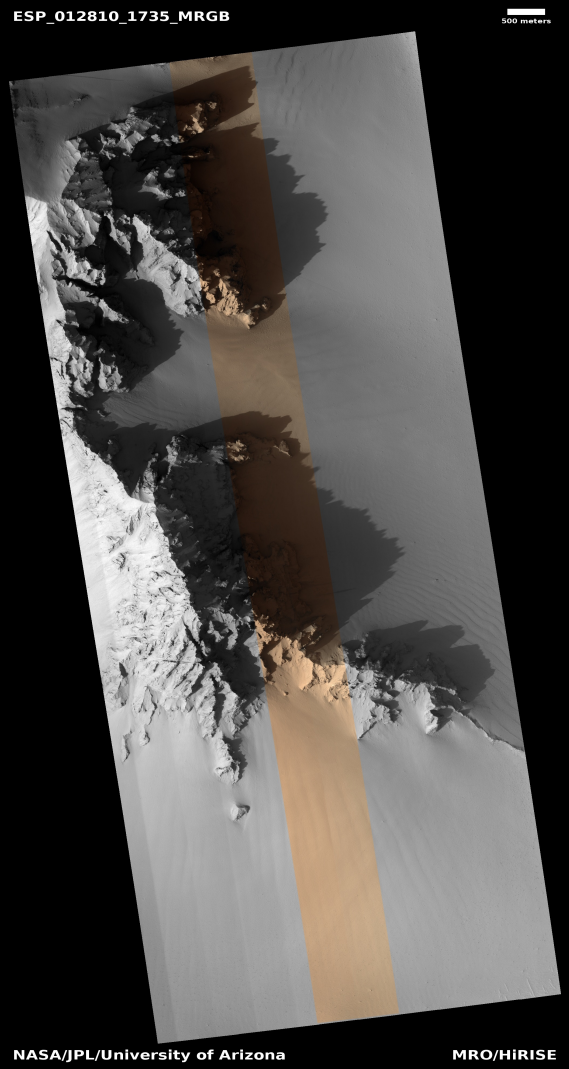
- **Stratigraphic Record.**
- Layered Deposits
- Cross-Bedding
- Noachian Bedrock?

Noctis Landing Science ROI-2A

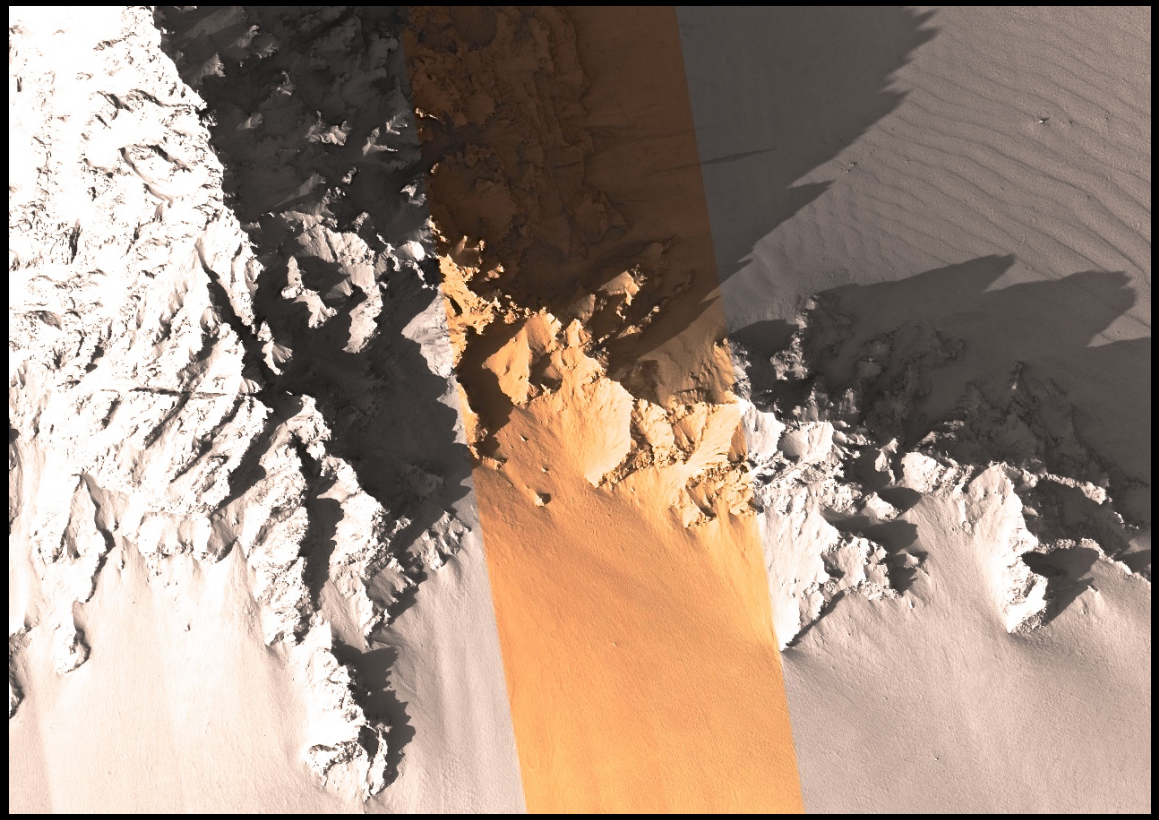




Noctis Landing Science ROI-2B



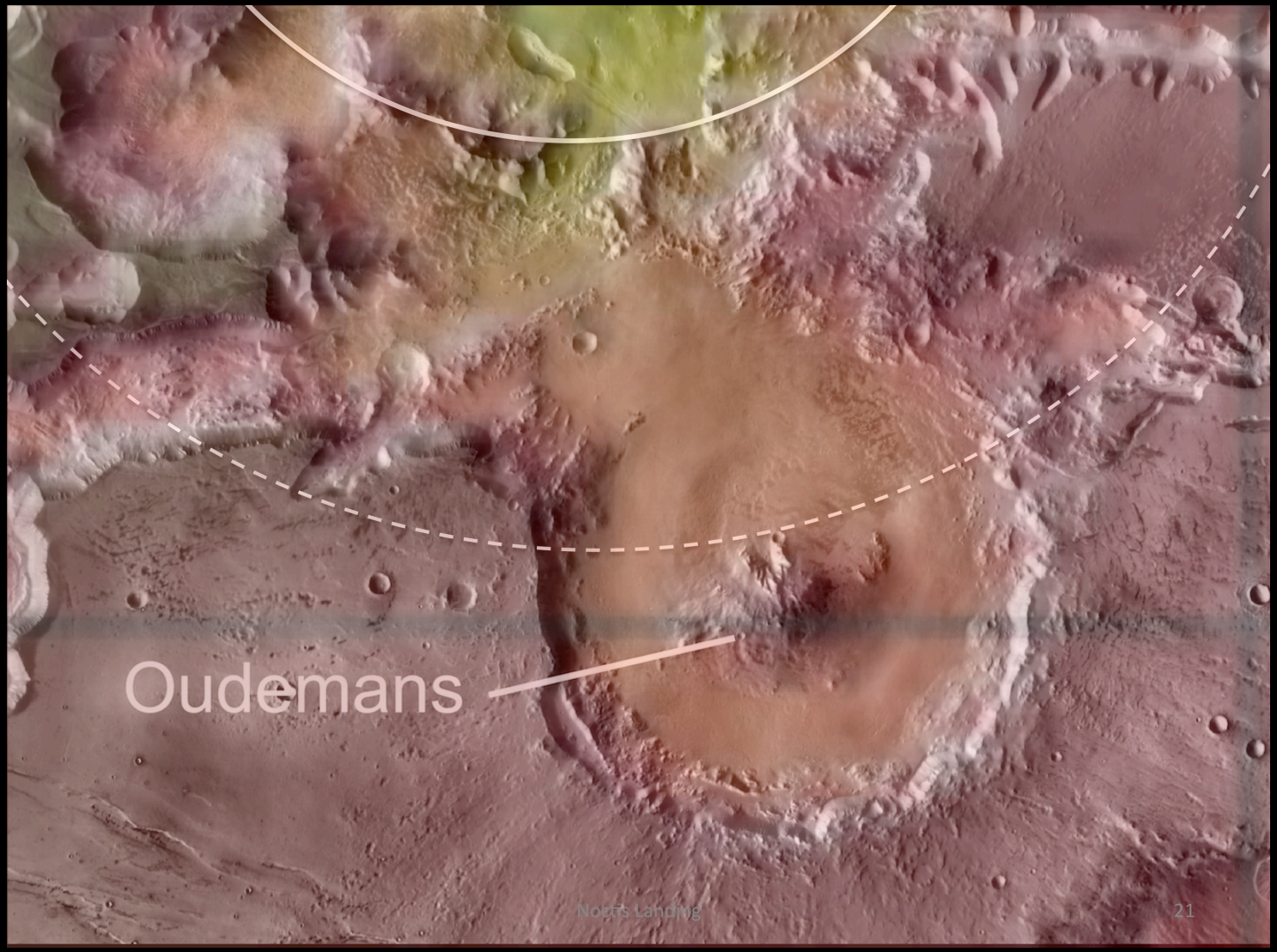
- **Stratigraphic Record**
- Tilted Layered Deposits



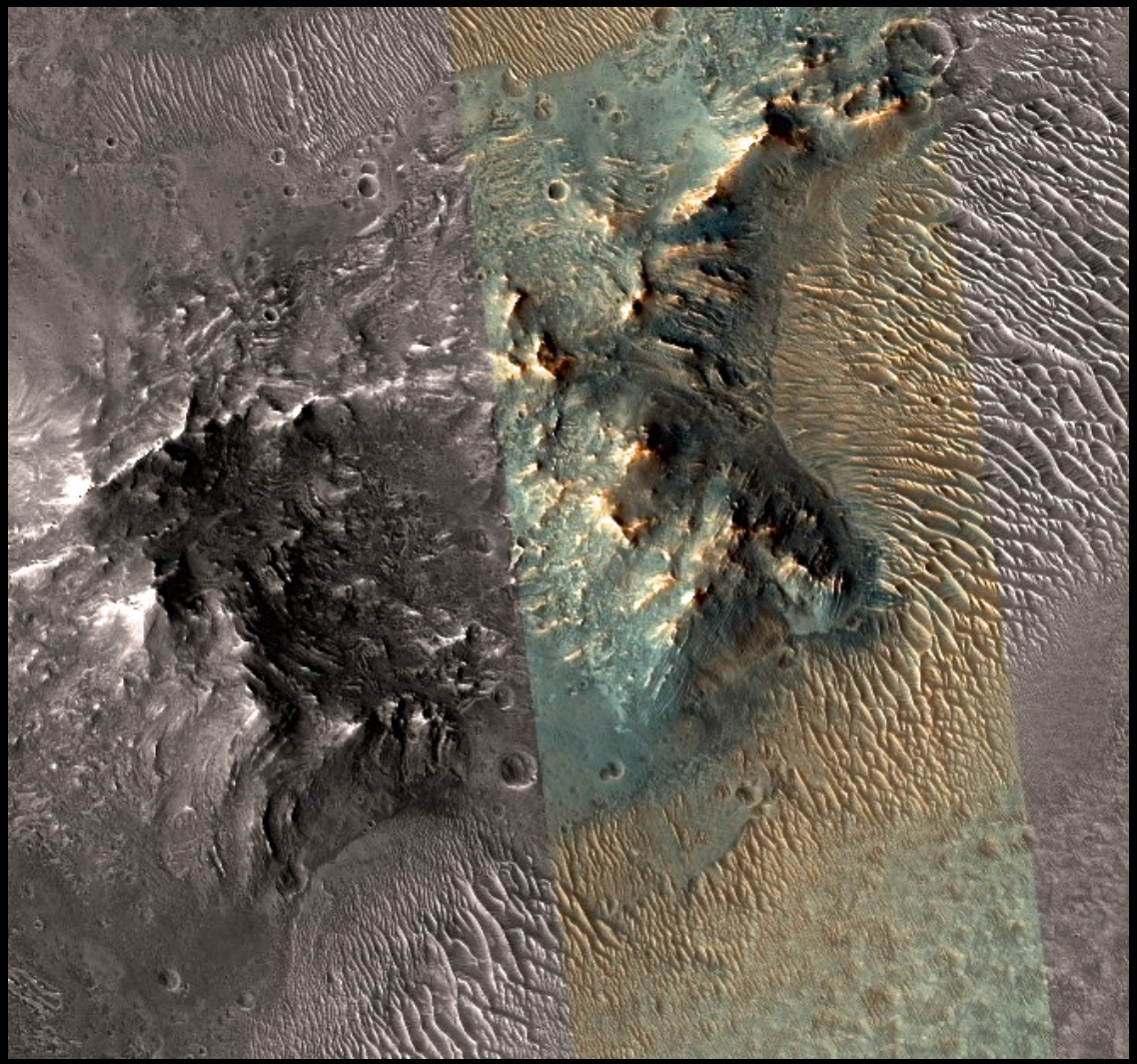
Noctis Landing Science ROI-3A

- **Drainage Channel.**
- H_2O?
- Volcanics?
- Discharge was low.

Noctis Landing Science ROI-4

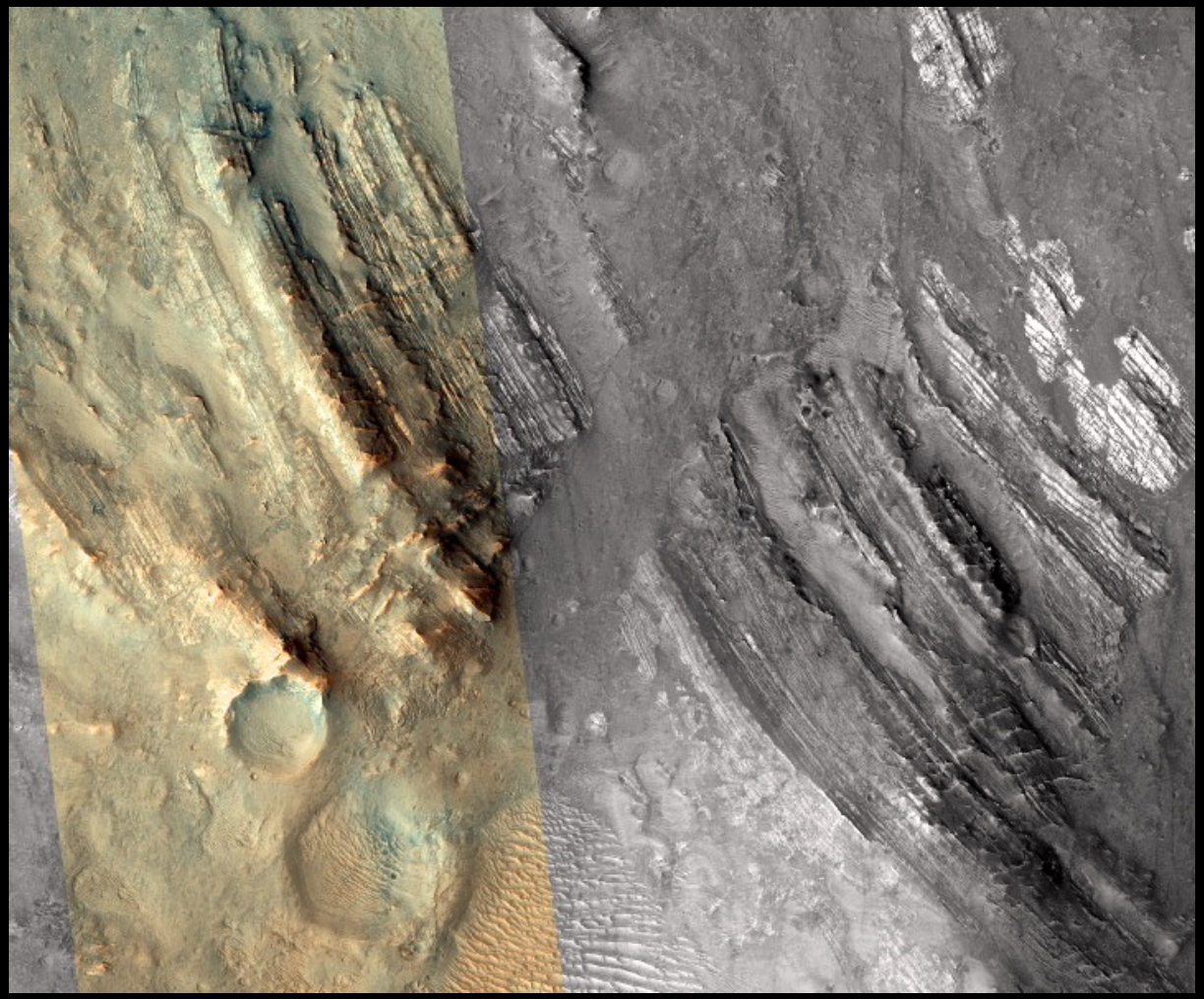


Noctis Landing Science ROI-4A



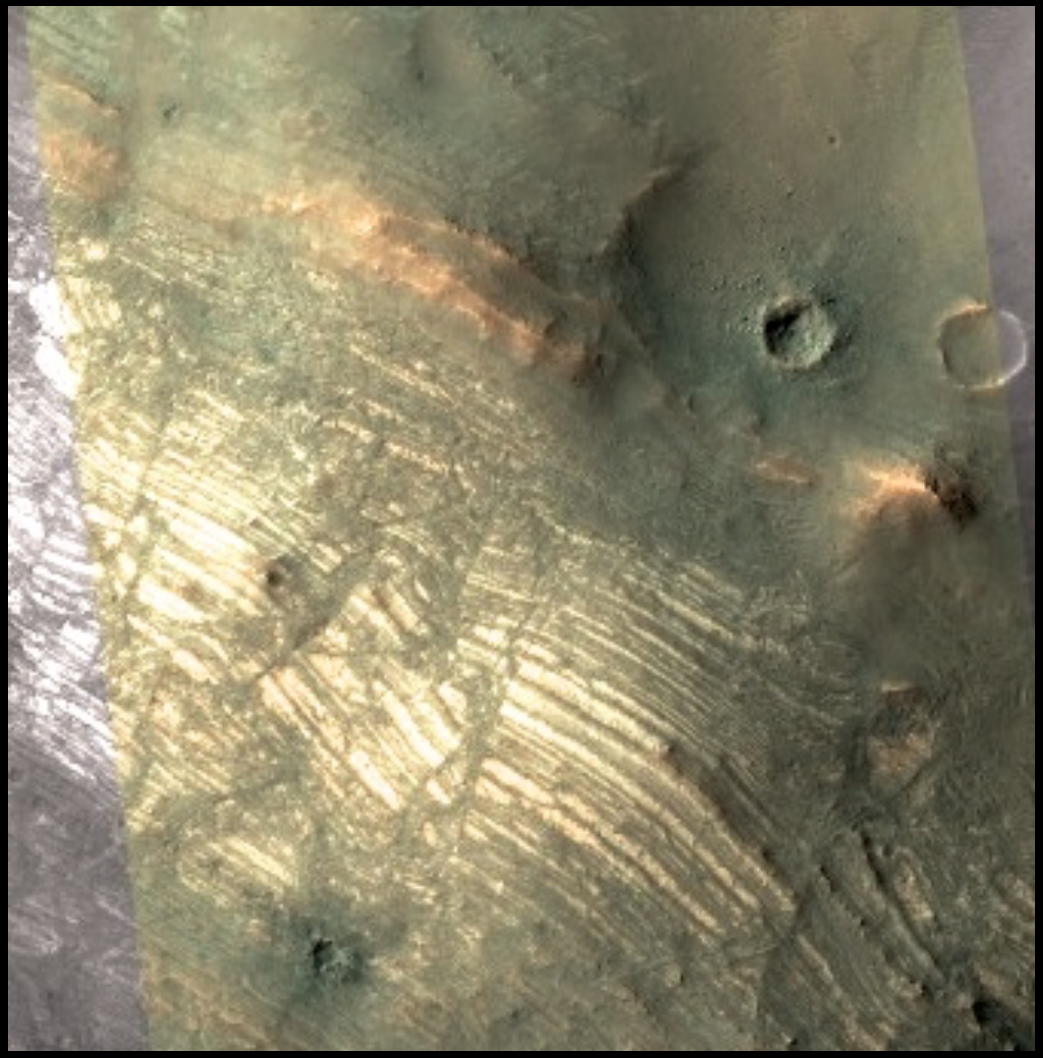
- **Oudemans Crater**
  Impact Ejecta
- **Stratigraphic Record**
- Megablocks of Tilted, Possibly Folded, Layered Deposits

Noctis Landing Science ROI-4B



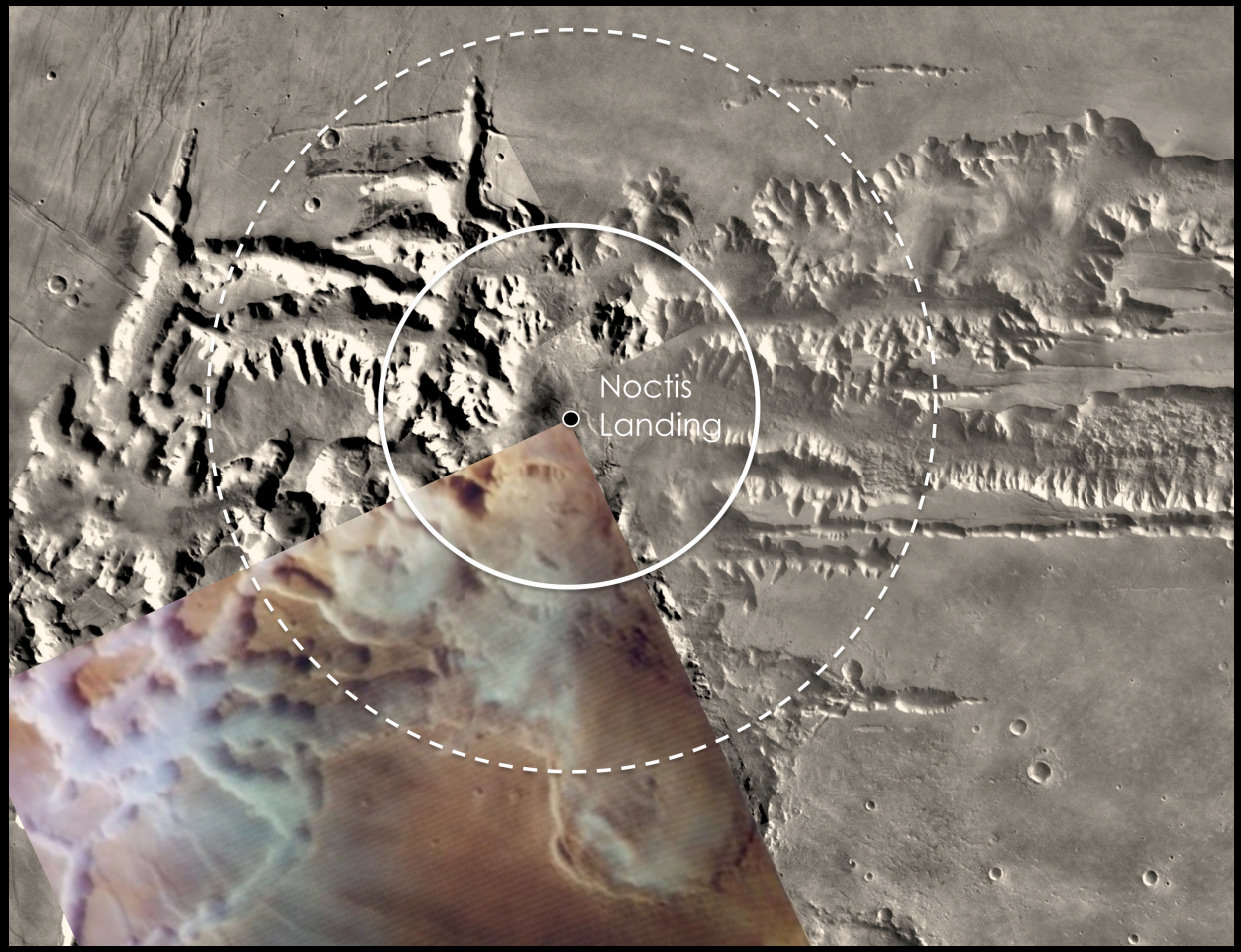
- **Oudemans Crater**
  Central Uplift
- **Stratigraphic Record**
- Megablocks of Tilted, Layered Deposits
- "Walkable Column"

Noctis Landing Science ROI-4B



Noctis Landing Science ROI-5

- **Noctis Labytrinthus**
- **Stratigraphic Record**
- Hydrated Minerals



Noctis Landing Science ROI-5A

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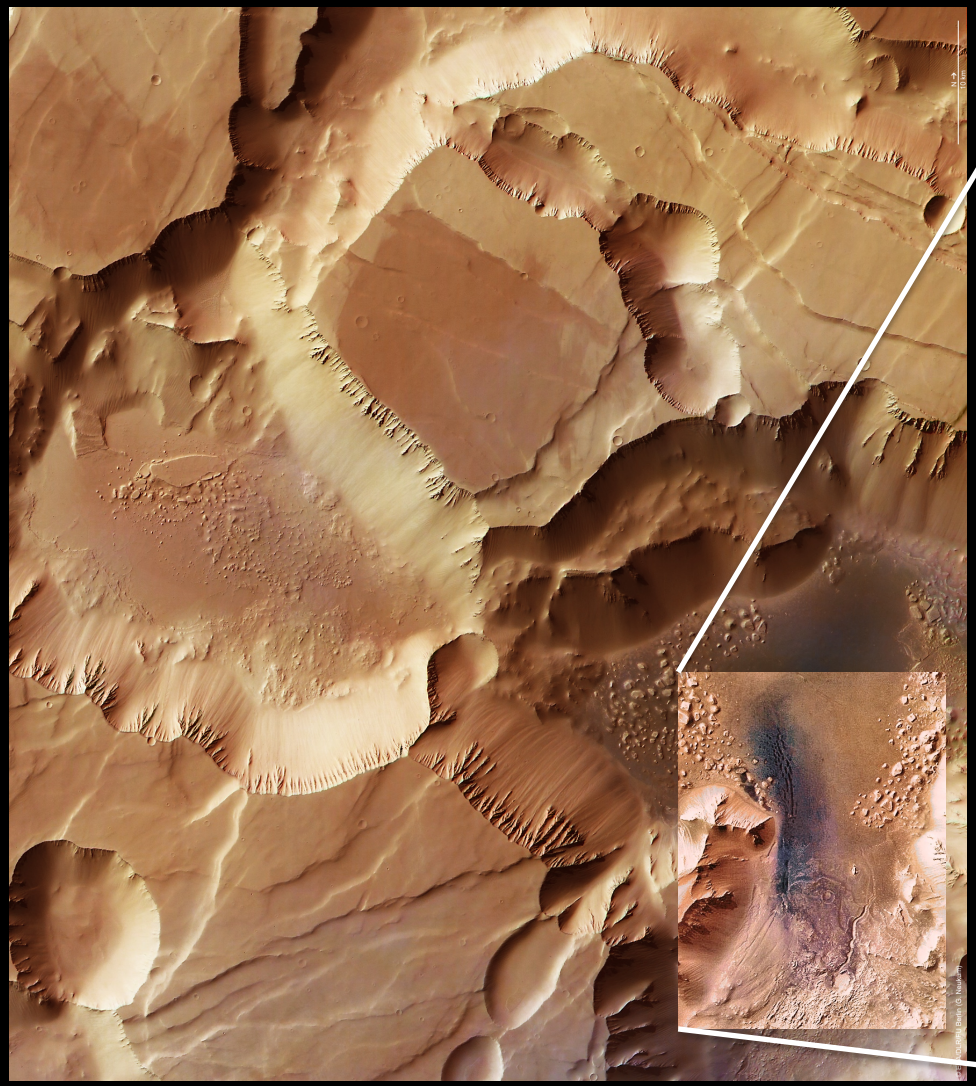

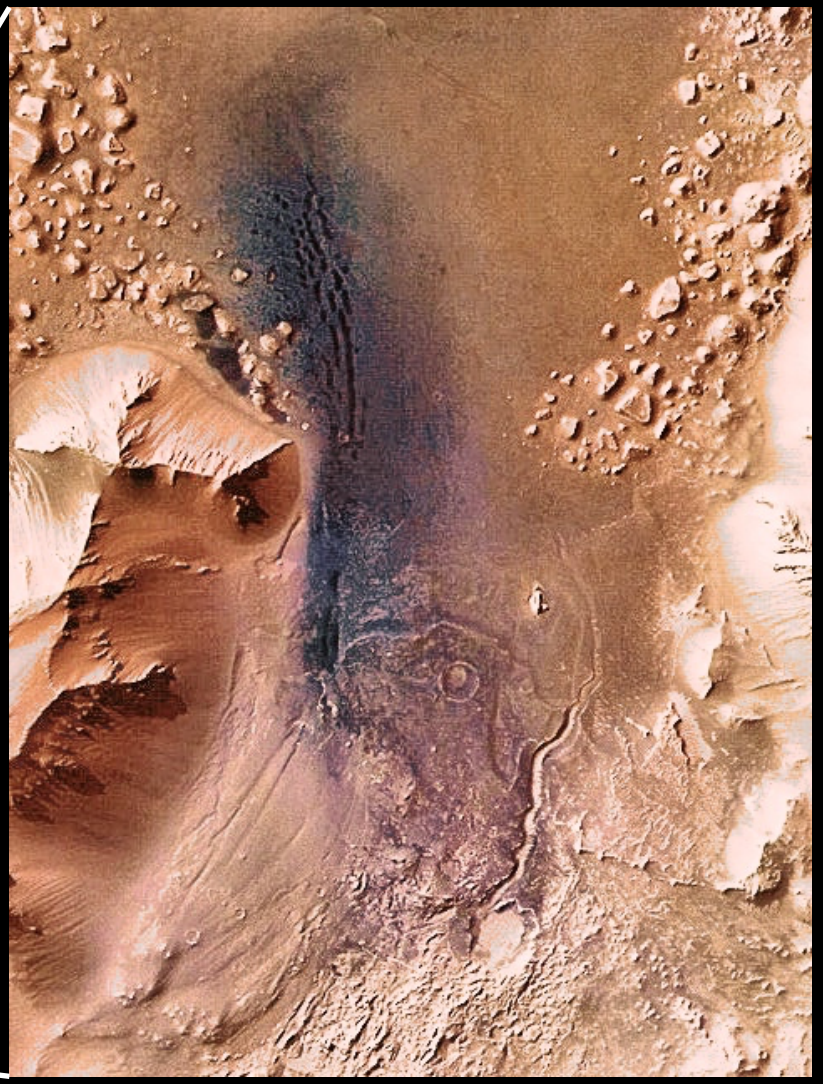

Noctis Landing Science ROI-5B

Noctis Landing Resource ROI-1

- **Hydrated Mineral Deposits**:
  Discrete outcrops ~5 km from Landing Site.
- **Resource:**
  H_2O Concentration Poorly Constrained.

Noctis Landing Resource ROI-2

- Ubiquitous Sand Dunes & Sheets (Sparse to Continuous Deposits)
- **Resource:**
  Sandbags for Radiation Shielding. Bagging can be robotic.
- **Pressurized Rover Traverses:**
  Sand should not be avoided, but conquered.

Noctis Landing: Science ROIs Rubric

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

Key	
●	Yes
○	Partial Support or Debated
	No
?	Indeterminate

Noctis Landing: Resource ROIs Rubric

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

Key	
●	**Yes**
○	**Partial Support or Debated**
	No
?	**Indeterminate**

Highest Priority EZ Data Needs
Noctis Landing

- Science
  - NASA MRO HiRISE + CRISM + THEMIS Data
  - ESA MEX HRSC + OMEGA Data
  - Why?: Assess Accessibility of Science Targets
  - How?: Drone Surveys?

- Resources
  - NASA MRO HiRISE + CRISM Data
  - ESA MEX HRSC + OMEGA Data
  - Why?: Assess 3D Extent of Hydrated Minerals Deposits?
  - How?: Drone Surveys?

Conclusions

1 Noctis Landing is at Strategic Scientific & Operational Crossroads
Valles Marineris + Tharsis + Subsurface

2 Oudemans may offer easier access to Mars Stratigraphic Record than Valles Marineris.

3 Plan for ~1000 km Radius EZ.

4 Excursion Time is more important that Distance Traversed per se.

5 More Data Needed. Drones Recommended.

6 Analogs for Science Ops Learning & Planning are Critical.