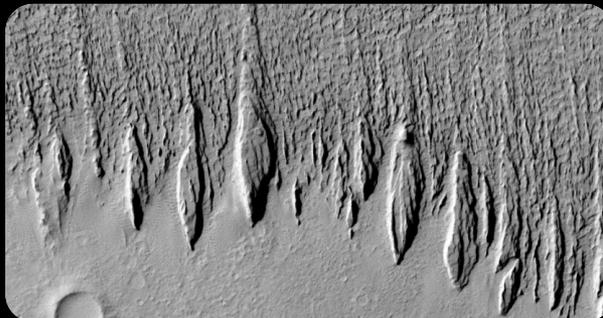




National Aeronautics and
Space Administration
Jet Propulsion
Laboratory
California Institute of
Technology
Pasadena, California



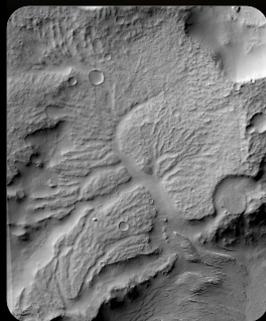
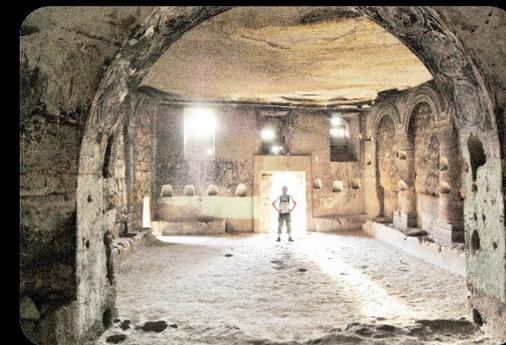
JPL

APOLLINARIS SULCI



Workshop Abstract #1043

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Laurent Sibille², Angel Abbud-Madrid³,
Tanguy Bertrand⁴, Kathryn Stack¹,
Austin Nicholas¹, Carolyn Parcheta¹,
Sylvain Piqueux¹, Michael Malaska¹,
James Ashley¹, Serina Diniega¹, Jay
Dickson⁵, Caleb Fassett⁶



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Exploration Zone Map

1st EZ Workshop for Human Missions to Mars



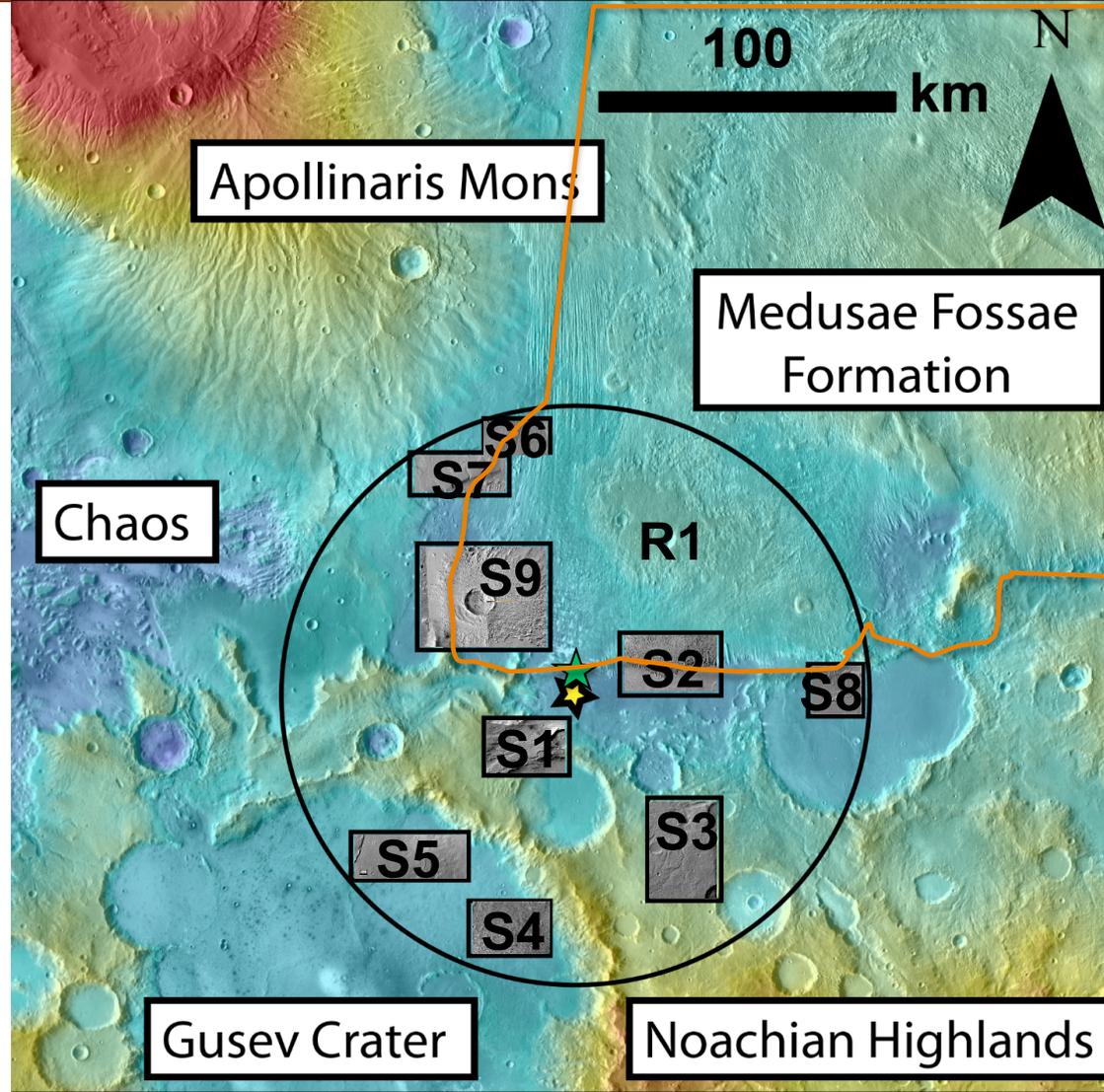
Apollinaris Sulci

★ Landing Site:

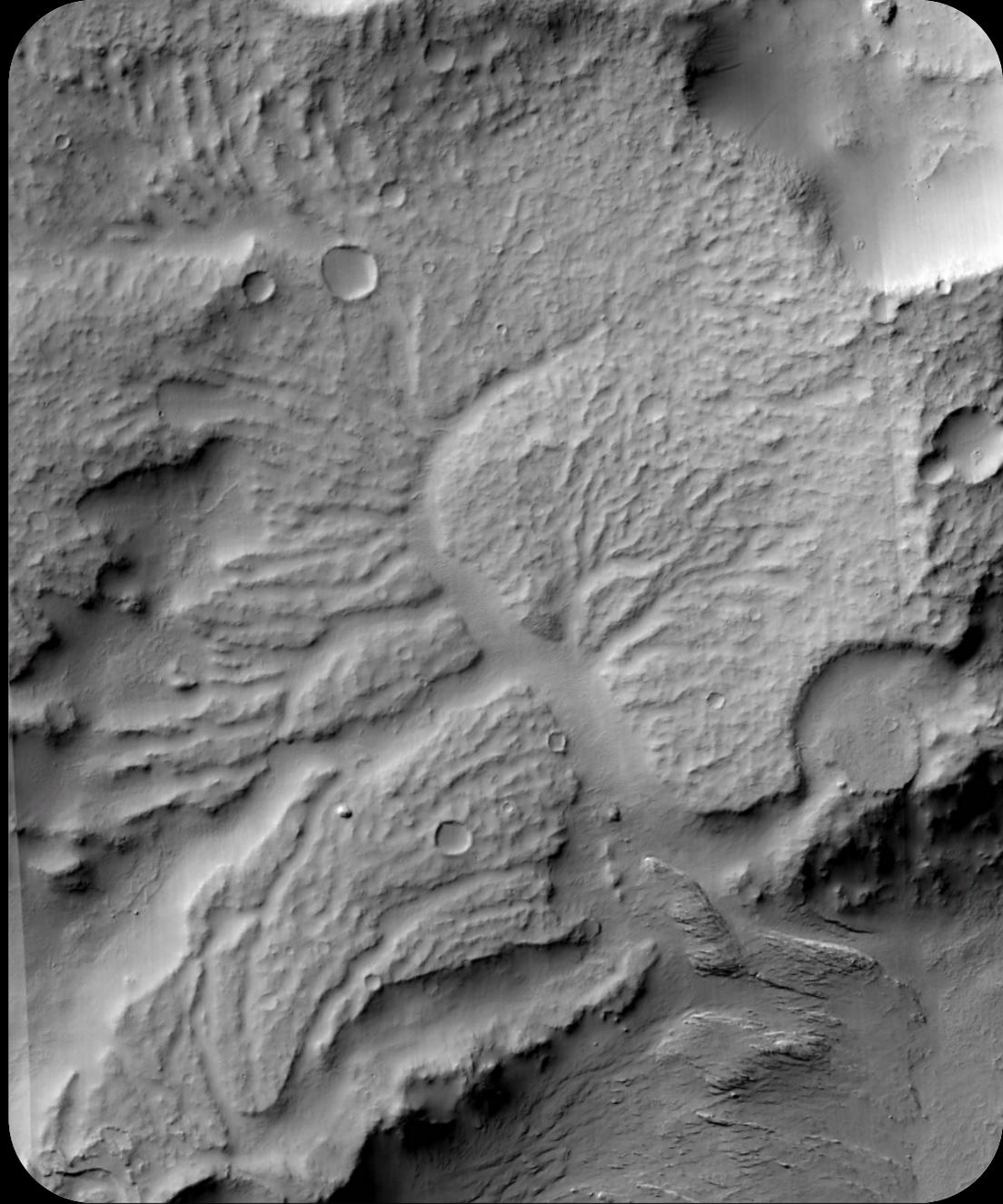
-12.623, 177.0211; -2142 m

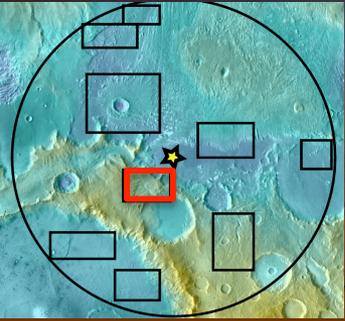
★ Surface Field Station:

-12.565, 177.0353; -2142 m



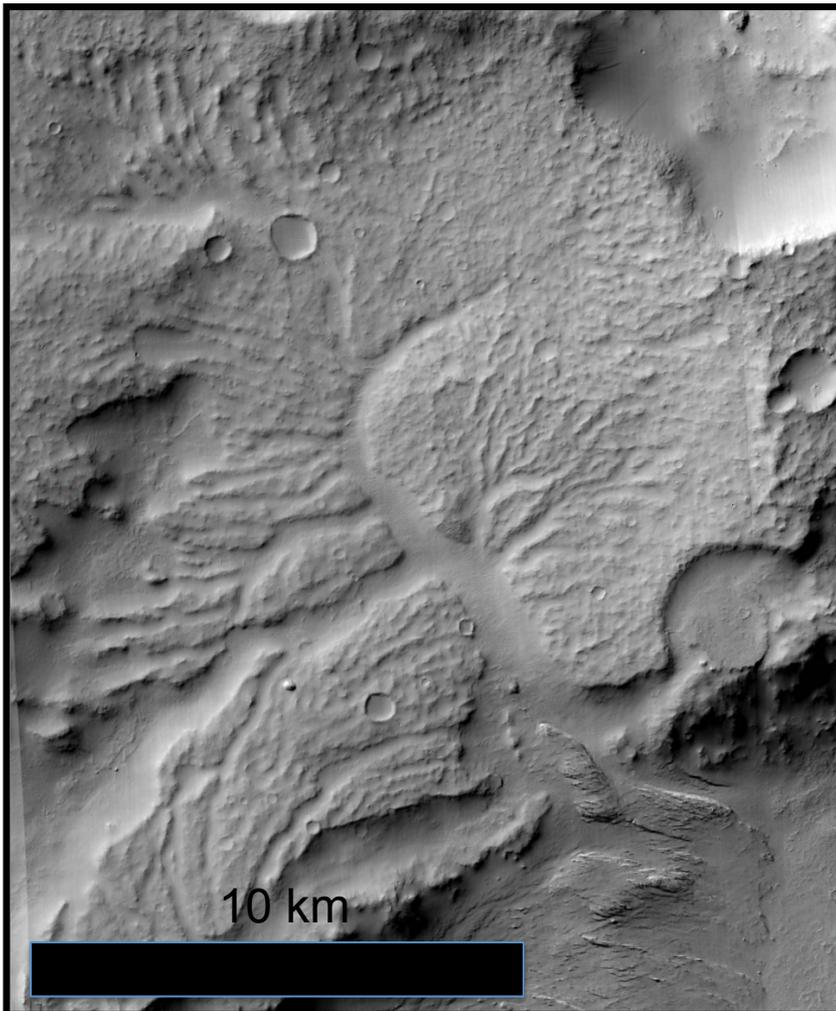
SCIENCE ROIs





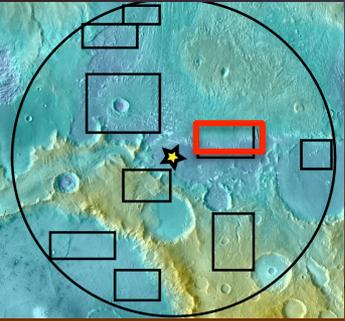
Science ROI 1

1st EZ Workshop for Human Missions to Mars



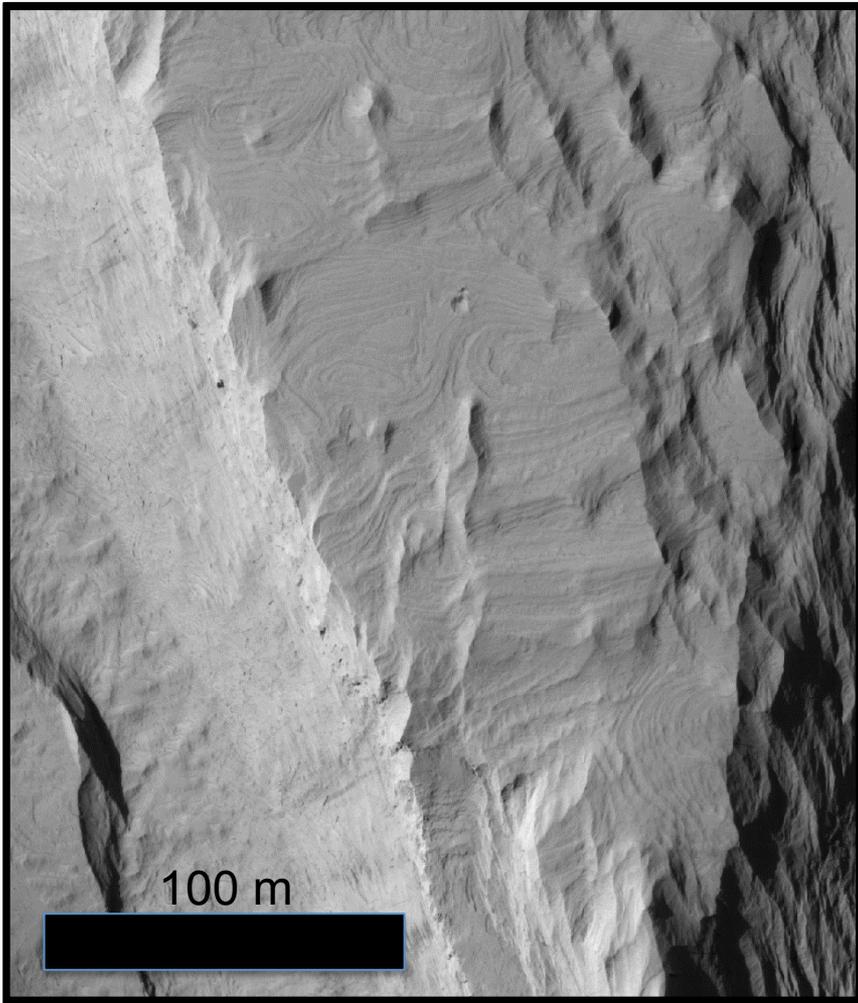
Galdakao Valley

- -12.998, 176.373; -1146 m; CTX, HRSC; partial HiRISE.
- Well-preserved valley network emptying into a crater
- Potential for past habitability; aqueous processes; stratigraphy



Science ROI 2

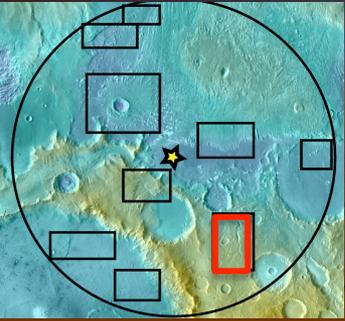
1st EZ Workshop for Human Missions to Mars



Yardangton

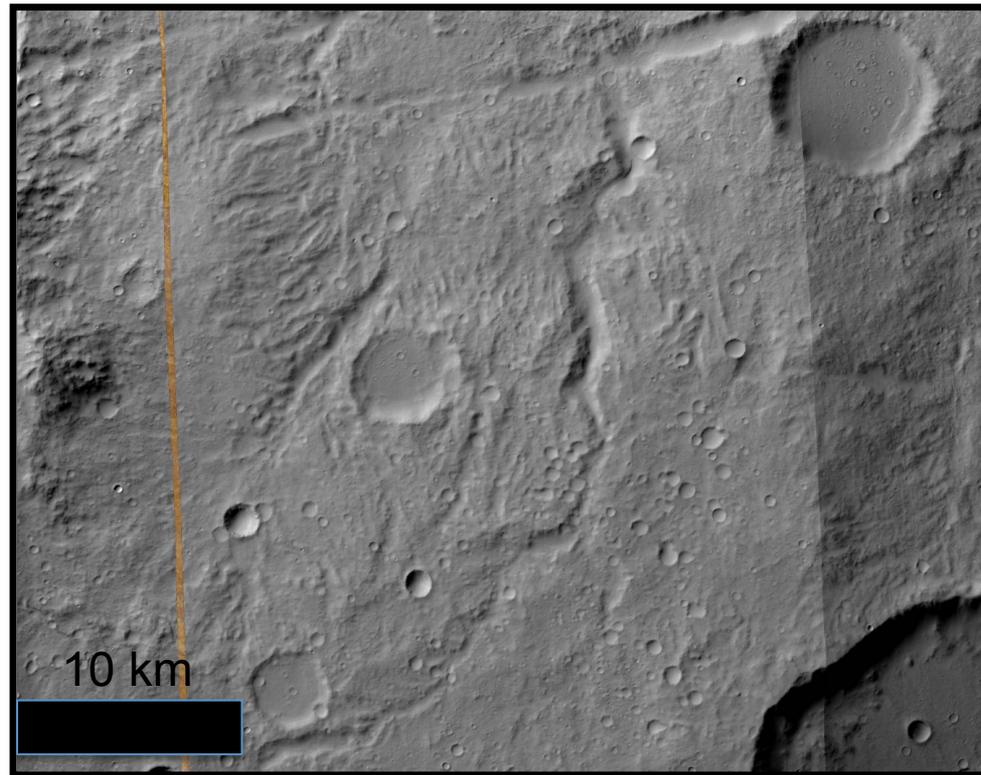
-12.615, 177.230; -2103 m;
CTX, HRSC, some HiRISE

- Finely layered, fine-grained unit known for preserving fine details of past environments; enhanced in a variety of elements
- Diverse aeolian units and meteorological environments; widespread unit; dateable plain



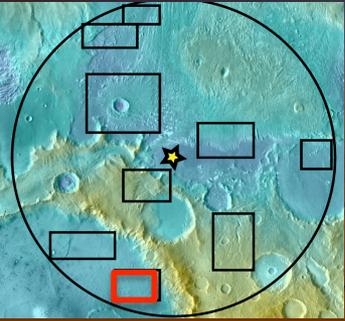
Science ROI 3

1st EZ Workshop for Human Missions to Mars



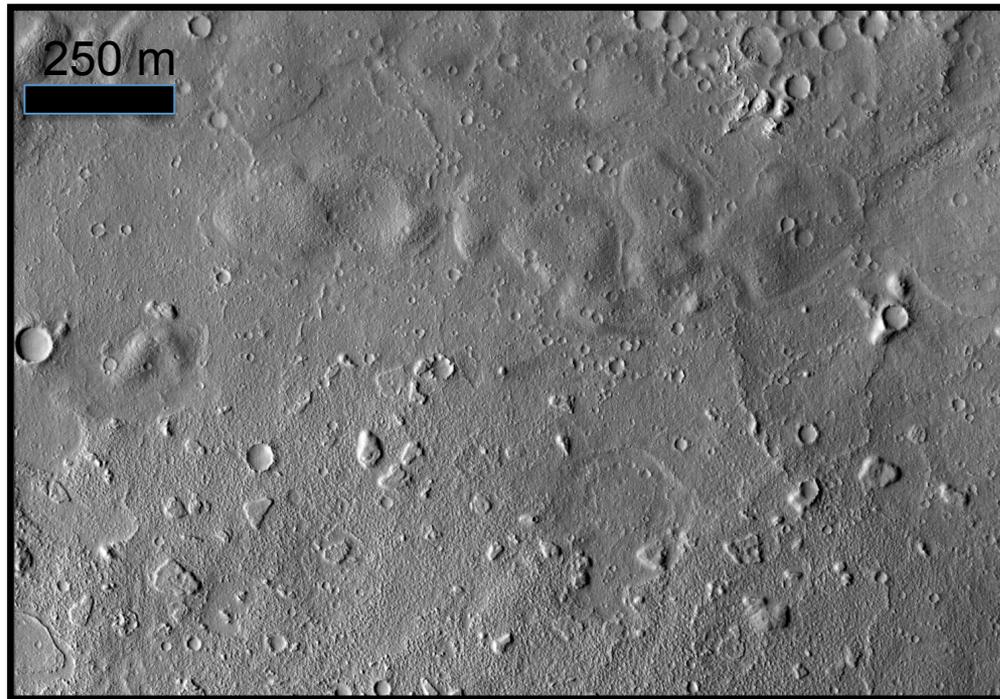
Valleys of the Ancients

- -13.378, 177.3547;
-1398 m; CTX, HRSC
- Classic Noachian valley networks and ponds of ancient lava
- Potential for past habitability, aqueous processes, dateable Noachian surfaces



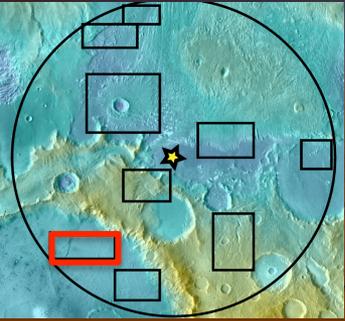
Science ROI 4

1st EZ Workshop for Human Missions to Mars



The Field of Dreams

- -14.284, 176.246; -1865 m; CTX, HRSC
- Possible Home Platef like environments
- Potential for past habitability, aqueous processes, meteorological diversity, dust devils



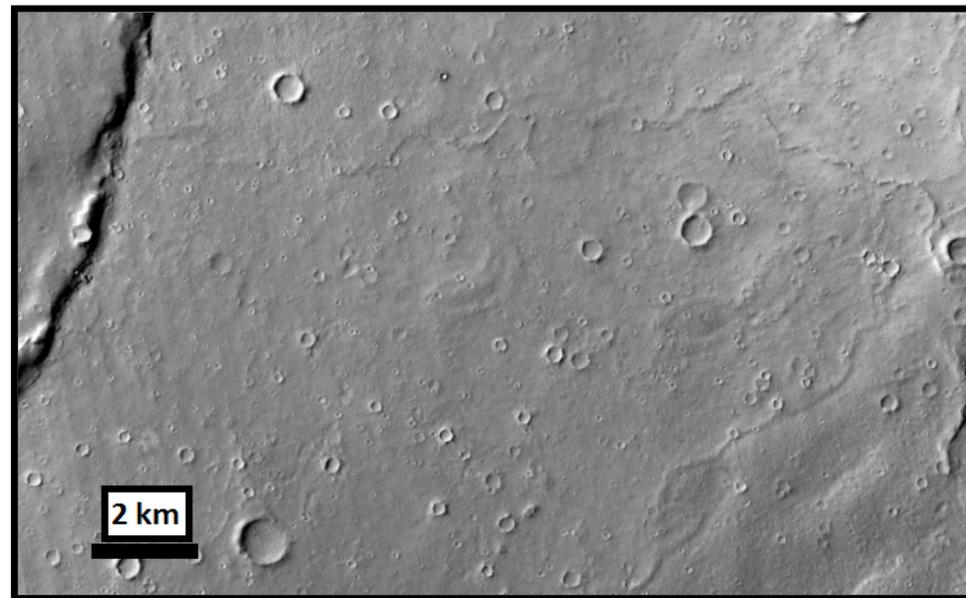
Science ROI 5

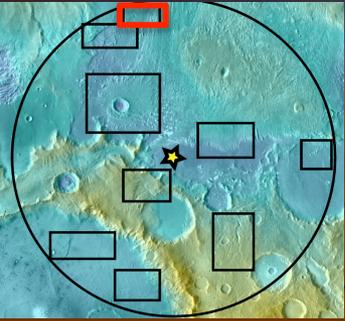
1st EZ Workshop for Human Missions to Mars



The Plains of Gusev

- -13.738, 176.1359;
-1900 m; CTX, HRSC
- Hesperian plains
- Dateable Hesperian igneous surface, wrinkle ridges, atmospheric exchange (dust devils)





Science ROI 6

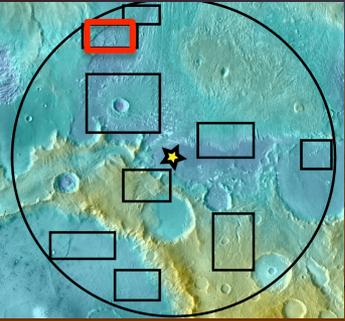
1st EZ Workshop for Human Missions to Mars



Apollinaris Mons

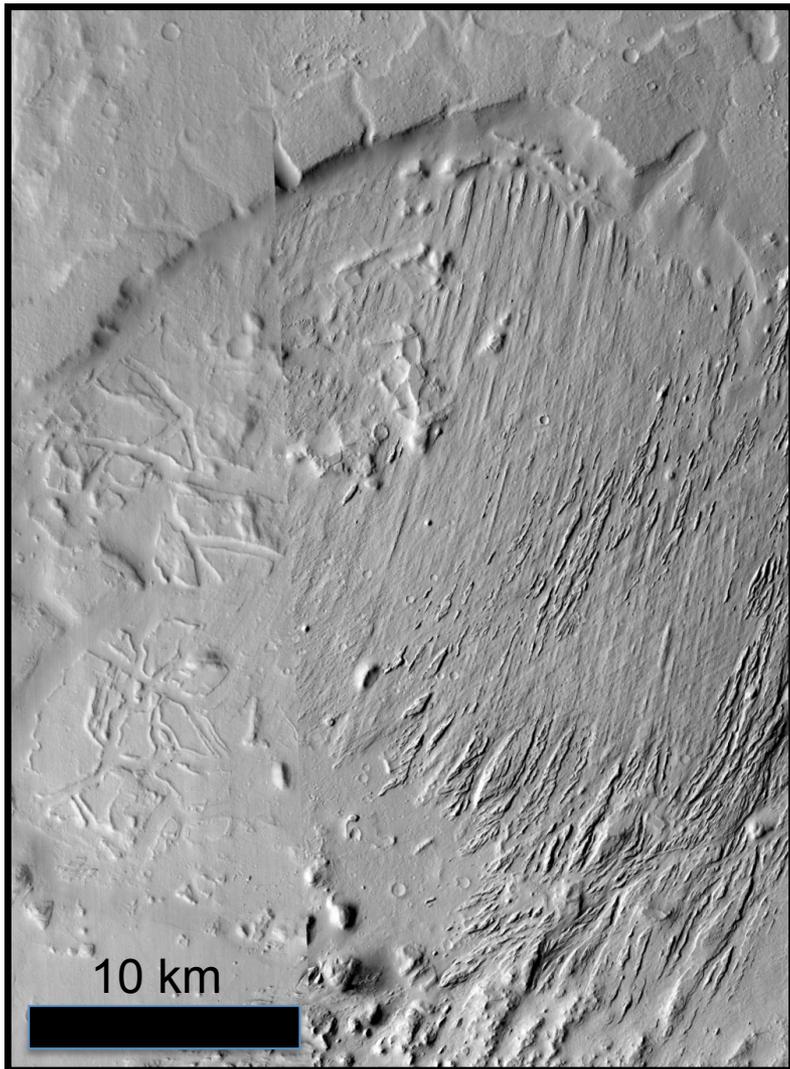
- -11.103, 176.2905;
-1776 m; CTX and HSRC
- Apollinaris fan deposit
- Dateable, Hesperian/
Amazonian igneous
surface; magnetic
anomaly; stratigraphy

10 km



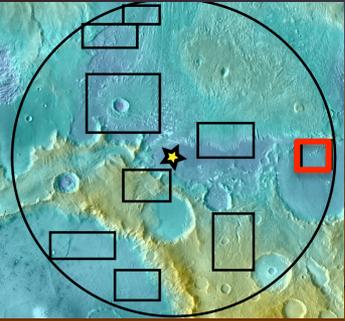
Science ROI 7

1st EZ Workshop for Human Missions to Mars



Chaos Spectacularis

- -11.514, 175.9043;
-2033 m; CTX and HRSC
- Chaos terrain
- Potential for aqueous processes, resolving questions about a widespread structural process



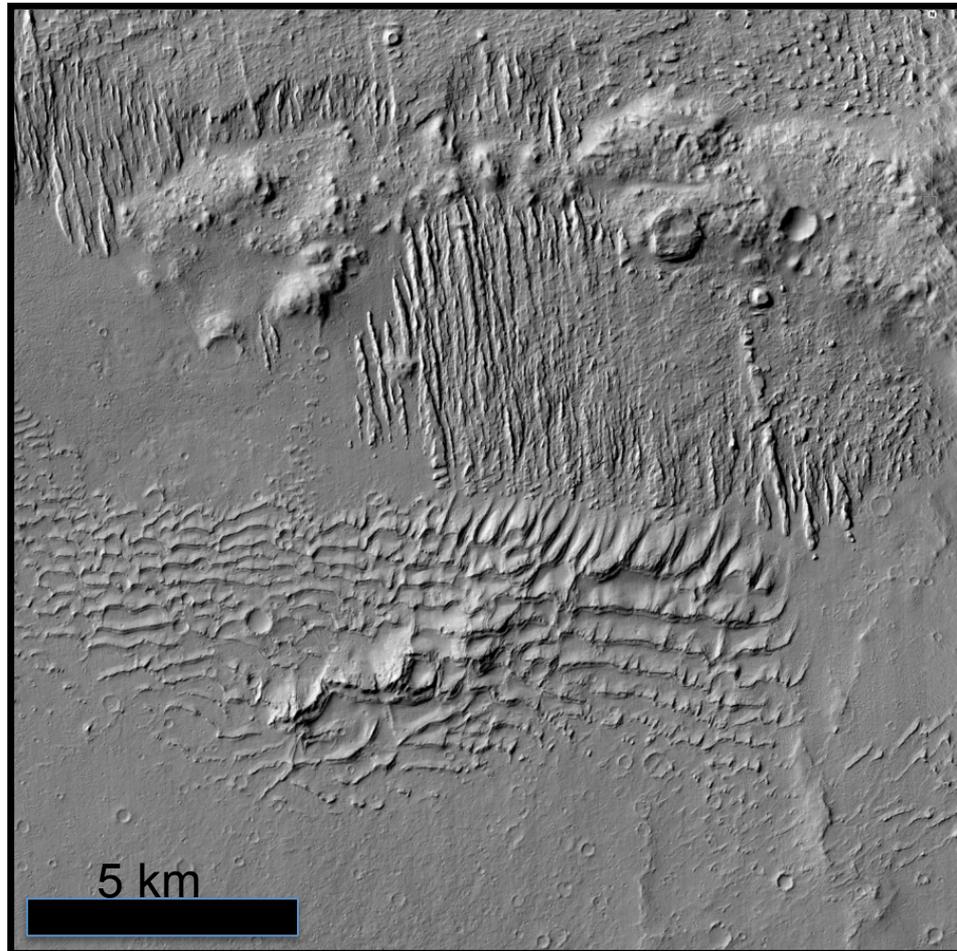
Science ROI 8

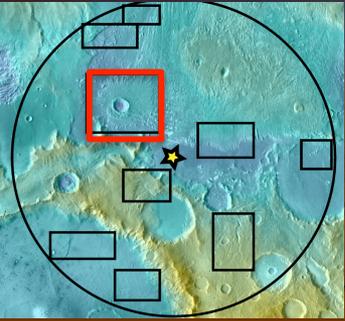
1st EZ Workshop for Human Missions to Mars



The Petrified Dunes

- -12.615, 177.230; -1900 m; CTX, HRSC, some HiRISE
- Ancient, indurated, unroofed dunes
- Potential for preservation of ancient features, diversity of aeolian features





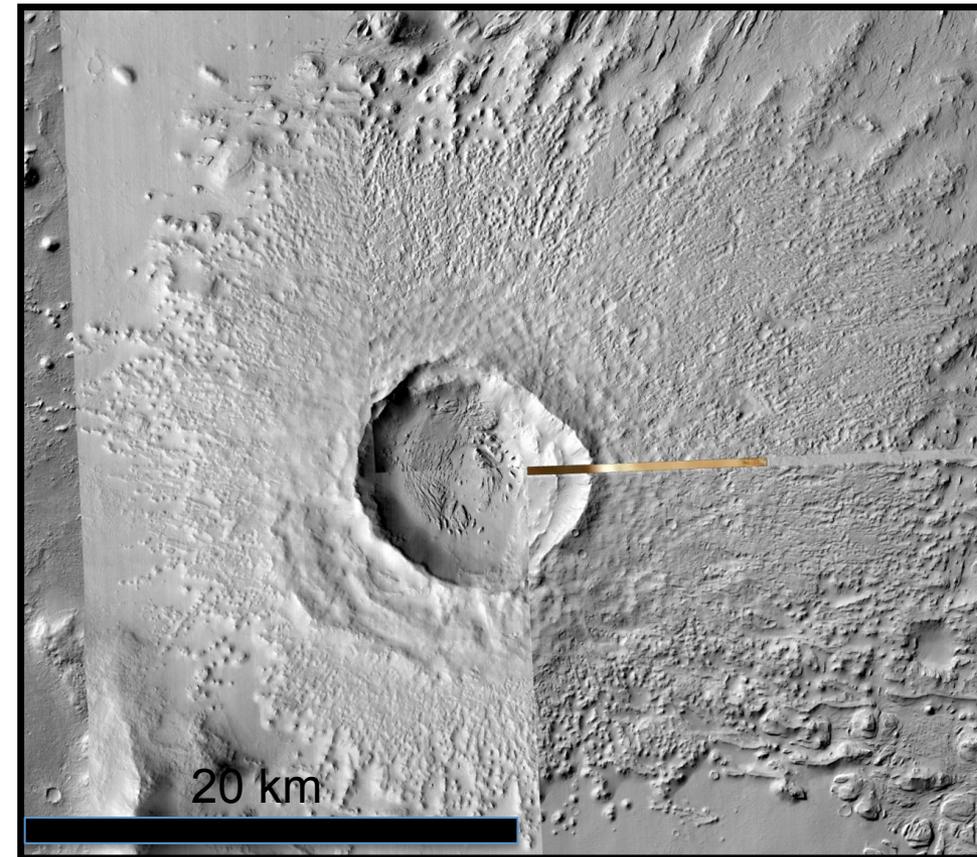
Science ROI 9

1st EZ Workshop for Human Missions to Mars



Sugar Land Crater

- -12.152, 176.1359;
-2302; CTX, HRSC
- Well-preserved crater
ejecta blanket; wrinkle
ridge
- Ejecta facies;
widespread structural
features (wrinkle ridge)





RESOURCE ROIs

General Resources

1st EZ Workshop for Human Missions to Mars

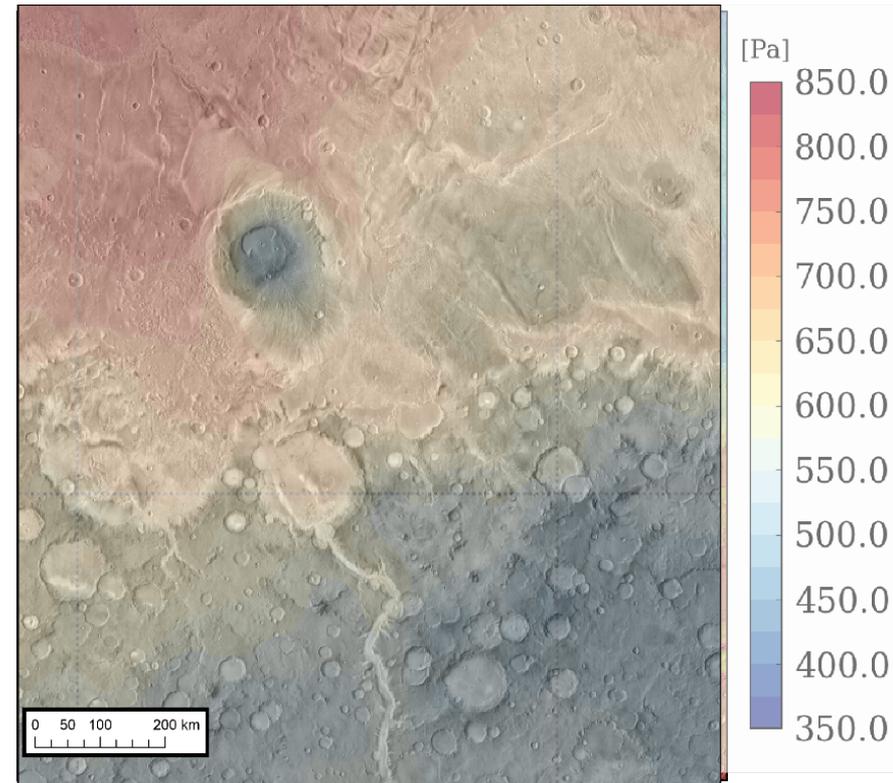


Near the equator: 12 S

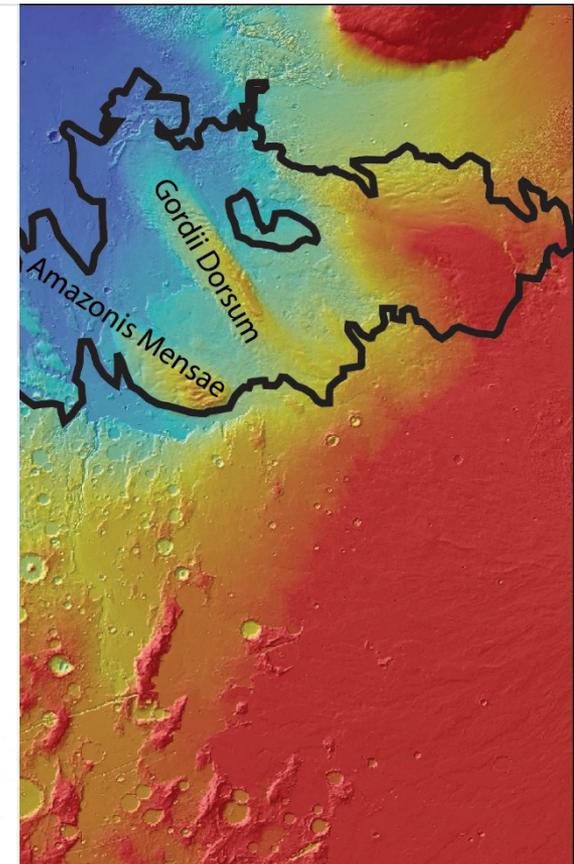
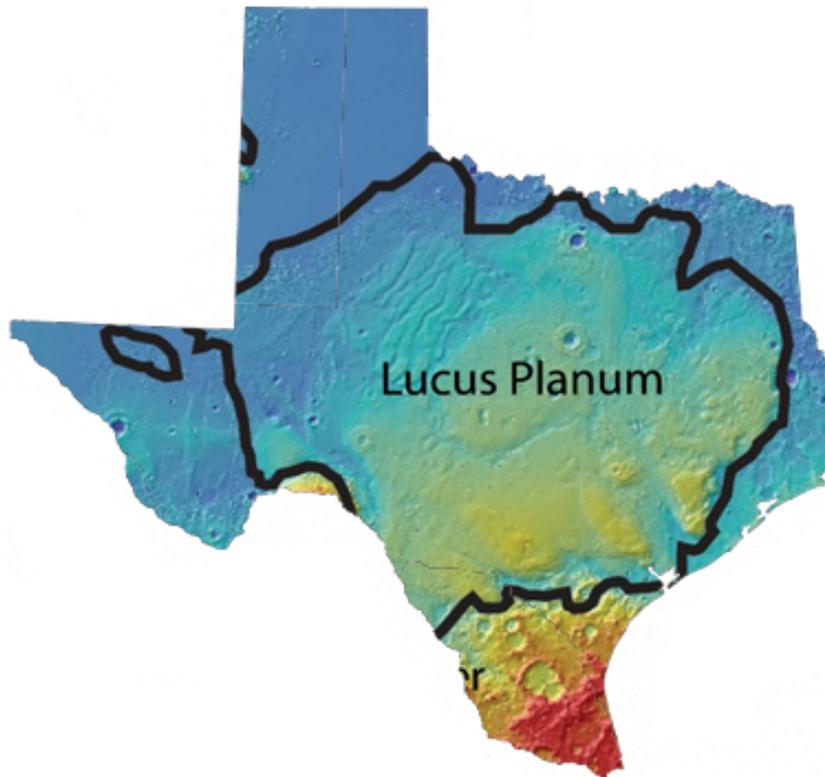
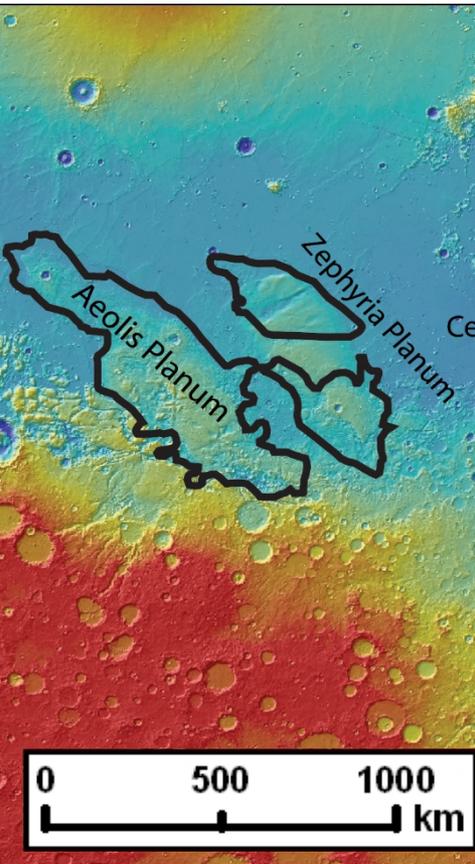
- Accessible in most Earth launch opportunities
- Good for MAV launch
- Good for solar energy (panels, farming)
- Benign thermal environment

Low altitude: -2200 m

- Good for landing
- Good for atmosphere-related ISRU

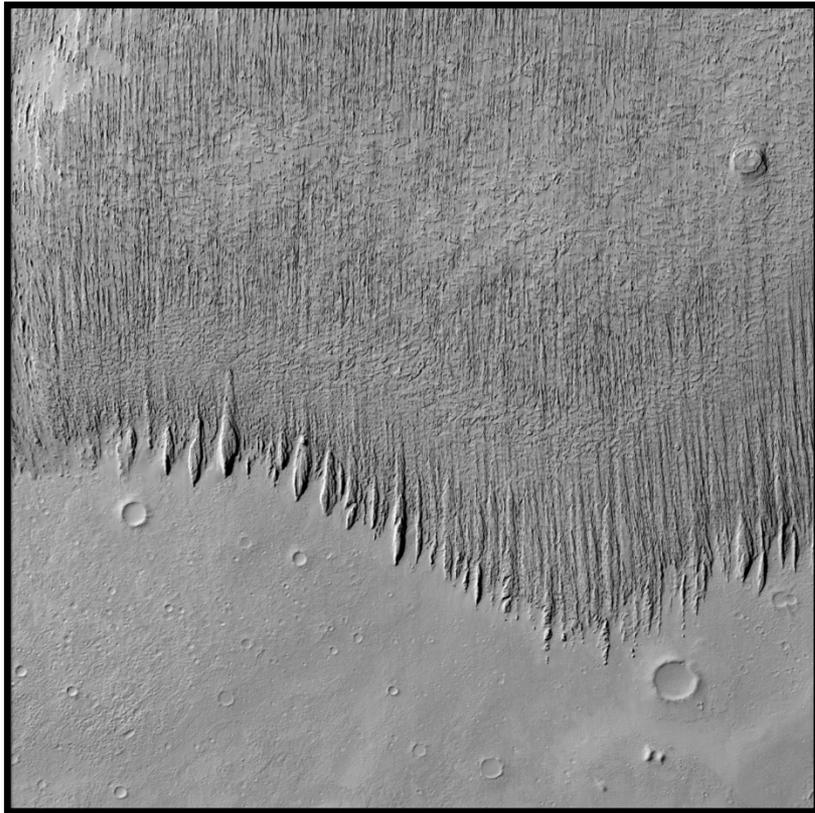


The Medusae Fossae



Resource ROI 1: The MFF

1st EZ Workshop for Human Missions to Mars

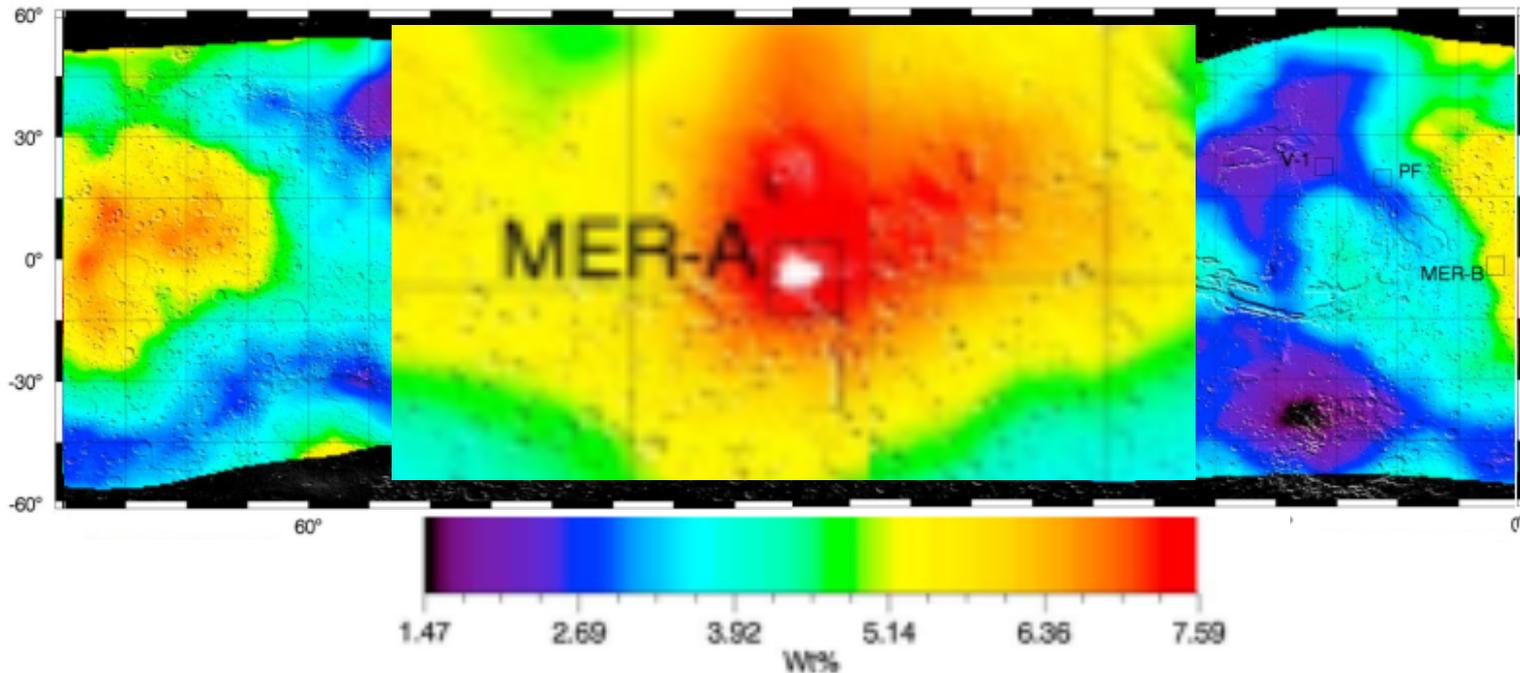


The Medusae Fossae Formation

- -12.615, 177.230; -2103 m; CTX, HRSC, some HiRISE
- The Medusae Fossae Formation: a vast resource for fine-grained materials for civil engineering (roads, berms, landing pads); possible resource for water, and excellent structural resource

Resource ROI 1: Water

1st EZ Workshop for Human Missions to Mars



- Gamma ray and neutron spectrometers find an enhanced hydrogen signature
- MARSIS and SHARAD radar suggests either an anomalously low density material or a high proportion of clean water ice

Resource ROI 1: Infrastructure



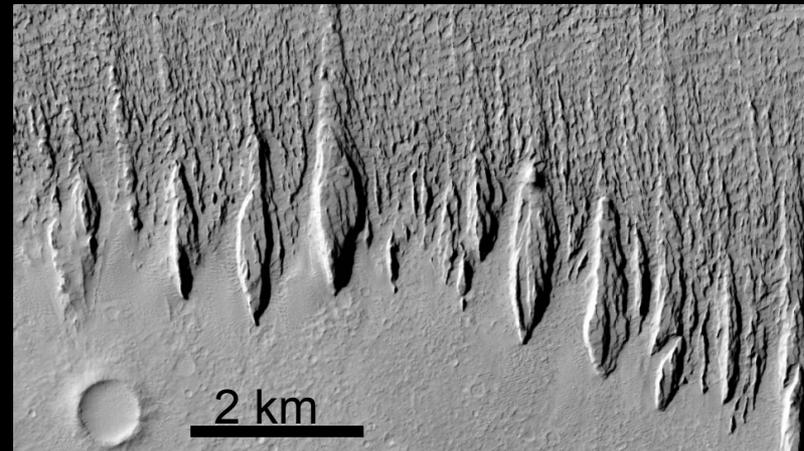
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Sheltered from radiation

Near a source of building materials



Image: NASA 3-D printed habitat challenge



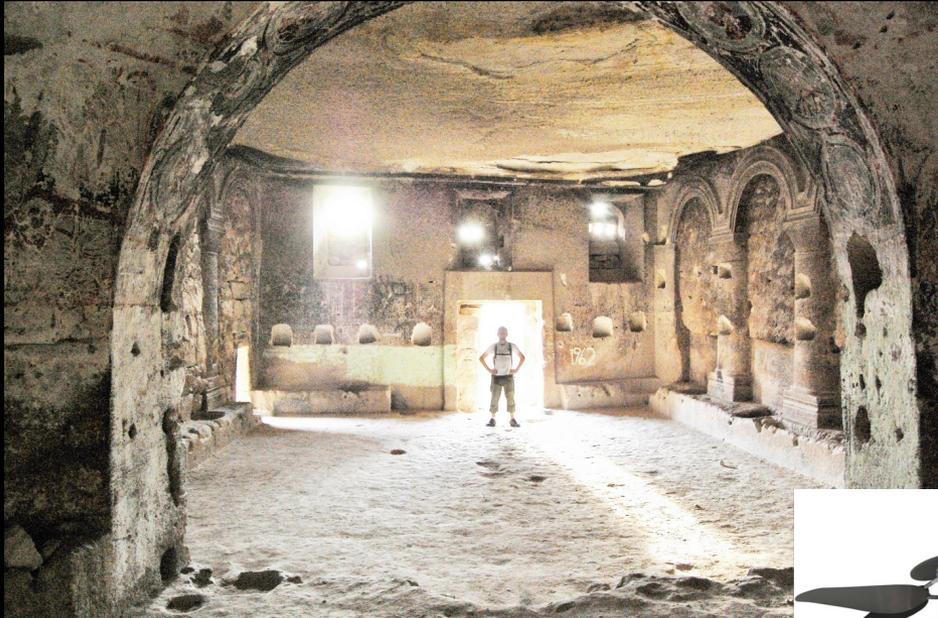


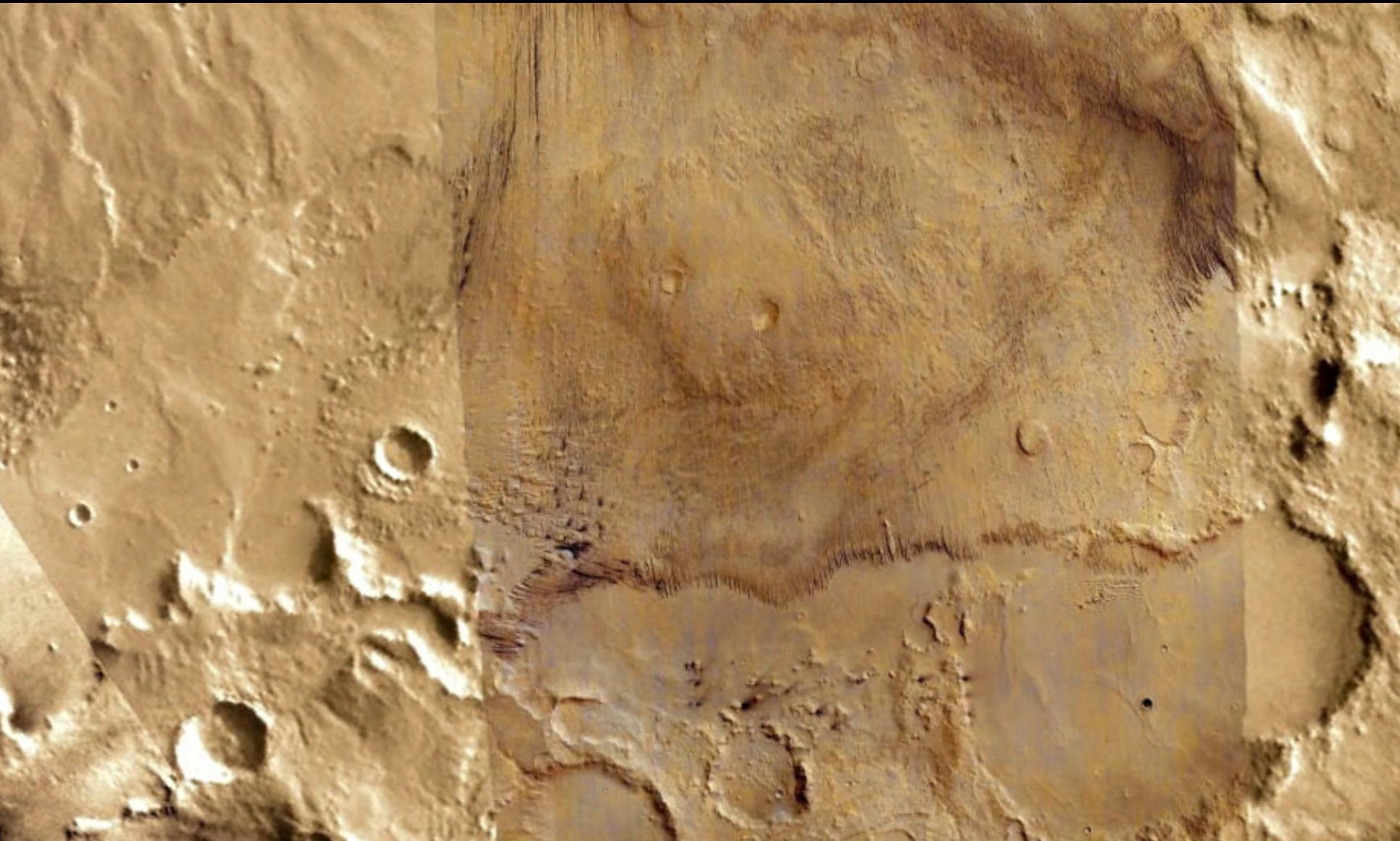
1st EZ Workshop for Human Missions to Mars



The Cappadocian Example

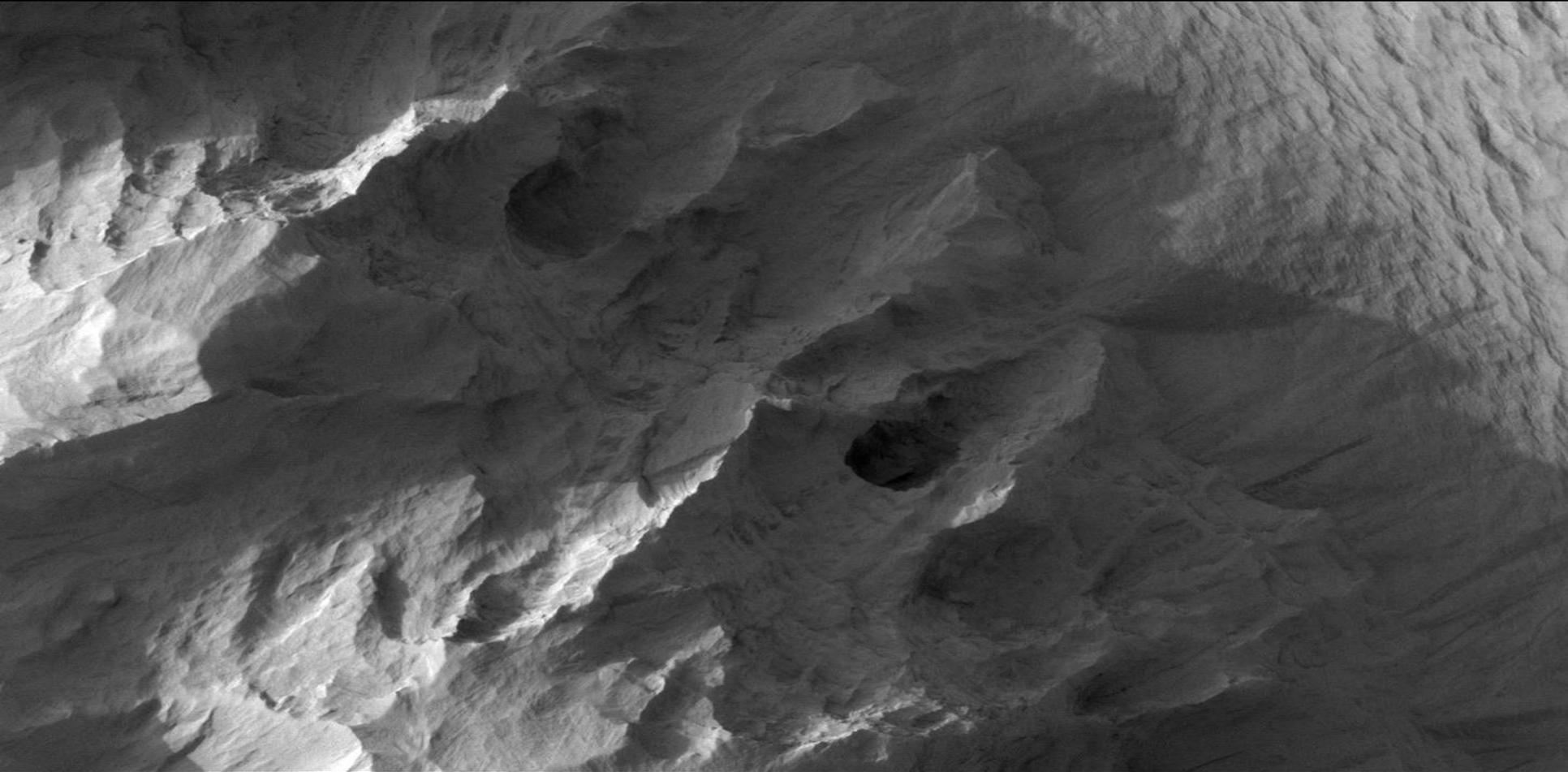
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Caves in the Medusae Fossae

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Mehrdad Ghazvinian





Science ROI(s) Rubric

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Site Factors			SROI1	SROI2	SROI3	SROI4	SROI5	SROI6	SROI7	SROI8	SROI9	EZ SUM
Astrobio	Threshold	AND/OR	Potential for past habitability									2,2
		Potential for present habitability/refugia									0,0	
	Qualifying	Potential for organic matter, w/ surface exposure									0,4	
Atmospheric Science	Threshold	Noachian/Hesperian rocks w/ trapped atmospheric gases									0,0	
	Qualifying	Meteorological diversity in space and time									3,0	
		High likelihood of surface-atmosphere exchange									2,0	
		Amazonian subsurface or high-latitude ice or sediment									0,0	
		High likelihood of active trace gas sources									0,0	
Geoscience	Threshold	Range of martian geologic time; datable surfaces									4,0	
		Evidence of aqueous processes									2,2	
		Potential for interpreting relative ages									6,0	
	Qualifying	Igneous Rocks tied to 1+ provinces or different times									5,0	
		Near-surface ice, glacial or permafrost									0,0	
		Noachian or pre-Noachian bedrock units									1,0	
		Outcrops with remnant magnetization									1,0	
		Primary, secondary, and basin-forming impact deposits									1,2	
		Structural features with regional or global context									2,0	
		Diversity of aeolian sediments and/or landforms									2,0	

Key	
●	Yes
○	Partial Support or Debated
	No
?	Indeterminate

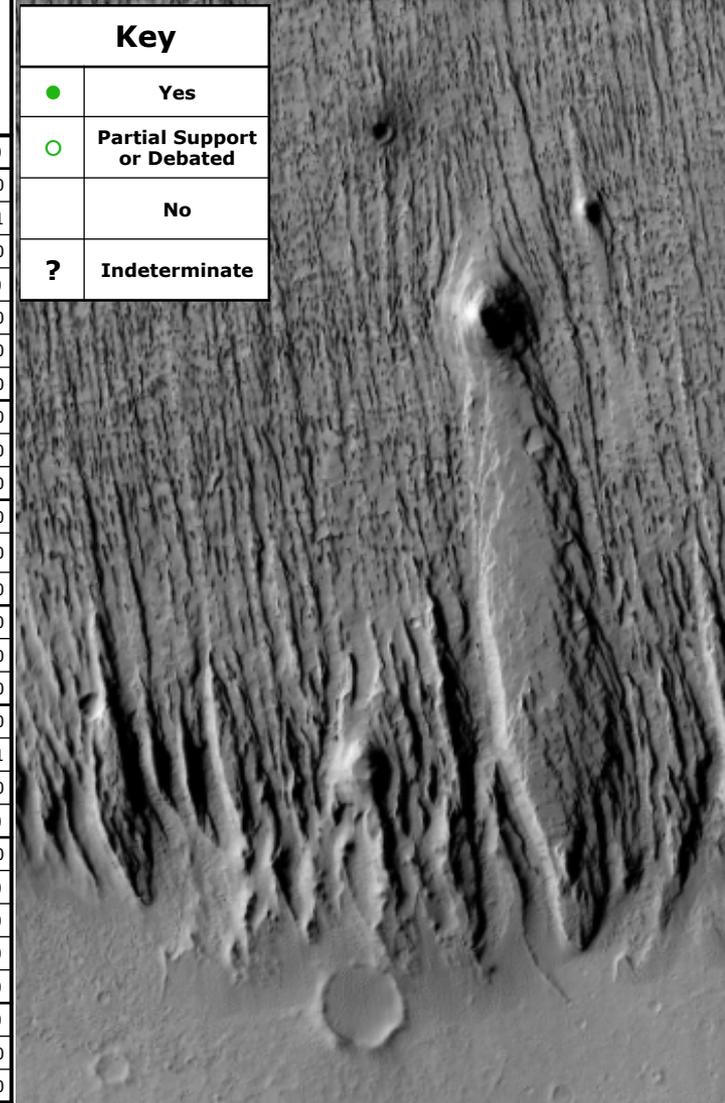
Resource ROI(s) Rubric

1st EZ Workshop for Human Missions to Mars



Site Factors			RROI1	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	●	0,1
			Quantity for substantial production	●	1,0
			Potential to be minable by highly automated systems	●	1,0
			Located less than 3 km from processing equipment site	●	1,0
			Located no more than 3 meters below the surface	●	1,0
			Accessible by automated systems	?	0,0
			Qualifying	Potential for multiple sources of ice, ice/regolith mix and hydrated minerals	●
		Distance to resource location can be >5 km	●	1,0	
		Route to resource location must be (plausibly) traversable	●	1,0	
	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		0,0
		Evidence of abundant cobble sized or smaller rocks and bulk, loose regolith	●	1,0	
		Utilitarian terrain features	●	1,0	
	Food Production	Qualifying	Low latitude	●	1,0
			No local terrain feature(s) that could shadow light collection facilities	○	0,1
			Access to water	○	0,0
			Access to dark, minimally altered basaltic sands	●	1,0
	Metal/Silicon Resource	Threshold	Potential for metal/silicon	●	1,0
			Potential to be minable by highly automated systems	?	0,0
			Located less than 3 km from processing equipment site	●	1,0
			Located no more than 3 meters below the surface	●	1,0
			Accessible by automated systems	?	0,0
		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
?	Indeterminate



Highest Priority EZ Data Needs

1st EZ Workshop for Human Missions to Mars



- Additional data needed for science:
 - **CRISM, CRISM+** (could supply missing compositional information about EZ, especially “Field of Dreams” ROI)
 - **HiRISE** (to assess layers in “Yardangton” ROI; details of “Field of Dreams” ROI)
- Additional data needed for resources:
 - **Radar** (SHARAD: assess the origin of the hydrogen enhancement; SAR: assess the distribution of the resource if made of ice)
 - **Curiosity** (If Curiosity makes it higher on Mount Sharp, it could test the composition and material properties of the formation!!)



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In America, all is easy, all is simple; and as for mechanical difficulties, they are overcome before they arise. Between Barbicane's proposition and its realization no true Yankee would have allowed even the semblance of a difficulty to be possible. A thing with them is no sooner said than done.

--Jules Verne, *From the Earth to the Moon*



BACKUP SLIDES

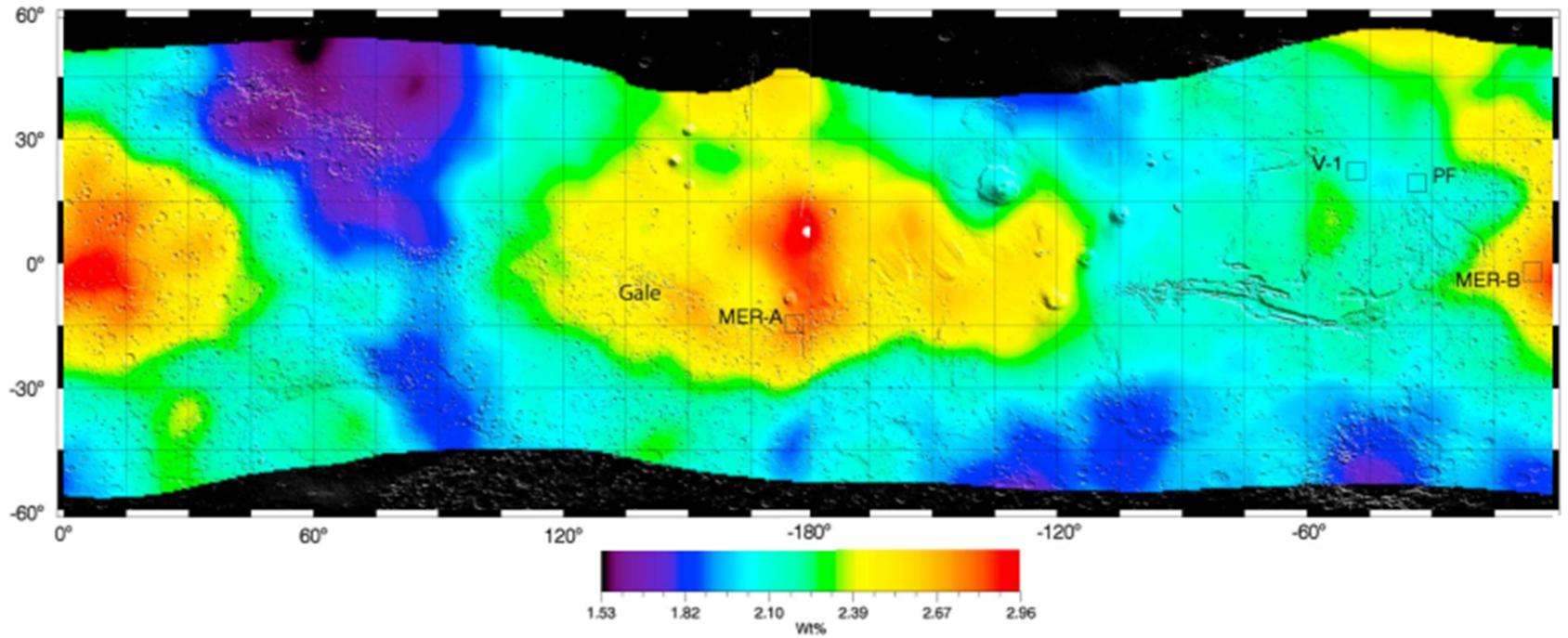
Prioritization List of EZ Data Needs

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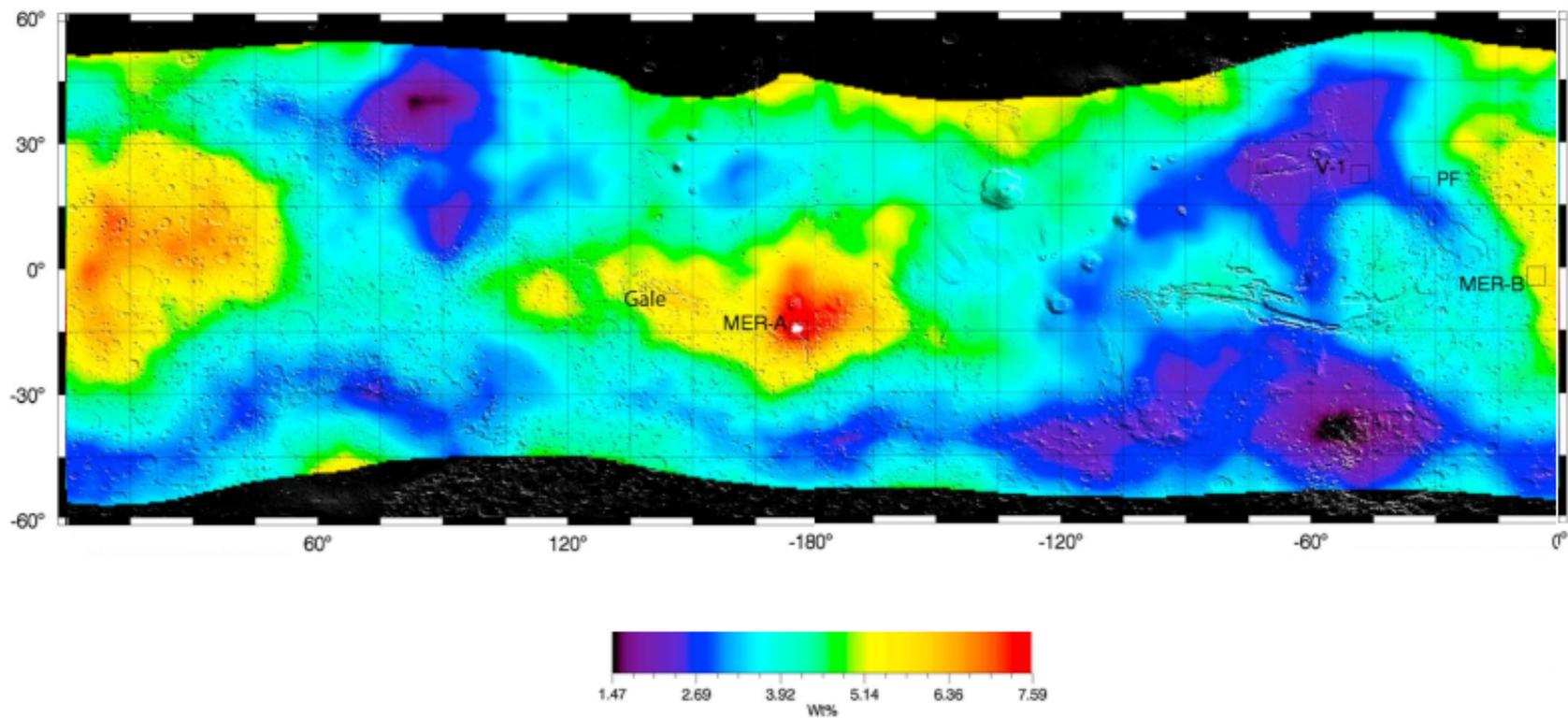


- **Orbiter/rover data to be collected to assess the science potential of the EZ.**
 - HiRISE (distribution of layers; diversity of aeolian units; regions of interest within valley networks)
 - CRISM (locations of interesting minerals)
 - SHARAD (possibly layers in the Medusae Fossae Formation, spatially varying dielectric constant)
 - Thermal camera (variations in thermal inertia; presence of volatiles in the near subsurface)
 - Sample of the Medusae Fossae Formation at Gale (chemical composition and origin of the Medusae Fossae Formation)
 - There has already been a precursor mission to Gusev Crater! (ground truth for basaltic plain; Home Plate-like features)
- **Orbiter/rover data to be collected to assess the resource potential of the EZ.**
 - HiRISE (nature of the Medusae Fossae Formation and best places to dig)
 - CRISM (discovery of metals or hydrothermal systems that might concentrate them)
 - SHARAD (variations in dielectric constant, presence of water)
 - Thermal camera (characterization of ice distribution in the shallow subsurface)
 - SAR (definitive identification of subsurface ice)

Sulfur

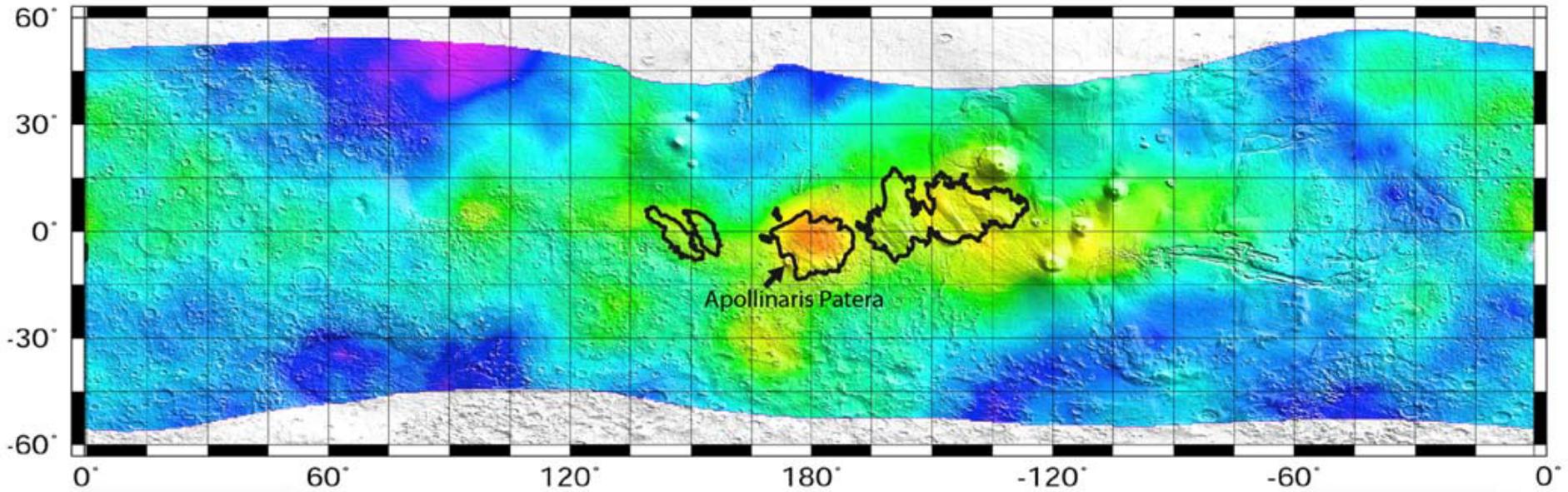
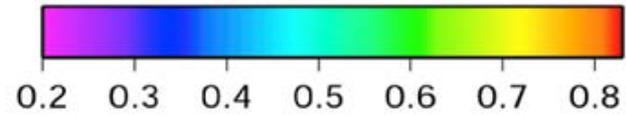


Water equivalent hydrogen

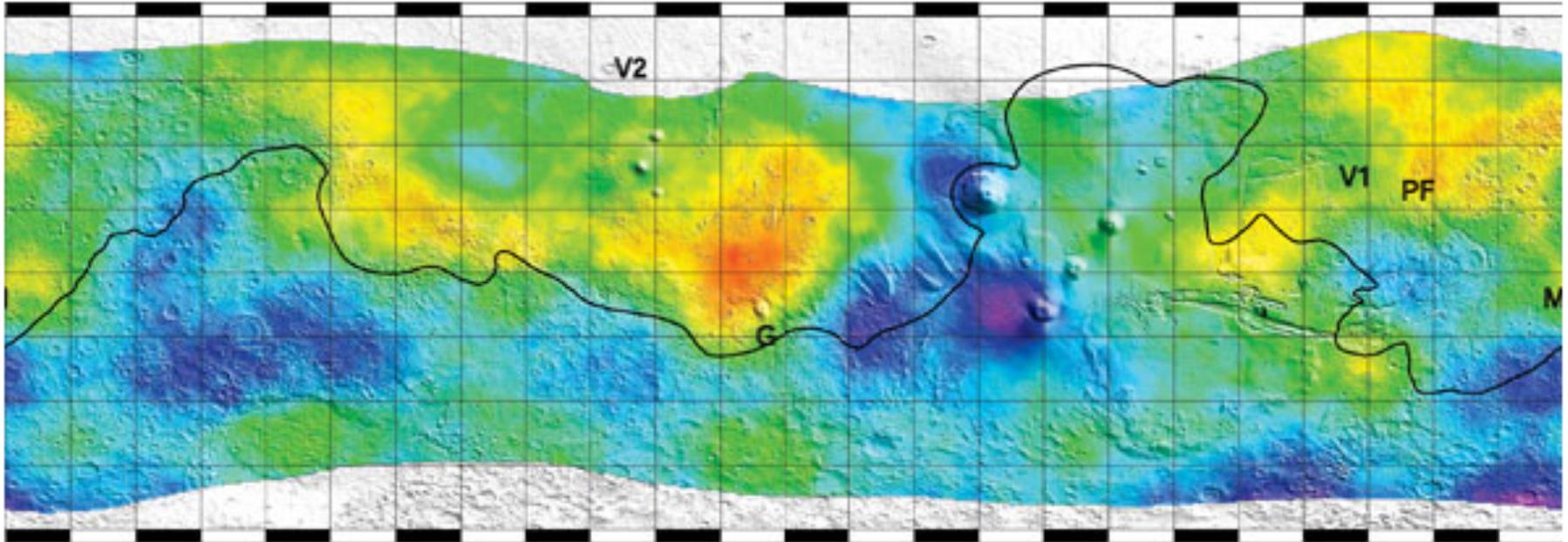
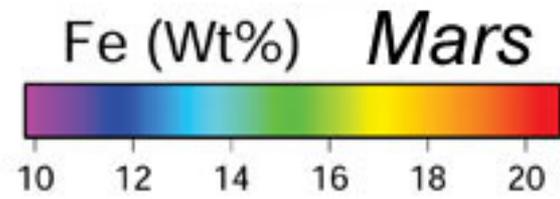


Chlorine

Cl (Wt%)

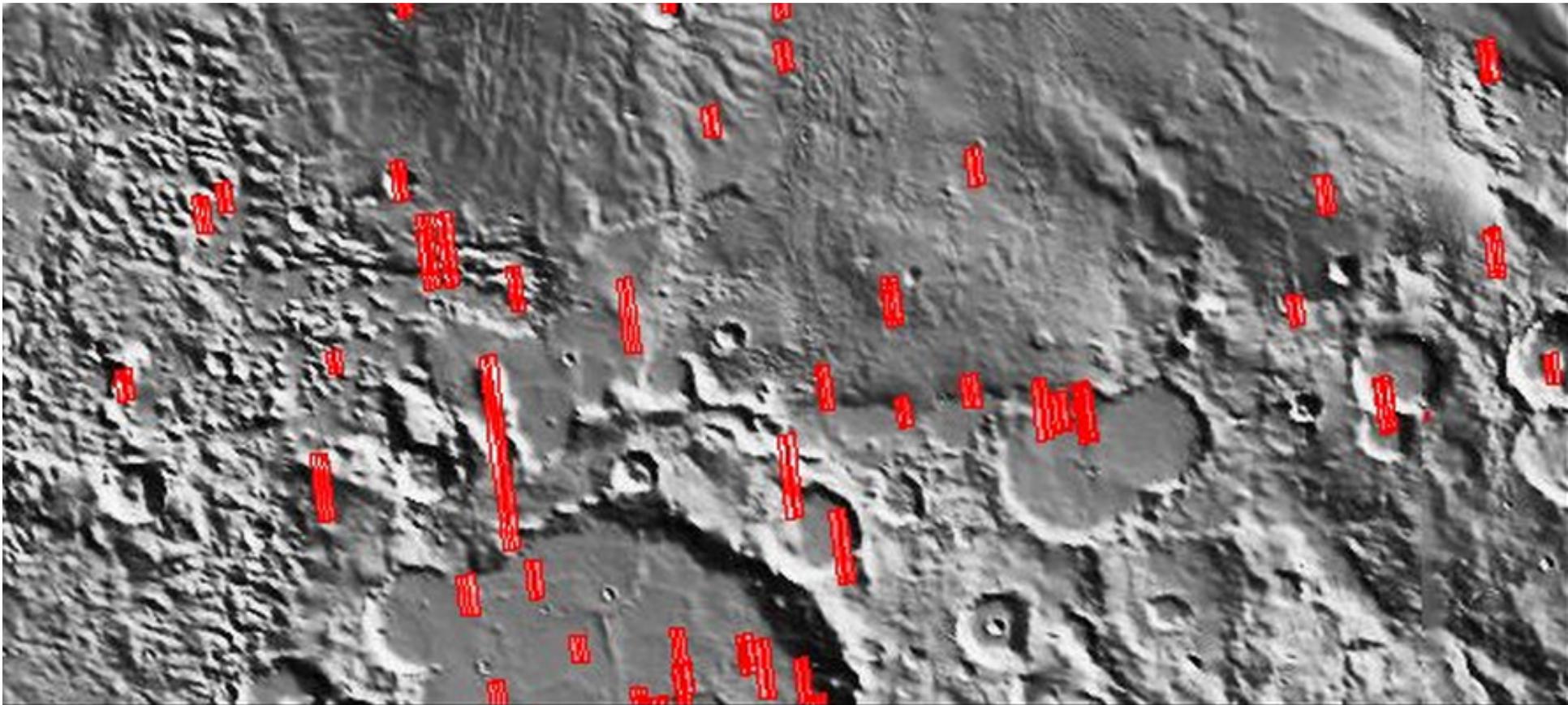


Iron



HiRISE

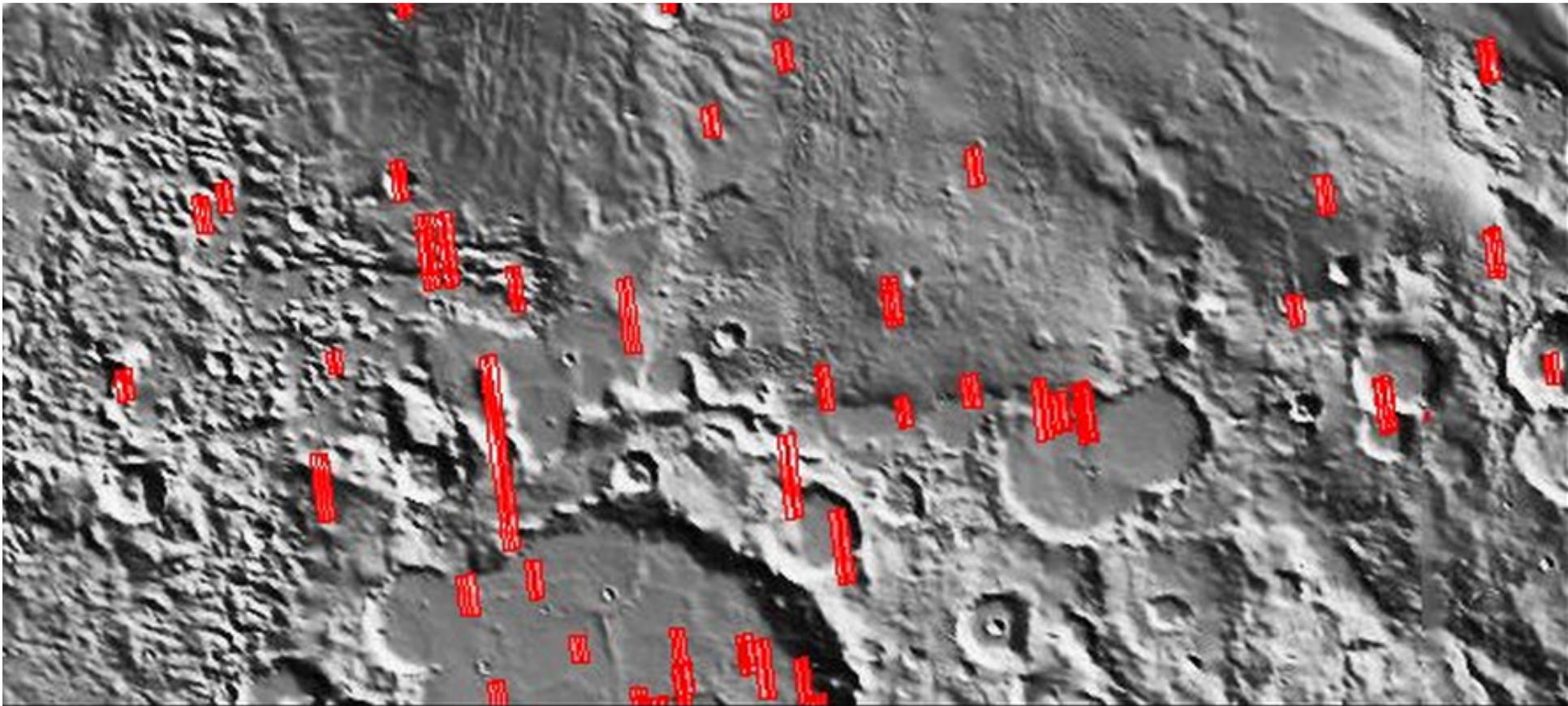
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HiRISE

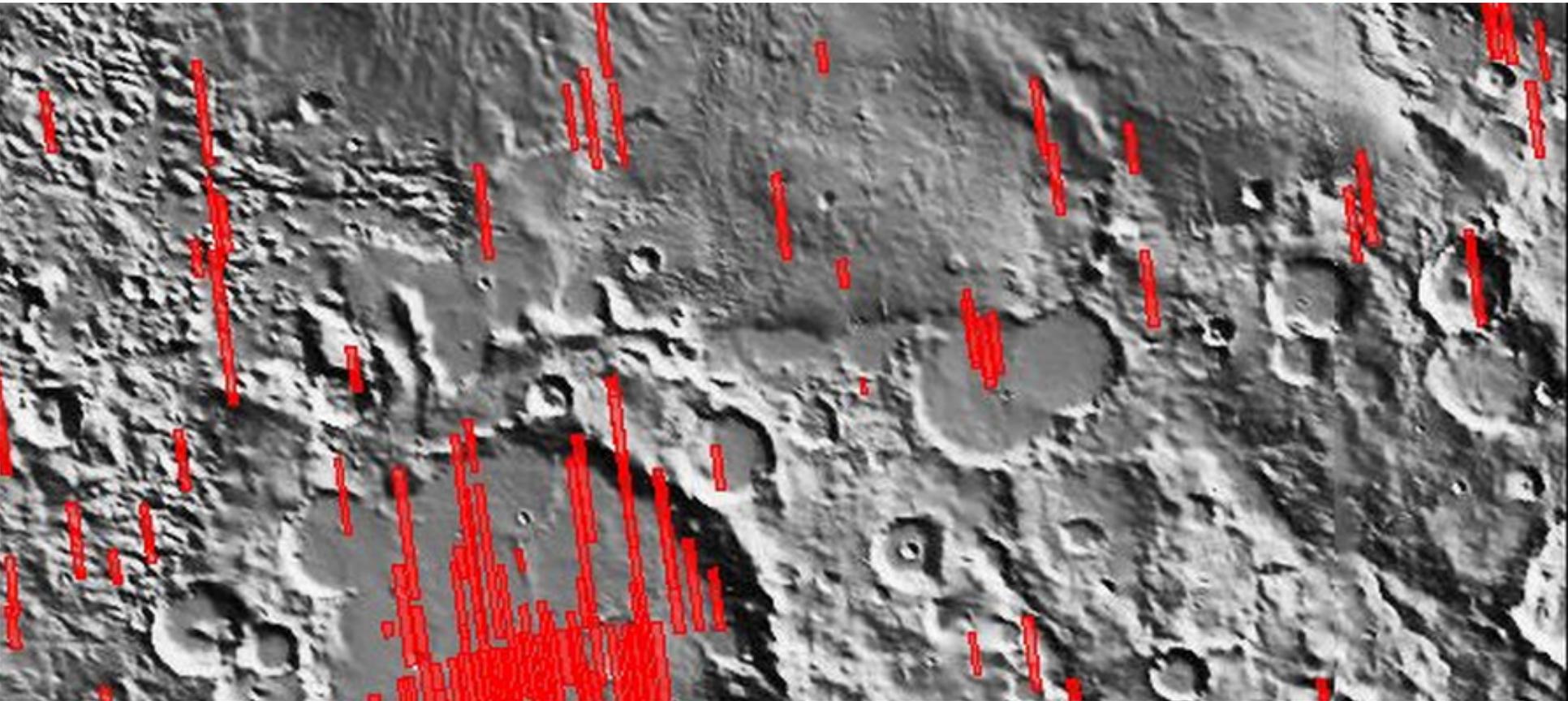
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Apollinaris Sulci

MOC

1st EZ Workshop for Human Missions to Mars

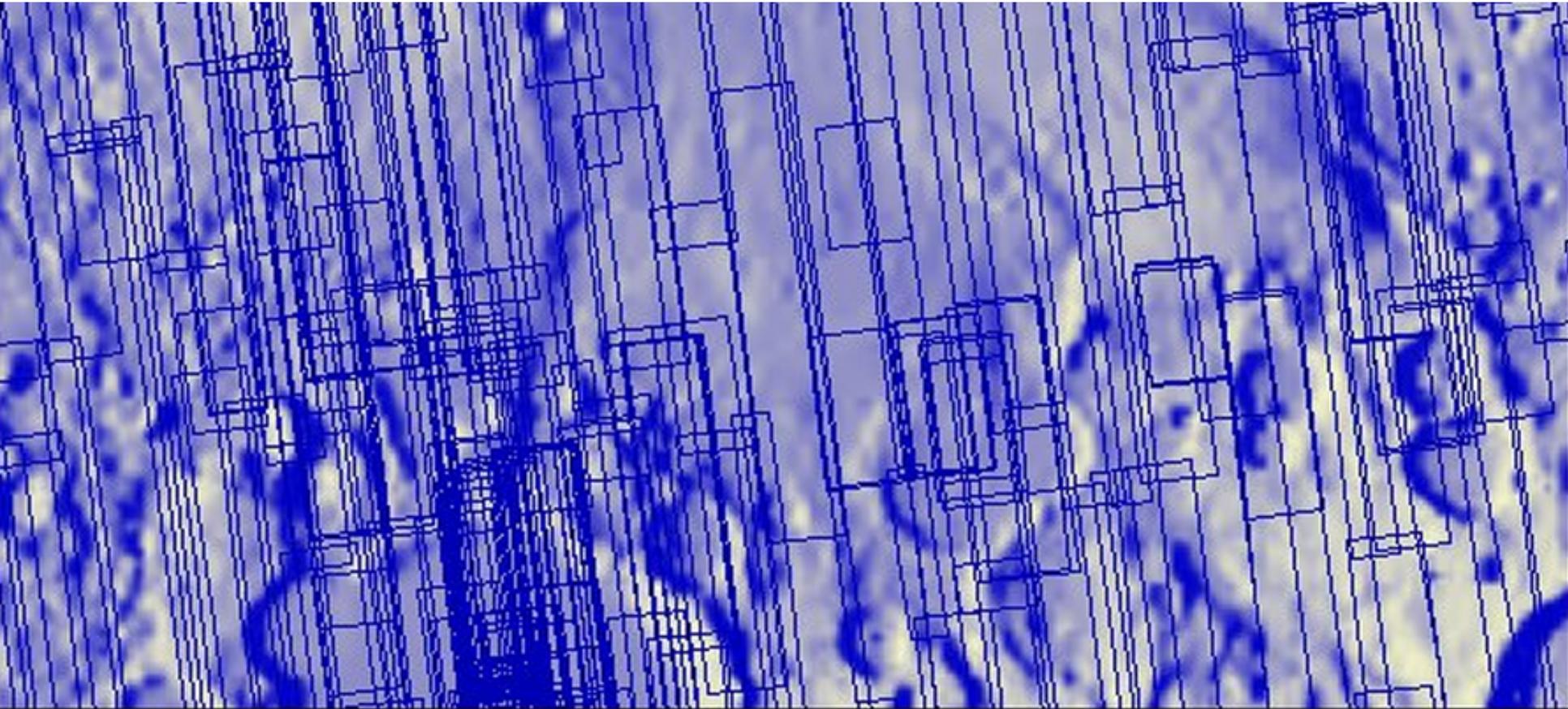


Replace With: EZ Location Name

CTX

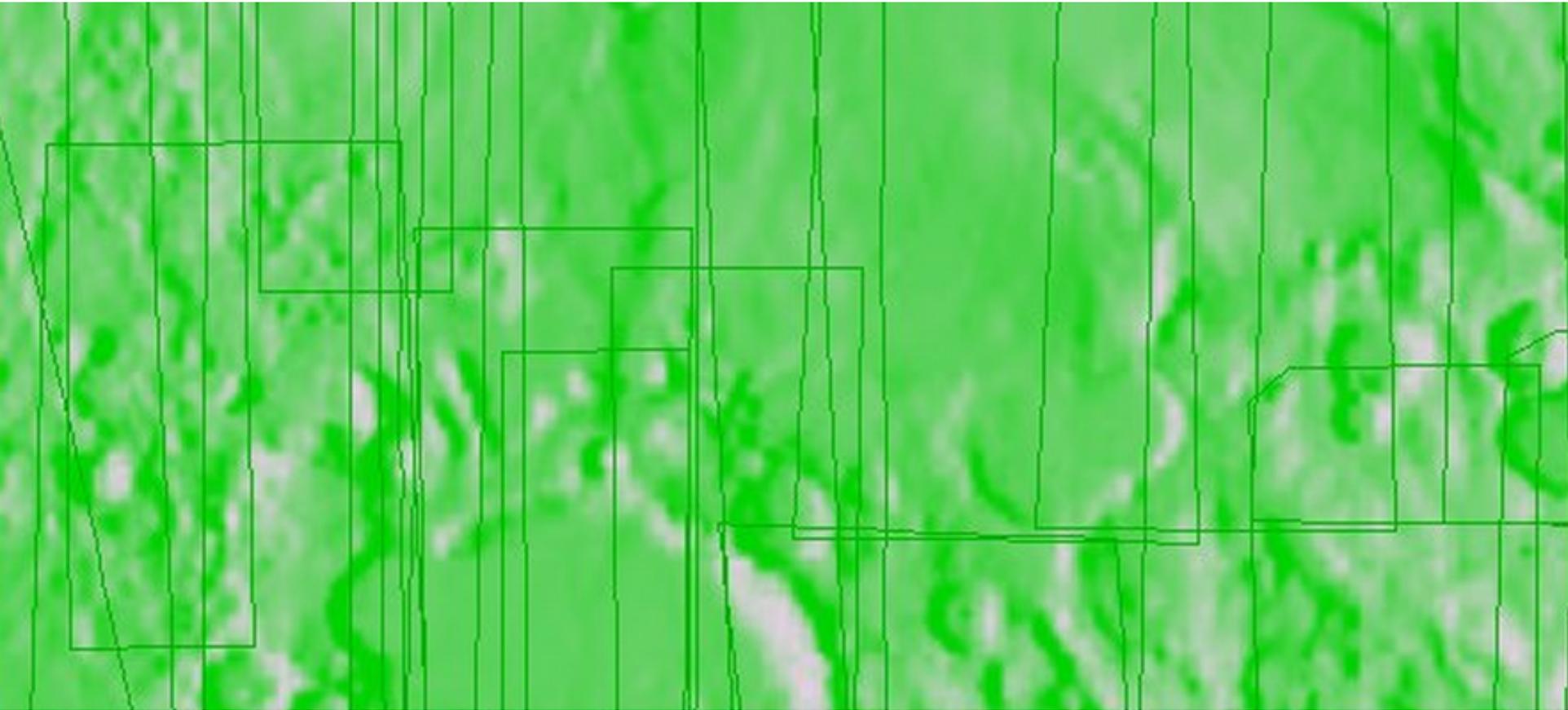


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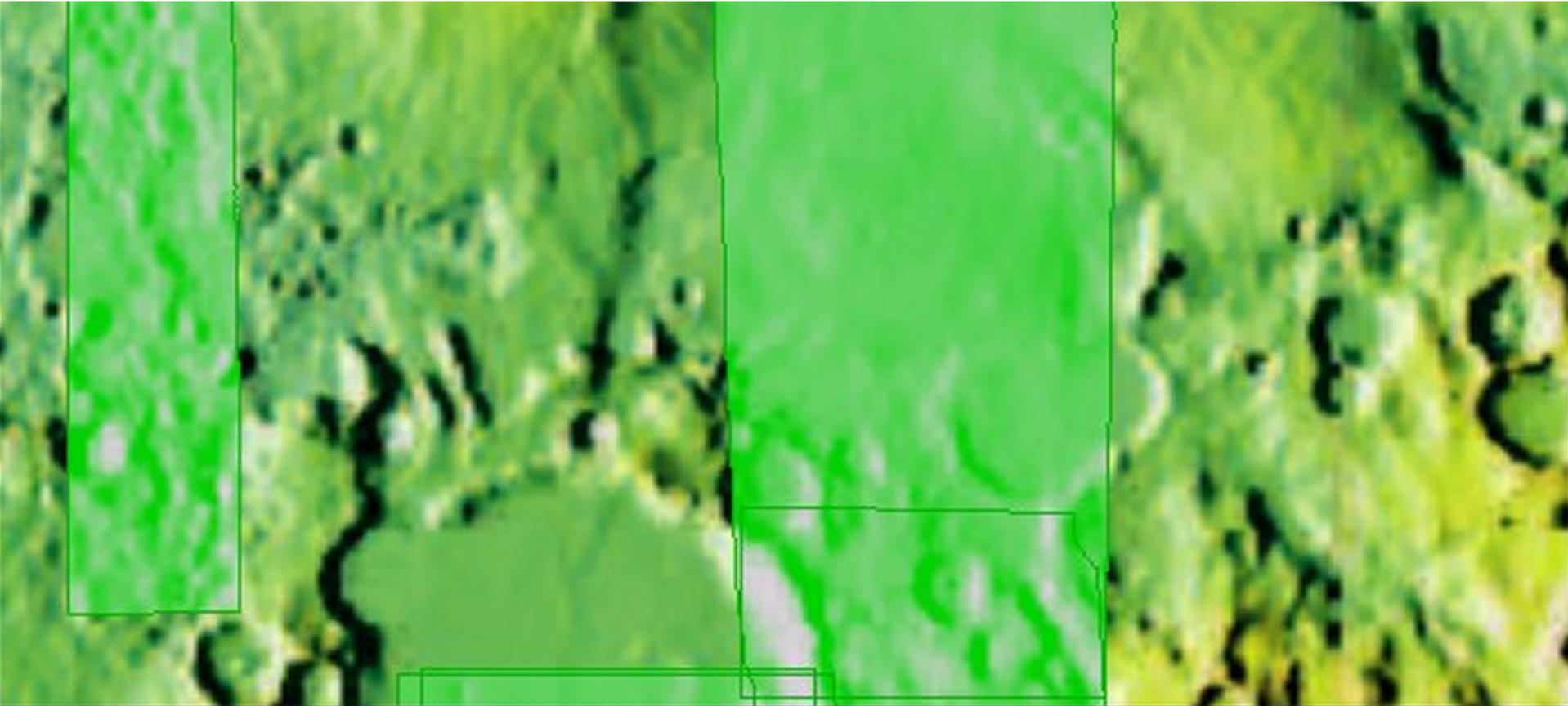
HRSC

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HRSC DTM_s

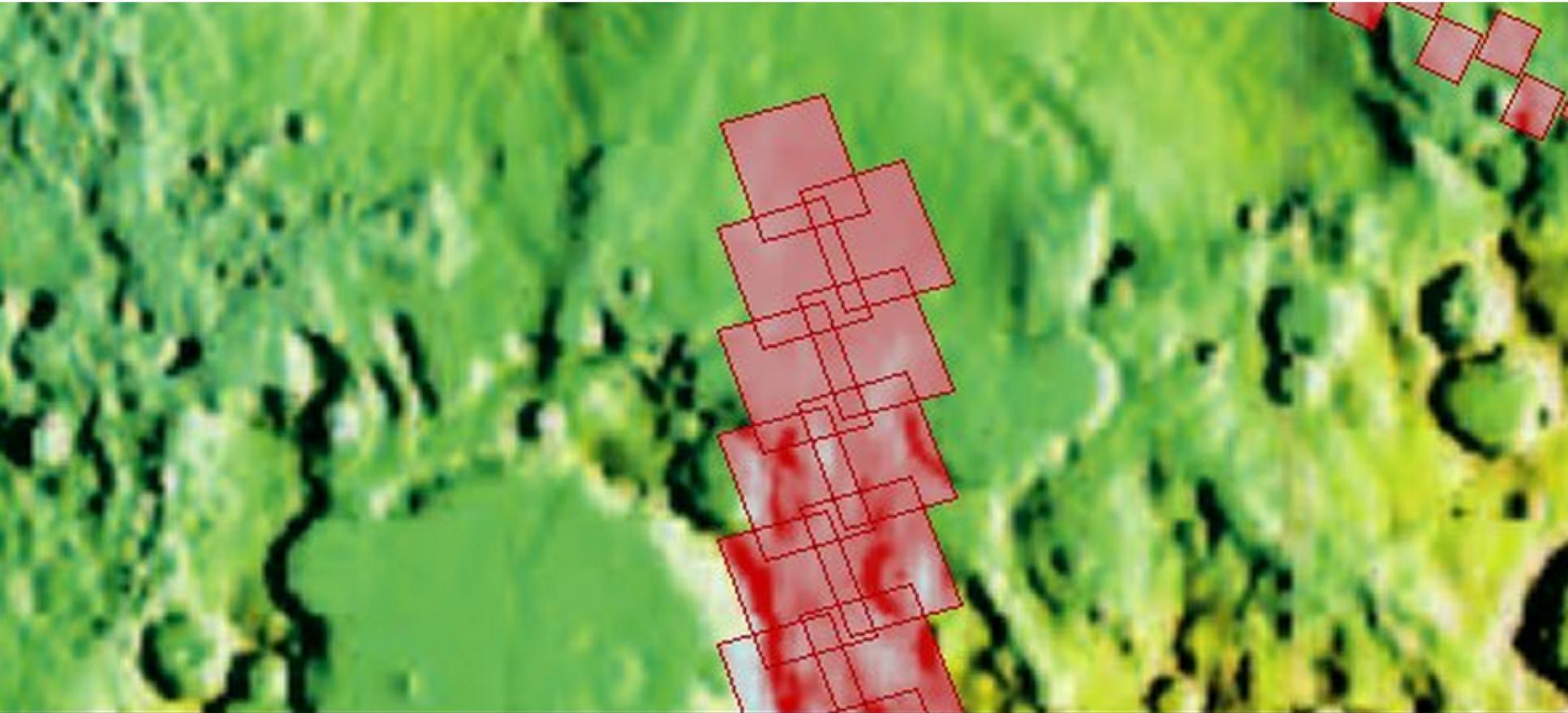
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Apollinaris Sulci

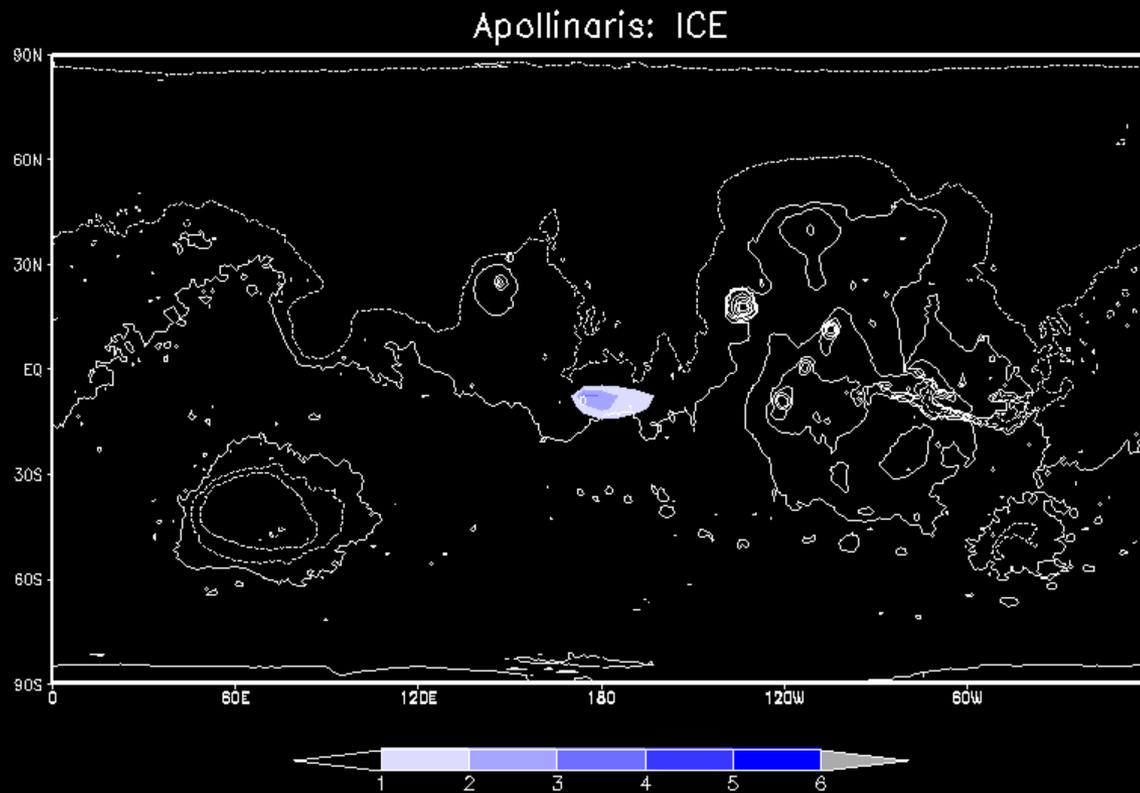
Viking Coverage

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Resource ROI 1: Water

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