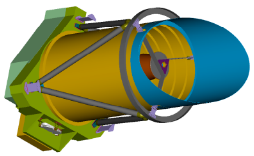
HiRISE Overview

Laszlo Keszthelyi (Co-Investigator)

U.S. Geological Survey



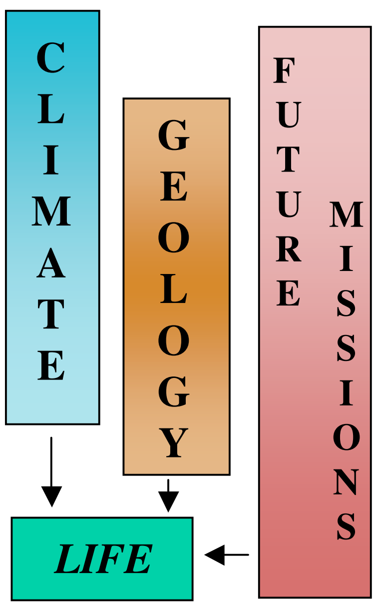
MRO Science Objectives

Project Manager: Jim Graf

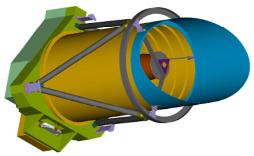
Project Scientist: Rich Zurek

Deputy PS: Sue Smrekar

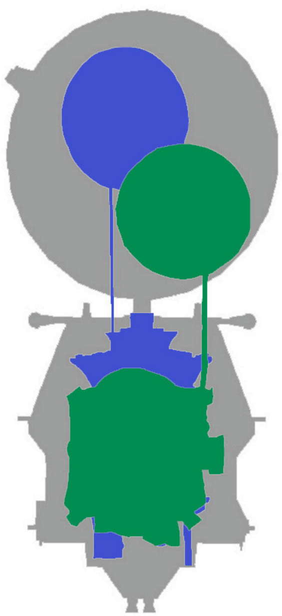
"Follow the Water" Theme



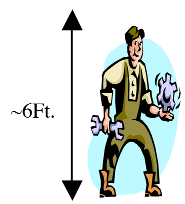
- ✓ **Characterize the present climate of Mars and its physical mechanisms of seasonal and interannual climate change**
- ✓ **Determine the nature of complex layered terrain on Mars and identify water–related landforms**
- ✓ **Search for sites showing evidence of aqueous and/or hydrothermal activity**
- ✓ **Identify and characterize sites with the highest potential for landed science and sample return by future Mars missions**
- ✓ **Return scientific data from Mars landed craft**

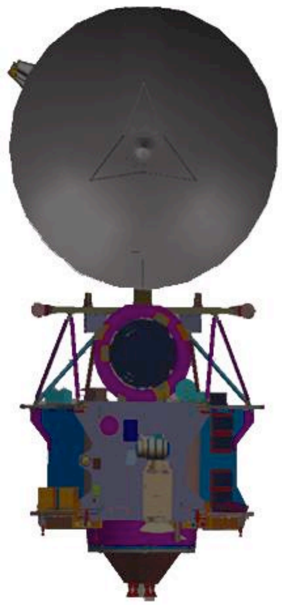


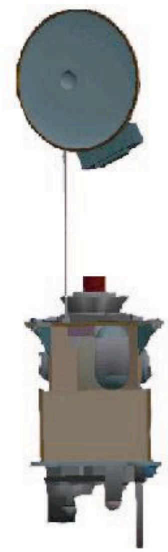
Mars Orbiters - A Comparison



MRO
MGS
Odyssey



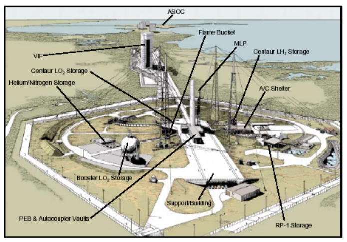




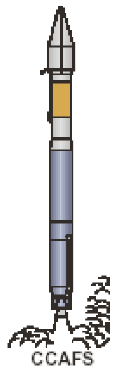
	MRO	Odyssey 2001	MGS
Launch Mass	**2180 kg**	**750 kg**	**1060 kg**
Operational Orbit	**255 x 320 km sun-sync frozen orbit**	**390 x 450 km sun-sync frozen orbit**	**370 x 430 km sun-sync frozen orbit**

Mission Overview

Launch
Aug 2005

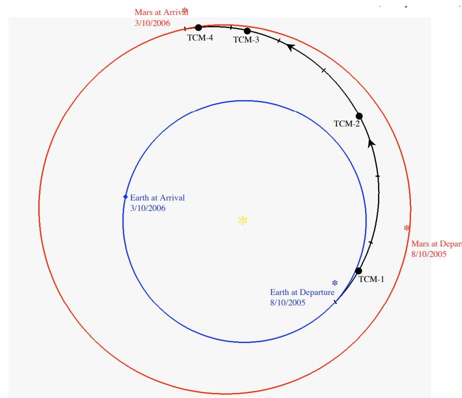


LC-41

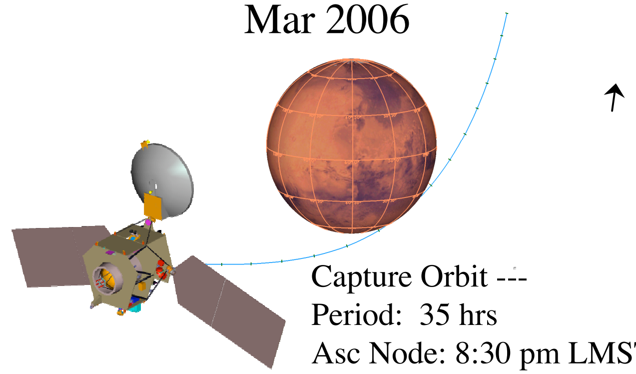


Atlas V-401

Interplanetary Cruise
Aug 2005 - Mar 2006

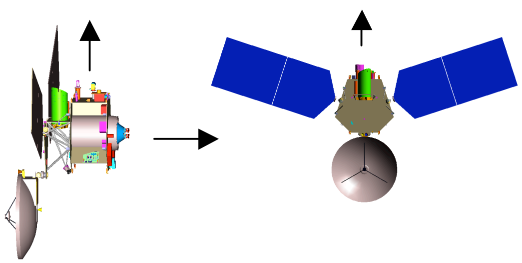


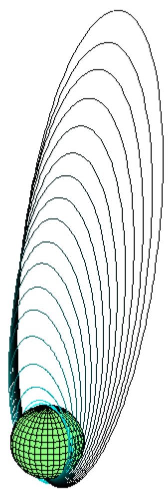
Approach and Orbit Insertion
Mar 2006



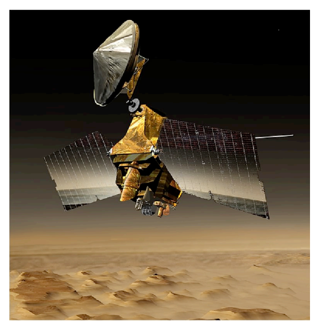
Capture Orbit ---
Period: 35 hrs
Asc Node: 8:30 pm LMST

Aerobraking
Mar-Sep 2006

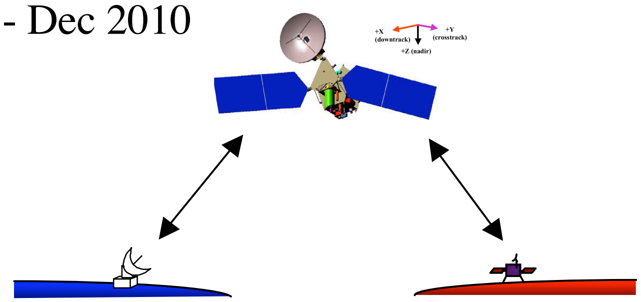




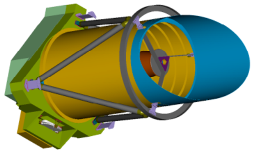
Primary Science/Relay
Nov 2006 - Dec 2010



Science Data Acquisition/Return



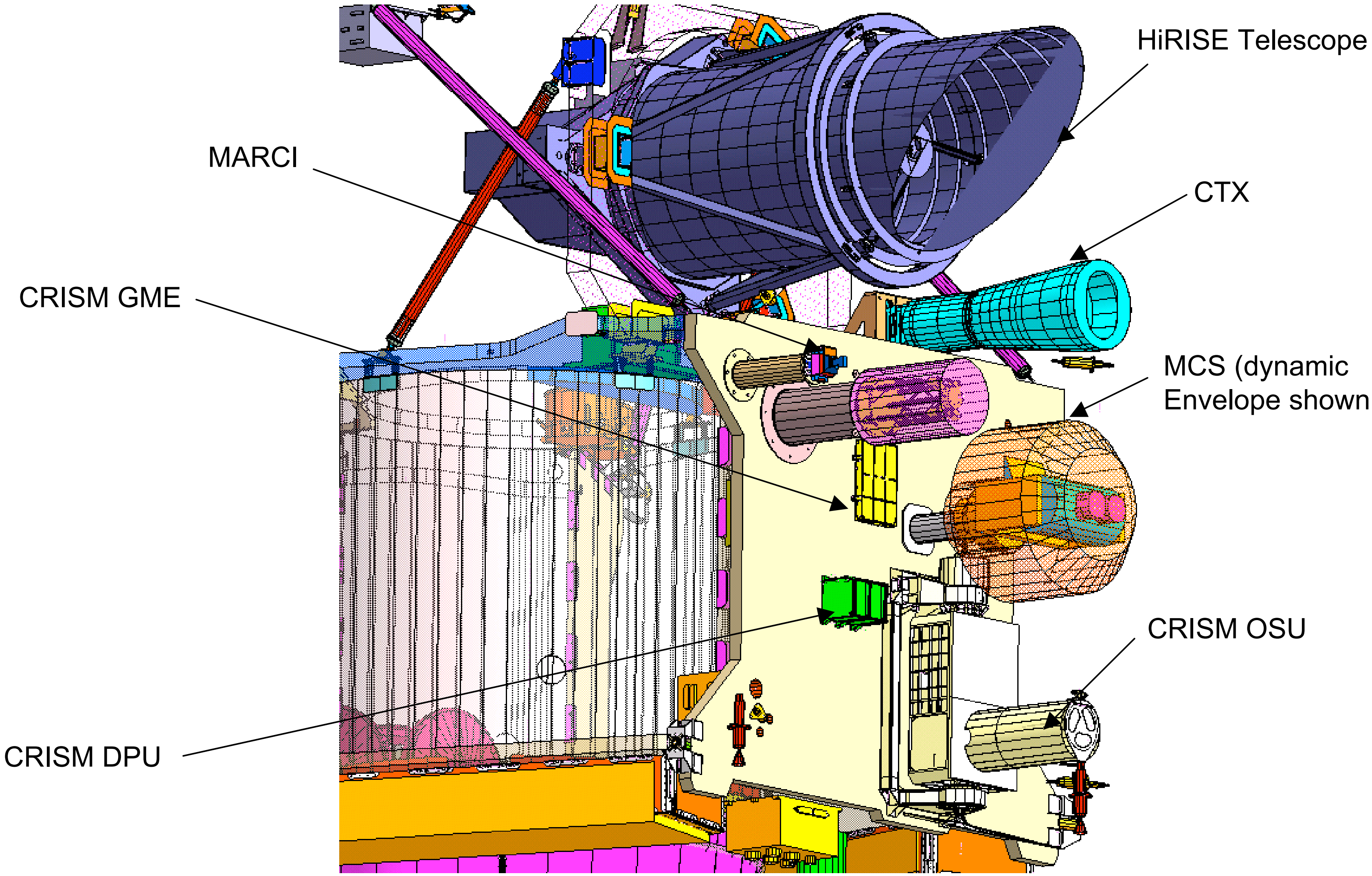
Primary Science/Relay Orbit ---
Period: 112 min
Hp: 255 km Ha: 320 km, Frozen
Ascending Node: 3:00 pm LMST (Sun-Sync)



MRO Payload Summary

Name	Type	Provider	PI/Team Leader	Spatial Scale @ 300 km	Swath @ 300 km	Spectral Coverage
HiRISE	Optical Targeted	PI UA-Ball	A. McEwen	30 cm/pixel	6 km	3 colors
CRISM	Optical Targeted	PI APL	S. Murchie	19 m/pixel	10 km	0.4 - 4.0 µm
Context Imager (CTX)	Optical Regional	Facility MSSS	M. Malin	6 m/pixel	30 km	Panchromatic Minus Blue
Shallow Radar (SHARAD)	Regional	Facility ASI	R. Seu	< 1000 m (w) < 20 m (v)	20 km (w) 1 km (v)	20 MHz Center 10 MHz Bandwidth
MARCI WA	Optical Mapping	PI MSSS	M. Malin	1 to10 km/pixel	limb-to-limb	0.25 - 0.75 µm
MCS	Atmospheric Mapping	PI JPL	D. McCleese	~ 5 km vertical	--	12 - 50 µm 0.3 - 3.0 µm
OpNav	Optical Targeted	Facility JPL-MT		24 µrad/pixel Phobos/Deimos	--	0.45 - 0.6 µm
Electra	Radio	Facility JPL MT/MRO		--	--	UHF
Ka Band	Radio	Facility JPL MRO		--	--	Ka hardware

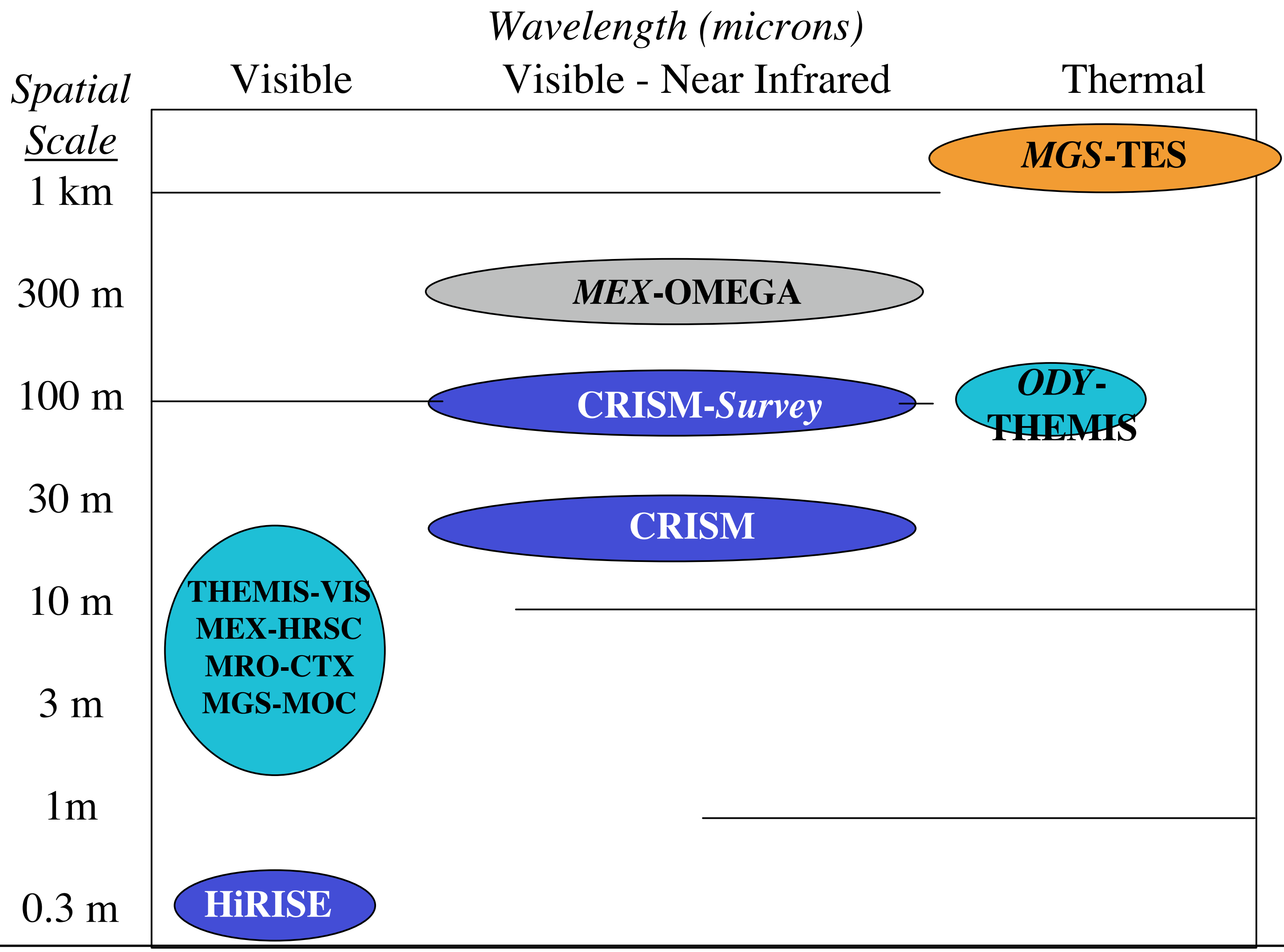
Instruments on Spacecraft



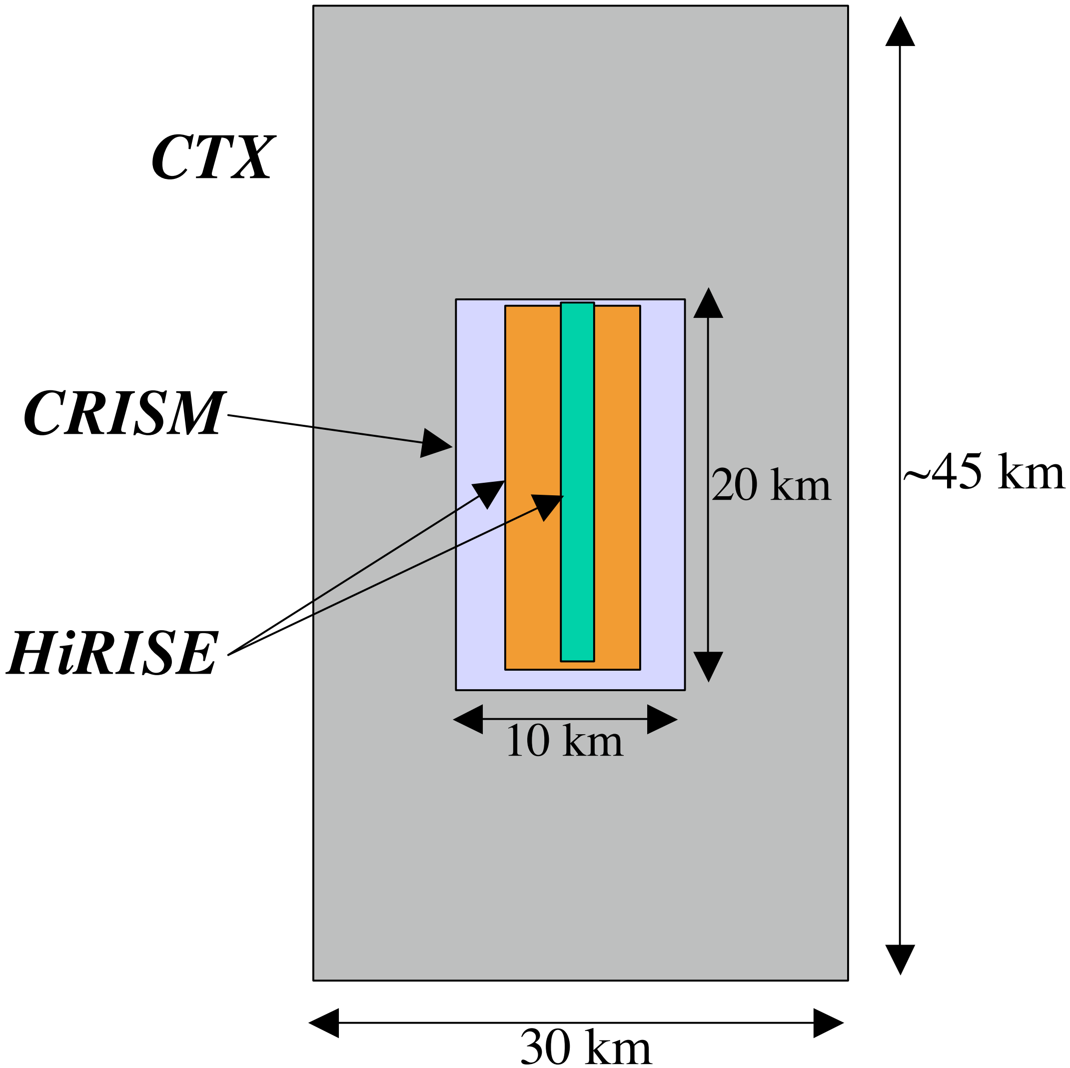
HiRISE Science Priorities

1. Achieve 1-meter spatial resolution with swath width > 3.5 km. (Explicit Level 1 science requirements.)
2. Achieve <0.5 m stereo vertical precision. (Interpretation of Level 1 science requirement.)
3. Distinguish and measure color and albedo variations

Comparison of Remote Sensing by MGS, Mars Odyssey, Mars Express (MEX), and MRO



MRO High-Resolution Observing Block

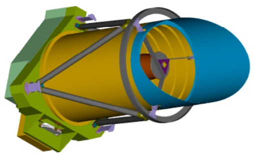


HiRISE Capabilities

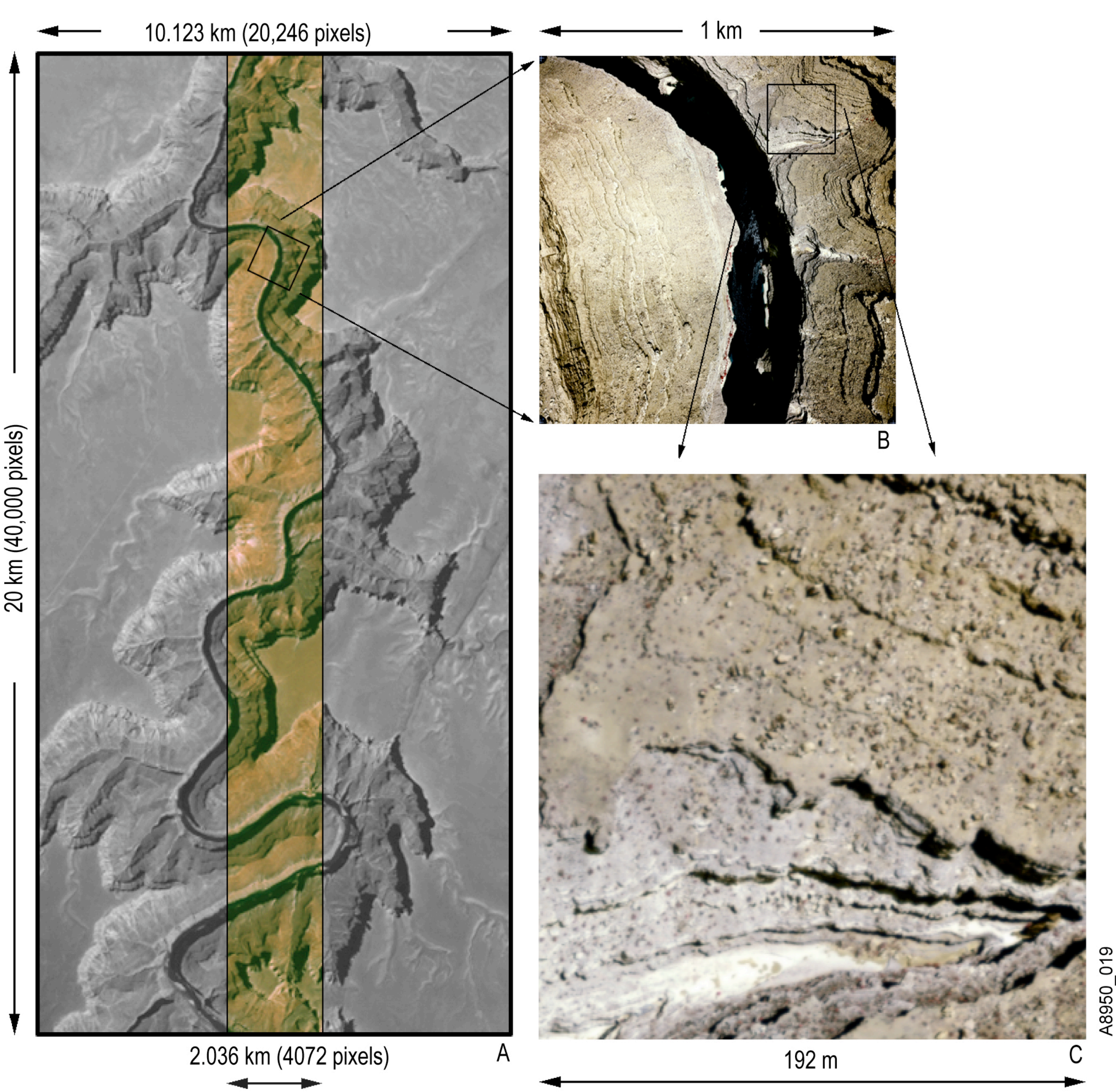
Quickbird image of Giza pyramid, 61 cm/pixel.

HiRISE Capabilities

Ground Sampling Dimension (GSD)	30 cm/pixel (at 300 km altitude)
Swath width (Red bandpass)	6 km (at 300 km altitude)
3-Color swath width	1.2 km (at 300 km)
Maximum image size	20,000 x 64,000 pixels
Signal:Noise Ratio (SNR)	>100:1
Color Bandpasses	Red: 550-850 nm Blue-Green: 400-600 nm NIR: 800-1000 nm
Stereo topographic precision	~20 cm vertical precision over ~1.5 m^2 areas
Pixel binning	None, 2x2, 3x3, 4x4, 8x8, 16x16; each CCD separately commanded.
Compression	Fast and Efficient Lossless Image Compression System (FELICS)

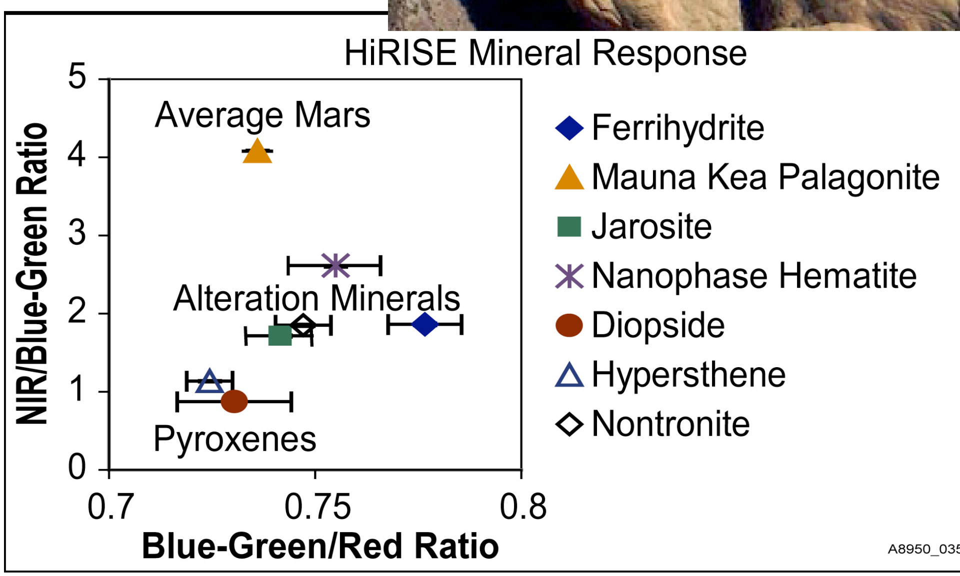


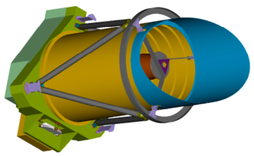
Simulation of a HiRISE image over a portion of the Grand Canyon. View is from 500 km range; MRO's Primary Science Orbit will be 255 x 320 km, so swath width over Mars will be from 5.1 to 6.4 km. (A) Landsat image showing the swath width, nominal length (could be up to 65,000 pixels), and color coverage. The blowup (B) is an air photo showing the location of (C), a simulated HiRISE image (50cm/pixel) incorporating the predicted telescope performance (MTF).



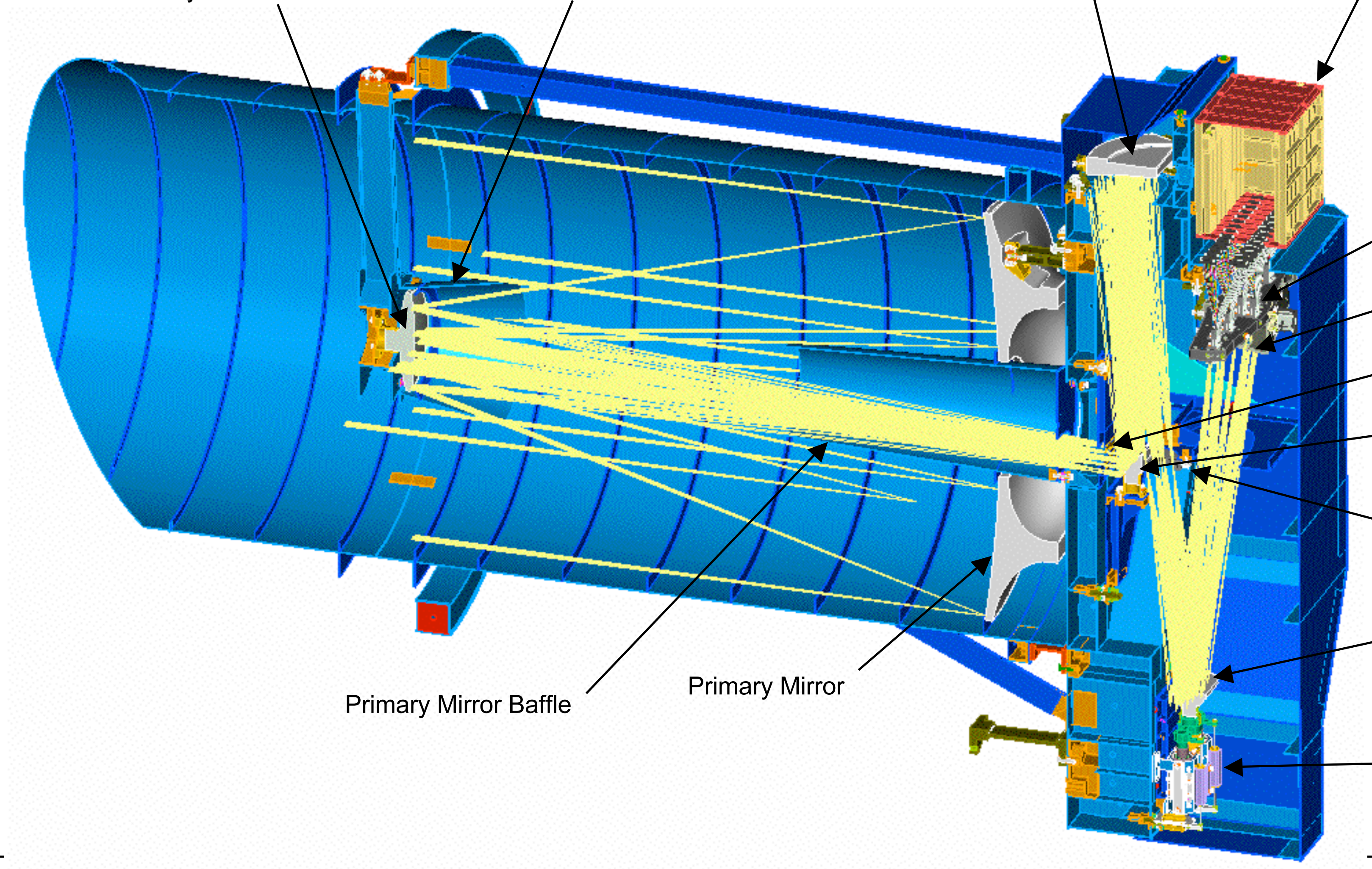
HiRISE color imaging will facilitate stratigraphic interpretations of compositional units identified by CRISM and other experiments.

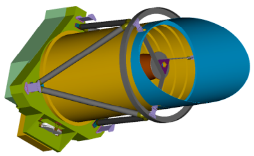
IKONOS image of sedimentary layers near Moab Utah, 4 m/pixel.



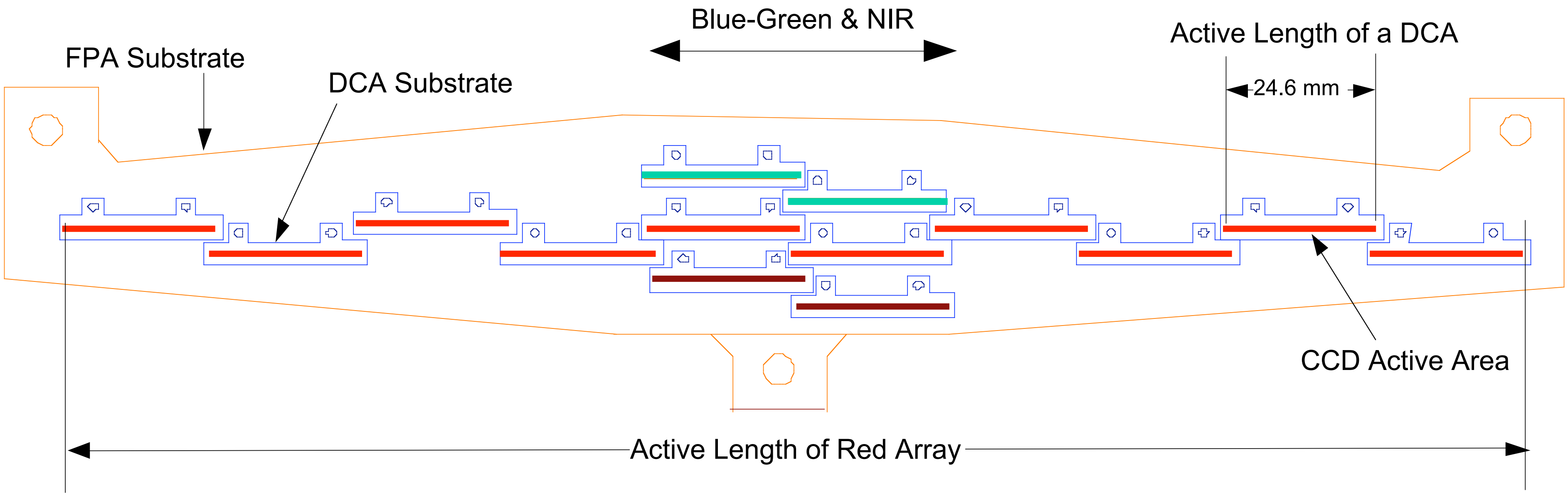


Telescope Components





HiRISE Focal Plane Assembly



- 14 CCDs (2048 x 128 pixels):
  - 10 CCDs Form Red Channel (20,000 pixels)
  - 2 CCDs Form Blue-Green Channel (4000 pixels)
  - 2 CCDs Form NIR Channel (4000 pixels)

Key Science Issues for HiRISE

Is there water near the surface today?
- Origin of gullies
- Ages of gullies, dunes, patterned ground

When and where have there been long-lived bodies of water?
- Oceans, lakes?

What is the total inventory of water and how has it cycled?
- Flood discharges, volcanic processes

How has climate varied?
- Polar layers, CO_2 inventory
- Were there thick ice sheets?

Landing Sites:

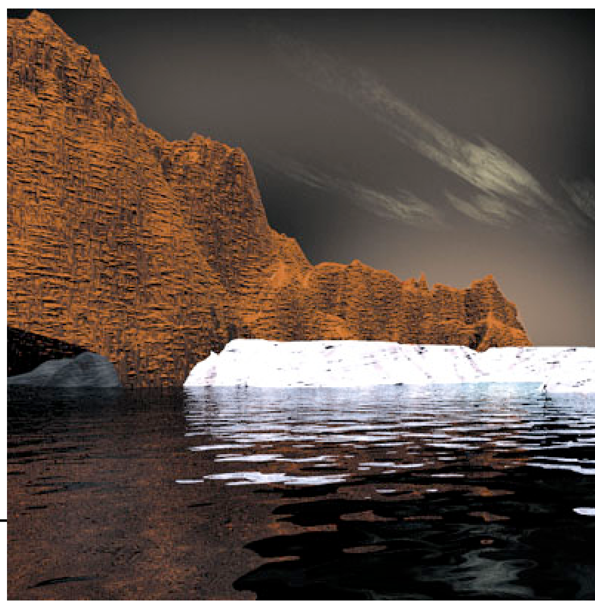
Past Landing sites: Viking, Pathfinder, MER, Beagle-2
- – Detailed orbital views may solve mysteries, lead to new interpretations

Future landing sites
- – Candidate landing site evaluations for PHOENIX, MSL, sample return?

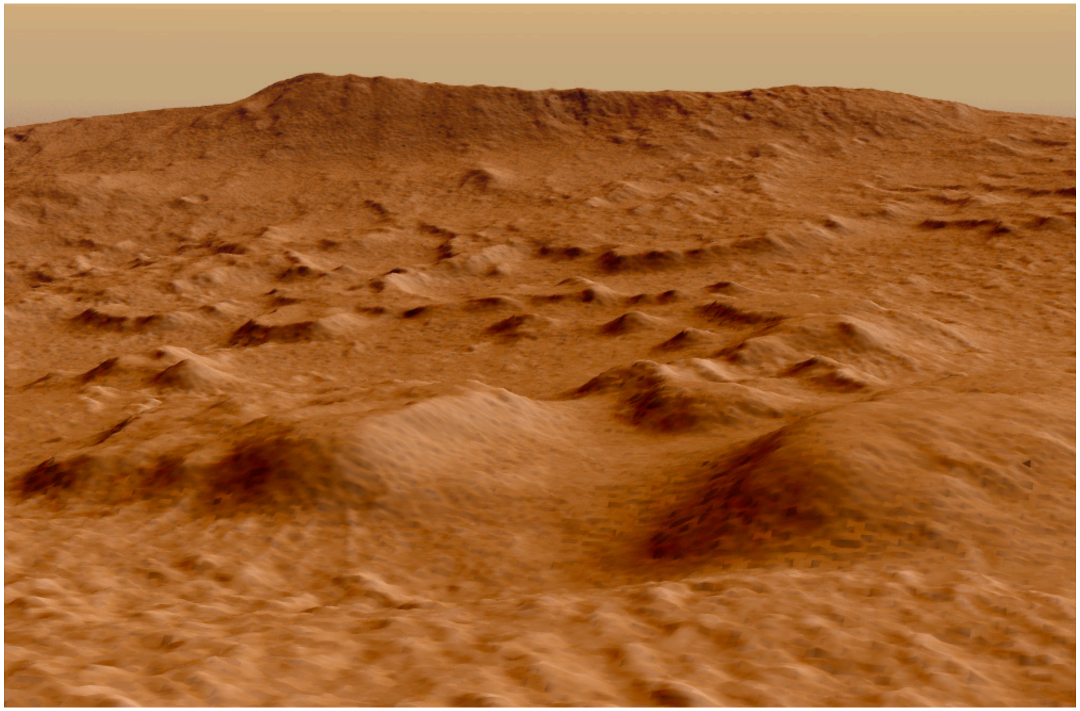
Active surface missions during MRO
- – PHOENIX, MSL
- – Electra relay on MRO

Meter-scale topography will be essential to evaluate landing hazards and rover trafficability.

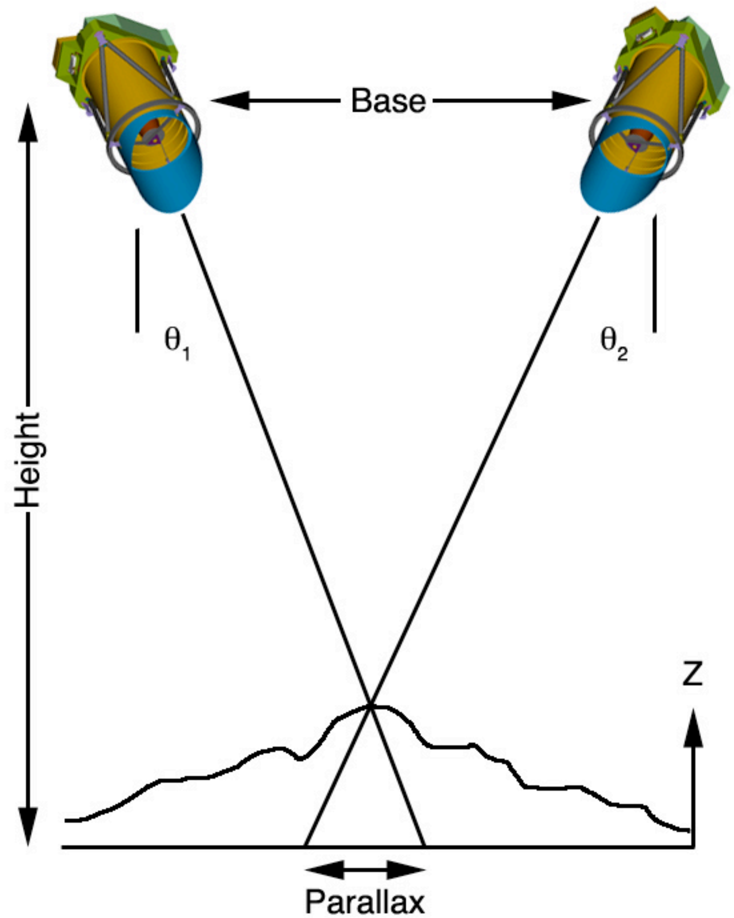
Ancient lakes and seas on Mars: Fact or Fantasy?



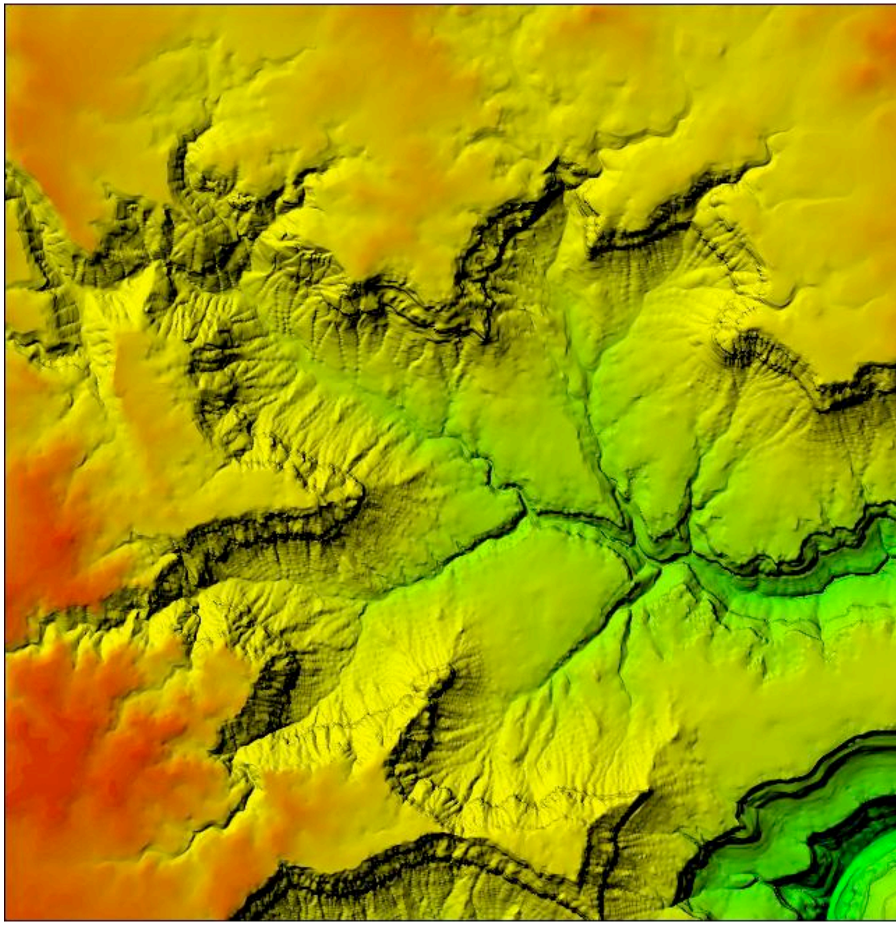
Stereo Data Acquisition



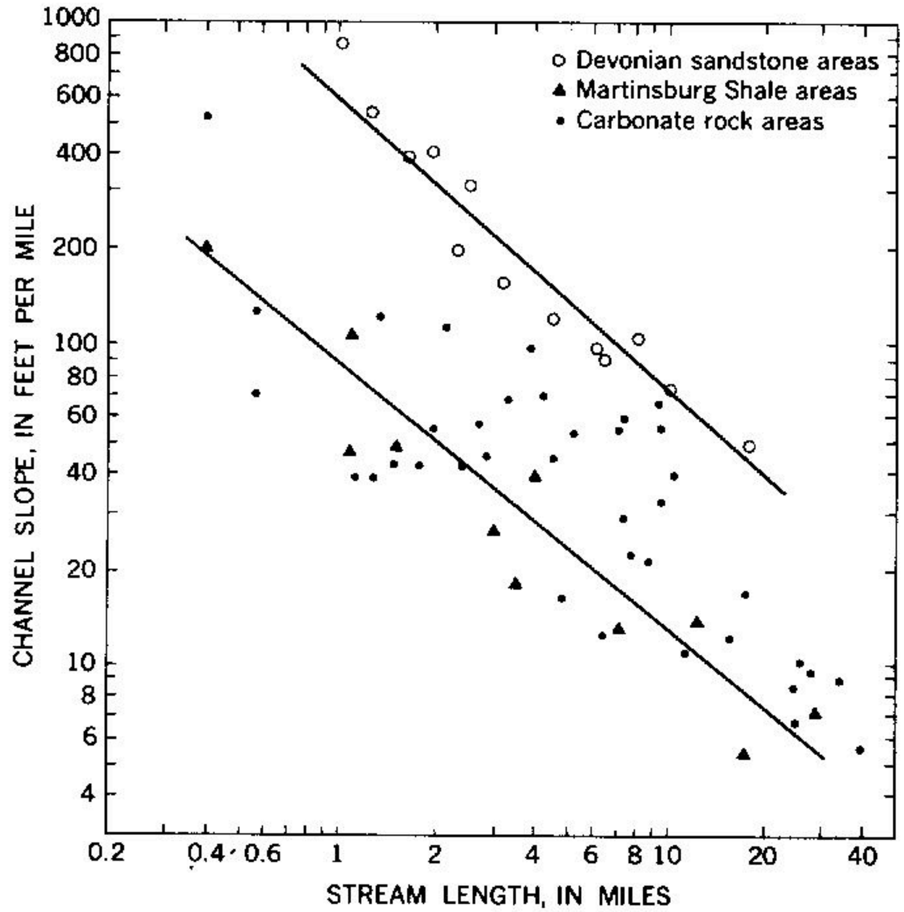
Synthetic oblique view of Gusev Crater, derived from DEM by R. Kirk.



High-Resolution DEMs Will Enable Quantitative Geomorphology

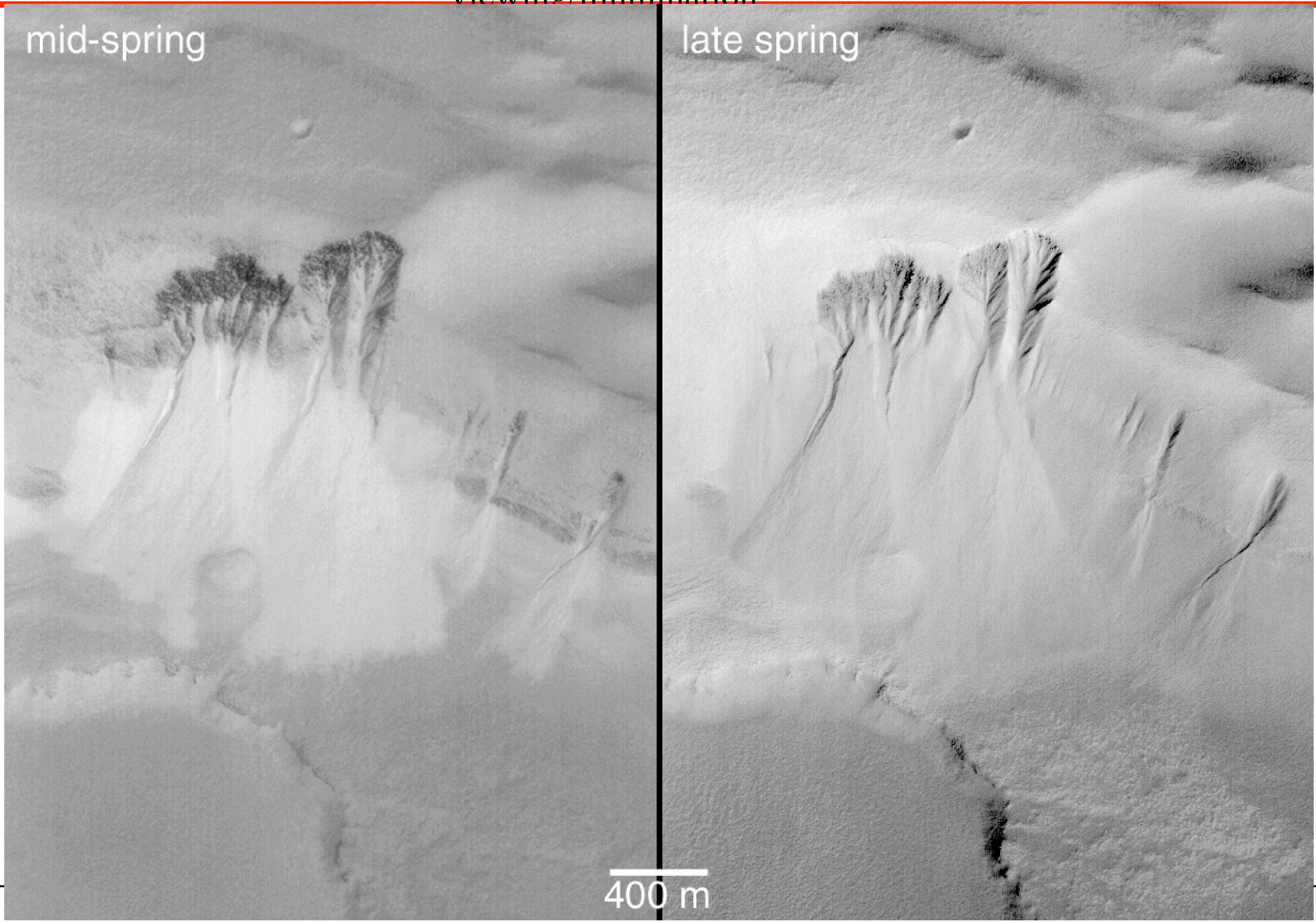


Controls on bedrock incision in the Grand Canyon are being studied with high-resolution DEMs by J. Pelletier et al.; see http://geomorphology.geo.arizona.edu//geomorphology.html



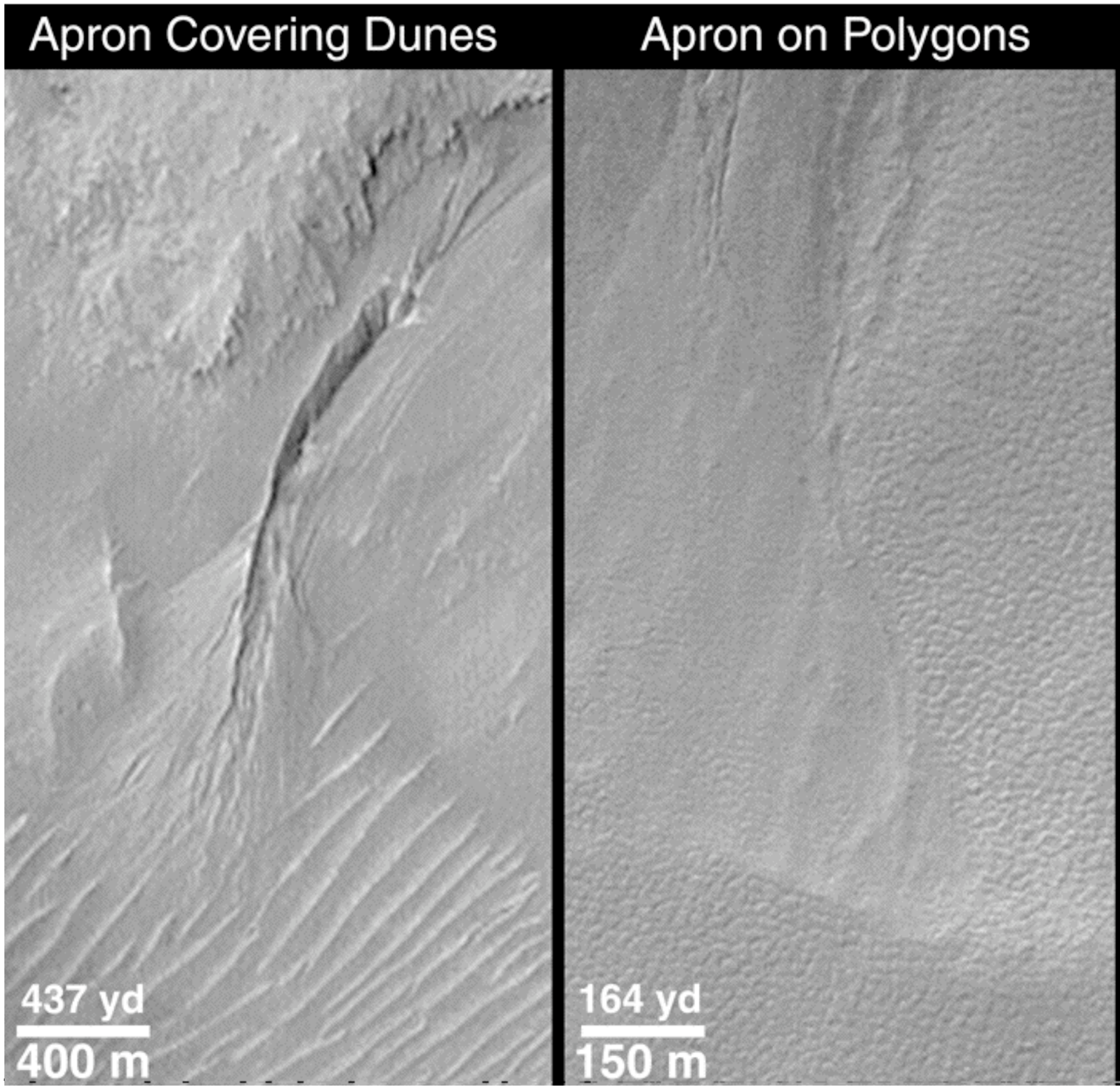
Other things being equal, one effect of lithology is to increase stream gradients in strongly resistant bedrock such as in Hack's classic example of steeper gradients in sandstone than in shale of the Shenandoah Valley, Virginia. (From J. Pelletier's class notes for Introduction to Geomorphology.)

Repeat Imaging of Gullies: best to match seasons to detect changes, or use DEMs to simulate any viewing/illumination



Credit: MSSS.com

Age Constraints on Gullies



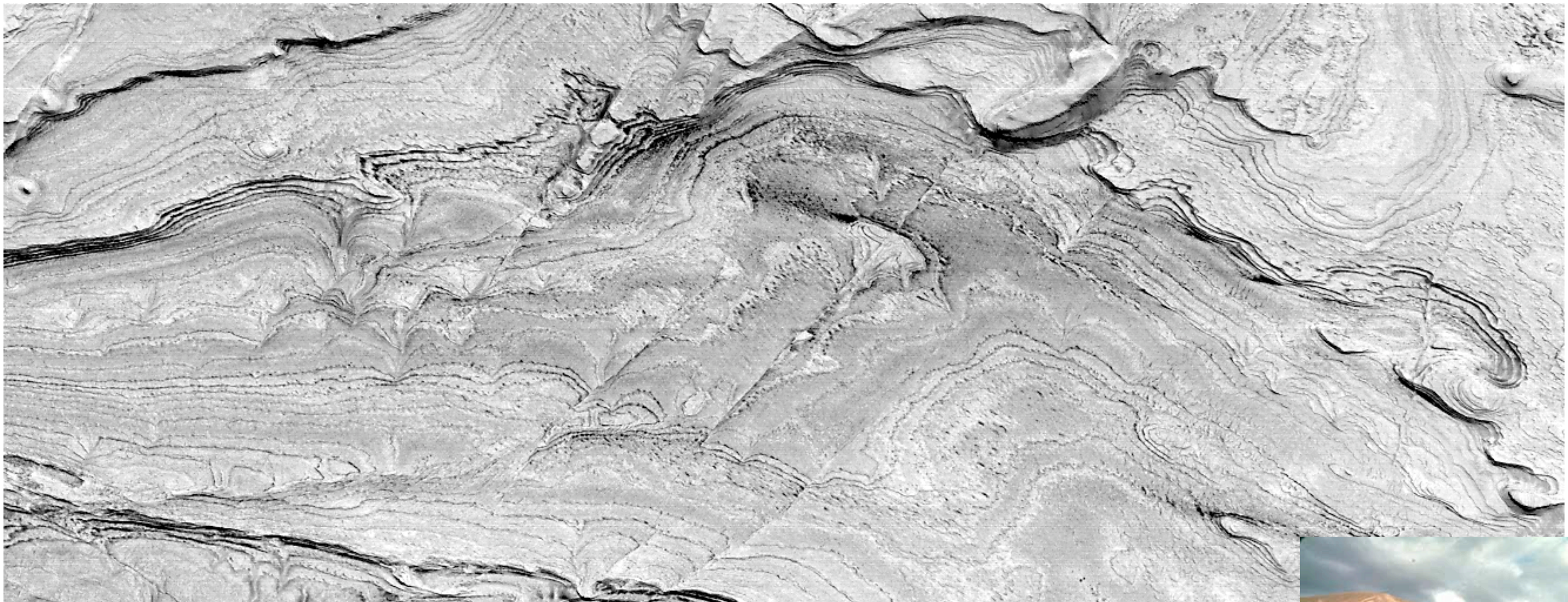
1. Lack of small craters:

Are they primary or secondary craters?

< a few millions years or less than ~ 100 million years?

2. Superimposed over dunes and patterned ground--how old are they?

Origin(s) of Layered Sedimentary Rocks



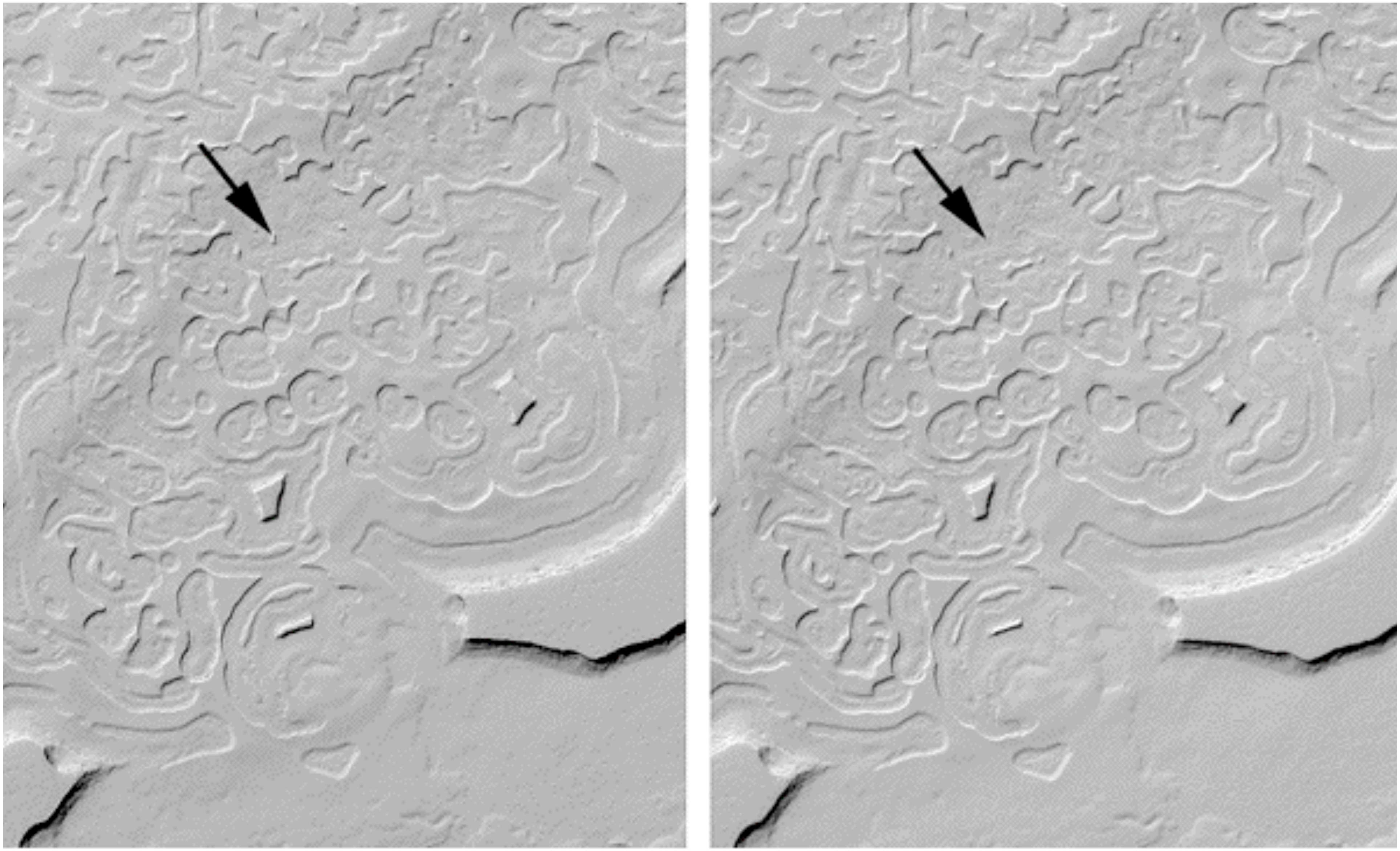
Credit: MSSS.com

Have there been long-lived bodies of water on Mars?

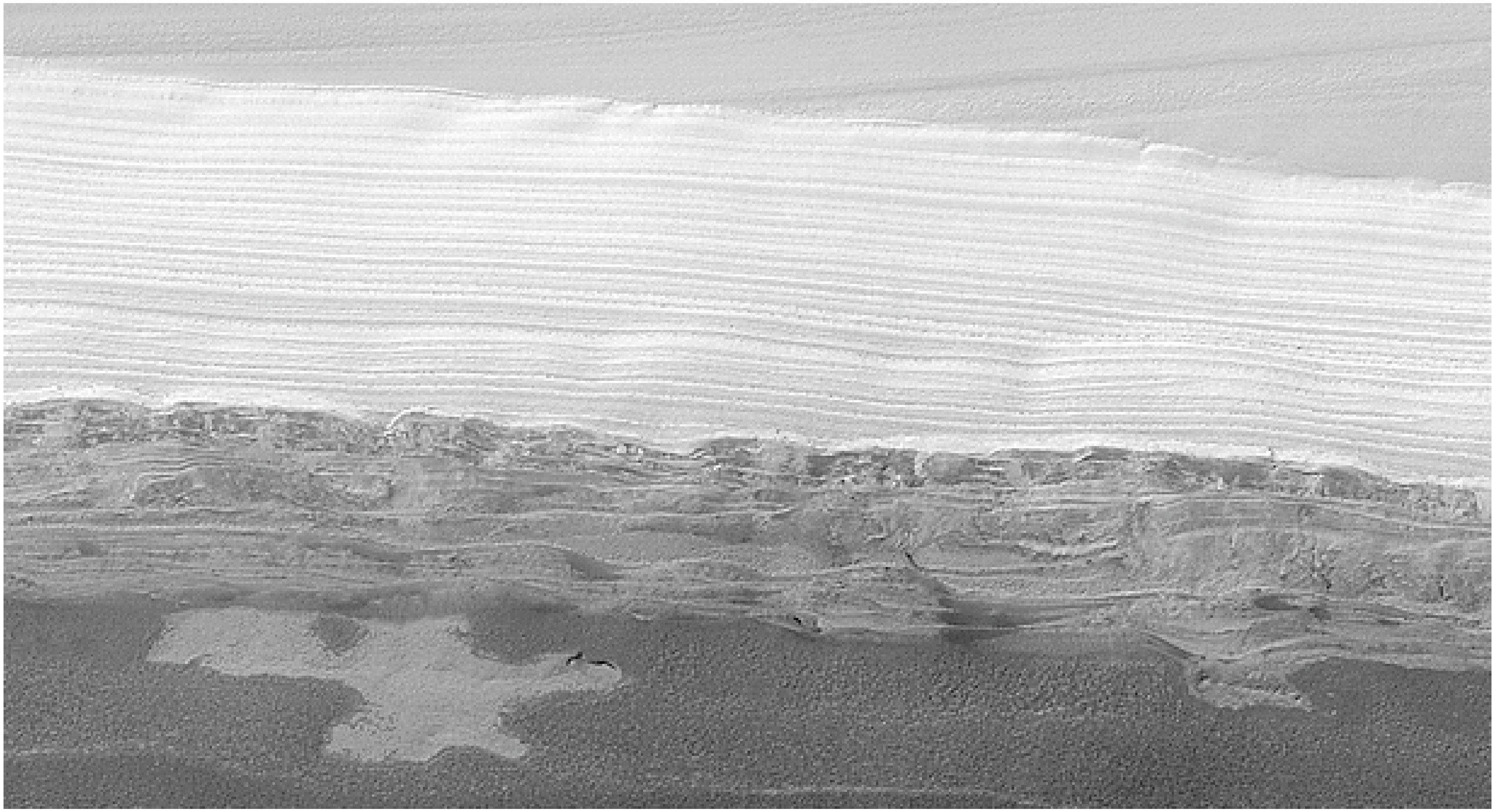
- Origin(s) of fine layered deposits key to this debate.
- Leading contenders are lake deposits or eolian/airfall deposits.
- HiRISE can detect finer details, but cannot resolve particle sizes.
- Maybe HiRISE can detect diagnostic structures such as eolian cross-bedding.
- HiRISE DEMs will tell us if the layers are horizontal or draped over pre-existing topography.
- Convincing interpretations may be possible by combining CRISM and HiRISE observations and with ground truth from MER.

Right: Cross-bedding in dunes (credit: A. Howard)

Monitoring Yearly Changes in S. Polar Residual CO_2 Cap



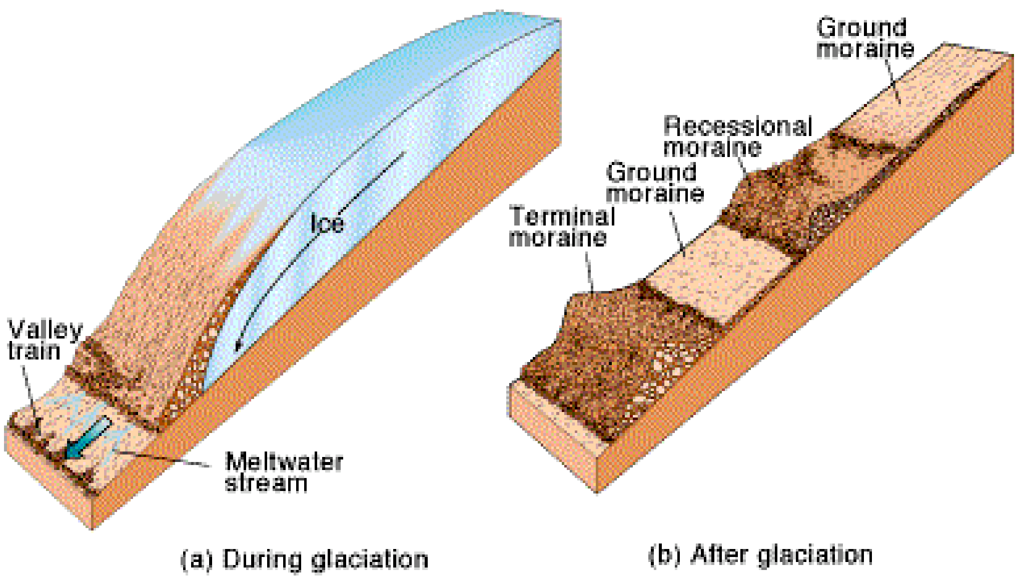
Polar Layers and Climate History

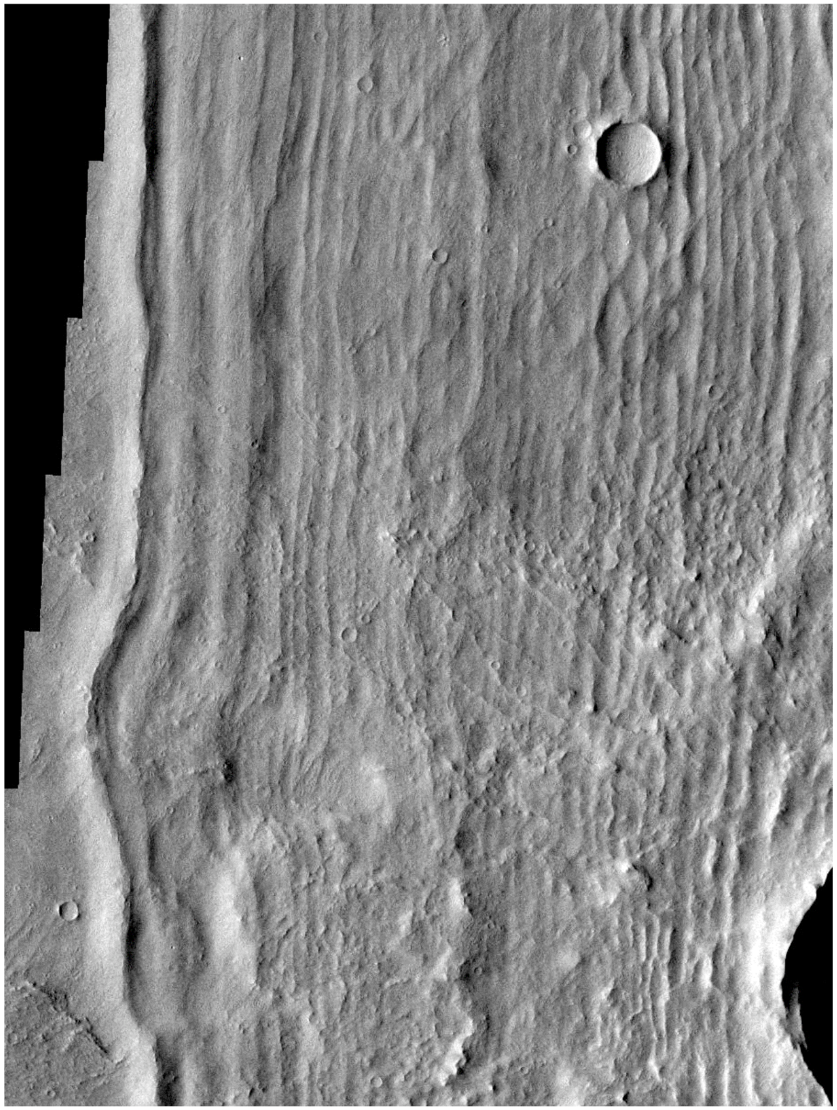


Most Mars researchers believe that the polar layered deposits are the result of variations in the amounts of dust and water ice deposited over many climate cycles, but the amount of time needed to form individual layers remains a major uncertainty. Studies of the thickness of polar layers are limited by image resolution and color data is needed to distinguish dust, ice, and sand. Analysis of HiRISE data should result in a better understanding of the timescales involved in the deposition of the layered deposits and provide important information regarding the climate history of Mars.

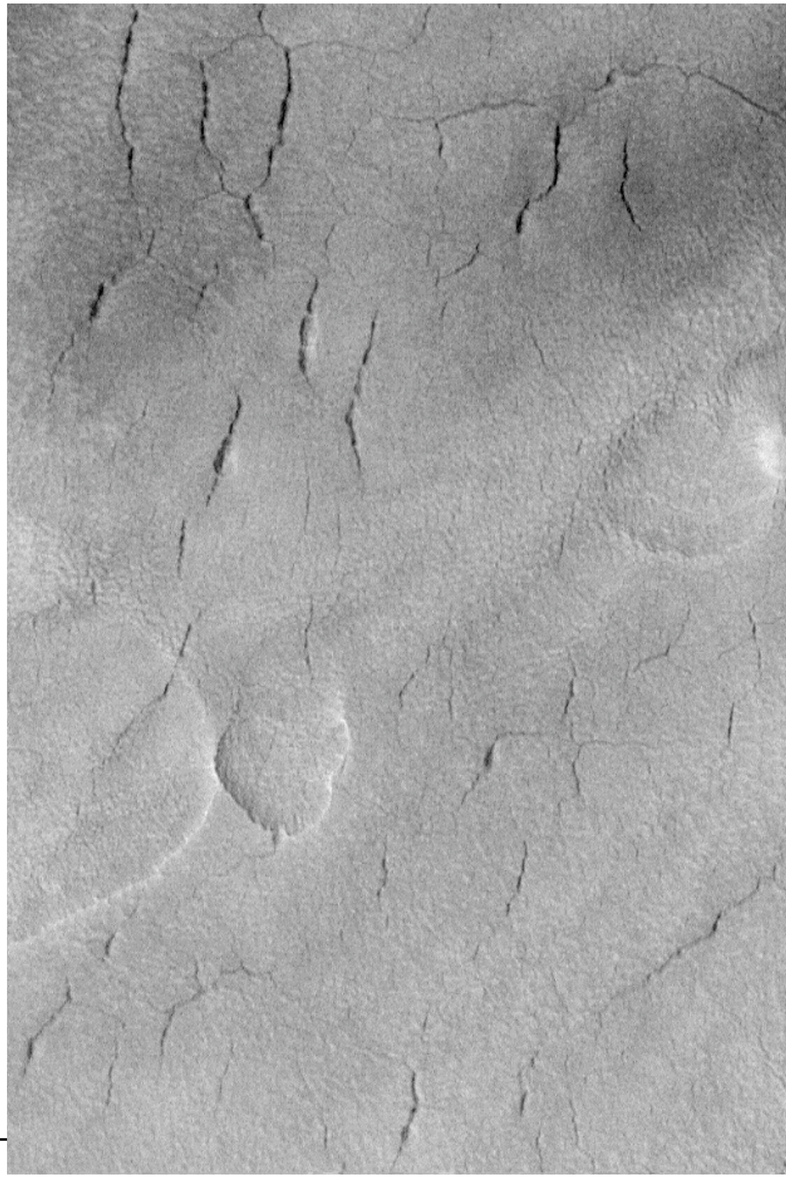
Glaciation on Mars?

Large-scale glaciation [Kargel and Strom, 1992] requires atmospheric transport of large quantities of water, and implies that major climatic change has occurred. Glacial moraines are very poorly-sorted deposits including large boulders, which should be discernable to HiRISE. Are the ridges west of Arsia Mons (right) glacial moraines? (THEMIS visible image, 18 m/pixel; image ~18 km wide).



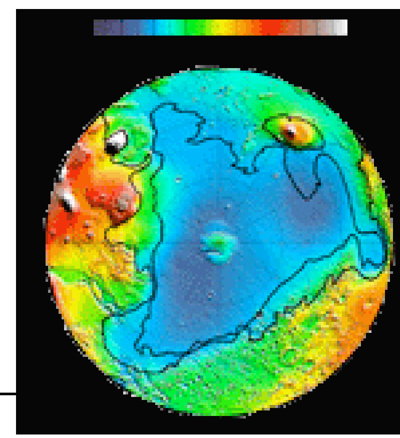


Origin of Vastitas Borealis Formation

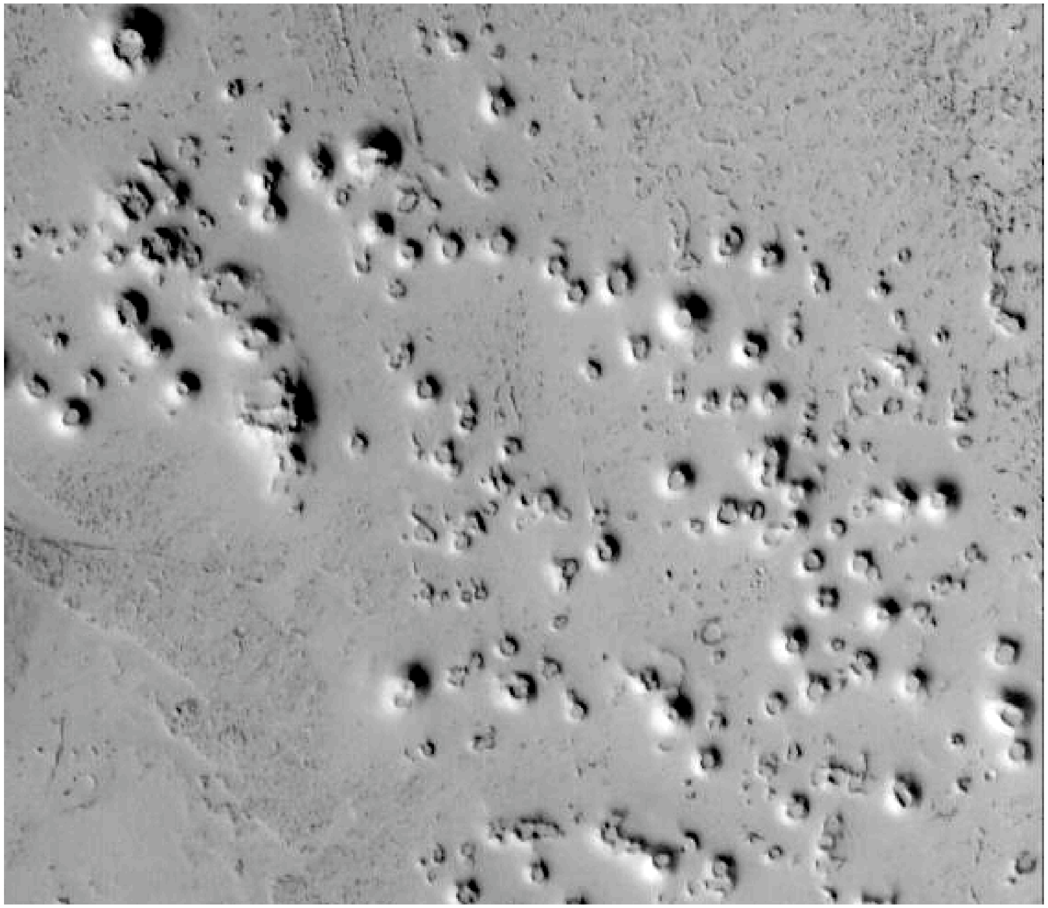


- Surface layer buries cratered northern plains.
- Many interpretations have been published.
- If ocean sediments, should be fine-grained except for ice-rafted boulders
- Presence of meter-scale rocks would be more consistent with flood deposits.

Possible outlines of northern oceans. Credit: MOLA team and Head et al. (1999).



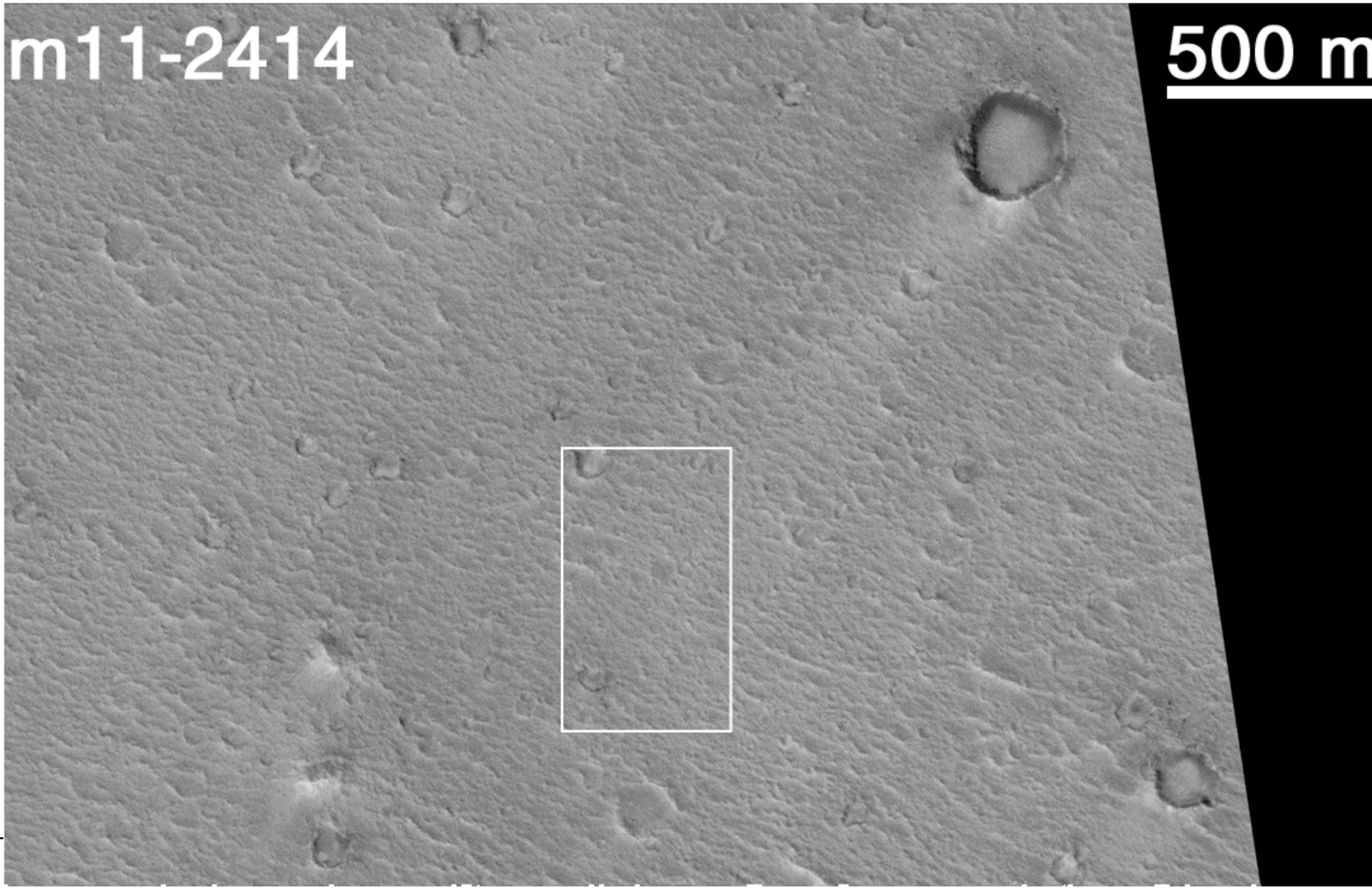
Volcano-Water and Volcano-Climate Interactions



Possible rootless cones on Mars (M08-1962). Rootless cones form when lava interacts with water under the flow, and are not primary vents for lava.

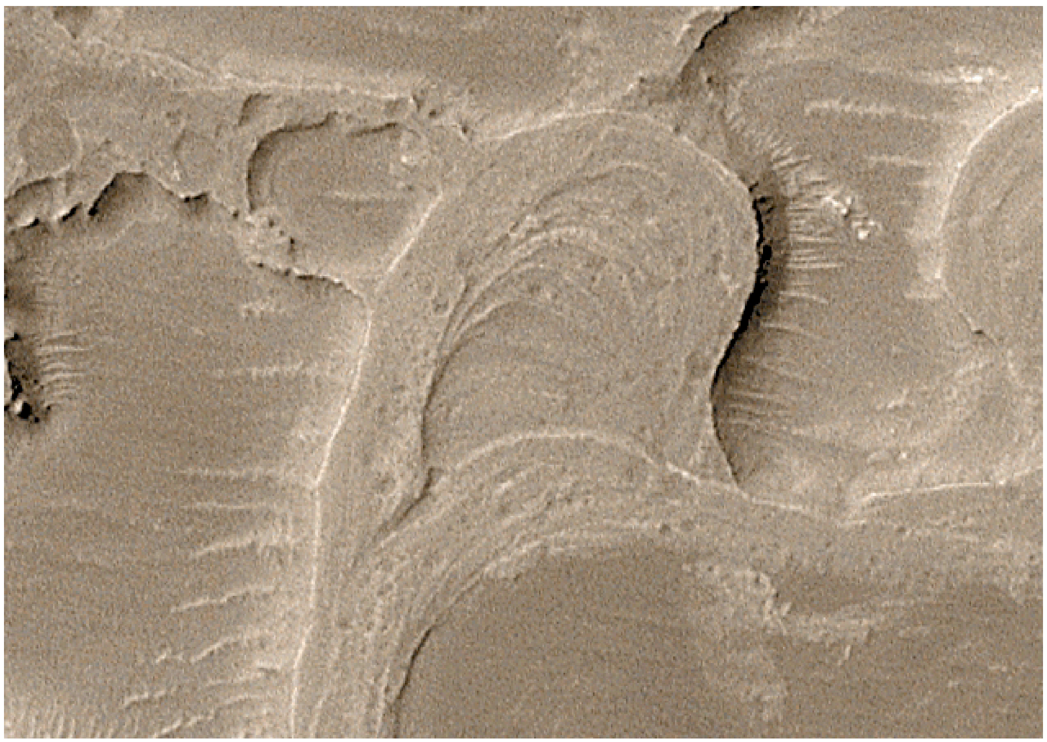
Rows of lava cones lining the fissure from which the Laki lava flow erupted in 1783-1784 in Iceland. This was the largest lava eruption for which detailed written records exist, but was tiny compared with geologically recent Martian eruptions. The gases from this eruption cooled the climate across the entire Northern Hemisphere (Thordarson et al., 1996). The cones in this picture are about 10 meters tall (30 feet).

Pathfinder: Are 1-2 m high ridges due to 2-3 billion years old fluvial morphology?

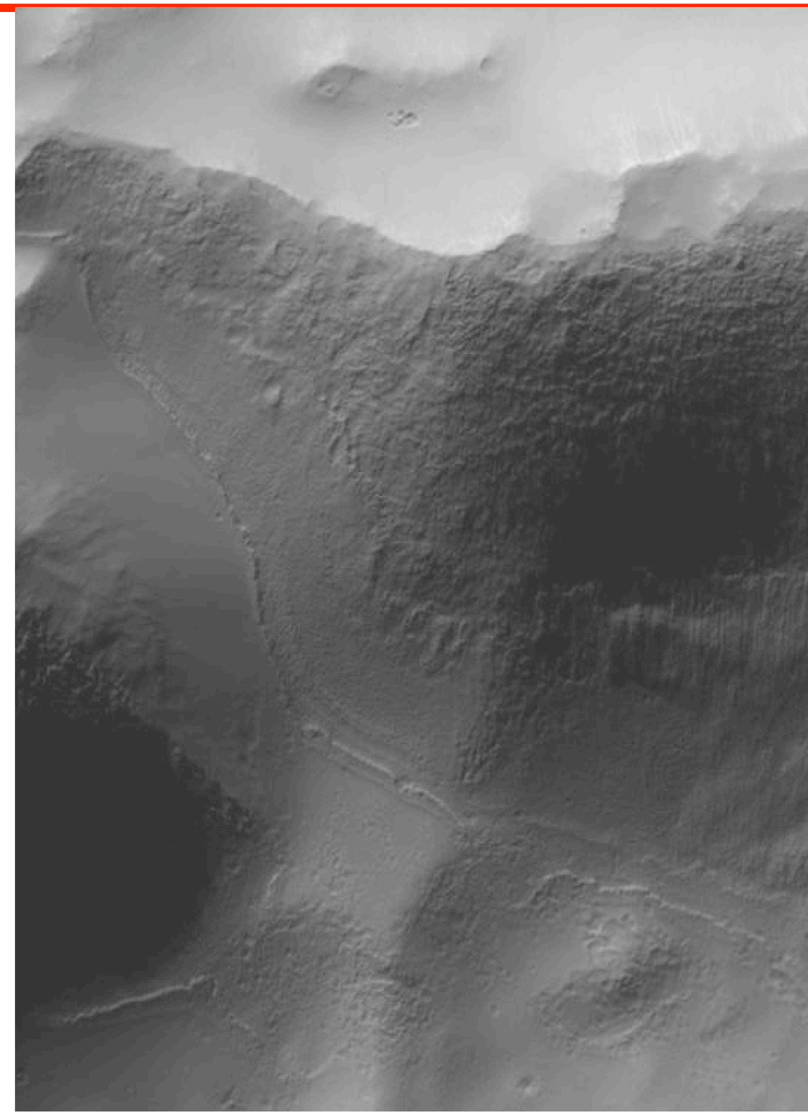


New Discoveries

Anything MOC can do, HiRISE can do better, except doing it first!
The most important new results from HiRISE will be new discoveries:
features and phenomena not yet detected on Mars.



River delta meanders? (Malin and Edgett 2003)



Recent surface mantle poleward of 30° latitudes [Mustard et al., 2001] (M20-00144)