Mars, Rocks, Dust and Thermal Infrared Spectroscopy

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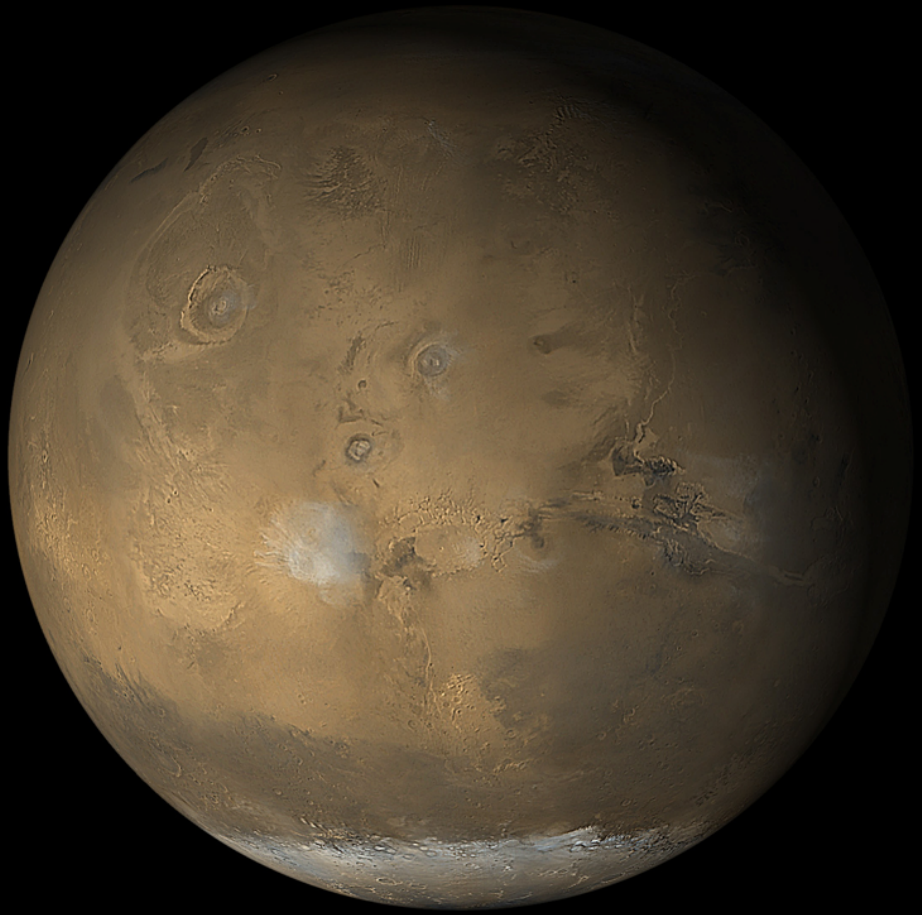
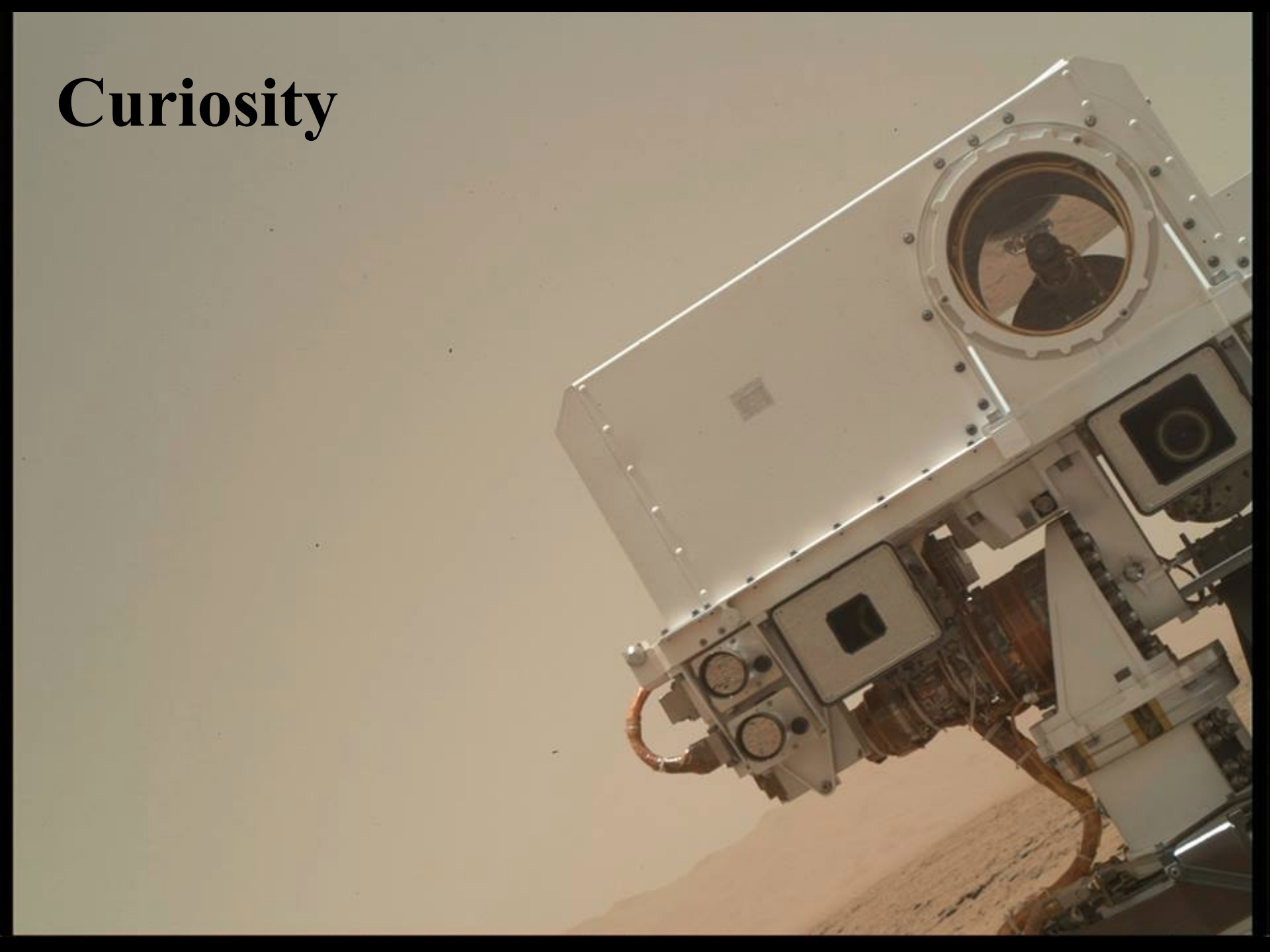
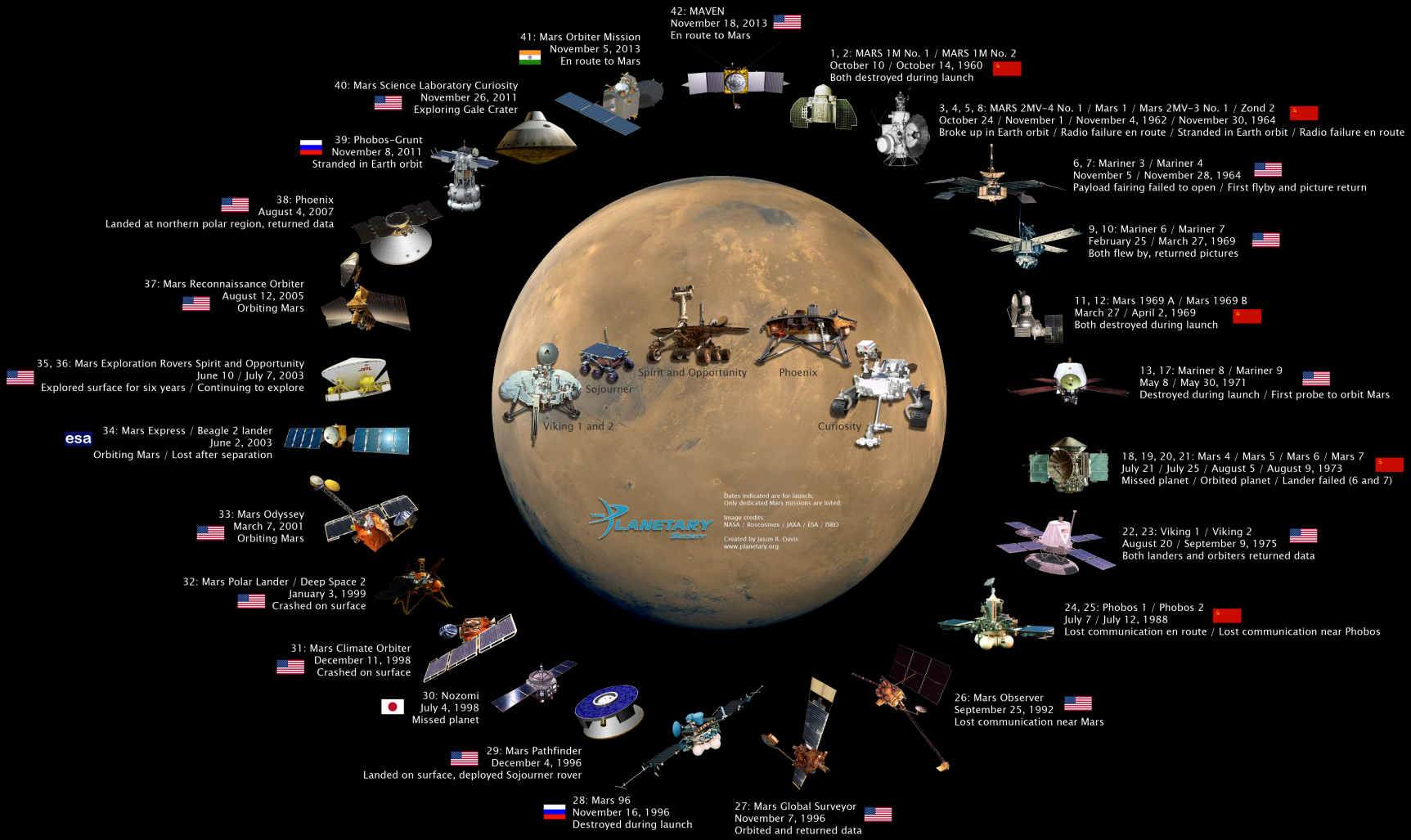
Mars



Curiosity

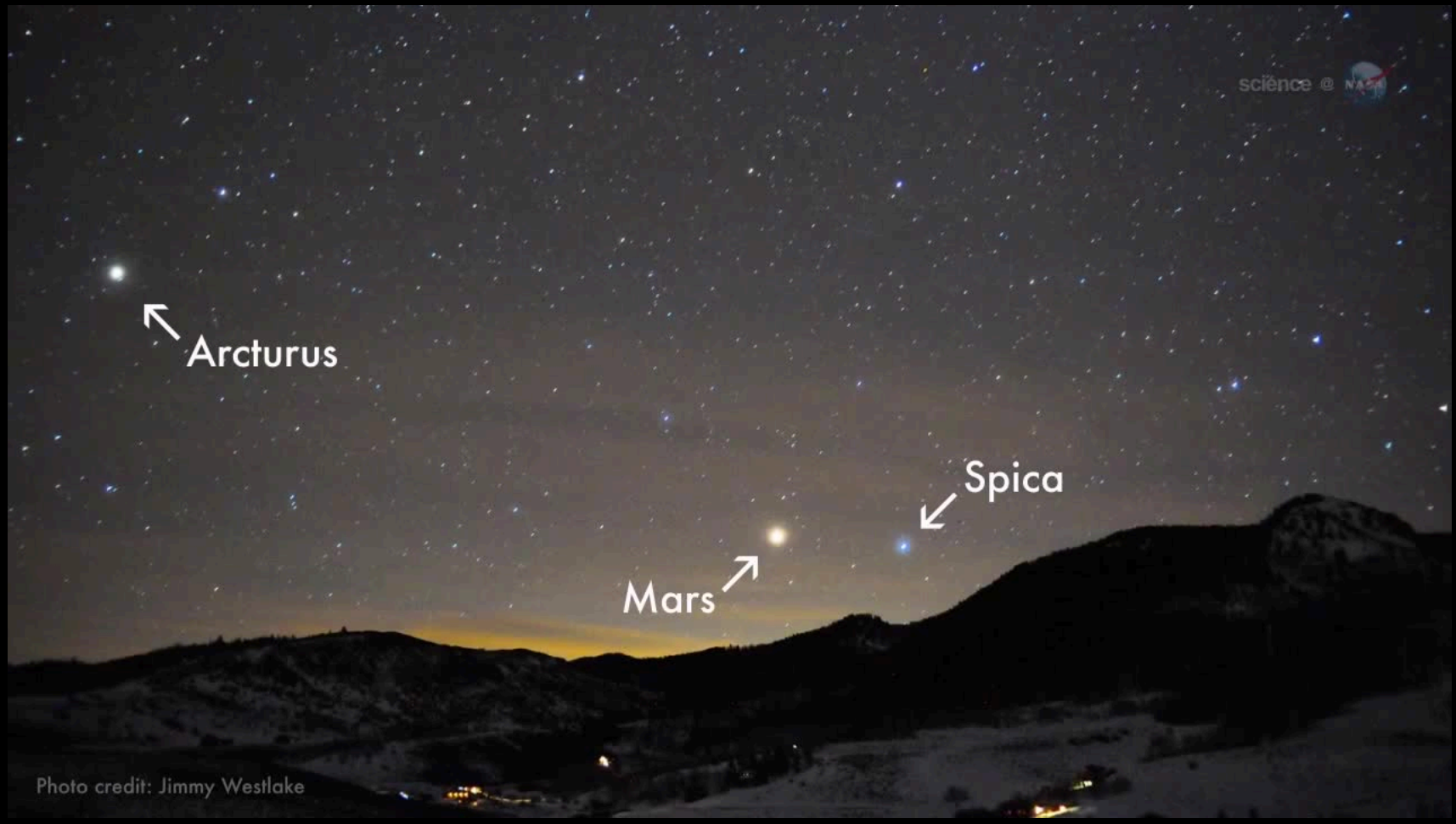


Mars Exploration Family Portrait



We’ve come far in our understanding of Mars

Mars in the night sky

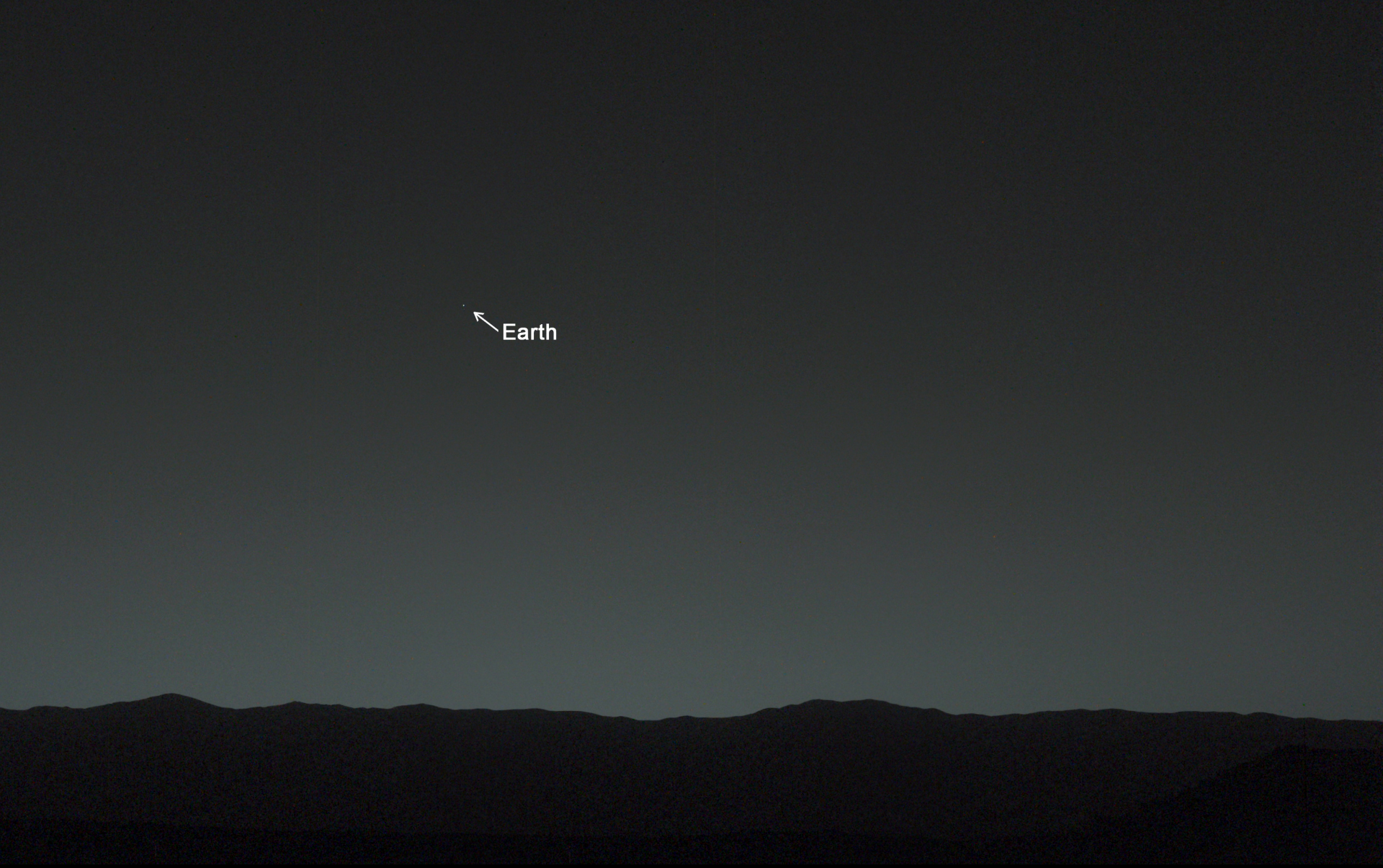


Taken by Jimmy Westlake on March 19, 2014 @ Stagecoach, Colorado, USA

Mars in the night sky

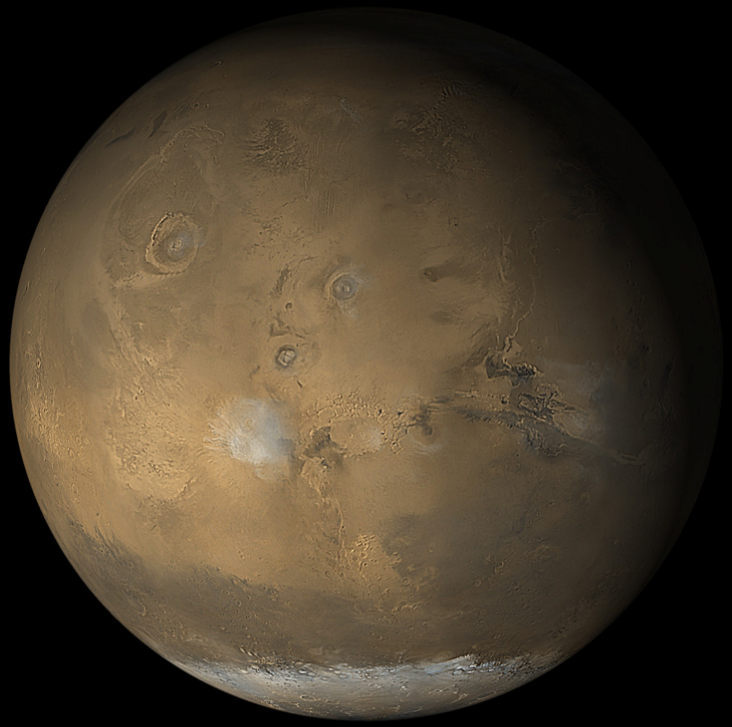
These 4 images were taken from March 27th to this morning April 6, 2014.

~ 50 years ago, scientist still thought bright and dark regions on Mars were due to seasonal variations of vegetation growth.


Earth


Earth
moon

Earthlings fascination with Mars is vibrant than ever



Why Mars?

Why is it special?

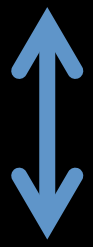
Why do we keep going back?

Why are we special?

Why is Earth different from all of the other planets?

Life

Life



Water

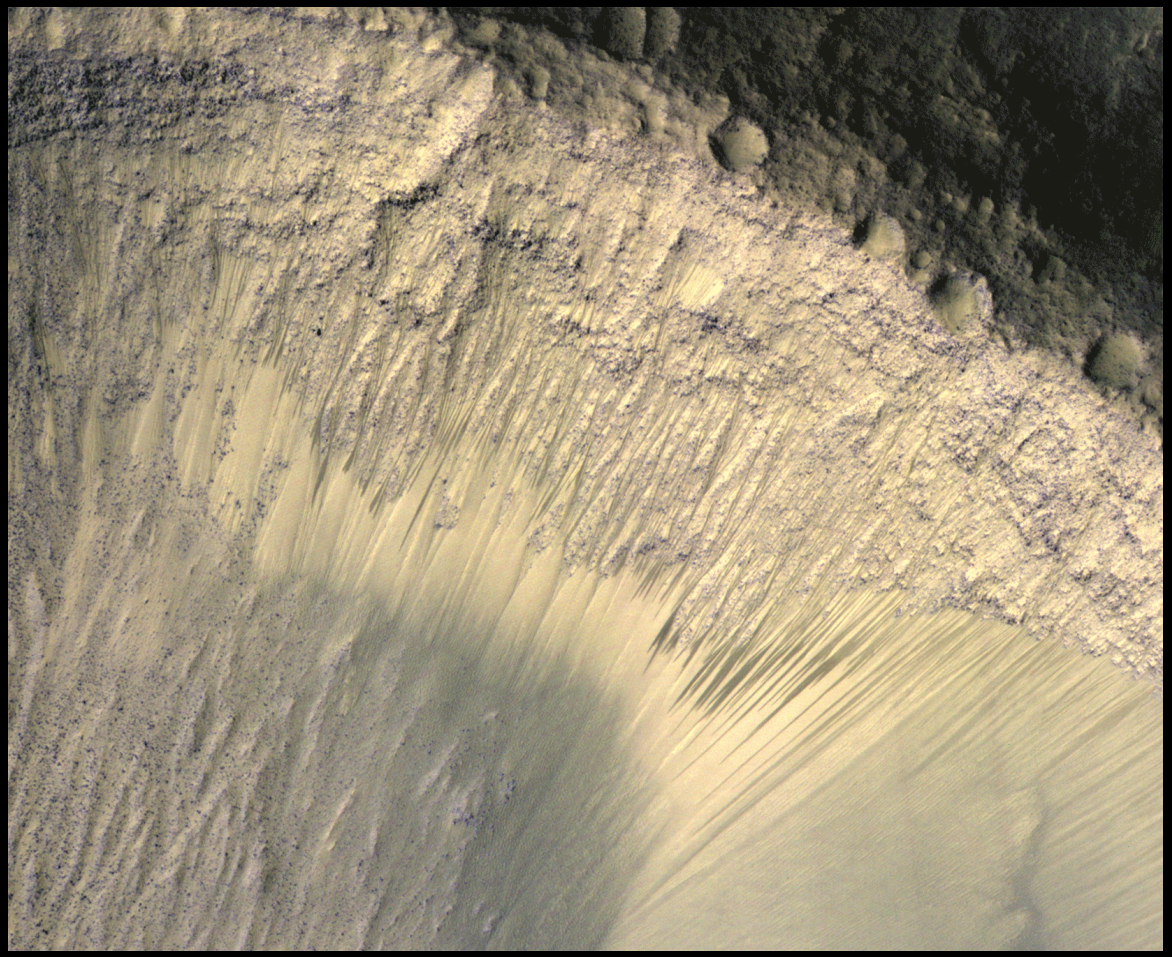
"follow the water"

How did Mars become the planet we see today?

What accounts for the differences and similarities between Earth and Mars?

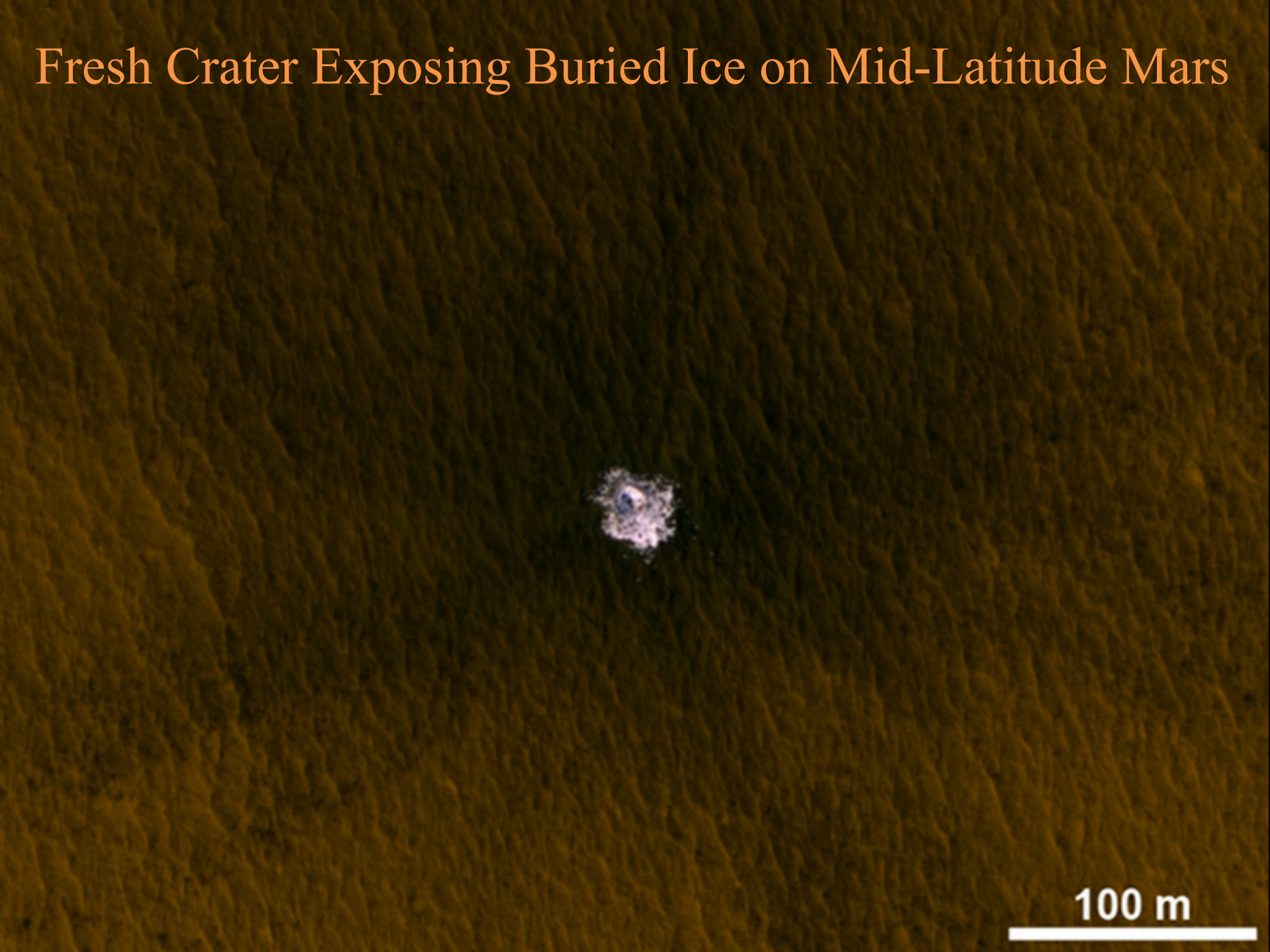
Evidence of water on Mars: Current processes

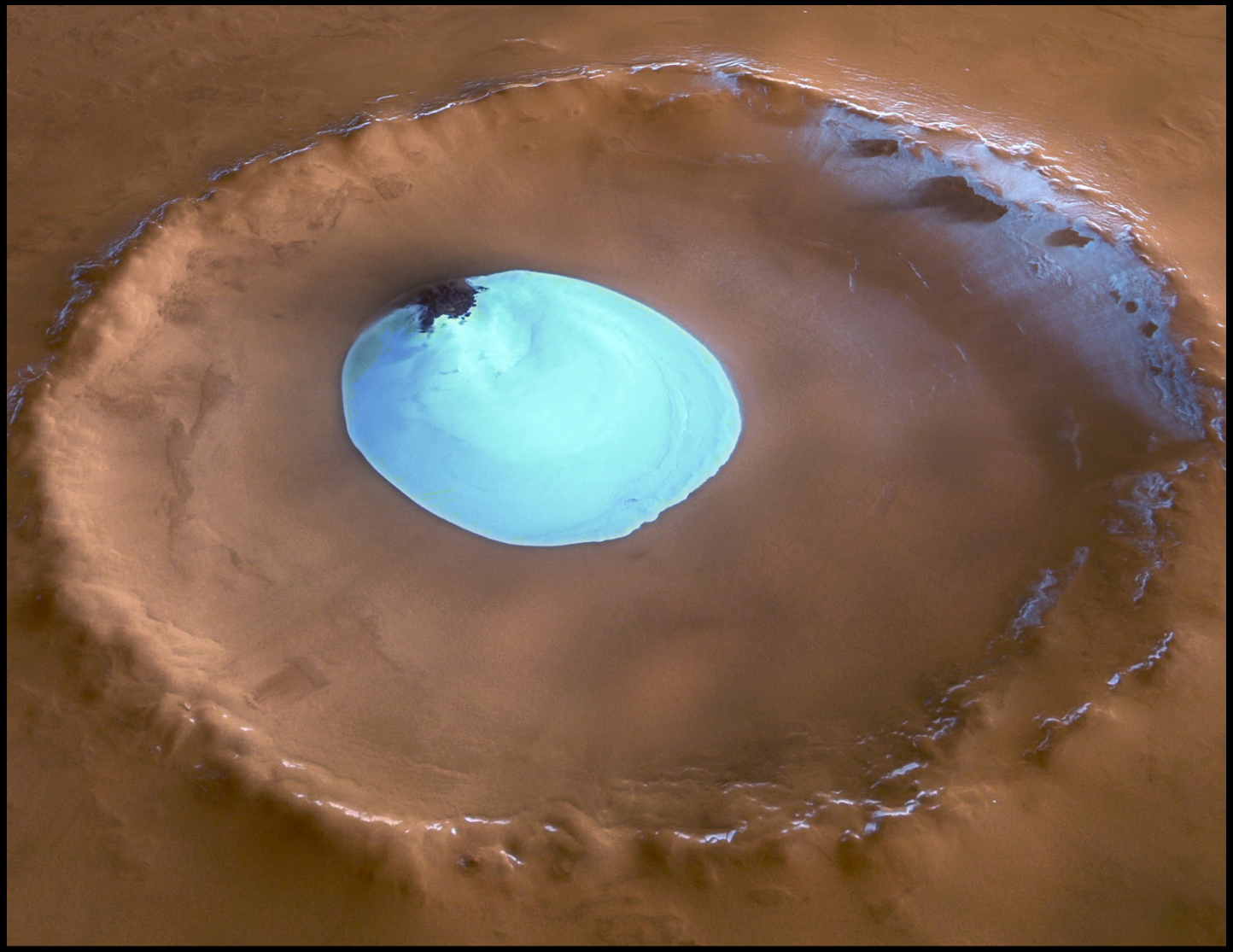
Seasonal Changes in Dark Marks on an Equatorial Martian Slope



Gullies in crater walls, possibly formed by occasional melting of subsurface ice or snow

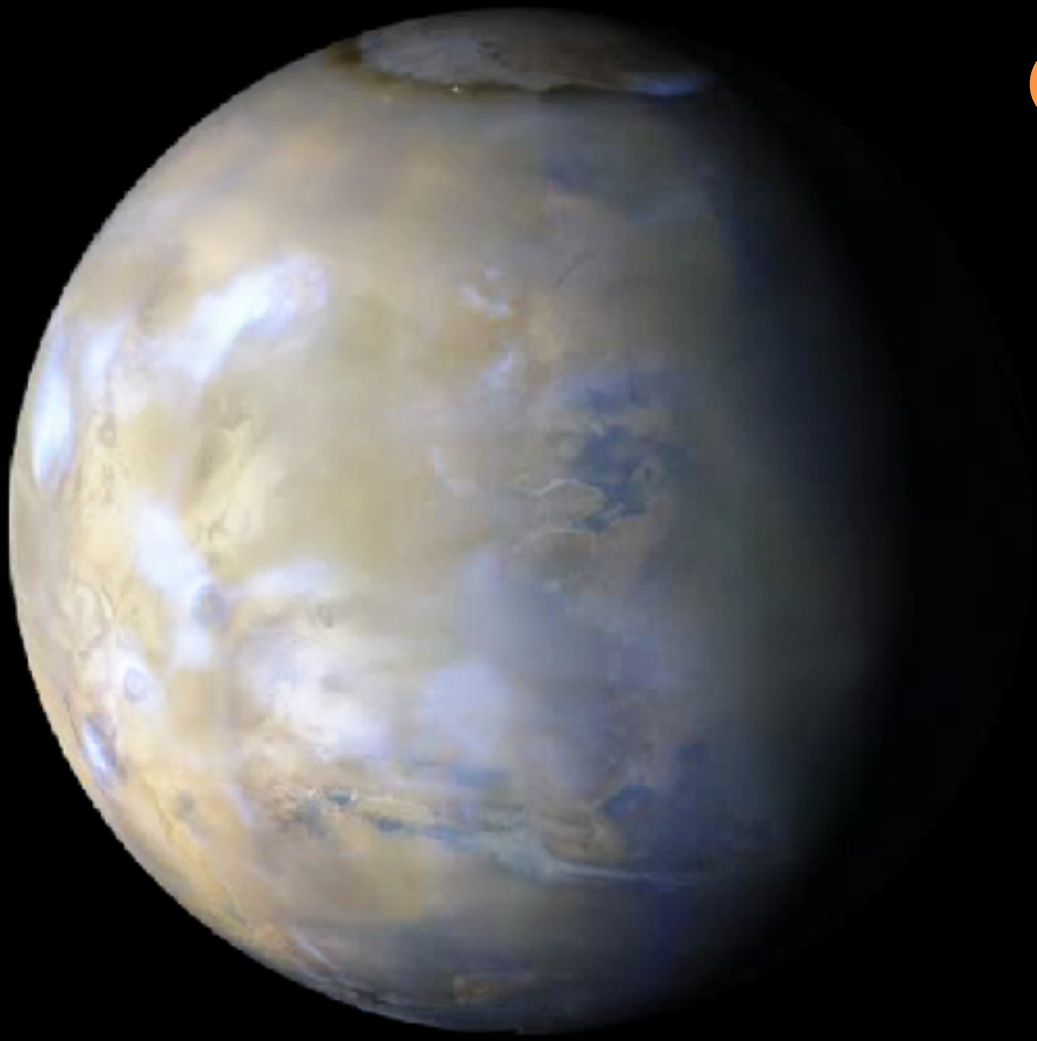
Fresh Crater Exposing Buried Ice on Mid-Latitude Mars





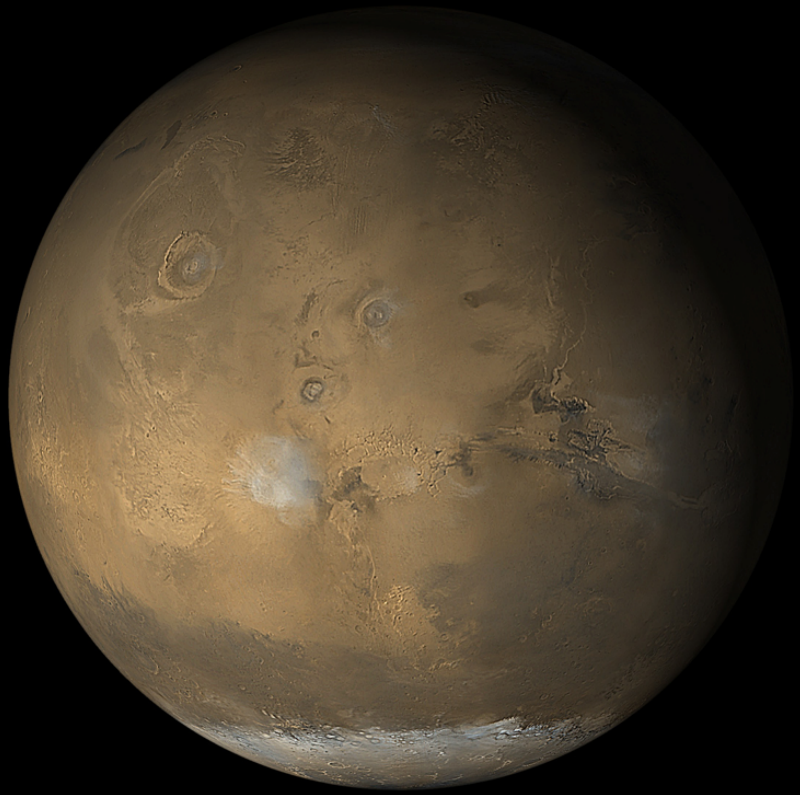
Residual water ice in an unnamed crater on Vastitas Borealis

Clouds

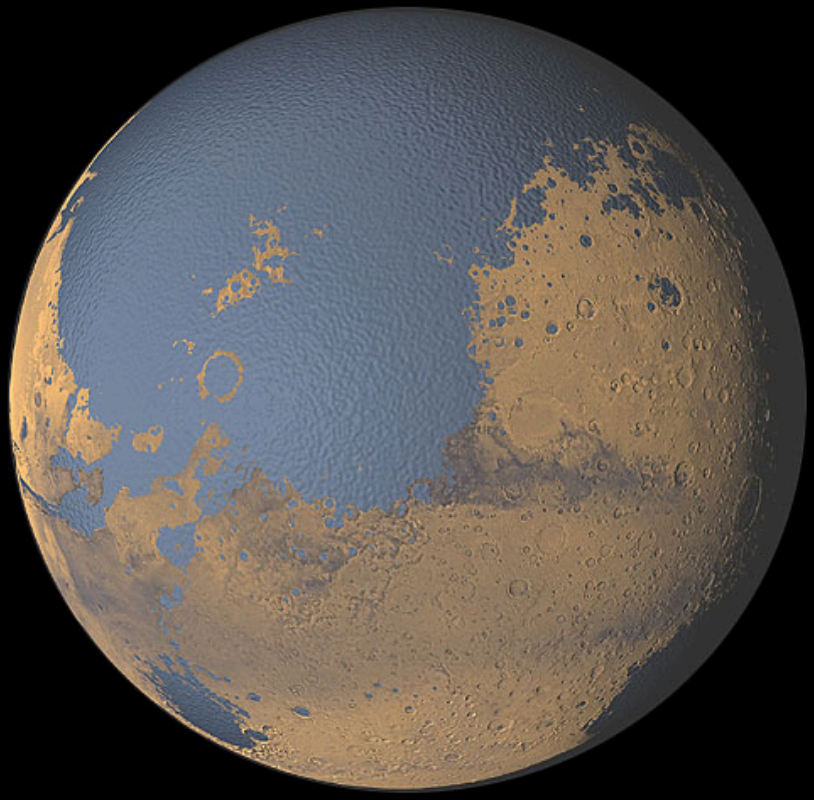


It snows on Mars!

Currently, water still plays a role, but a “minor” one



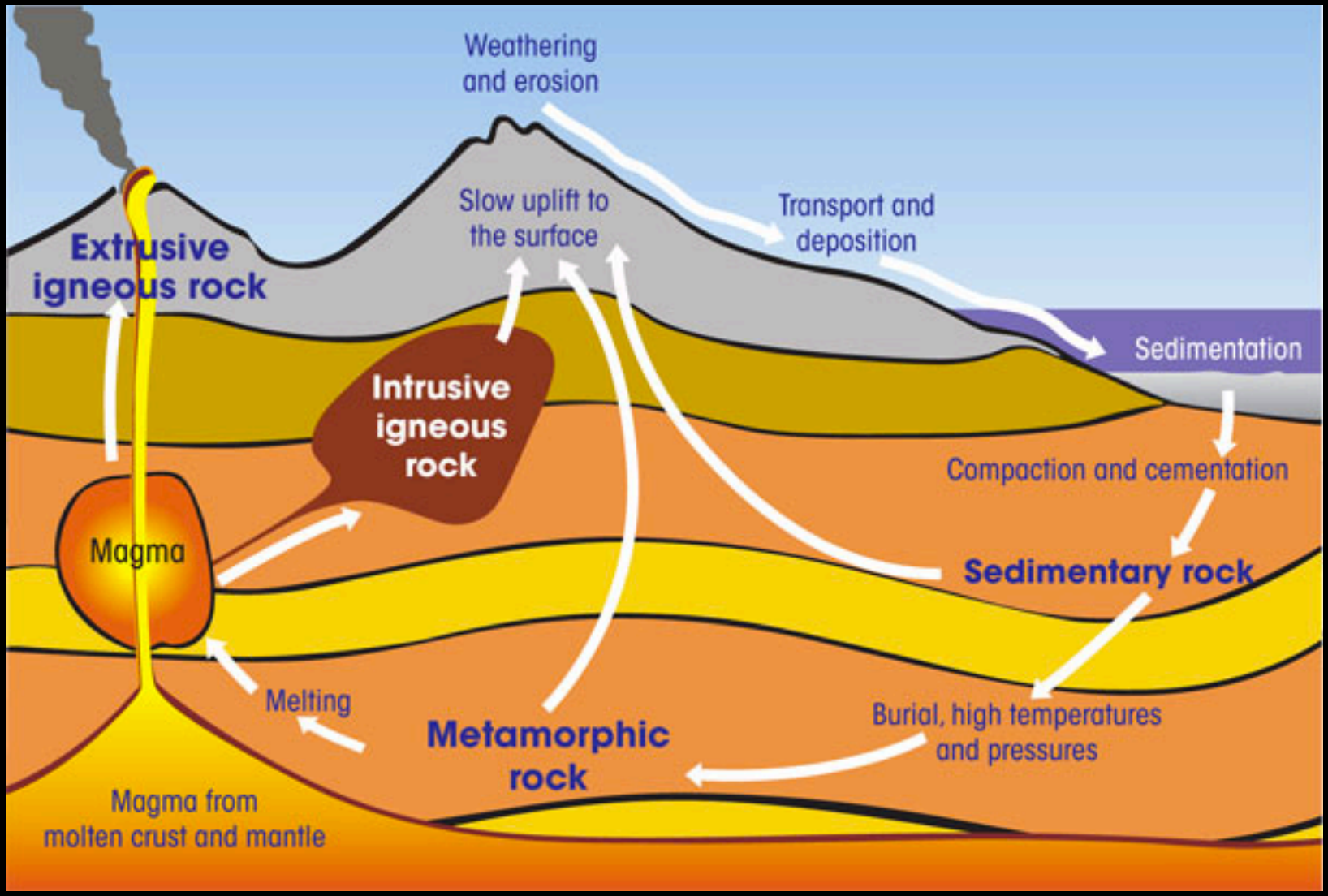
But what about in the past?



Evidence of water on Mars: Past processes

Geologic record

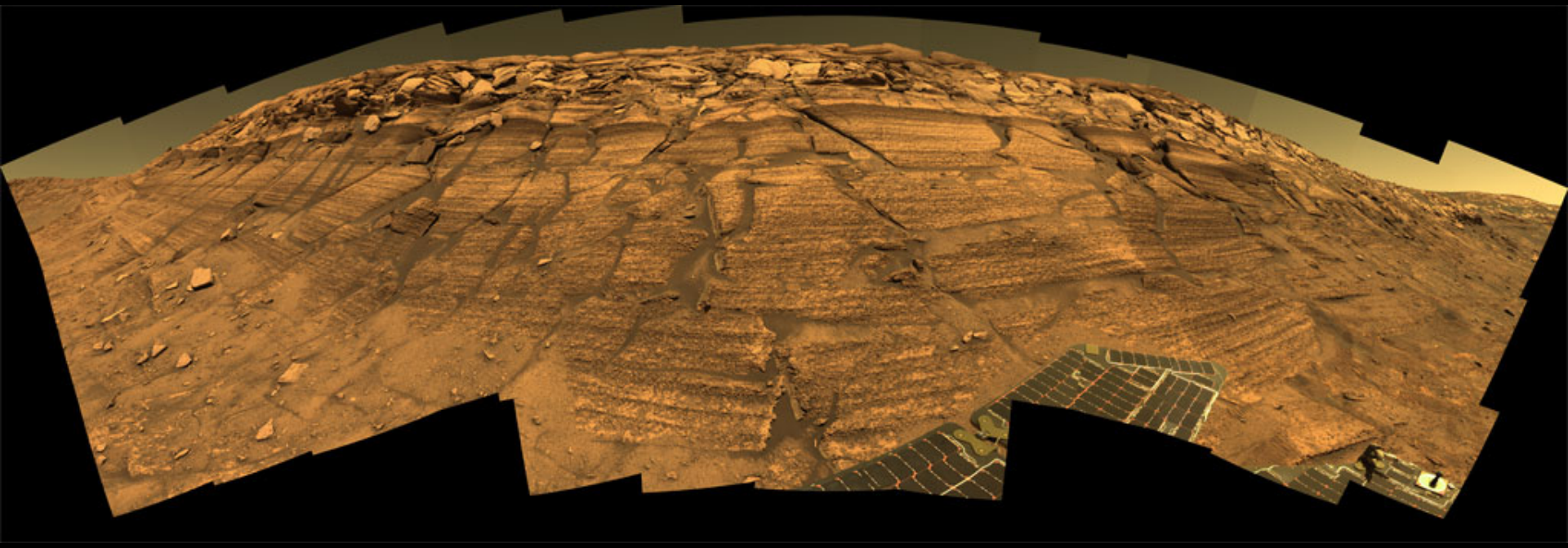
Every rock is a record of the environment in which it formed



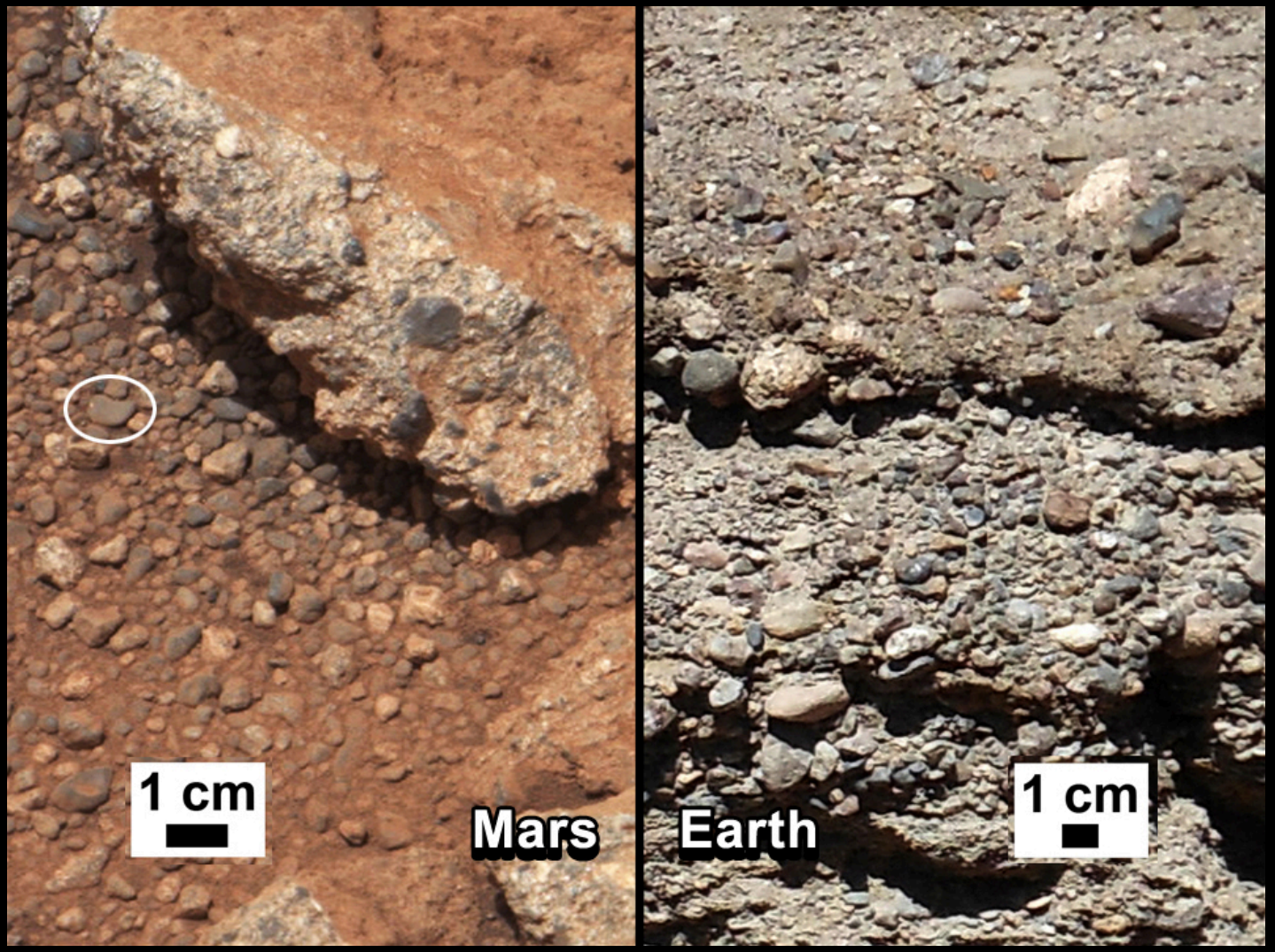
Bulk composition of Mars is basaltic (volcanic)

Mar 4, 2014, 1:19:52 PM UTC

Panorama at Burns Cliff, sols 287-294

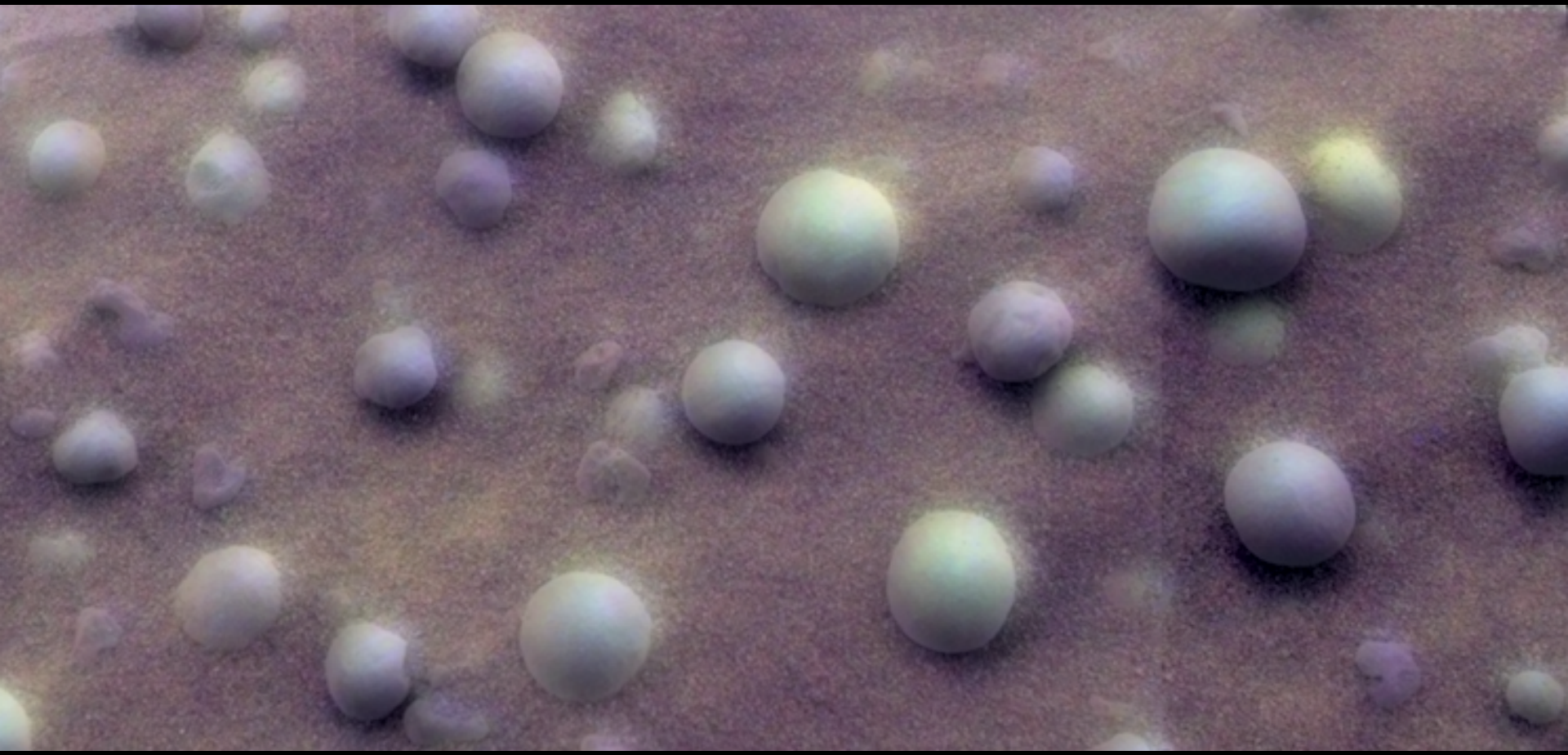


Sulfate rich sandstones; very acidic waters, low ph



Conglomerates on Mars!

Blueberries at "Stone Mountain," sol 14



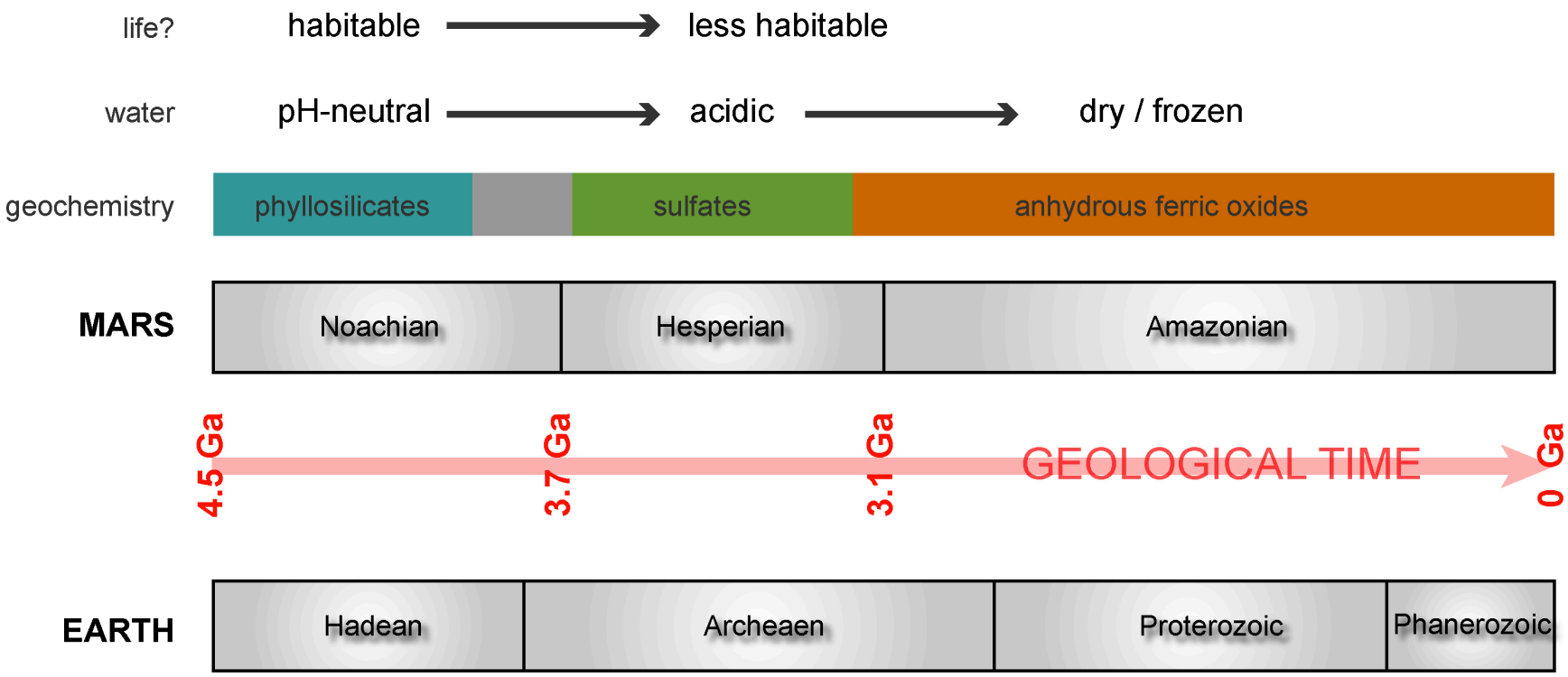
A mosaic of Microscopic Imager images, colorized with lower-resolution Pancam data, from sol 14 (February 7, 2004).

- Sediments and sedimentary structures can tell us about the processes that deposited them (depositional environments).

- Mineralogy can help us determine the environmental conditions.

Couple what we physically see in the rocks to their composition

Mars Geologic Time Scale



Adapted from Bibring et al. (2006)

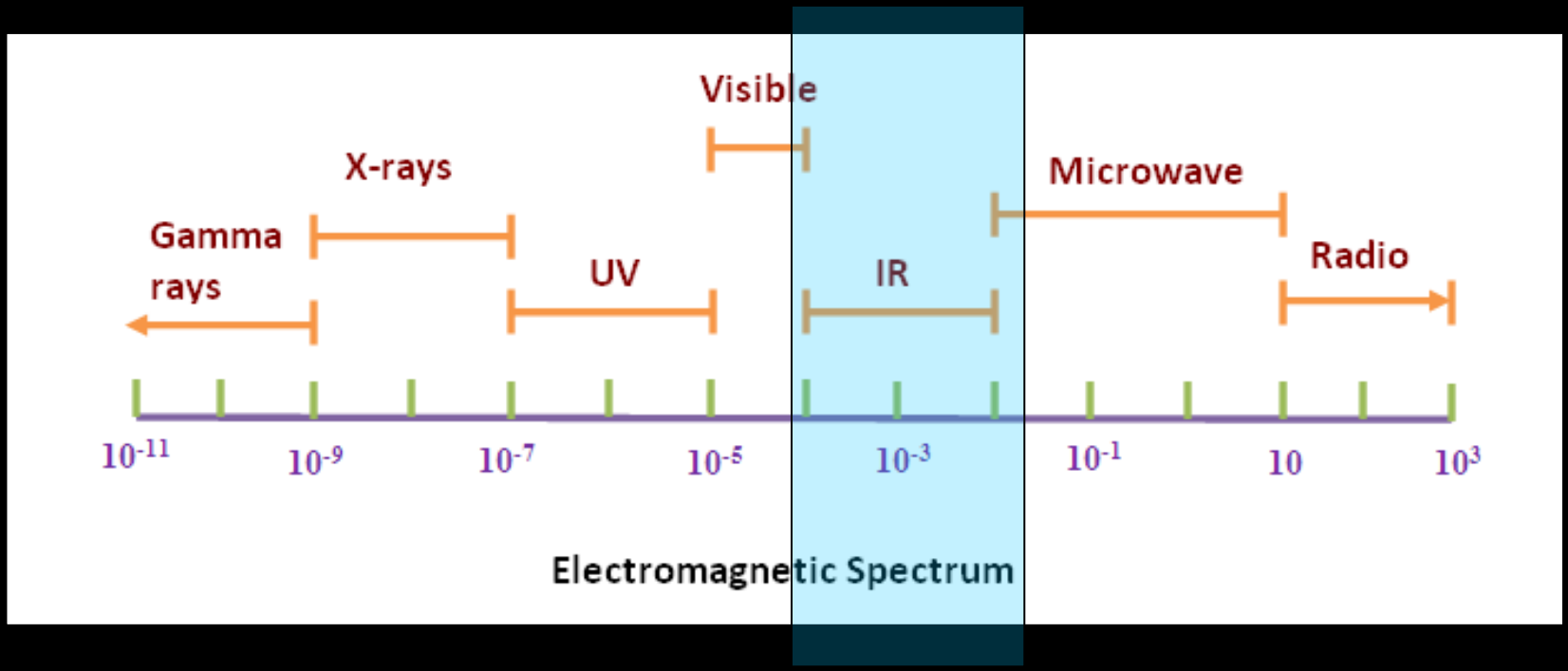
My research group at UW focuses on mineralogy

Variety of methods to determine the composition of the rocks

Orbit: Near Infrared and Thermal Infrared Spectrometers

Rover: Alpha Particle X-Ray Spectrometer, Laser-Induced Breakdown Spectrometer, Thermal Infrared Spectroscopy, Mossbauer

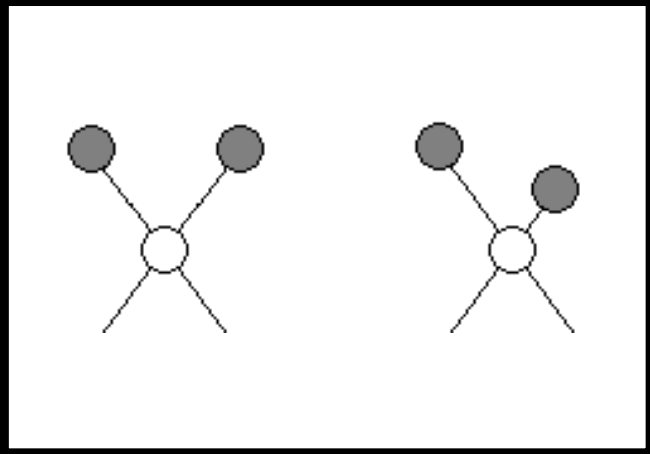
Thermal Infrared (TIR) Spectral Range



Spectral range:
Wavelength = 5 - 50 µm

1 µm (micron) = 10^{-6} meters

- Atoms in molecules are in continuous vibration with respect to each other



- Vibrations happen at specific frequencies
  - dependent on properties such as bond type (e.g. covalent, coulombic, hydrogen) and mass of atoms.

- Frequencies of vibration coincide with IR frequencies

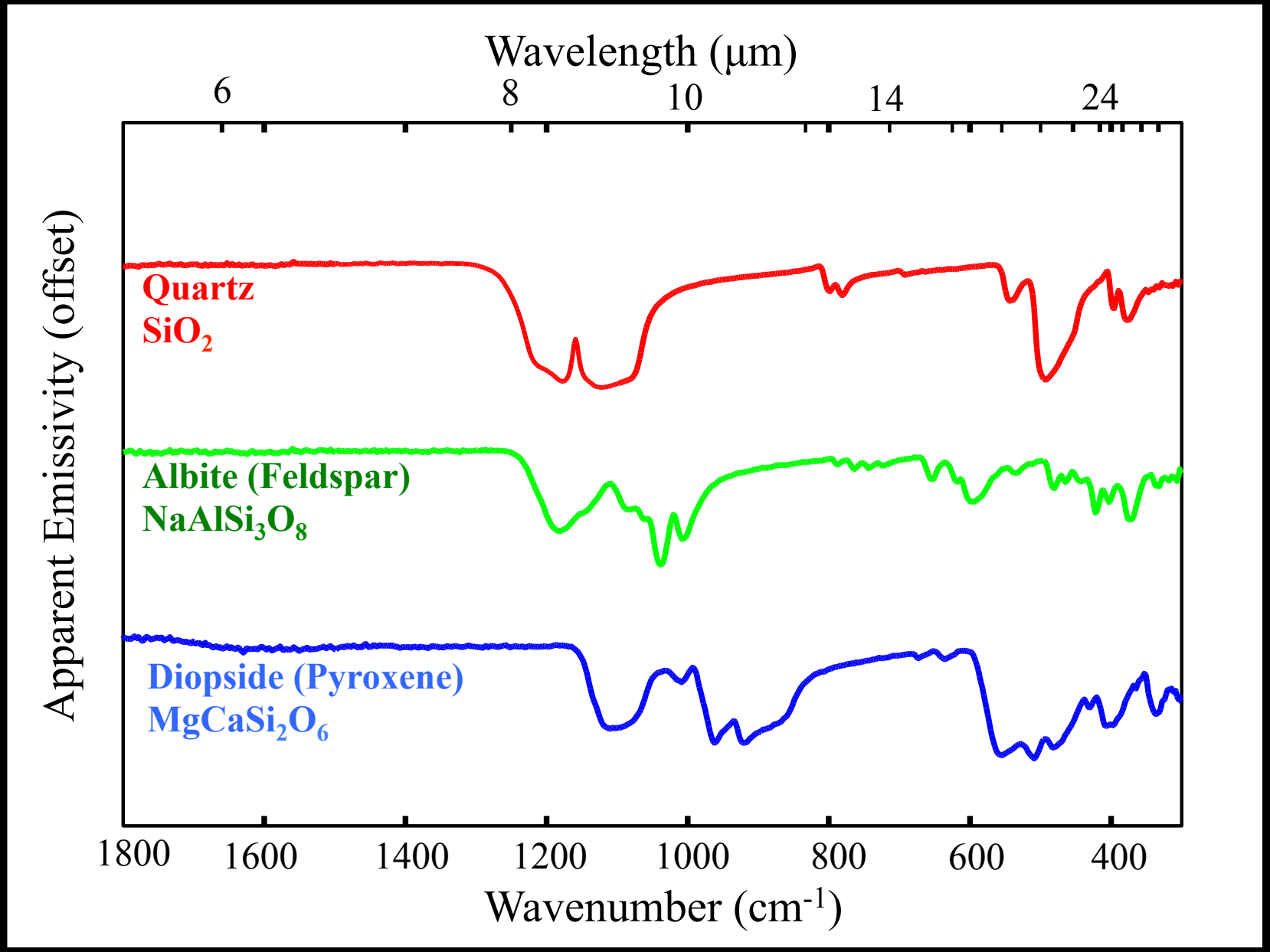
- Silicates have characteristic vibrations in the IR
  - all contain a basic Si-O tetrahedral anion; various cations are bonded to these anions

Quartz

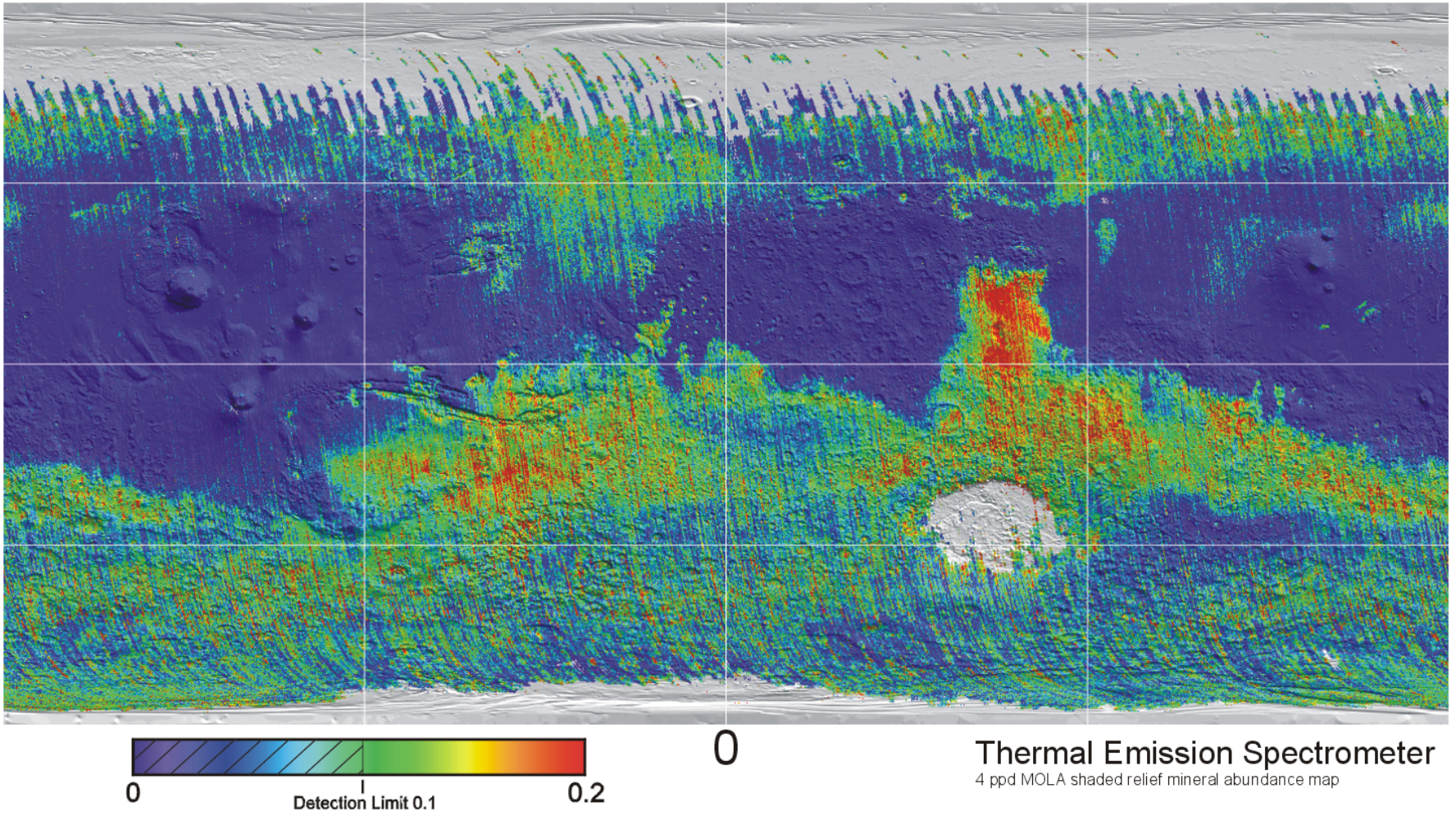
Albite

Diopside

Example TIR Spetra of Rock forming Minerals



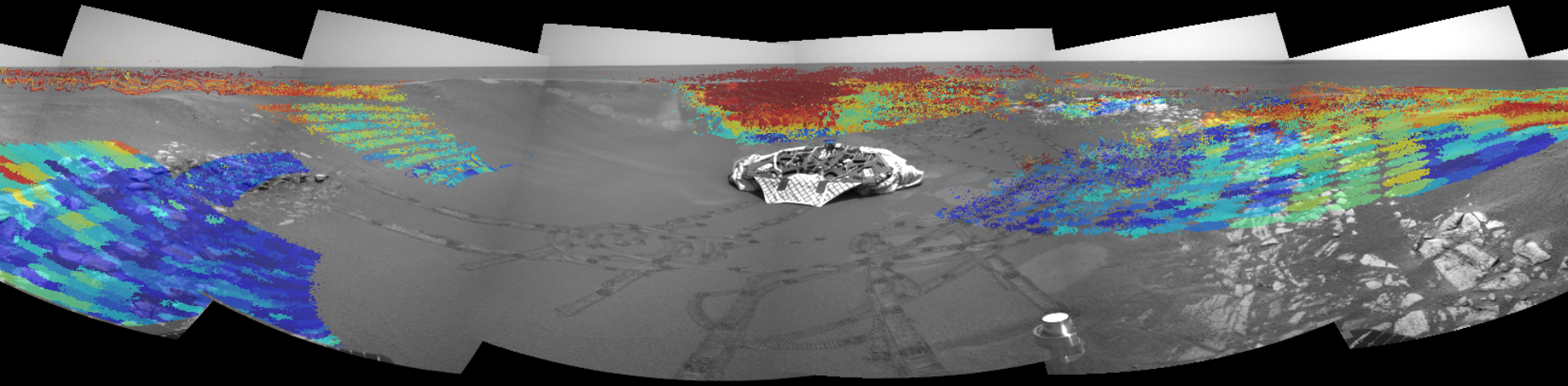
Plagioclase



Thermal Emission Spectrometer

4 ppd MOLA shaded relief mineral abundance map

Hematite



Miniature Thermal Emission Spectrometer
Panoramic Camera

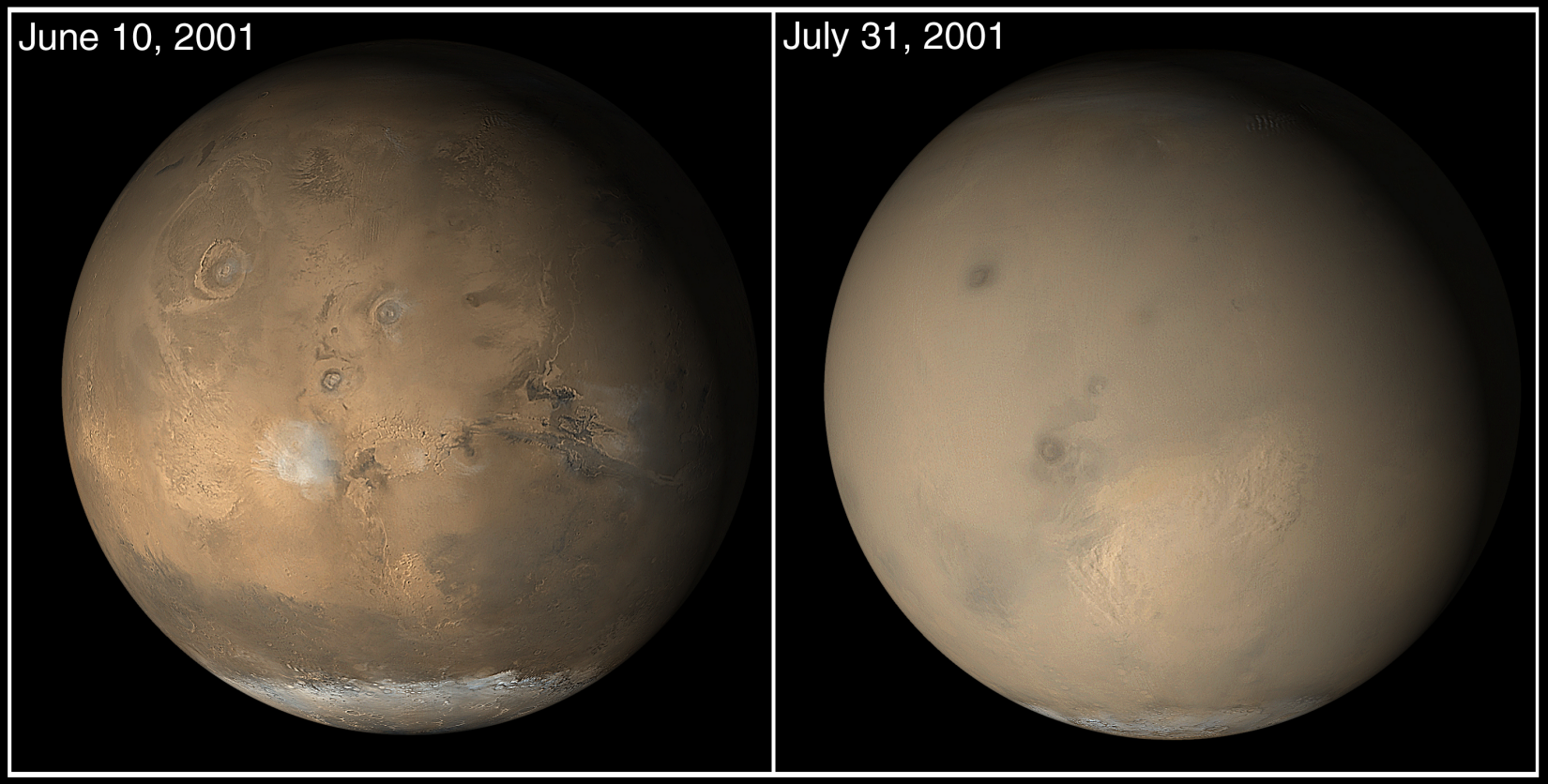
Mars is dusty

Outcrop in Moonlight Valley - sol 540
NASA/JPL-Caltech/MSSS/Thomas Appéré

Dust is everywhere and on everything.

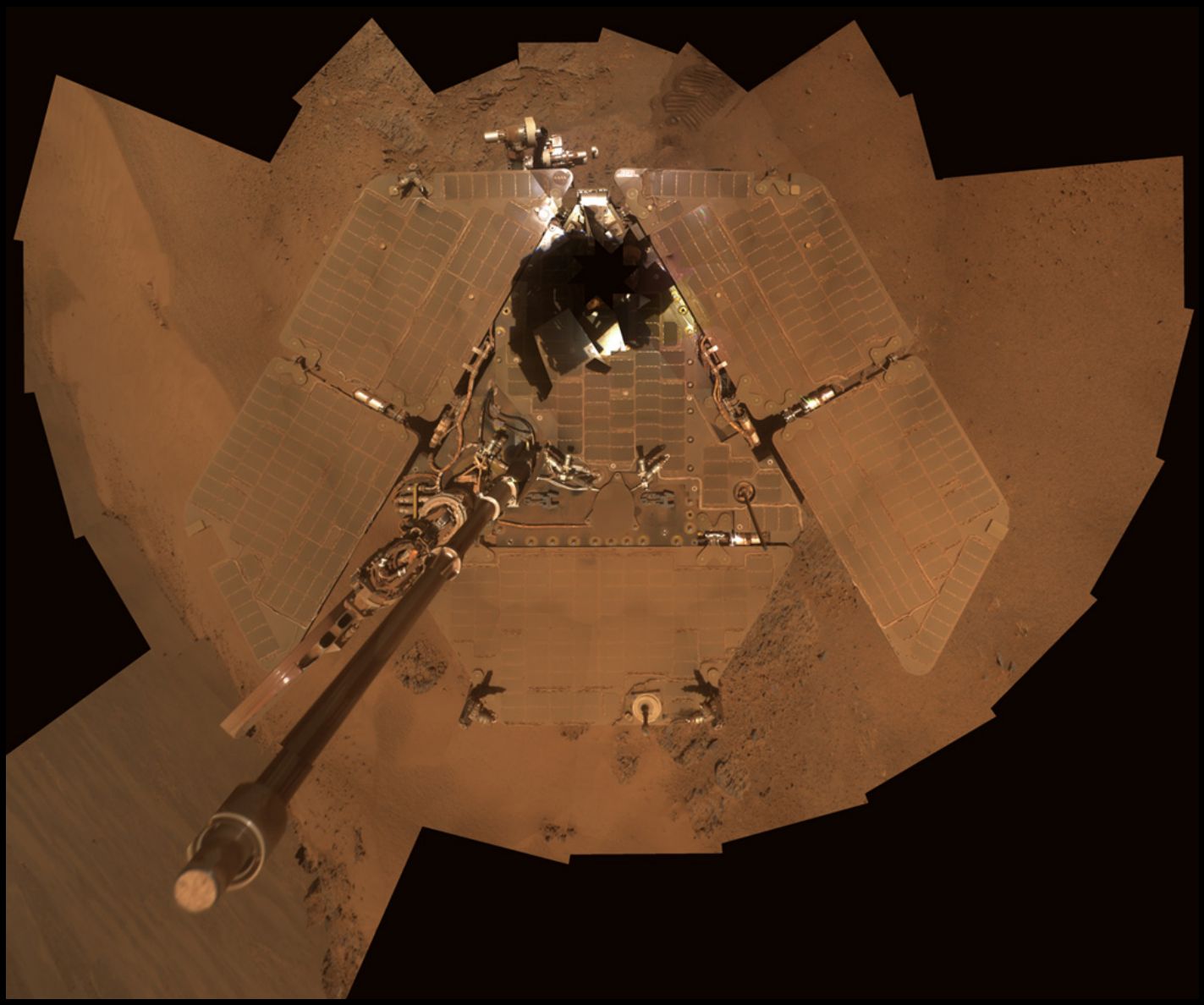
Dust is above the surface.

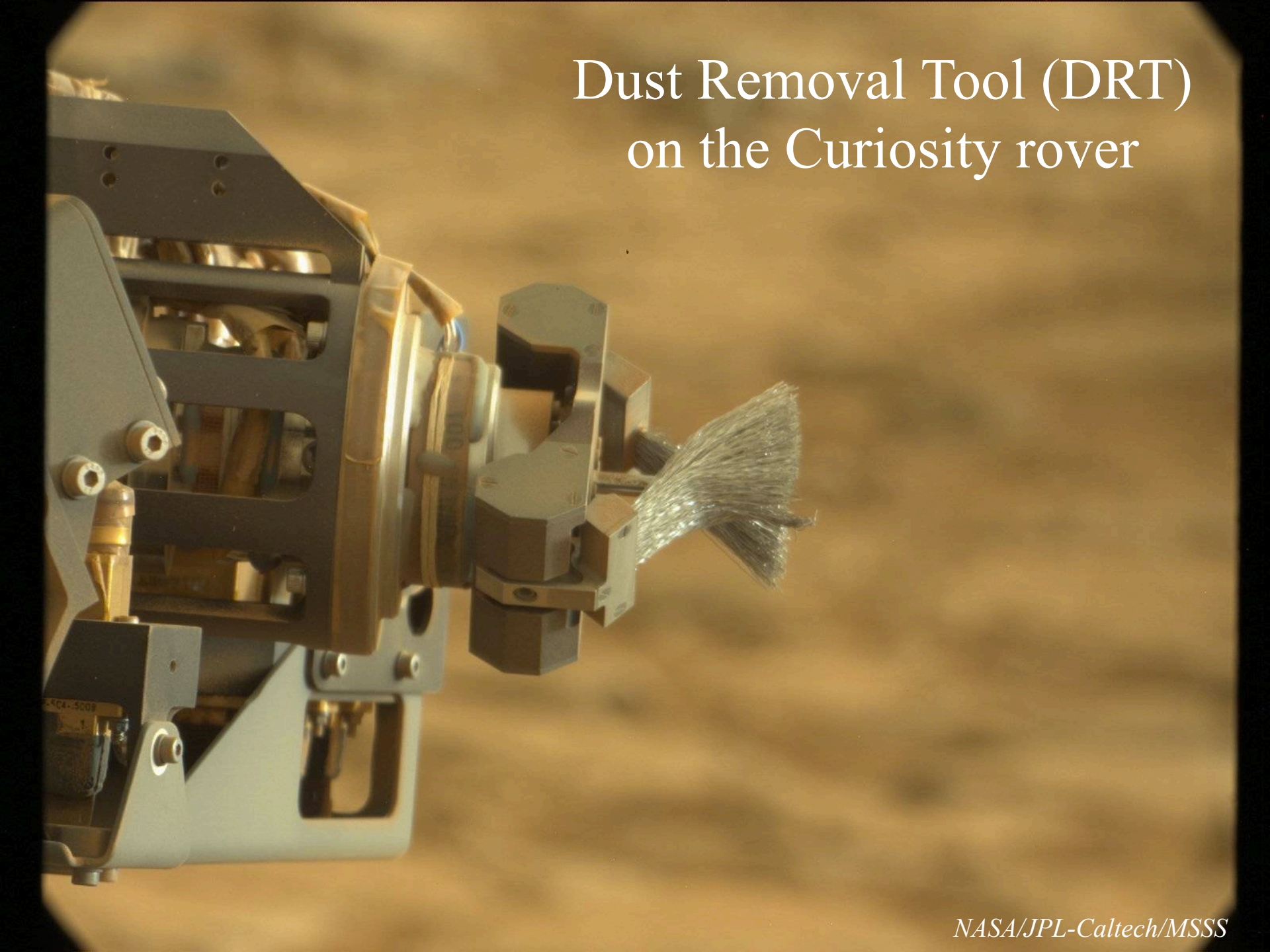
It’s transported regionally.



Transported Globally

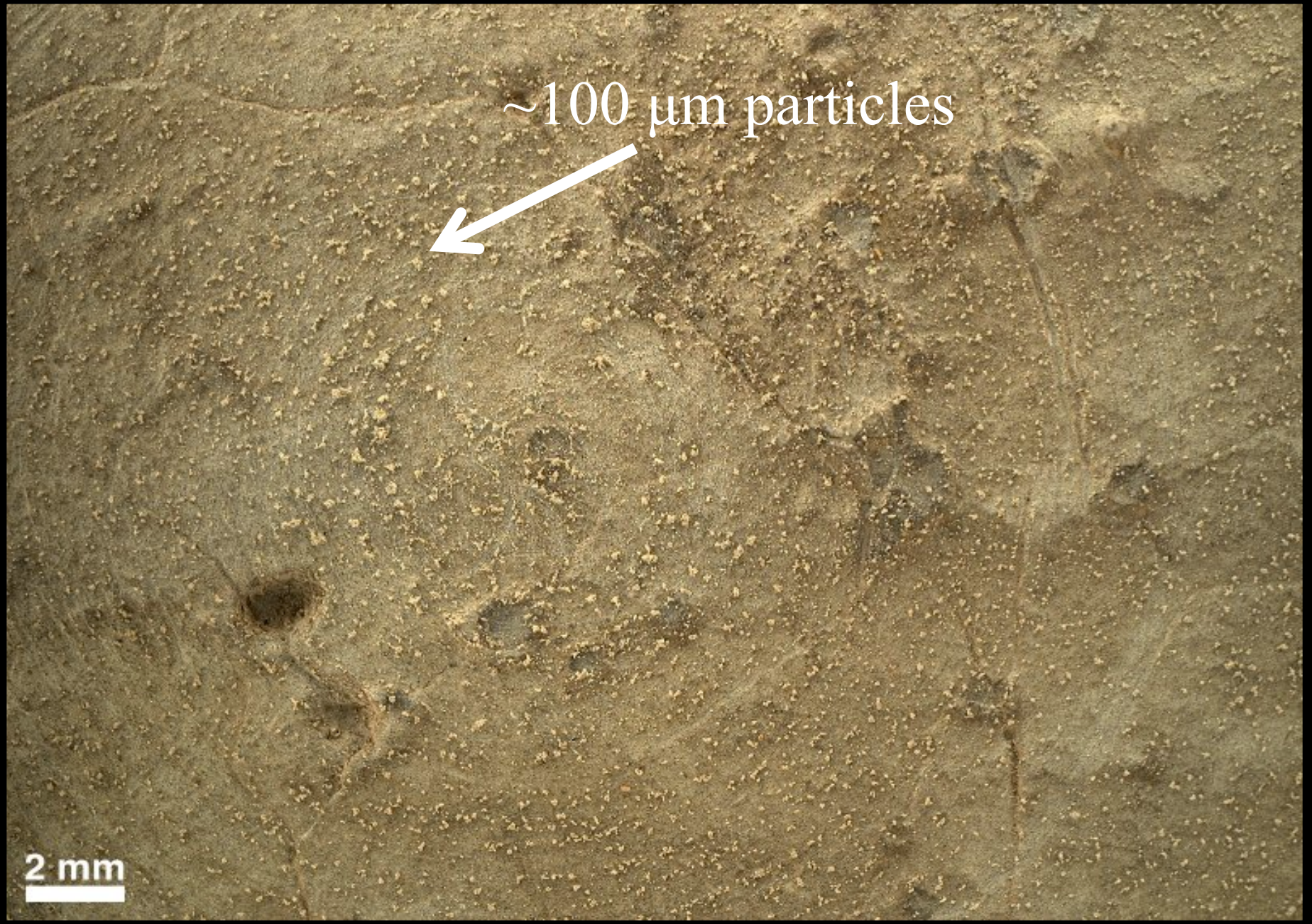
Dust on Mars Exploration Rover (MER)



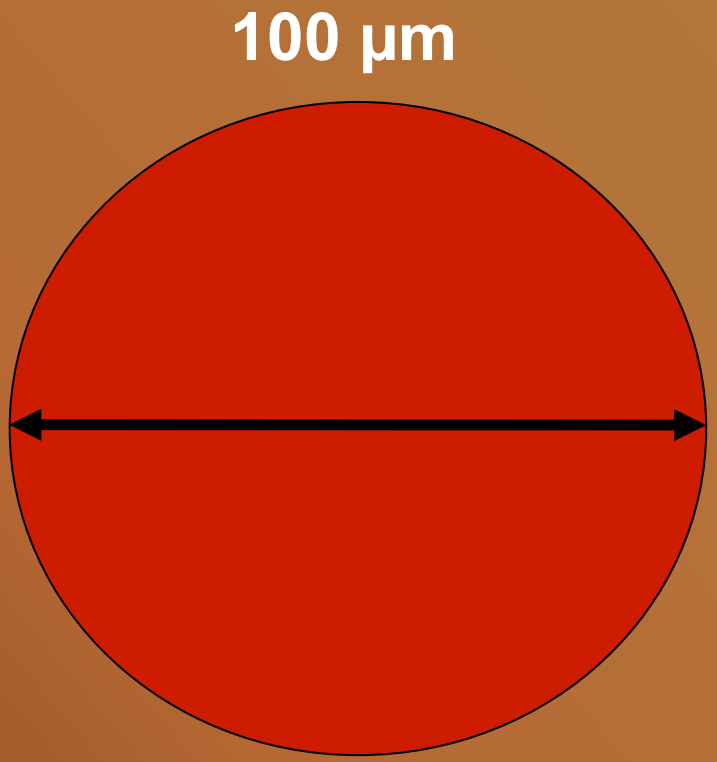

Dust Removal Tool (DRT)
on the Curiosity rover
NASA/JPL-Caltech/MSSS

Dust is on the surface.

NASA/JPL-Caltech/MSSS



NASA/JPL-Caltech/MSSS



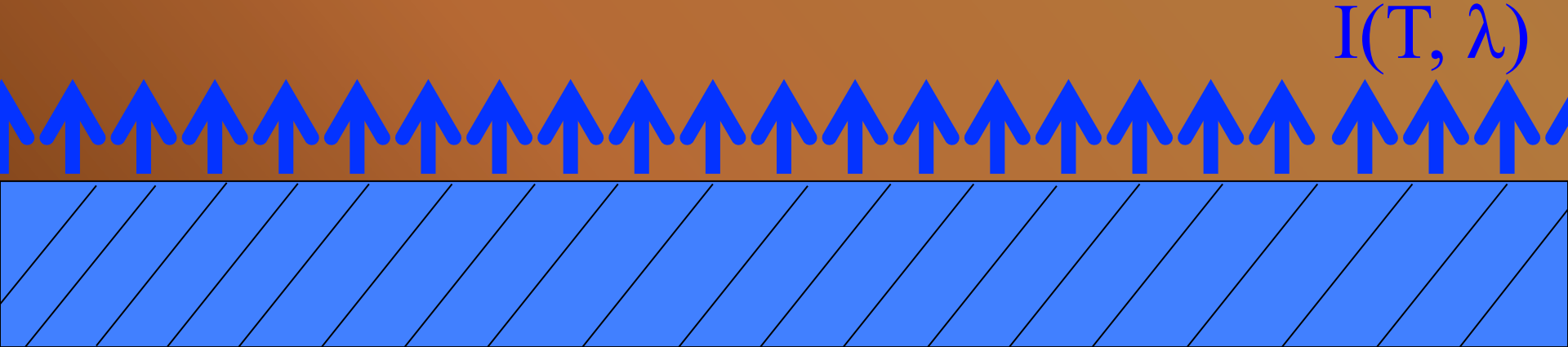
Average Human Hair

Atmospheric Dust on Mars

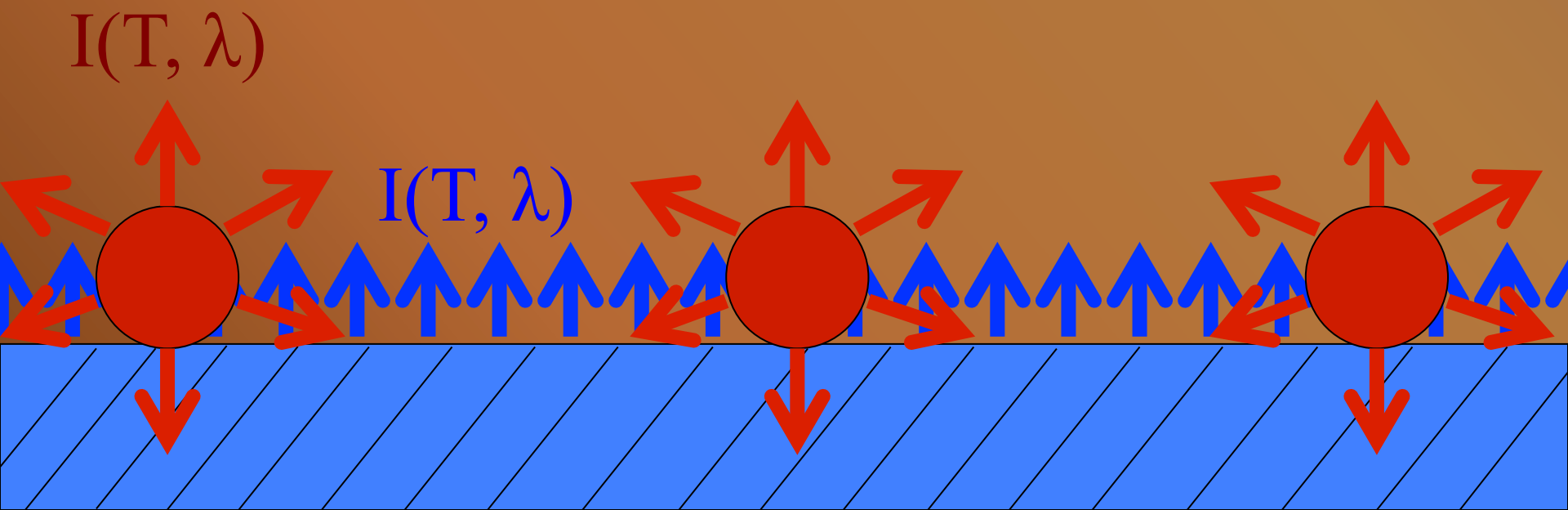
Dust is a contribution in remote sensing data sets of Mars that cannot be avoided.

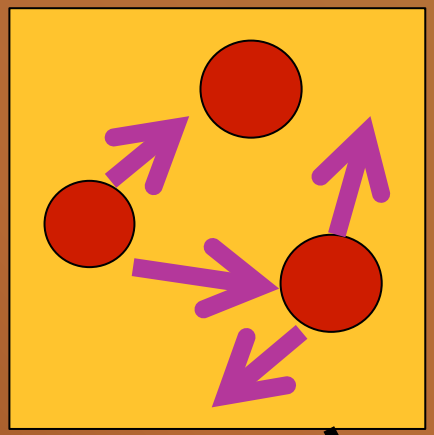
Regardless of the spectral range of interest.

What we want to observe

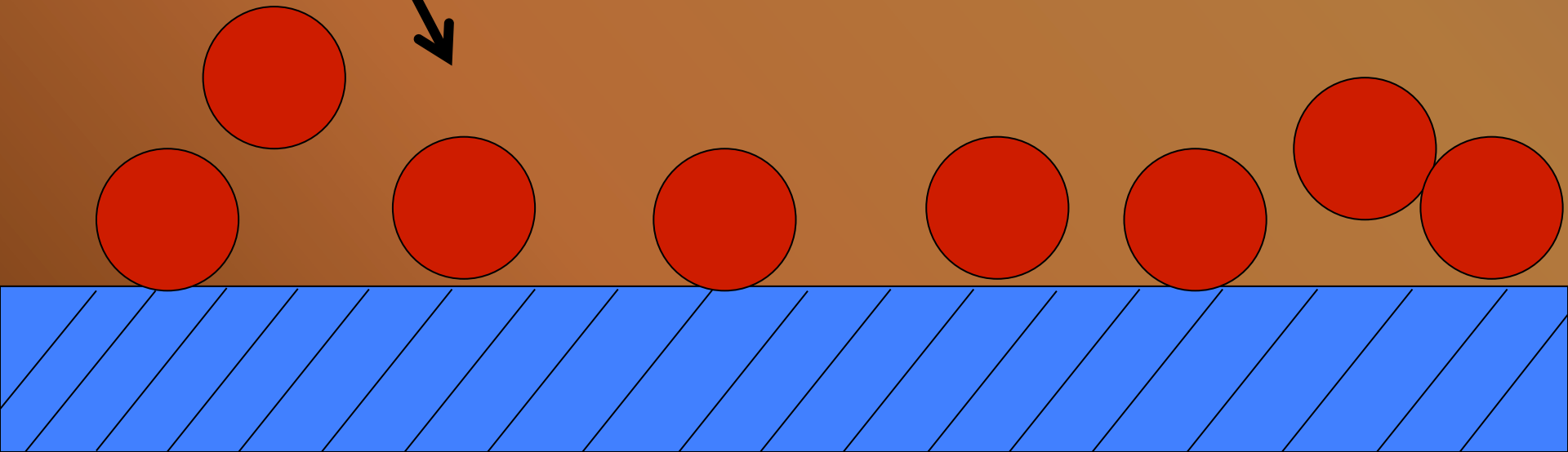


Reality





Reality is messy



There are a variety of effects that dust can have in the TIR.

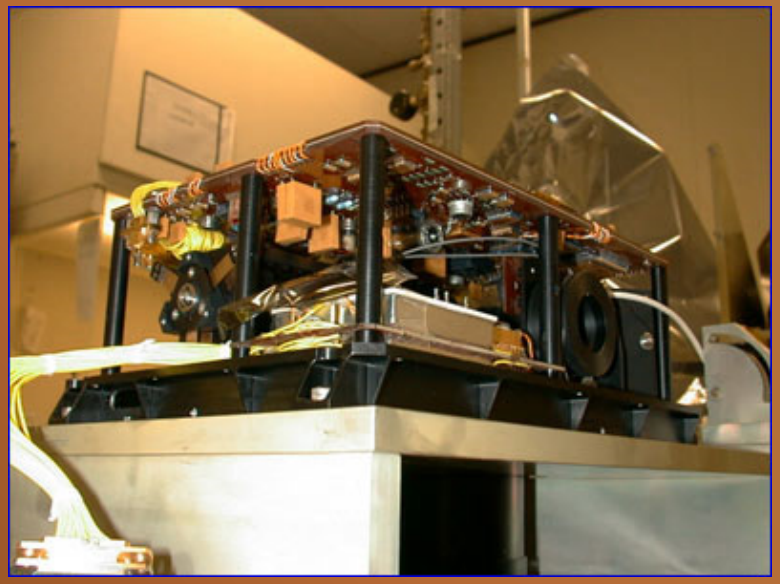
*** I specifically study the effects of thin *** mantles of dust (< ~10 μm).

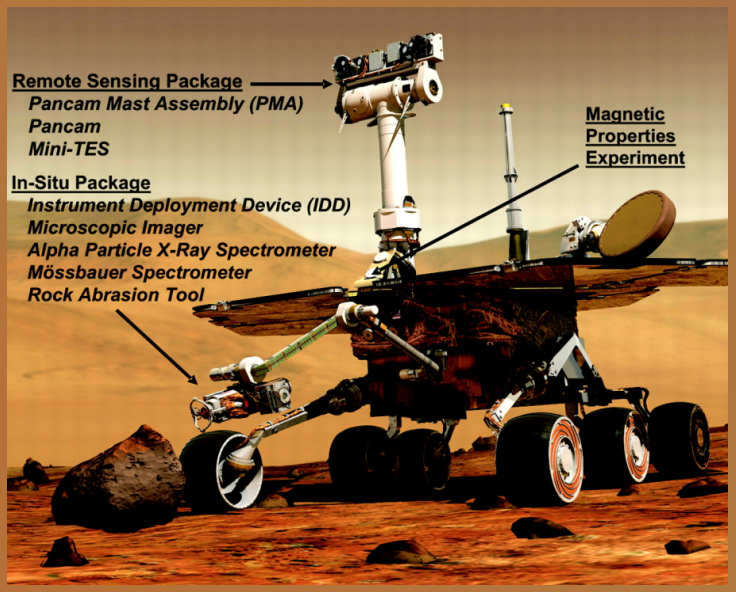
Methodology

1) I've been taking TIR laboratory measurements of dust coated surfaces.

2) Numerically reproducing what the spectral effects of dust are in TIR measurements taken by Mini-TES.

Miniature Thermal Emission Spectrometer (Mini-TES)



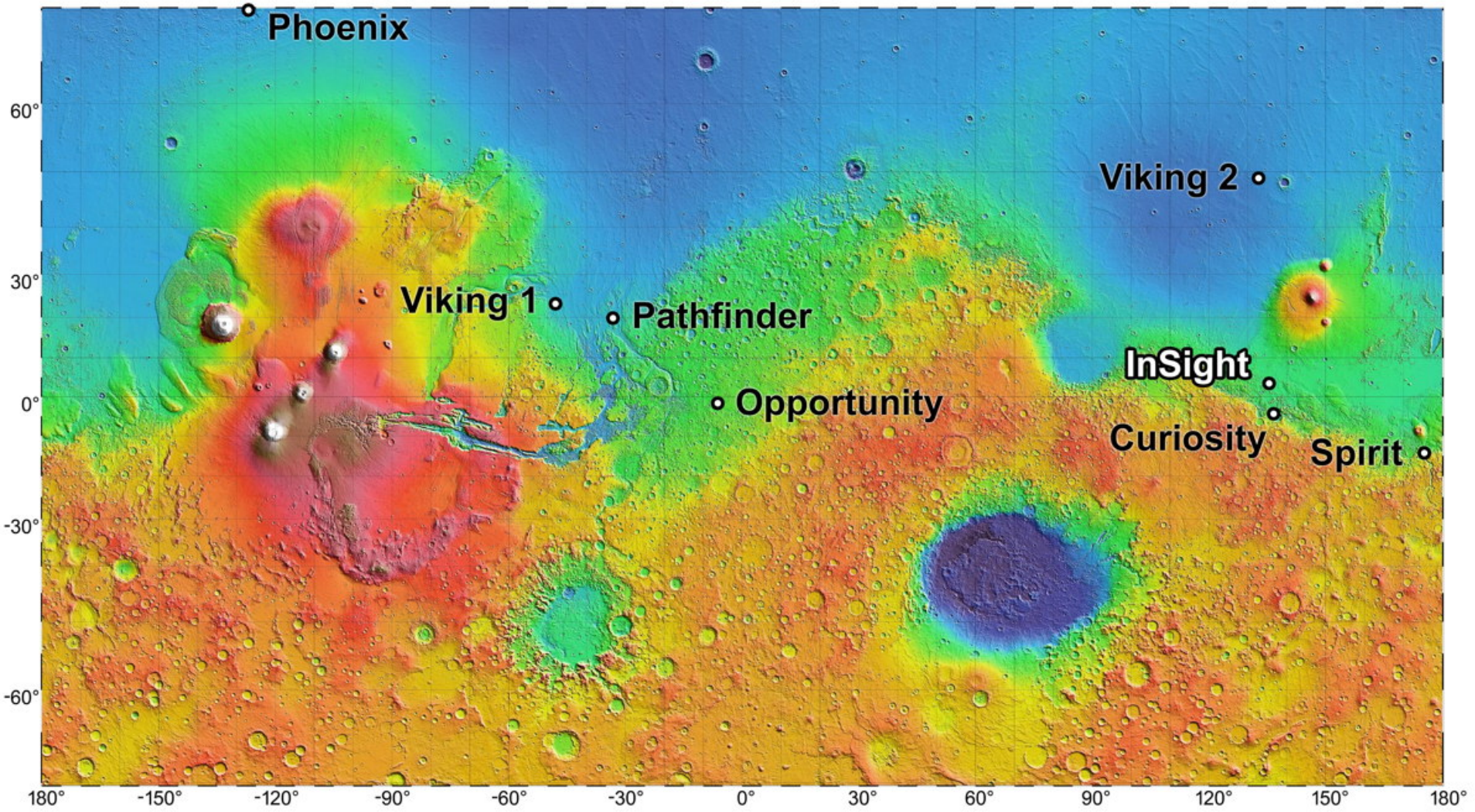


Michelson interferometer

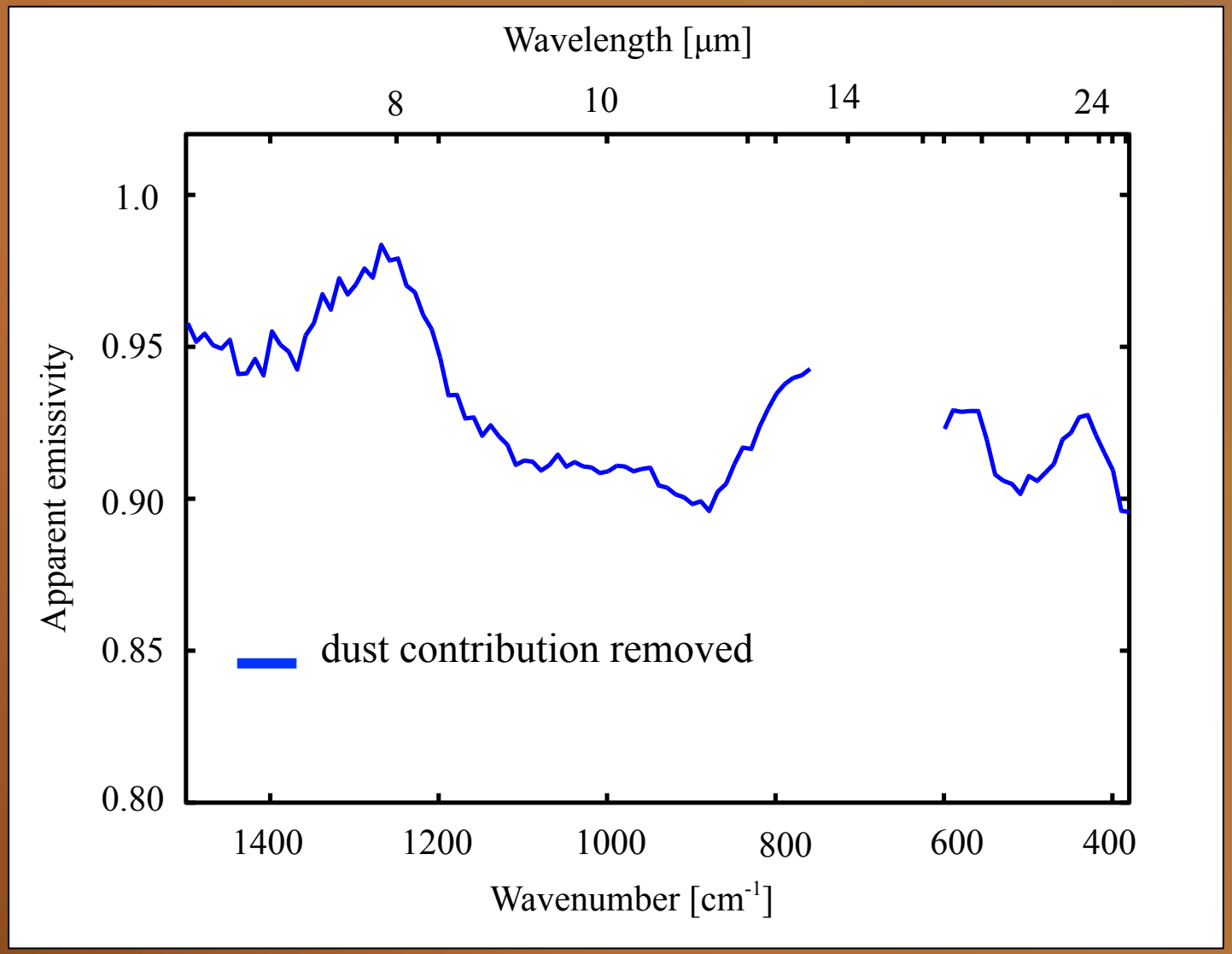
Spectral Range: 5 – 29 μm (339 to 1997 cm^{-1})

Spectral Resolution/Sampling: 10 cm^{-1}

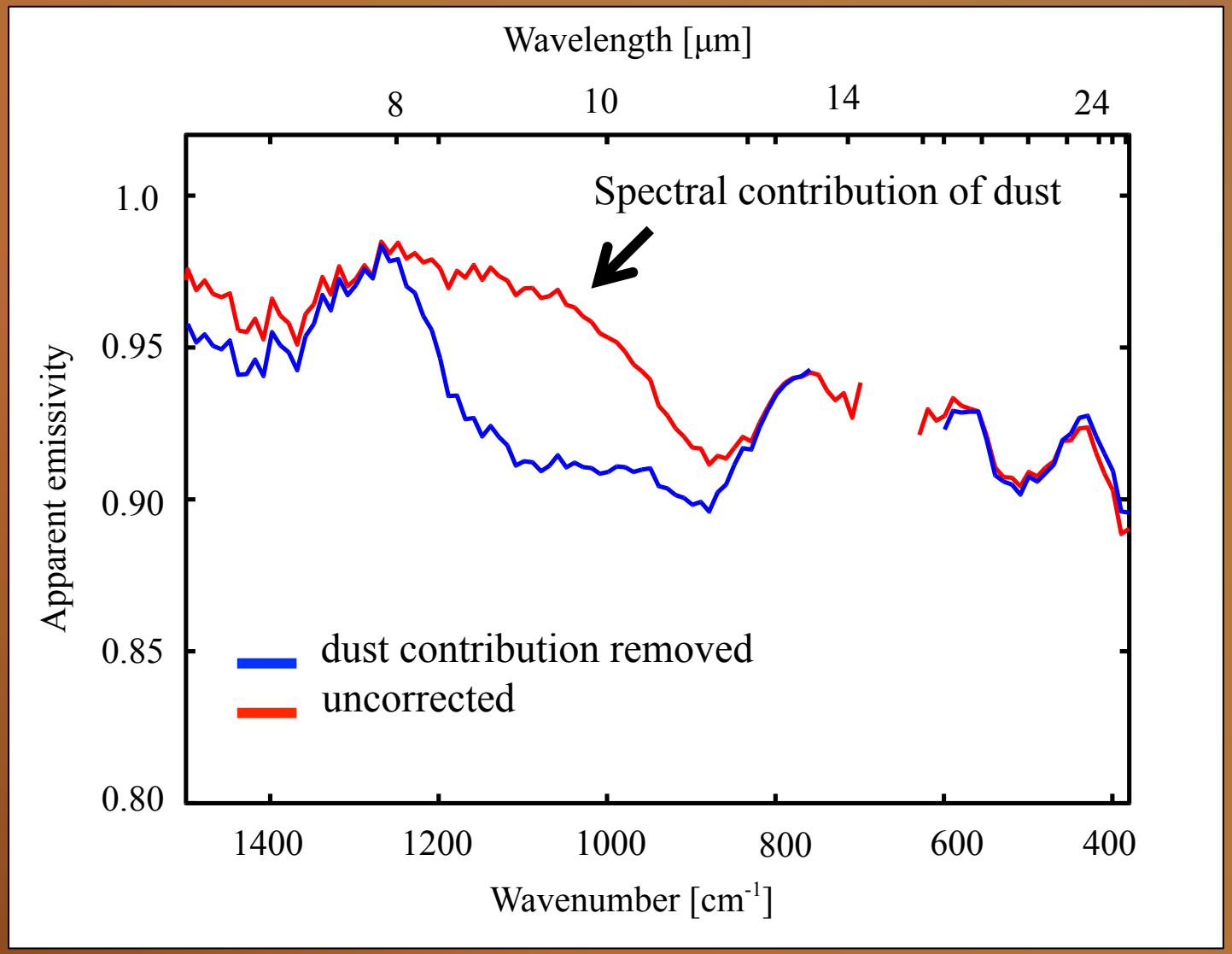
Landing Sites



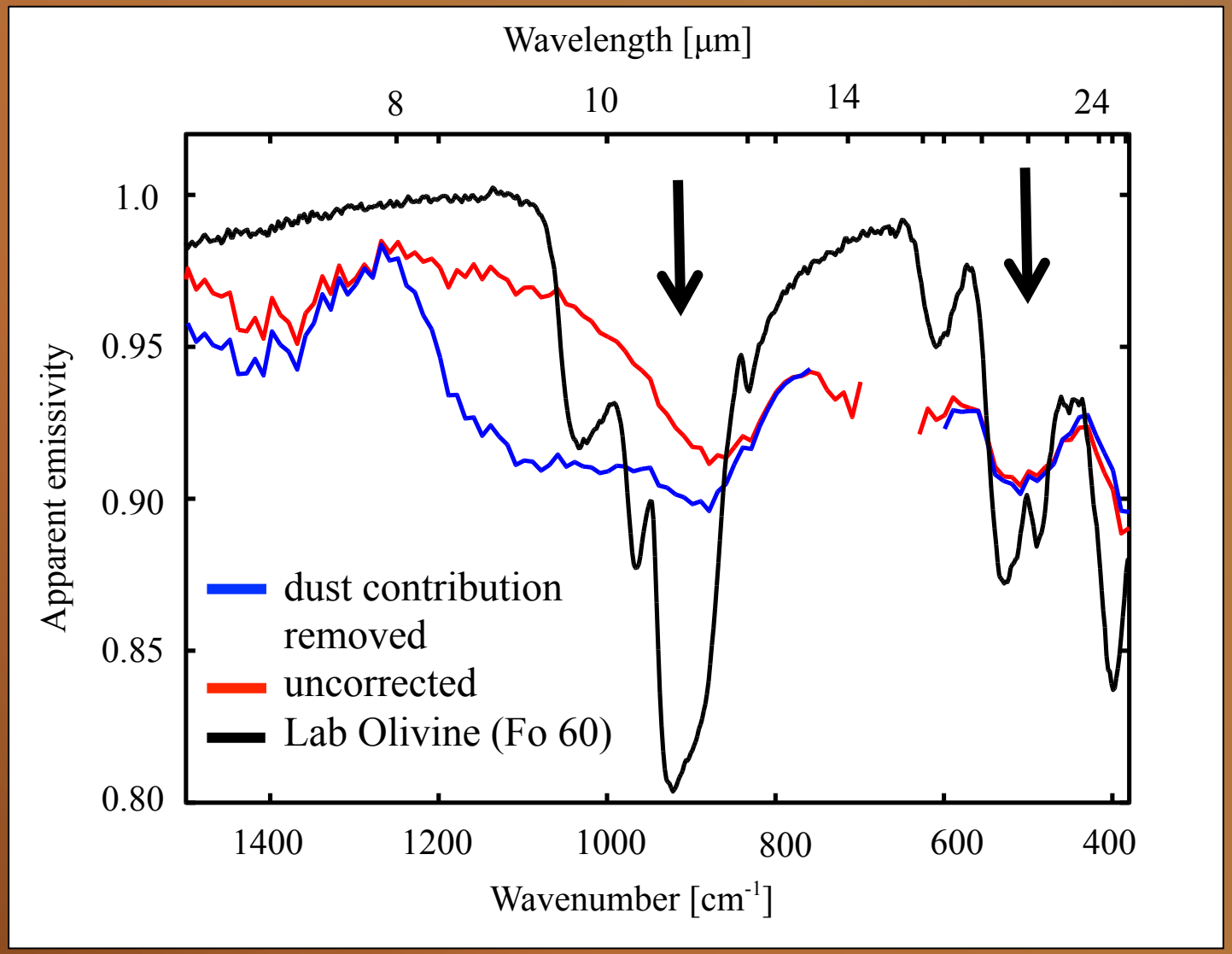
Mini-TES measurement of Dusty Basaltic Rock



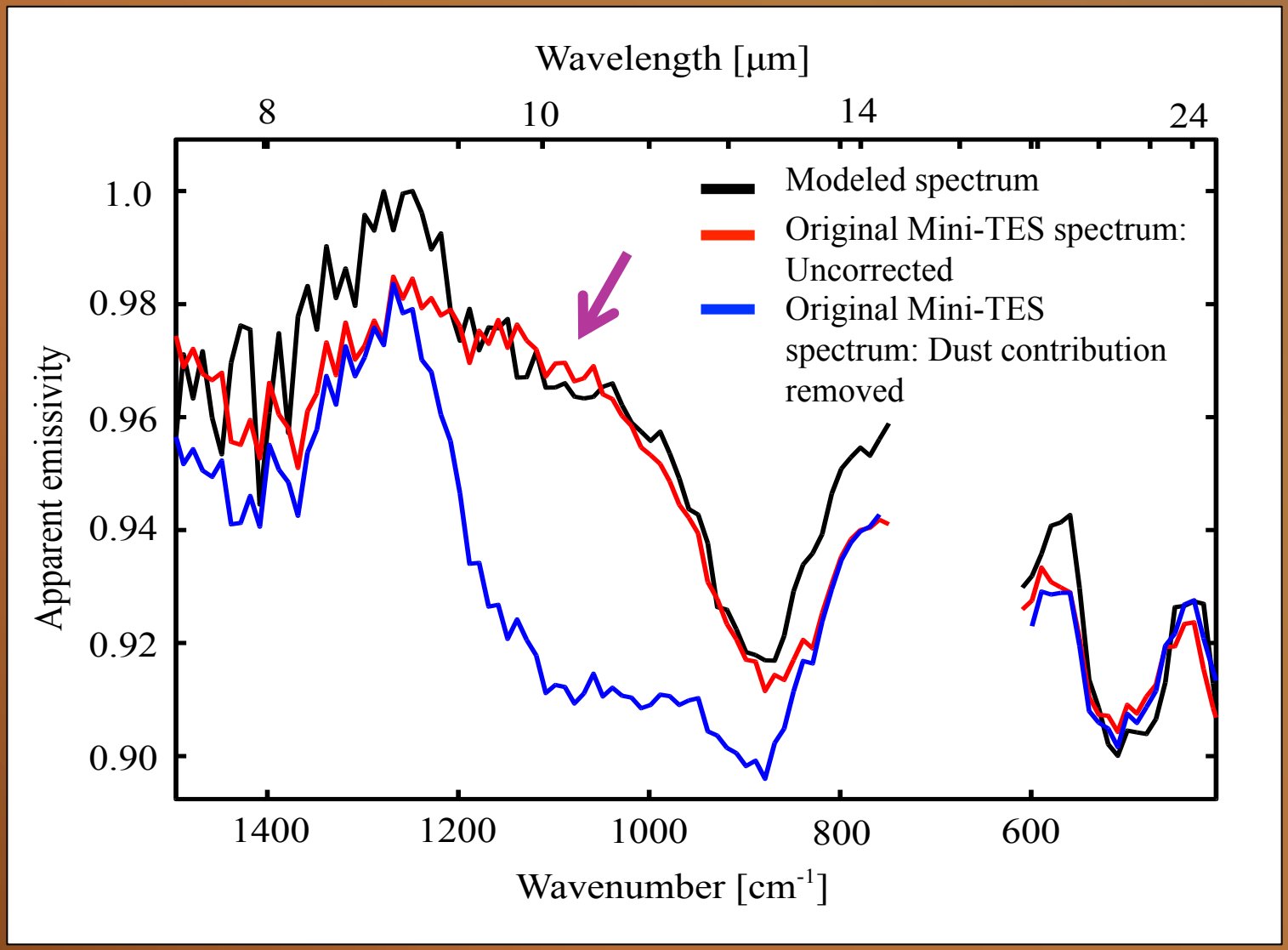
Mini-TES measurement of Dusty Basaltic Rock



Spectral features of dust coincided with those of other silicate minerals



Modeled Mini-TES measurement of a olivine rich basaltic rock mantled with optically thin dust



SUMMARY

- We know Mars had liquid water in its past
- Plenty of geomorphic, sedimentologic and mineralogical evidence
- We can use TIR spectroscopy to do local and global analysis of what mineral specific phases are on the surface.
- Mars is dusty and the dust complicates TIR measurements taken of the Martian surface

Sol 587's Dusk at Gale

NASA/JPL-Caltech/MSSS/Damia Bouic - http://www.db-prods.net