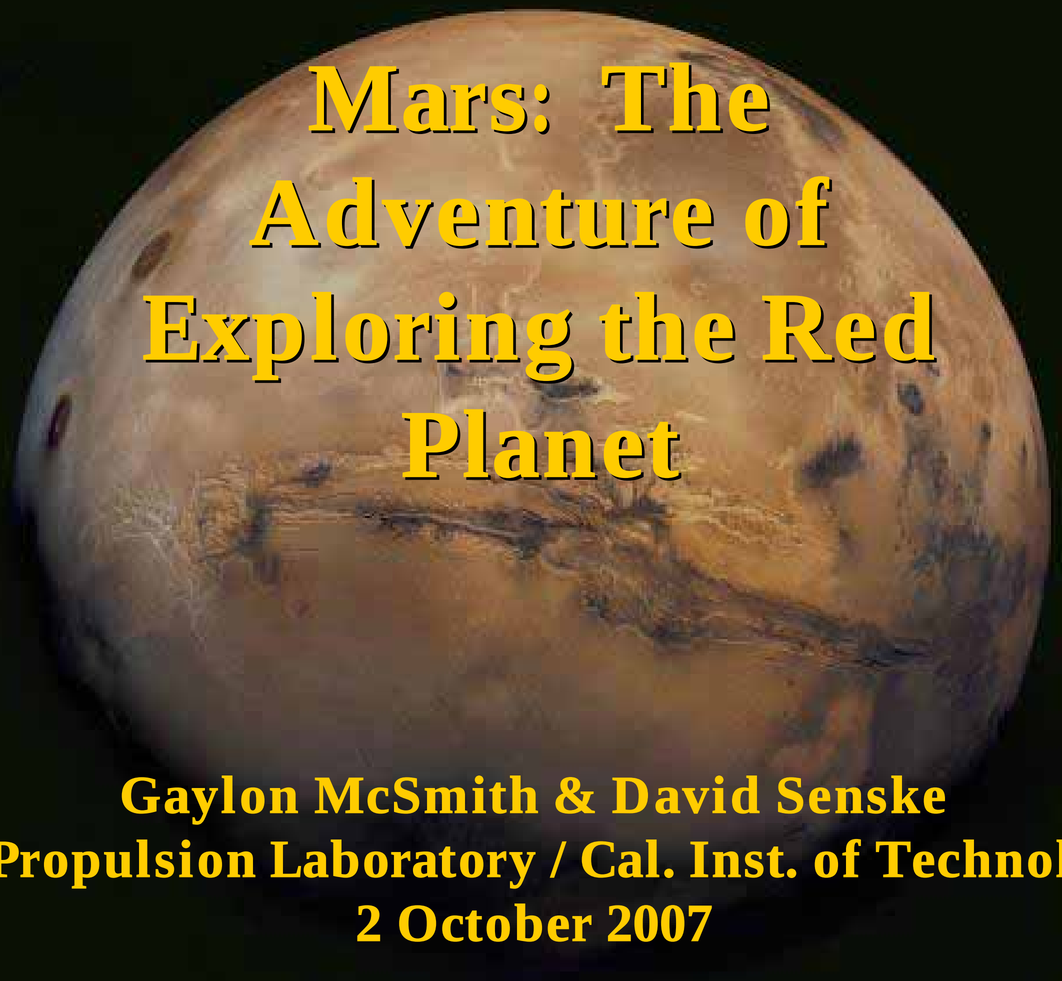


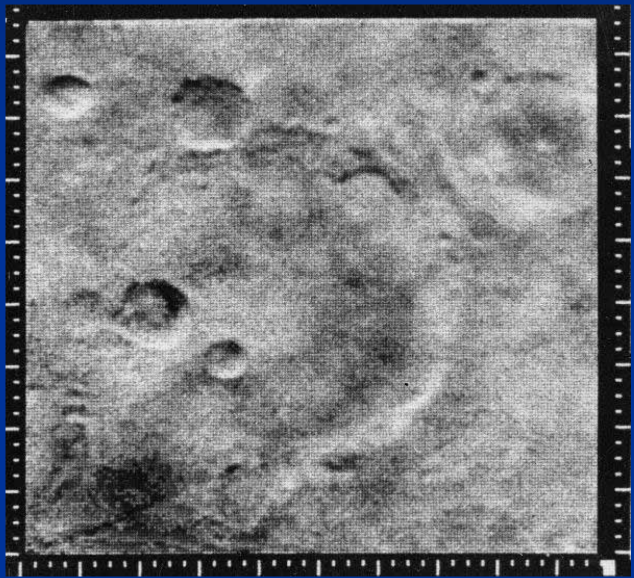
Mars: The Adventure of Exploring the Red Planet

Gaylon McSmith & David Senske
Jet Propulsion Laboratory / Cal. Inst. of Technology
2 October 2007

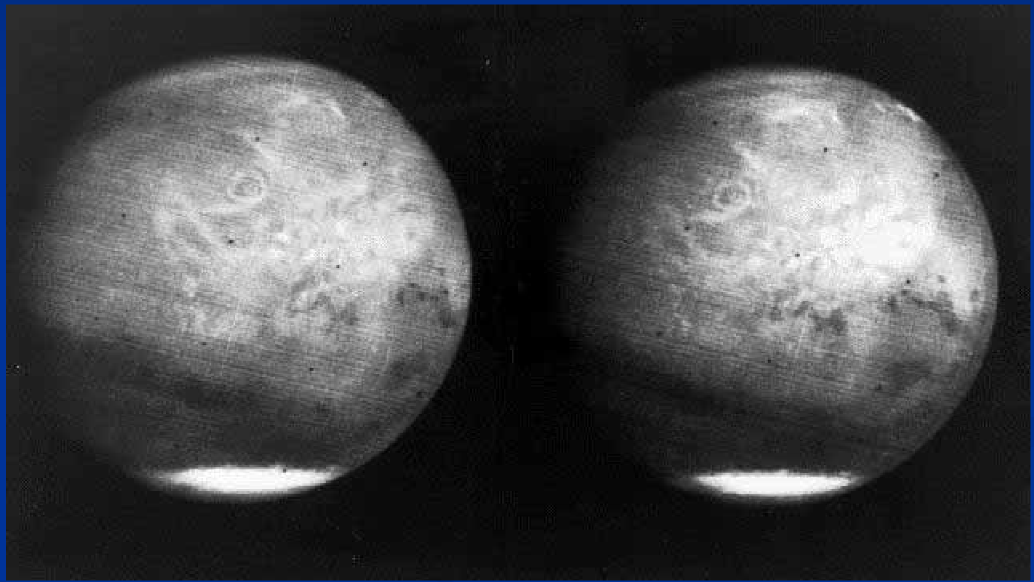
Failed Attempts to Reach the Red Planet

- Mariner 3 was launched on November 5, 1964 but the shroud encasing the spacecraft atop its launch vehicle failed to open properly and Mariner 3 did not reach Mars.
- Mariner 8 failed at launch on May 8, 1971.
- Mars Observer was launched on September 25, 1992, ended with disappointment on August 22, 1993 when contact was lost with the spacecraft shortly before it was to enter orbit around Mars.
- Mars Climate Orbiter was launched on December 11, 1998 and was lost on arrival September 23, 1999. Engineers concluded that the spacecraft entered the planet's atmosphere too low and probably burned up.
- Mars Polar Lander was launched on January 3, 1999 and was lost on arrival at Mars on December 3, 1999.

Our First Closeup View



1965, Mariner 4 finds Martian Craters



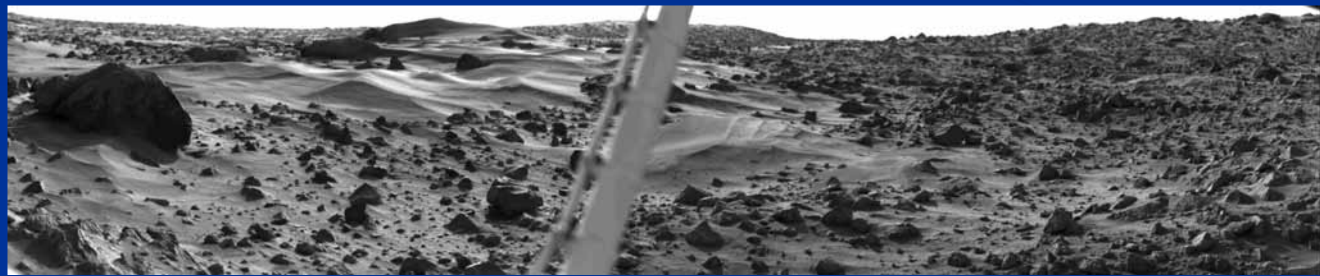
1969, Mariner 7 shows Details of Polar caps and surface terrain

The Vision of the Red Planet Begins to Clear

1971 Mariner 9 Discovers channels on Mars--water flowed on the surface, but where is it now? Could life have gained a foothold on Mars?

1976 Viking at Mars: The Search for Life

Assumption: If life arose on Mars it would be like that on Earth…



Viking Lander 1: Chryse Planitia

Viking Lander 2: Utopia Planitia

1976 Viking at Mars: The Search for Life

- **The Gas Exchange Experiment (GEX)**--look for changes in the makeup of gases in a test chamber; changes that would indicate biological activity. The results from this test were taken to suggest biology.
- **The Labeled Release Experiment (LR)**--detect the uptake of a radioactively-tagged liquid nutrient by microbes. Gases emitted by microbes would show the tagging. Initial results were in line with this prediction but in the end, the overall results were inconsistent.
- **The Pyrolytic Release Experiment (PR)**--"cooking" soil samples that had been exposed to radioactively-tagged carbon dioxide to see if the chemical had been used by organisms to make organic compounds. Seven of nine experimental runs seemed to show small concentration of micro-organisms but the results were later discounted.
- **The Gas Chromatograph -- Mass Spectrometer Experiment (GCMS)**--heat soil sample revealed an unexpected amount of water but failed to detect organic compounds. This absence was so absolute that it seemed there must be some mechanism actually destroying carbon compounds on the surface--concluded life not present.

The surface of Mars is a fairly hostile environment due to the solar ultraviolet radiation

After Nearly 20 Years
NASA & JPL Return to Mars!

1997 Mars Pathfinder: Leading the way for roving and direct sampling of the surface

Ares Valles

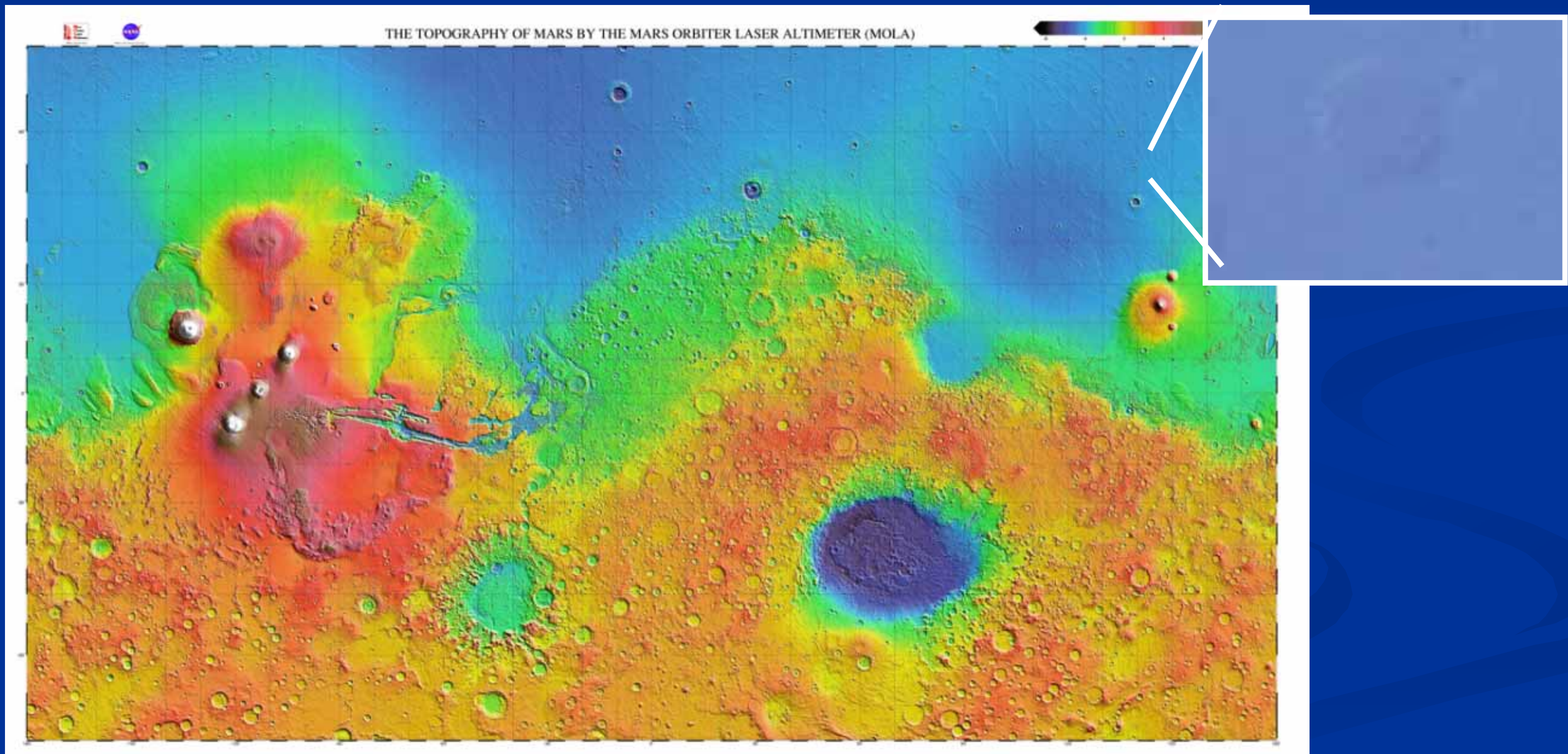
- Some Rock Chemistry distinct from Martian Meteorites

- Rounded rocks suggest emplacement in running water; a past warmer, wetter Mars climate?

Mars Global Surveyor

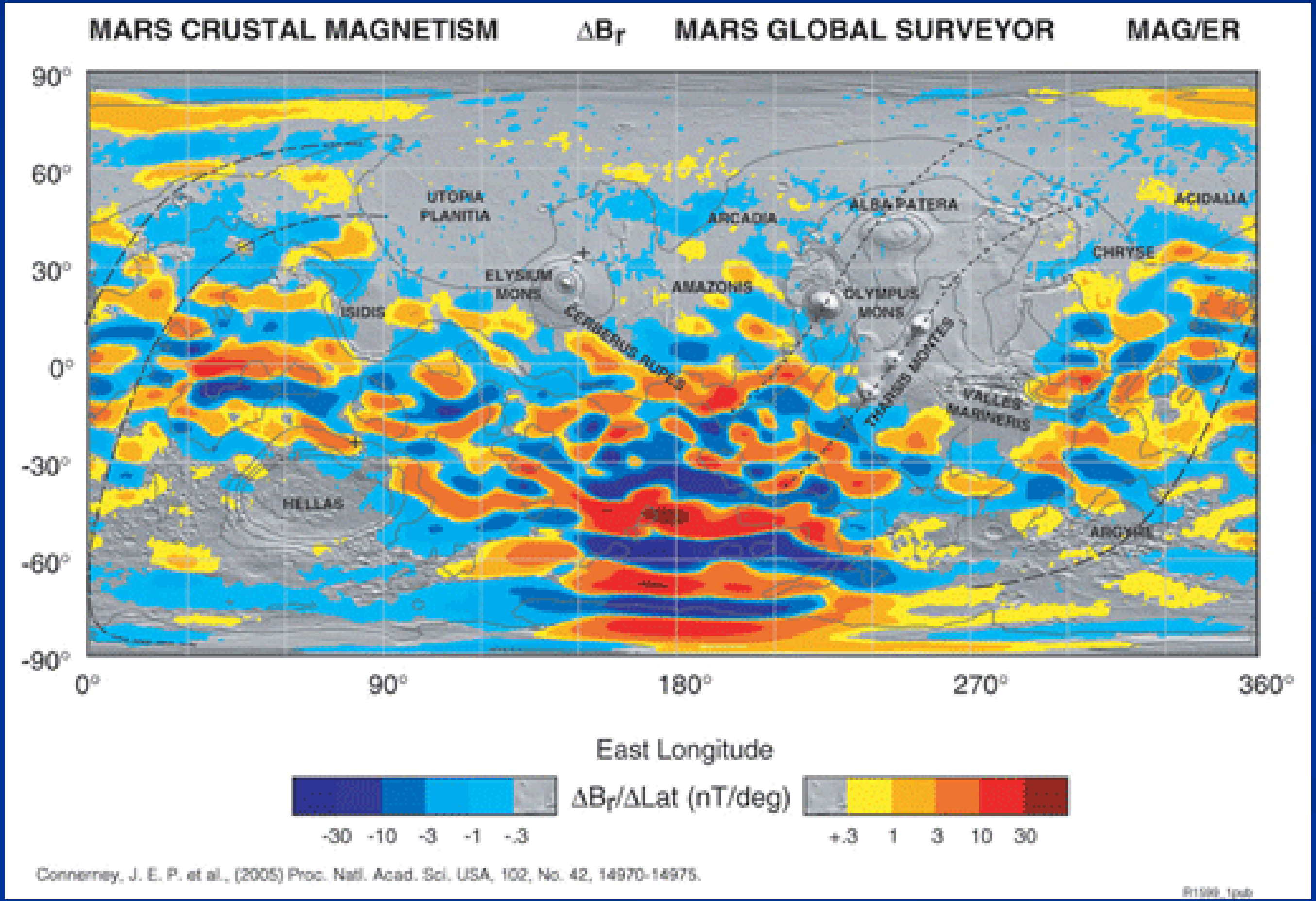
The first Global Topographic map of Mars

• Southern Highlands more heavily cratered (older) than northern lowlands; Detailed topography shows many buried craters



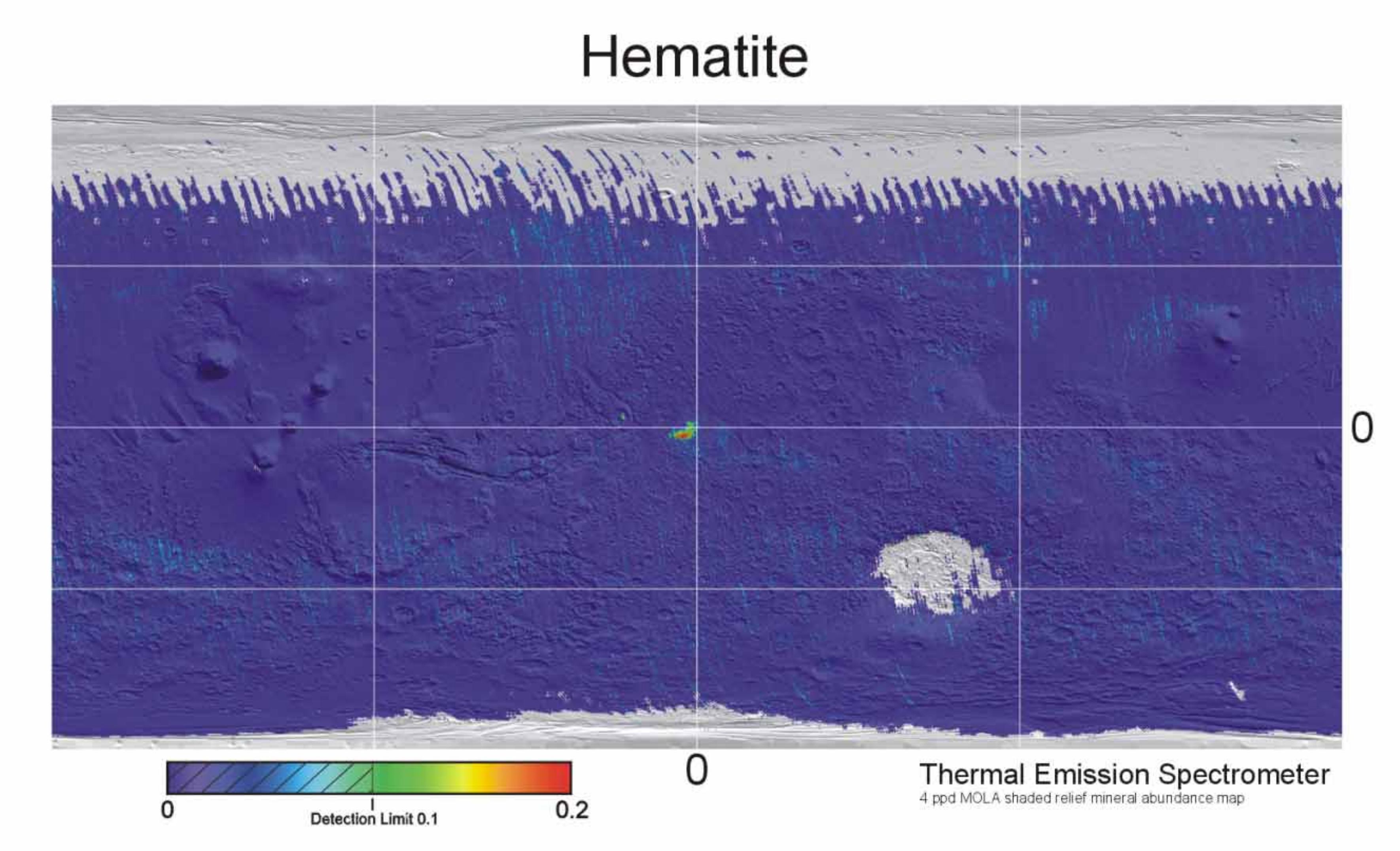
Mars Global Surveyor

Mars once had a magnetic field…but not anymore



Mars Global Surveyor

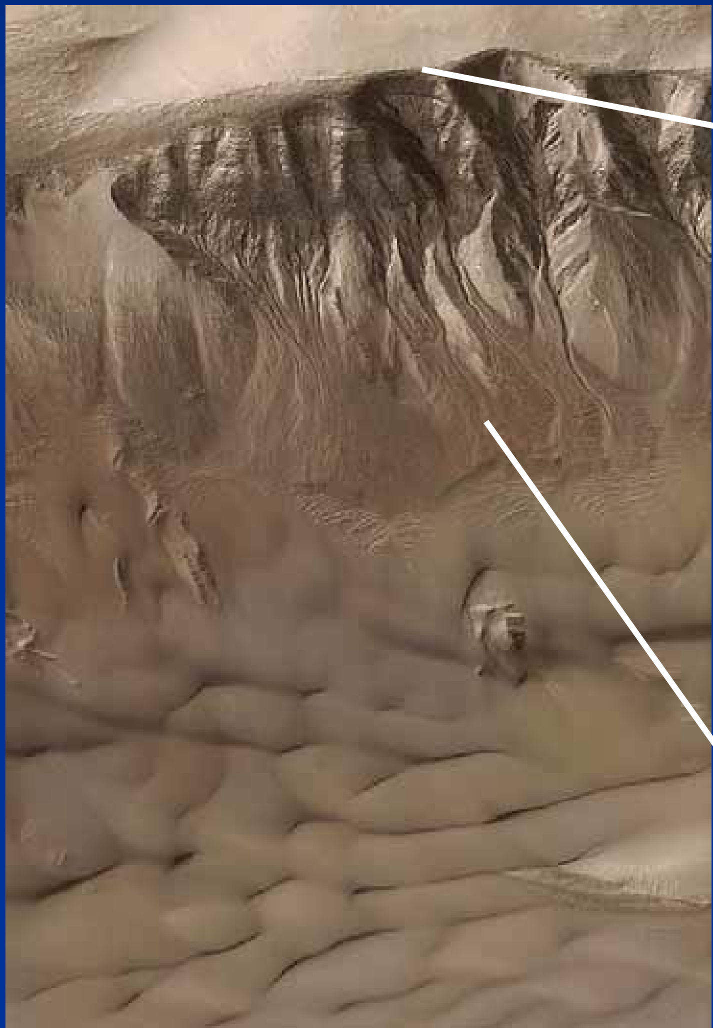
- Thermal Emission Spectrometer: Identifying Rock types--Hematite



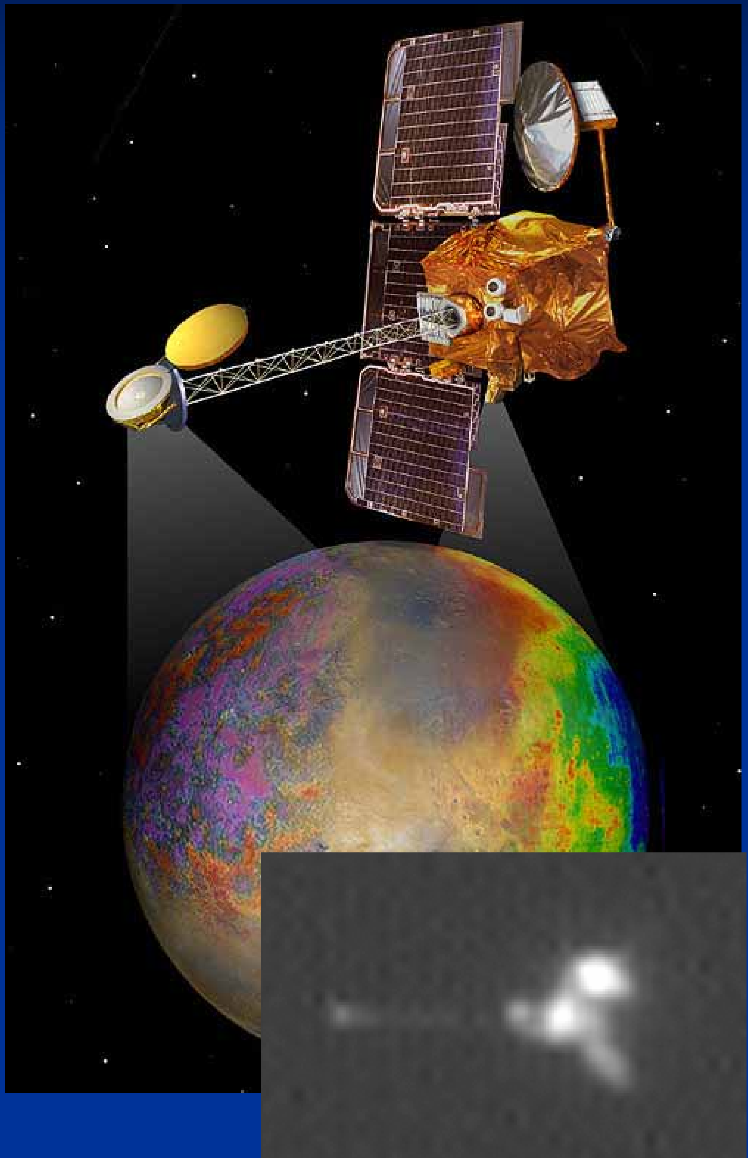
Mars Global Surveyor

- **Mars Orbiter Camera: Gullies; Recent fluids on the surface?**

Crater at 42.4°S, 158.2°W in Newton Basin



2001 Mars Odyssey



- Globally map the elemental composition of the surface
- Determine the abundance of hydrogen in the shallow subsurface
- Acquire high spatial and spectral resolution images of the surface mineralogy
- Provide information on the morphology of the Martian surface
- Characterize the Martian near-space radiation environment as related to radiation-induced risk to human explorers
- Observing interannual variations and other secular changes
- Acquiring data complementary to those obtained by other spacecraft at Mars

2001 Mars Odyssey Science Instruments

GRS - Gamma Ray Spectrometer suite

- Gamma Sensor Head (elemental abundance)
- Neutron Spectrometer (hydrogen/water/CO_2 mapping)
- High Energy Neutron Detector (hydrogen/water/CO_2 mapping)

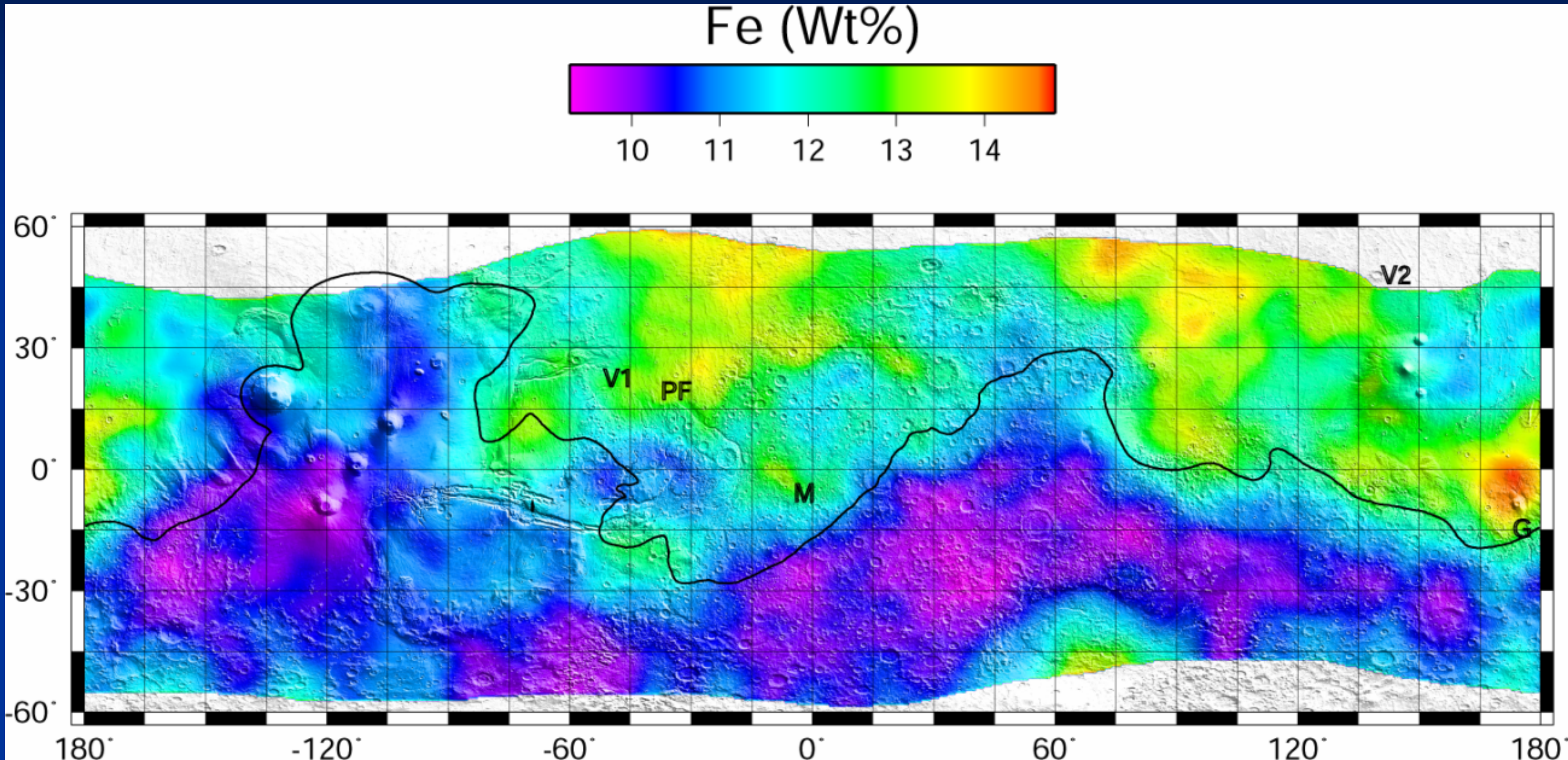
THEMIS - Thermal Emission Imaging System

- Thermal Infrared Camera - 9 bands, 100 m/pixel
- Visible Camera - 5 bands, 18 m/pixel (summed to 36 m/pixel)

MARIE - Martian Radiation Environment Experiment

- Multiple detectors for human hazards of space radiation
- Instrument ceased working in October 2003

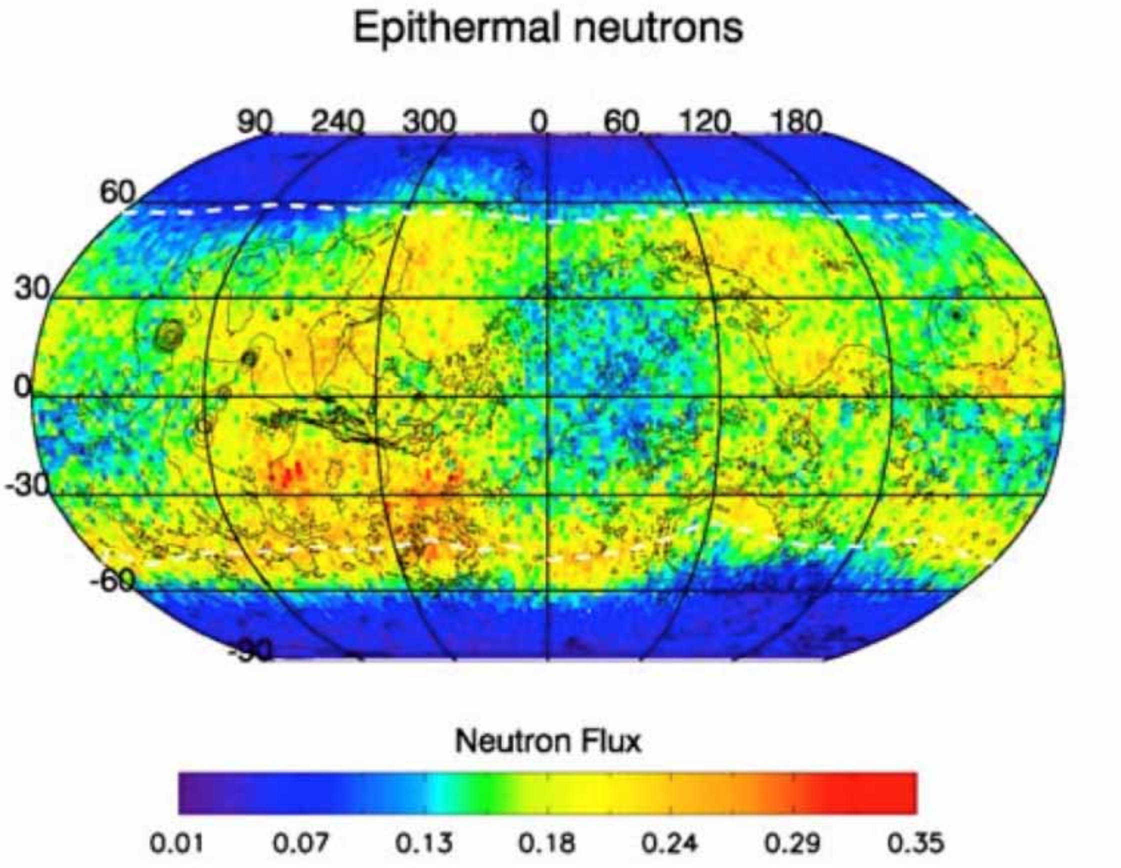
Gamma Ray Spectrometer Element Maps - Iron



- Iron abundance follows the global topographic dichotomy boundary (zero elevation contour shown).
- May indicate leaching of ancient highlands iron by acid rain during early warm/wet period.

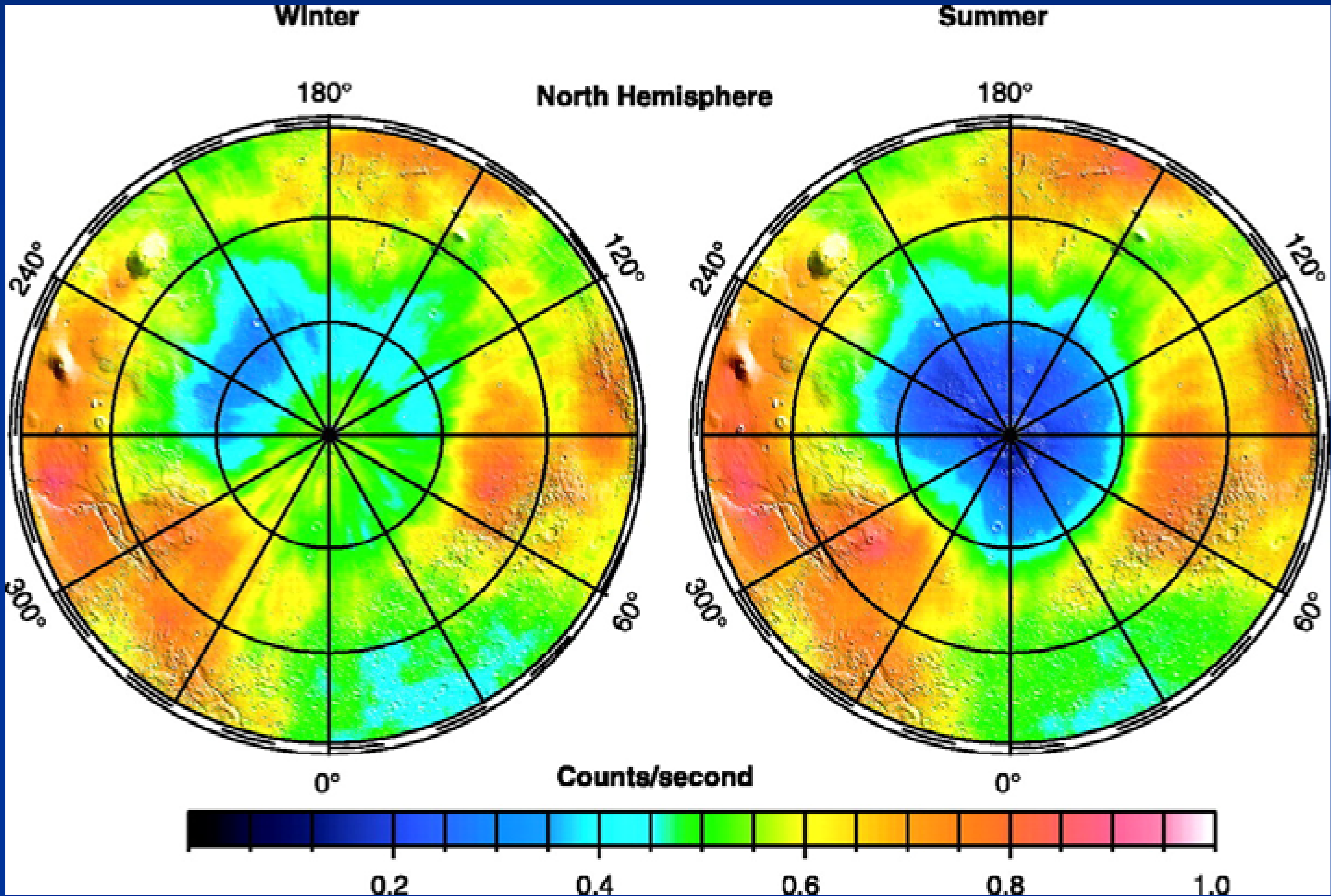
GRS/Univ. of AZ

Results from Our Russian Partners



Emission of epithermal neutrons by frost-free surface of Mars.

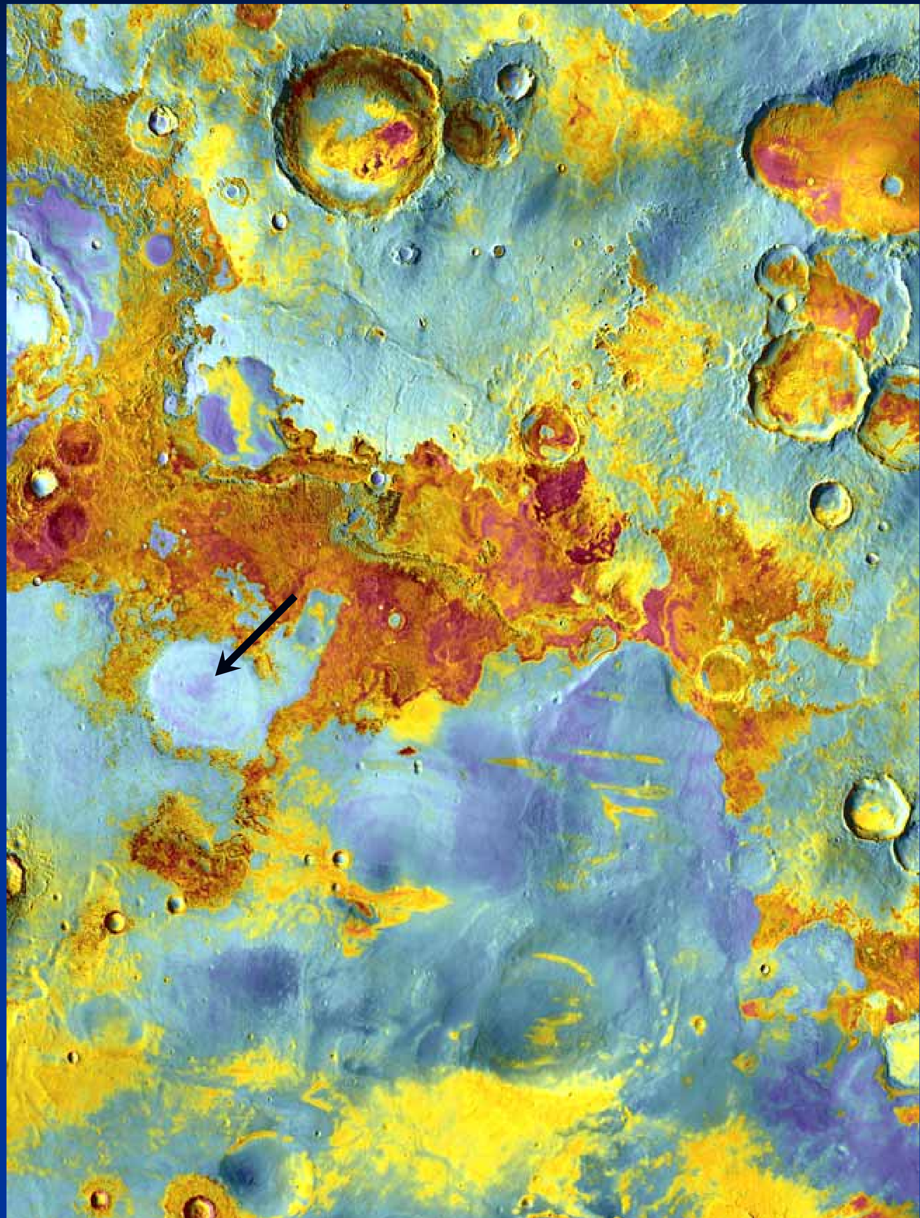
HEND Reveals Seasonal Changes



An Explanation for the formation of Gullies

- Melting of ice beneath a snow pack

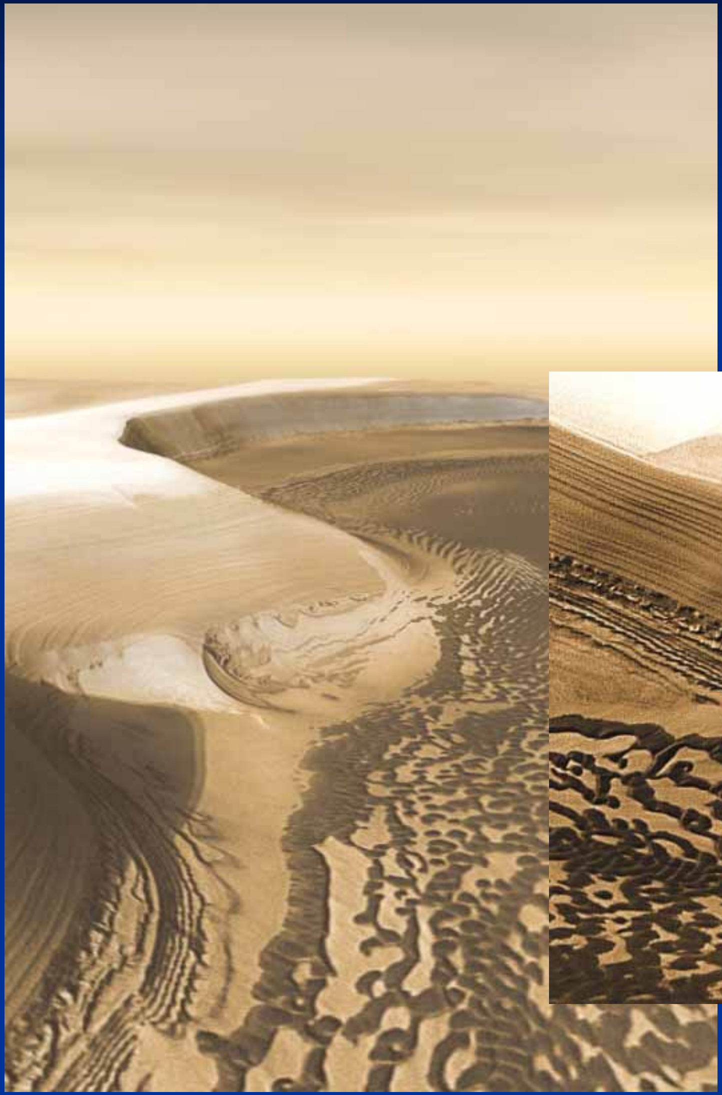
THEMIS Results

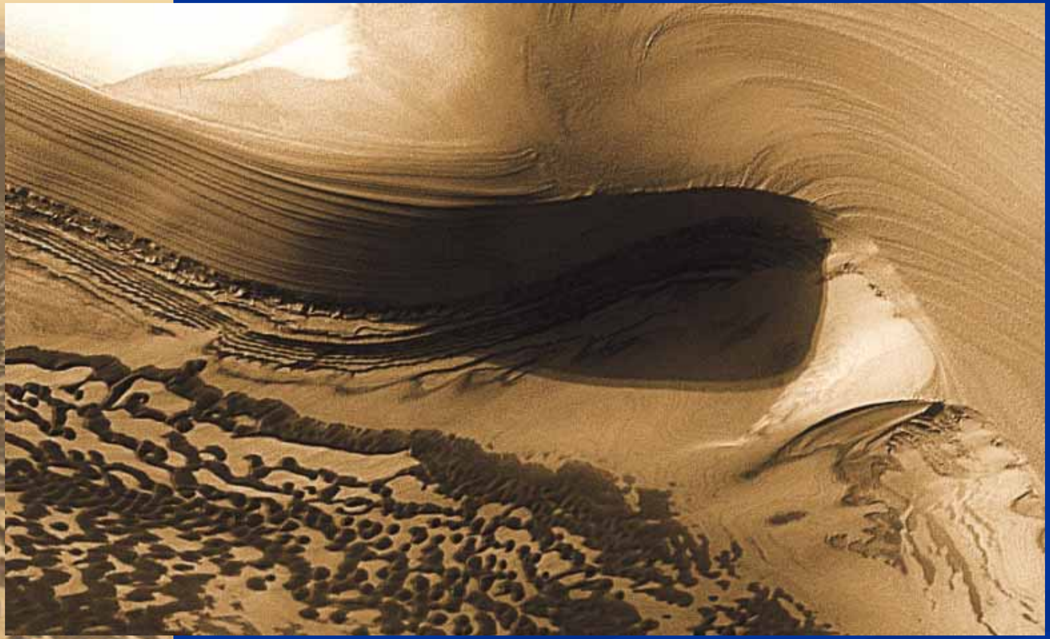


THEMIS false color IR Image of a portion of Meridiani Planum (~400-km NE of Opportunity landing site). Reddish areas have more rocks and hardened sediments, while bluish areas feature more dust, sand, and fine-grain material. The feature indicated by the arrow is shown in TES data to contain 15-20% Hematite.

Location: 1.9N, 359.2E
Pixel Scale: 100 m
Image Size: 260 x 341 km

Chasma Boreale





THEMIS Visible image mosaic combined with MOLA topography

Location: 84.9°N, 359.1°E
Pixel Scale: 18 m

(Vertical Exaggeration = 2.5x)

Summary--Key Discoveries and Results

Key Discoveries:

-- "Finding the water" GRS suite discovery of significant Water Equivalent Hydrogen in the upper 1-meter of the surface both north and south of 60°-- A key observation that has helped lead to the Phoenix Mission

-- First global elemental maps (GRS)--large variability in the distribution of crust forming elements

-- First discovery of significant diversity of surface mineralogy (THEMIS); Basalts, Andesites, Granitoids

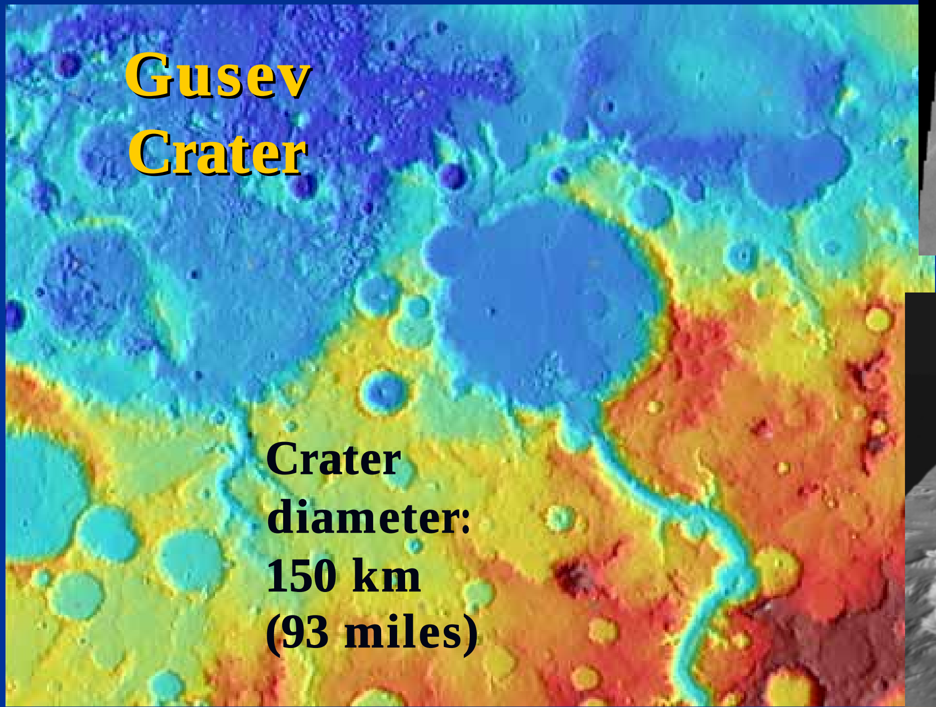
-- First detection of interannual variations of Argon in the polar Regions

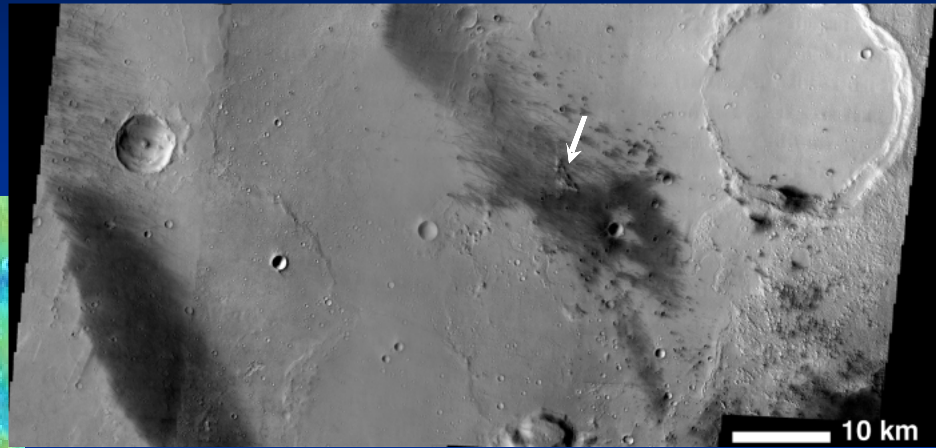
-- First direct monitoring of radiation environment at Mars (dose rate ~ twice that observed at International Space Station)

Mars Exploration Rovers

Mars Exploration Rovers

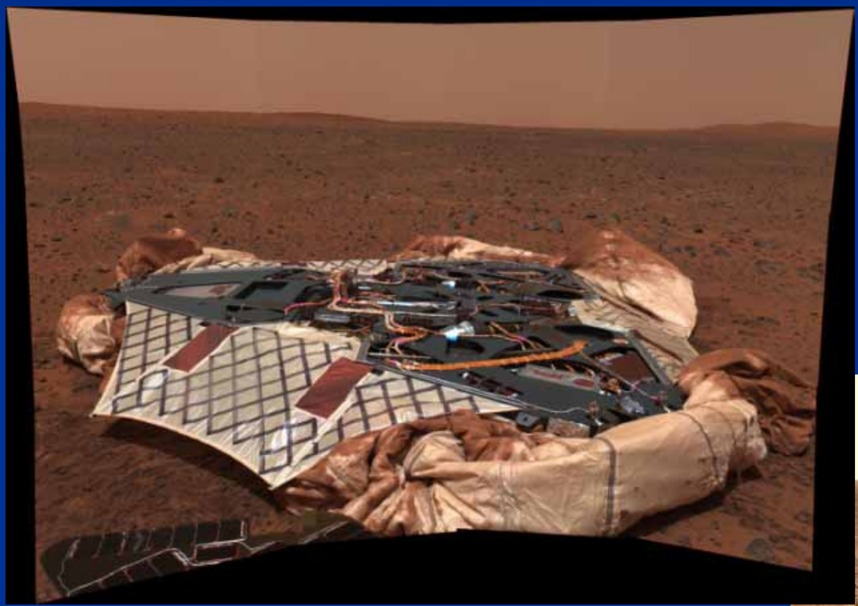
Spirit--Gusev Crater





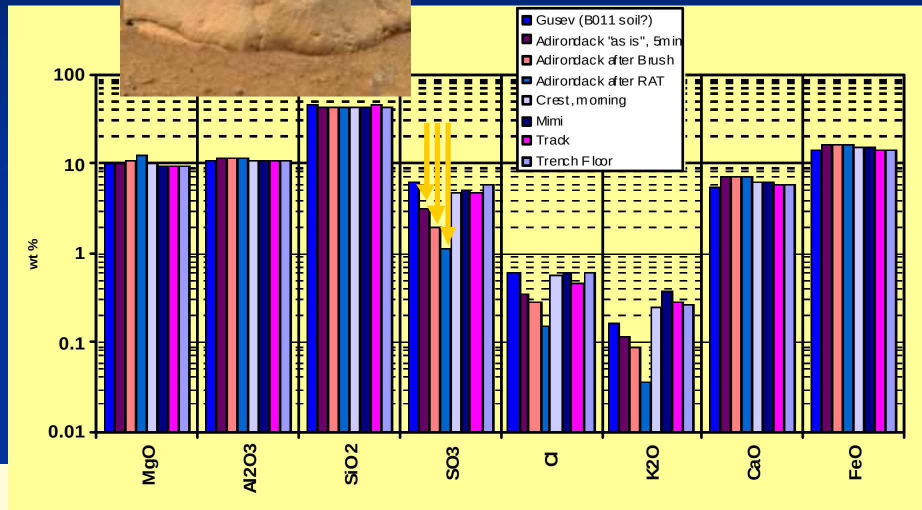
Mars Exploration Rovers

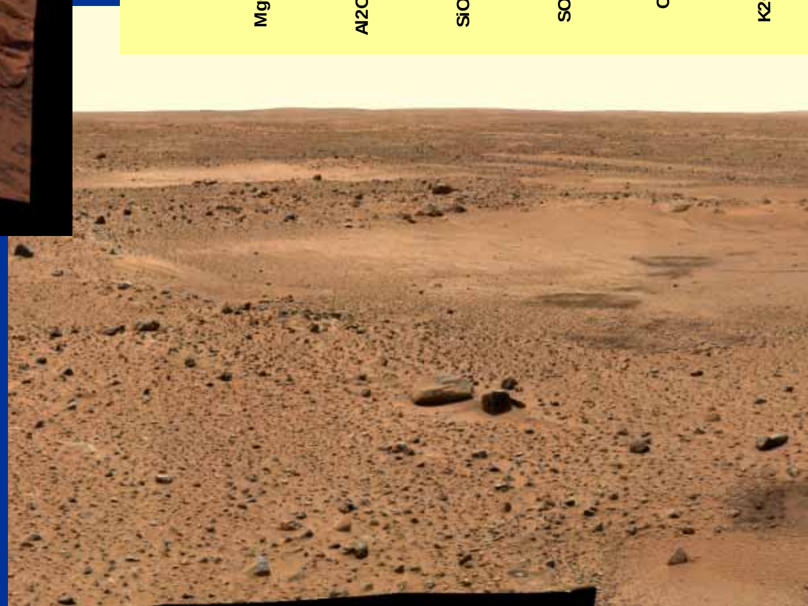
Spirit--Gusev Crater



The empty nest

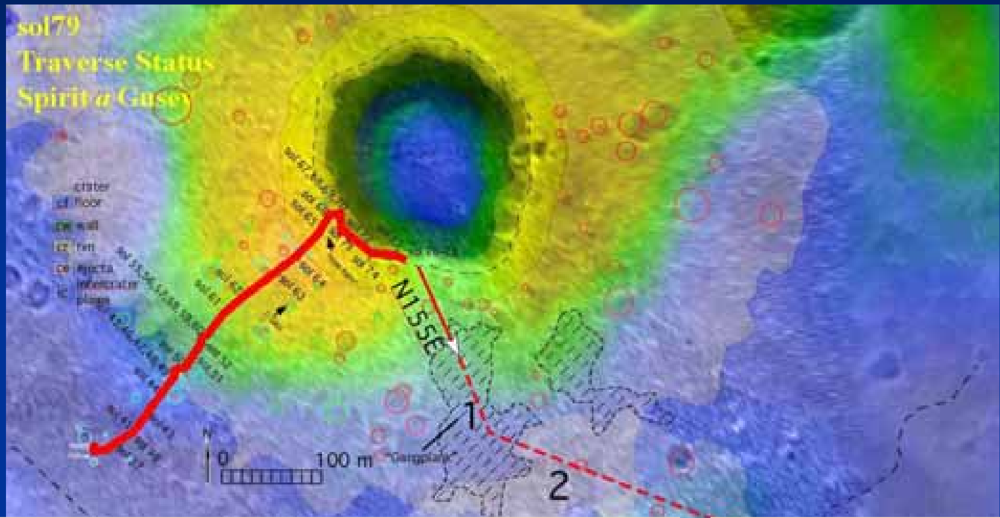
Basaltic rocks





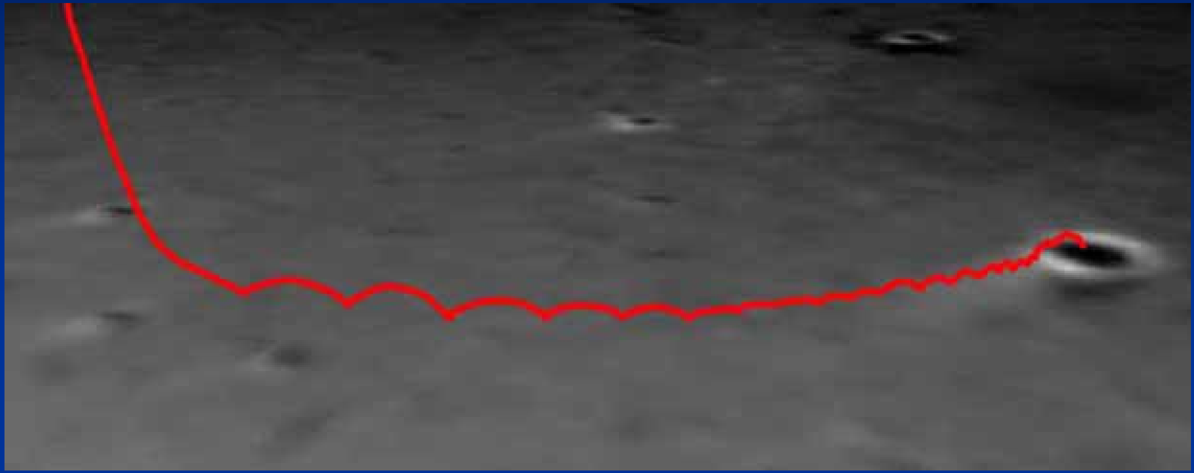
The Plains of Gusev

Exploration Mars Rovers



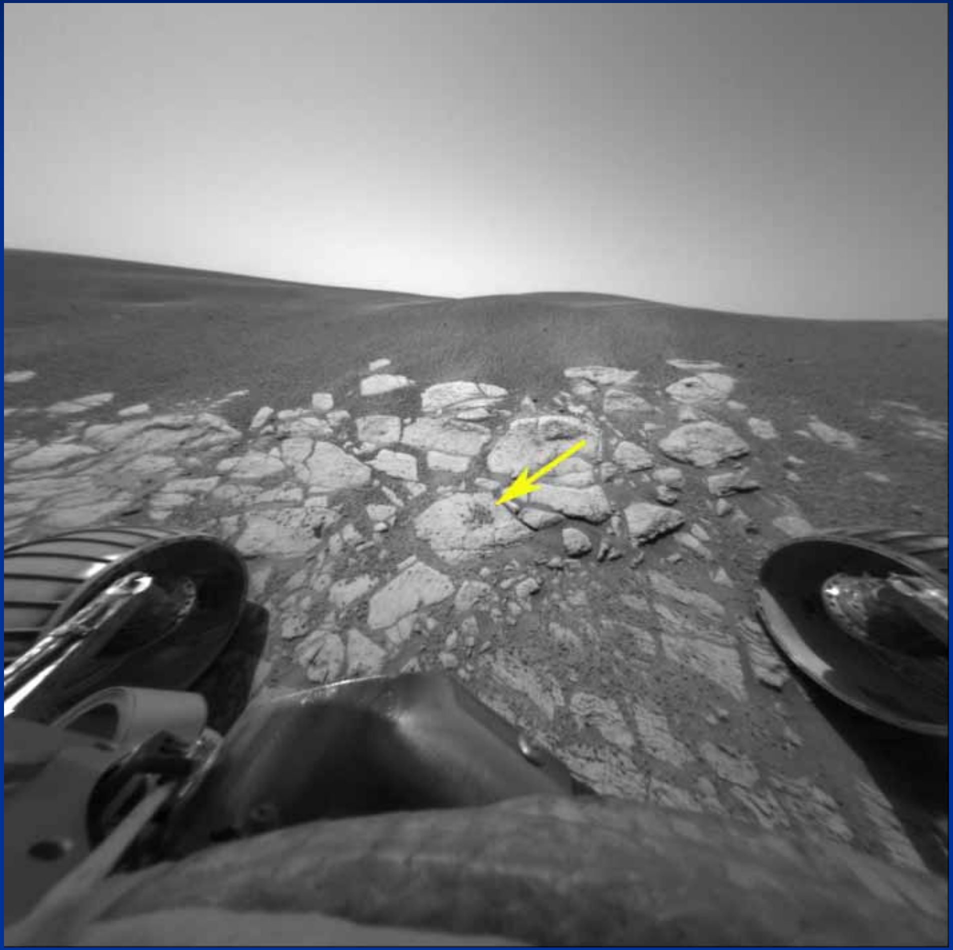
Spirit at
Bonneville Crater

Mars Exploration Rovers



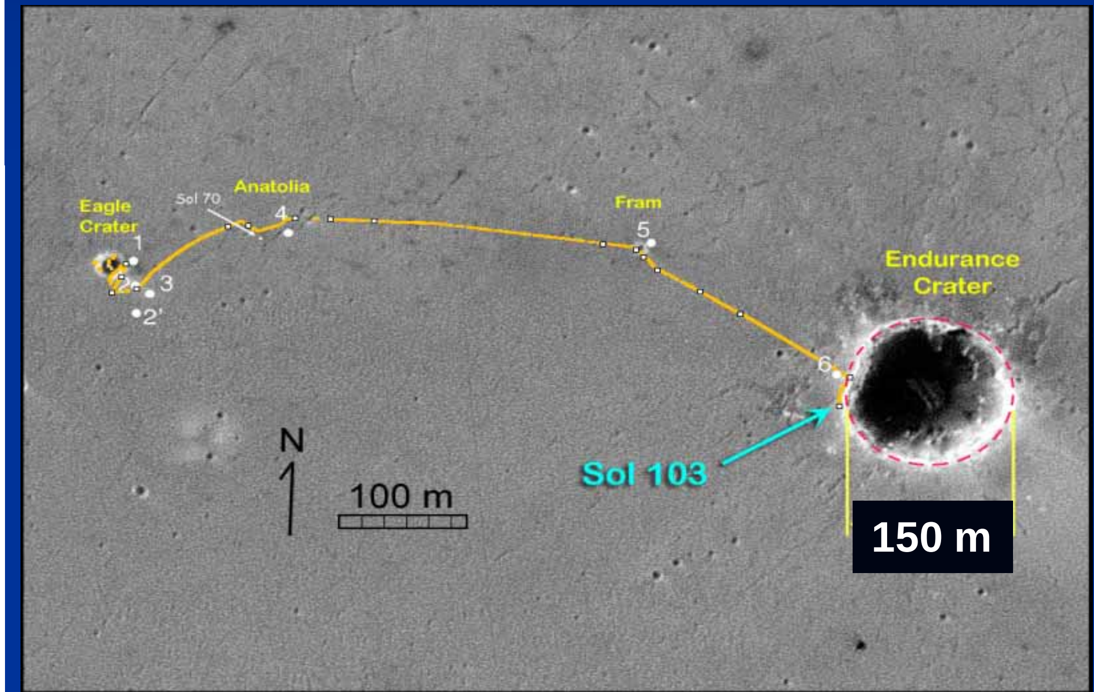
"Cosmic Hole-in-One" at Eagle Crater

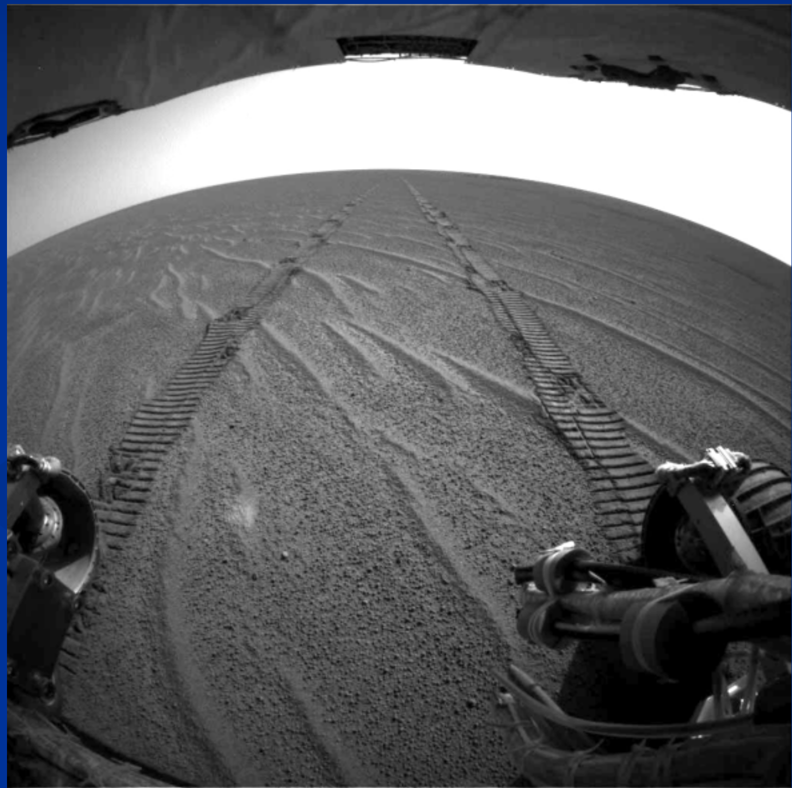
Mars Exploration Rovers



Mars Exploration Rovers

Opportunity on the Road to Endurance Crater

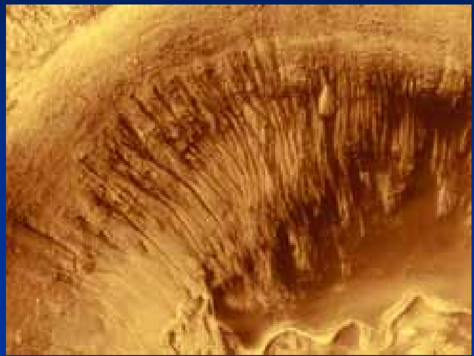




Mars Reconnaissance Orbiter

Mars Reconnaissance Orbiter

MRO Science Goals

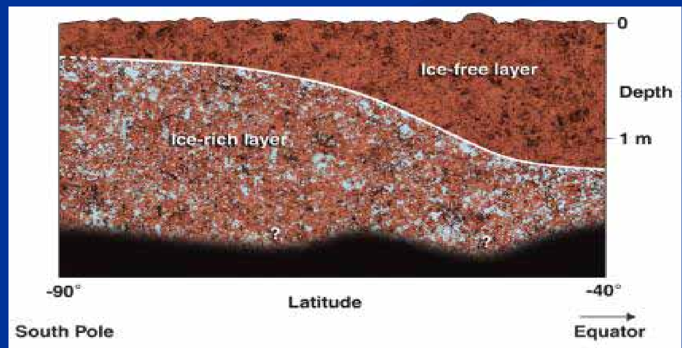


Understand the Processes of Climate Change, Past and Present

Characterize the Nature and History of Different Terrain Types

Find Sites Showing Evidence of Aqueous and/or Hydrothermal Activity

Characterize the Present Climate; Understand Seasonal & Year-to-Year Variability



Identify Subsurface Structure and Potential Reservoirs of Water Ice

Identify Landing Site for future missions

Mars Reconnaissance Orbiter

First HiRISE Image of eastern Bosporos Planum

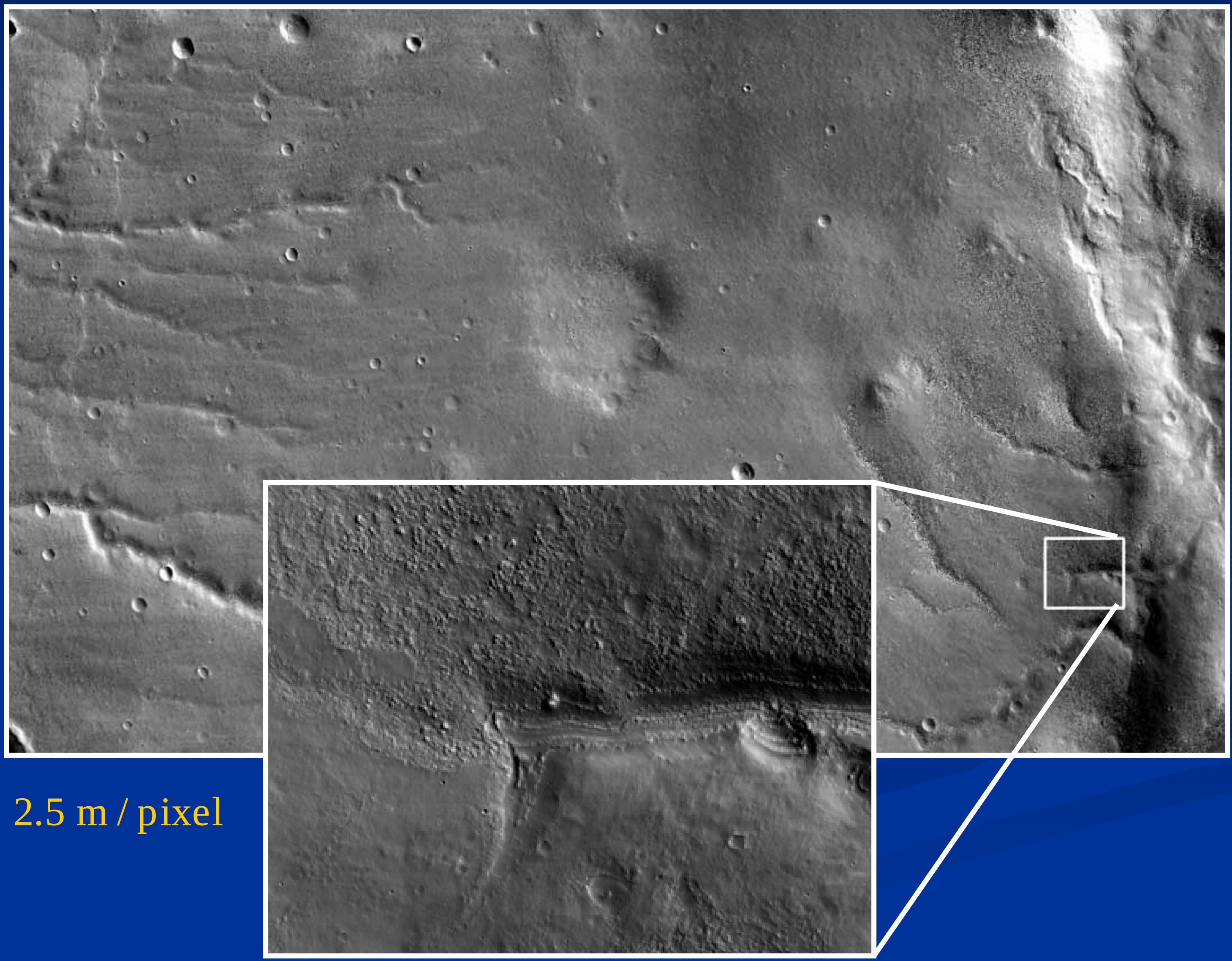


Image Scale: 2.5 m / pixel

Phoenix

Phoenix

Science Goals

- Study the Martian hydrological cycle
  - Land where Odyssey has found water ice in the subsurface
  - How is water stored and released from the polar region?
  - Determine the diffusion of water vapor through the regolith
- Determine the recent history of the subsurface ice
  - Has liquid water altered the mineralogy of the soil?
  - What is the aqueous chemistry of the soil? In other words, if the ice melts, what is the chemical environment?
- Study the polar region processes
  - How does the climate change with season?
  - Study the boundary layer processes
  - What are the processes that shape the geology?
- Determine the habitability of the ice-soil boundary
  - Are organic molecules able to survive intact in this environment?
  - Do environmental factors support the presence of life?
  - Are there environmental hazards?

Phoenix

Landing Site Area for Phoenix

•No large craters in center area
•Benign slopes, with low rock abundance
•Lowest elevations
•Reasonable amount of soil over ice