

UT Environmental Science Institute

#38

#### The 2004 Mars Exploration Rover Mission: Evidence for Water and Prospects for Life

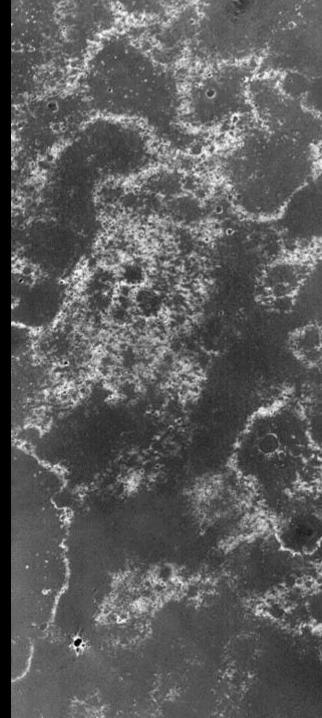
#### Dr. John Grotzinger October 13, 2005

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#### The 2004 Mars Exploration Rover Mission:

Evidence for Water and Prospects for Life

#### John Grotzinger on behalf of MER Athena Science Team



#### Mars Science Strategy: Follow the Water!







LIFE

CLIMATE

GEOLOGY

HUMAN

When? Where? Form? Amount?

#### **The Athena Science Payload**

Remote Sensing Package Pancam Mast Assembly (PMA) Pancam Mini-TES

In-Situ Package Instrument Deployment Device (IDD) Microscopic Imager Alpha Particle X-Ray Spectrometer Mössbauer Spectrometer Rock Abrasion Tool Magnetic Properties Experiment

# The Team



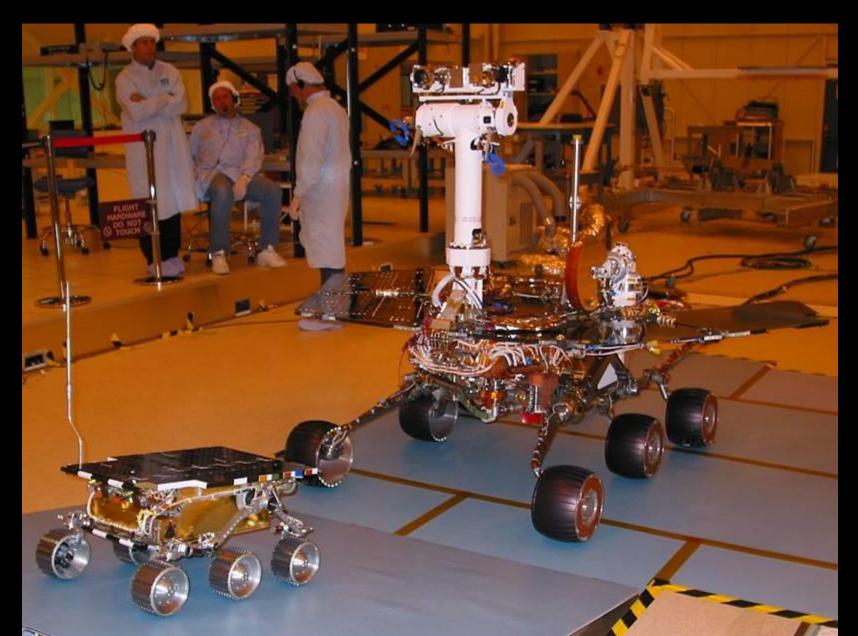
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# **Mars Pathfinder**



# The MER Rover



#### Wrap it up and cram it in.....





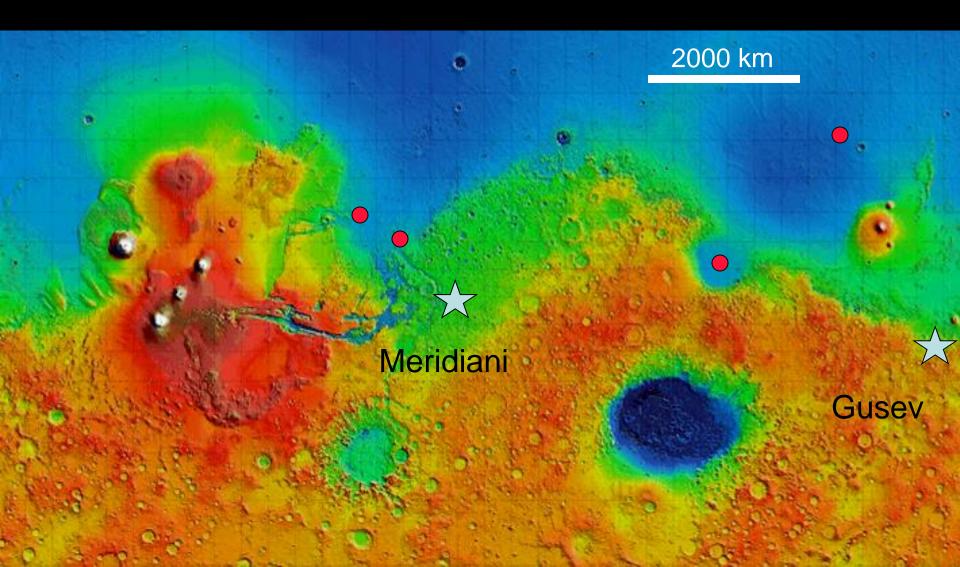


# The Three Challenging Mission Phases





### **Opportunity at Meridiani Planum**



# Hematite: Mineralogic Beacon

Hematite Distribution Map from Tes Data 5°N 0 6°S 10°W 2°E Ω 0% 15% hematite (Figure based on Christensen et al., (2001) JGR, v. 106(E10), Plate 2, p.23,877.)



### Meridiani Landing Site

**Opportunity Lander** 



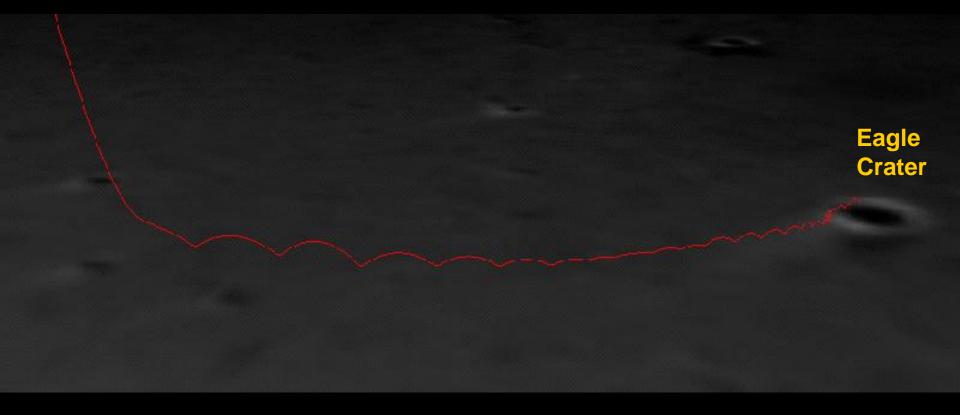
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"First Bounce" and Effects of Rocket Firing

# Heatshield Impact Site



## Hole in One

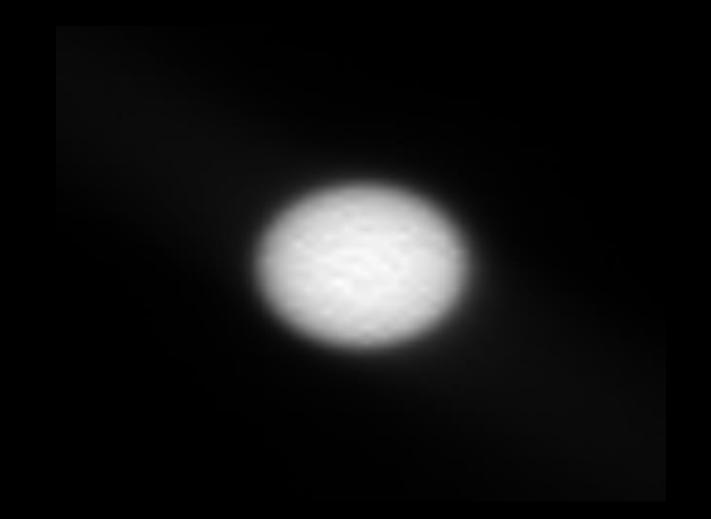


## **Backshell and Parachute**

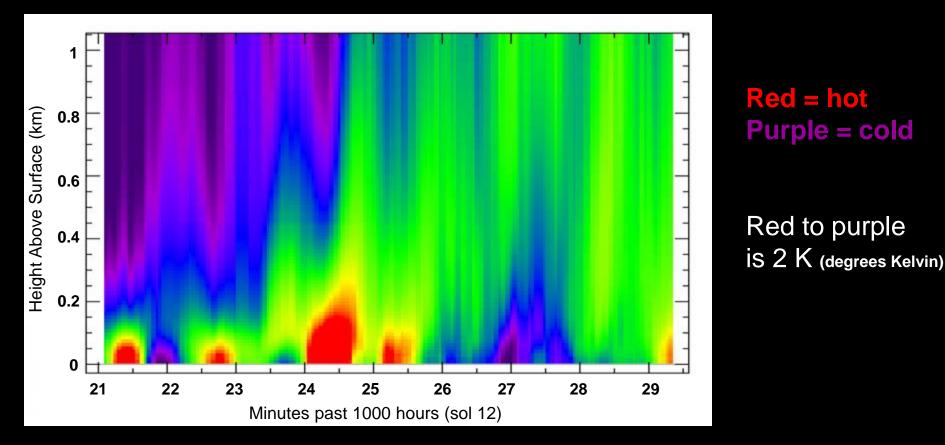
#### You are here



# **A Martian Eclipse**



### Short-Timescale Temperature Excursions



- Largest temperature variations confined to lowest 100 meters or so
- Appears that temperature perturbations propagate upward

# **Dust Devils**

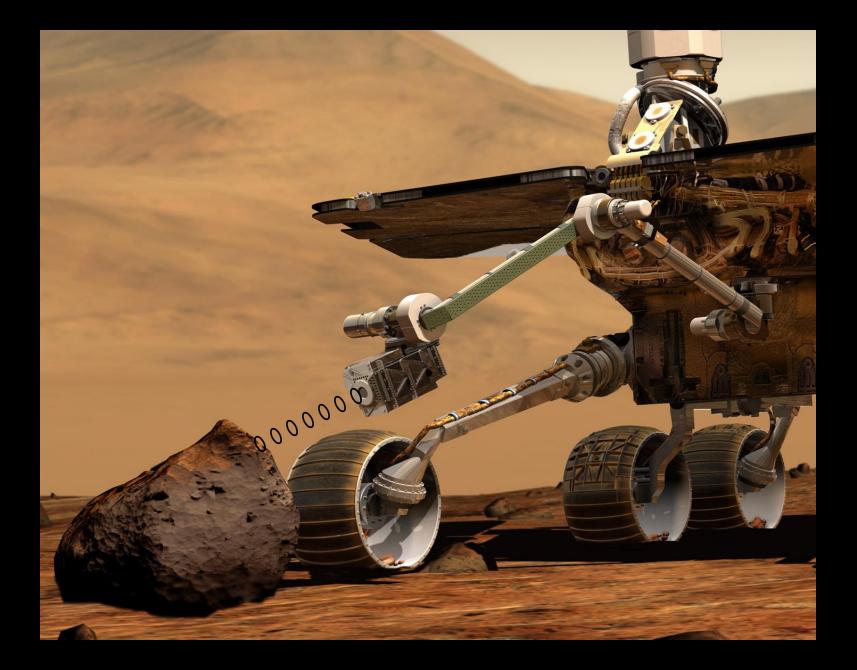
### **Spirit: View from Lander**



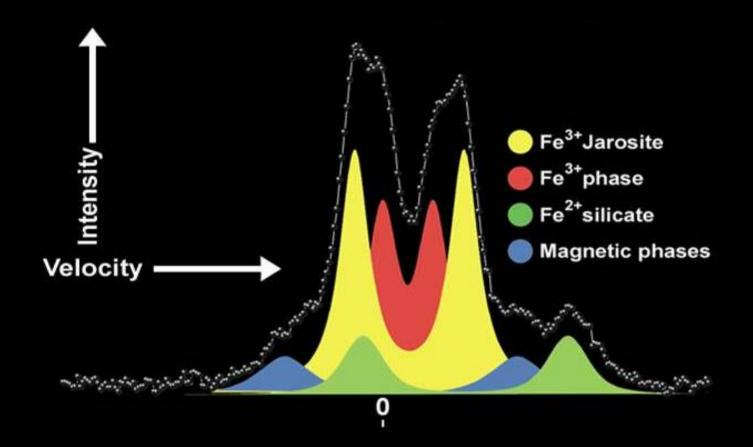
#### **Opportunity: View from Lander**







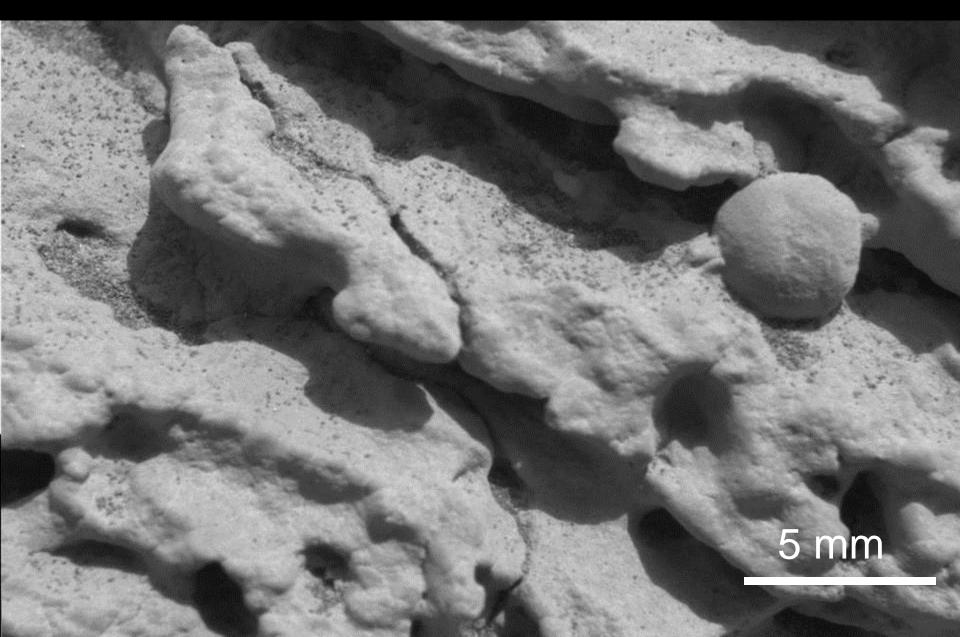
#### Mössbauer Spectrum of El Capitan: Meridiani Planum Jarosite: (K, Na, X<sup>+1</sup>)Fe<sub>3</sub>(SO<sub>4</sub>) (OH)<sub>6</sub>



# **Rio Tinto, Spain**



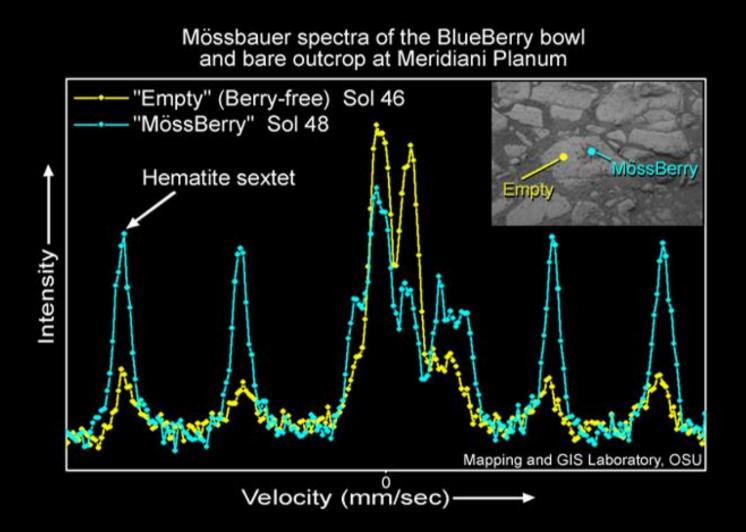
# **Spherules**



## The "Berry Bowl"



## **Mössbauer on the Berry Bowl**



### Sediment Bedforms (e.g. Ripples)

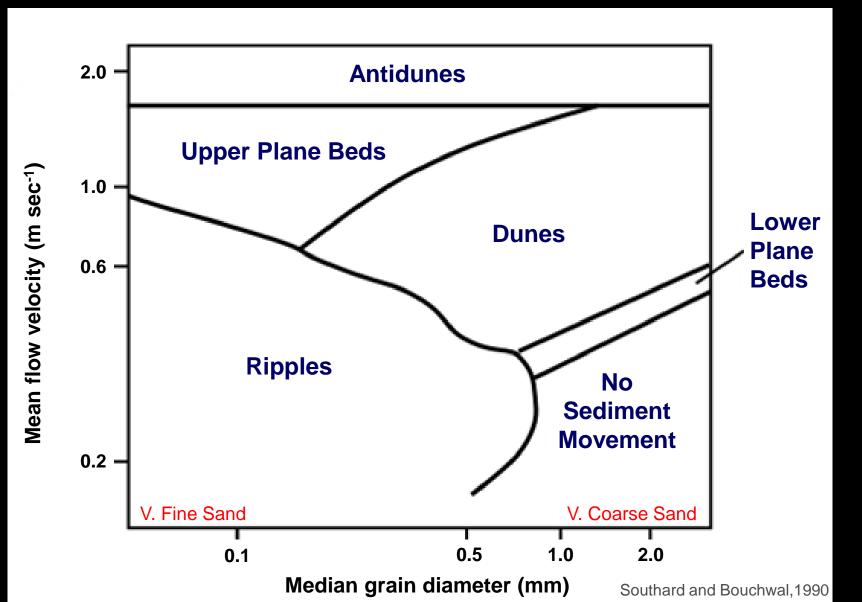


#### **Ancient Terrestrial Ripples: 1.4 Billion Years Old**



#### **Ripple Cross-Bedding in 3D**

# **Bedforms in Flowing Water**



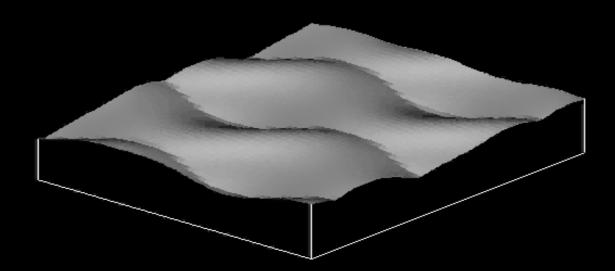
# **Current Ripples in Water**



Flume experiments by Dave Rubin and Jon Nelson, USGS

6 hours of ripple migration Image is 60x40 cm

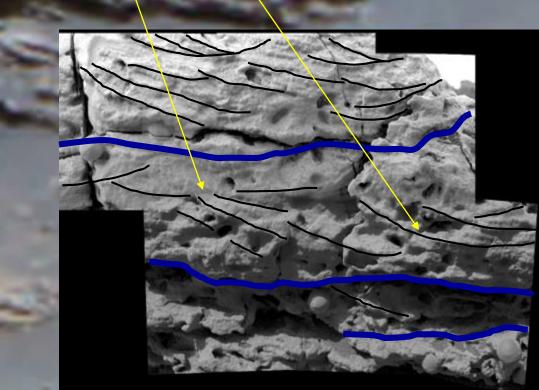
#### **Current Ripples in Cross Section**



Simulation by Dave Rubin, USGS

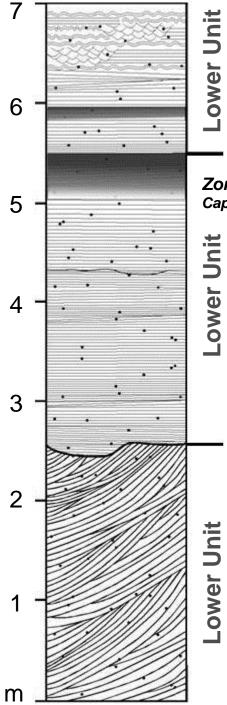
#### **Festoon Cross-Bedding on Earth**

#### Festoon Cross-Bedding on Mars



#### Burns formation (Endurance crater)

2.0 m



Interdune/Playa Festoon Cross-lamination Wavy Bedding Translatent Strata

Whatanga Contact

Zone of Recrystallization Capillary Fringe of Water Table?

> Eolian Sand Sheet Translatent Strata Low-Angle Strata

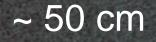
Wellington Contact

**Deflation Surface** Water Table Controlled?

Eolian Dune Field Cross-Bedded Sandstone

### **Burns Stratigraphy**

# **Modern Sand Dunes on Mars**



### Interdune Surface

## **Interdune Deflation Surface**

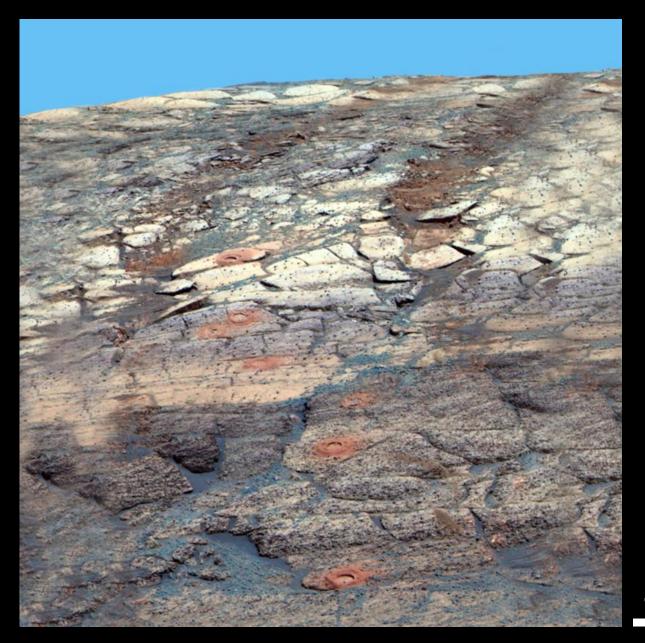
### Modern Mars Analog: Um Asamin



## **Modern Interdune Depression**



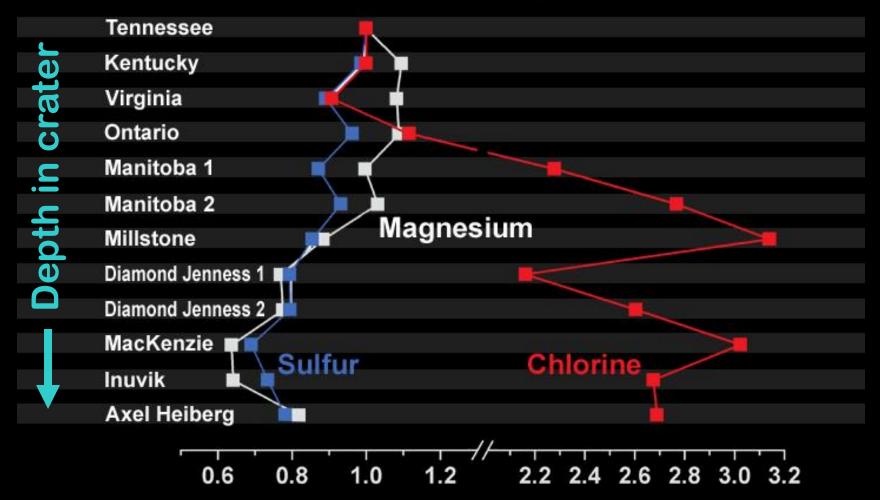
## **Endurance Chemostratigraphy**



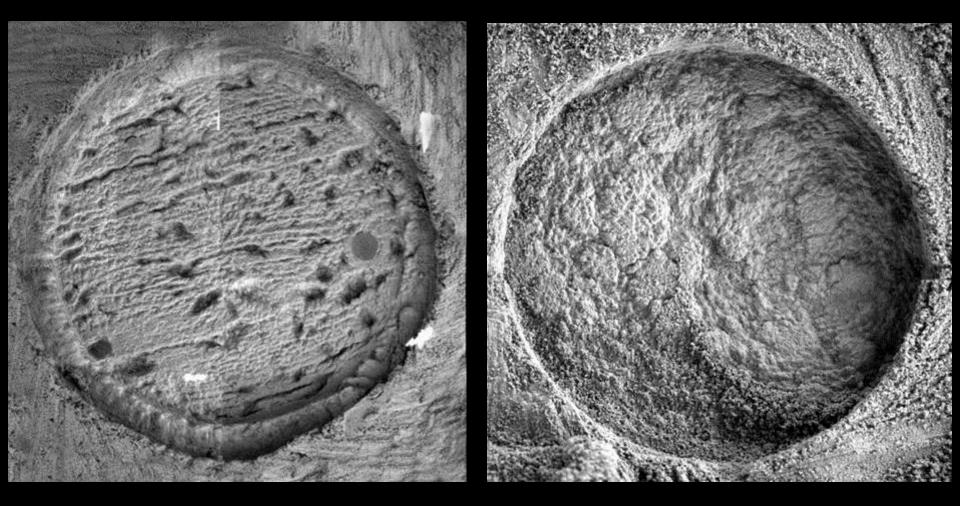
~ 50 cm

### Ratio to surface rock average

#### Selected Elements in Endurance Crater Rocks



### **Changes Down Section: Texture**



#### **Diamond Jenness**

#### Ontario

- Meridiani environment appears to have been acidic, hypersaline, and only intermittently wet.
- Life exists at such extremes on Earth.
- But Meridiani data suggest potential challenges to origin as well as persistence of life.

Rio Tinto Extremophiles



### **The Good News**

- Evidence of any life that might have existed might well be preserved in chemical sediments and concretions.
- Chemical and textural details of Meridiani salts and iron oxides likely to reveal much about environmental history.

• All this favors Meridiani Planum as a target for sample return.





- Rovers have:
  - Operated for over 1200 days
  - Returned over 100,000 images
  - Analyzed dozens of rocks and soils

# Summary

- Evidence for water:
  - Mössbauer detection of jarosite
  - Crystal molds, concretions, diagenesis
  - Festoon ripple cross-bedding
  - Stratigraphic succession of environments



- Prospects for Life:
  - Preservation potential is good
  - But did life originate under such extreme conditions?



# Dr. John Grotzinger

Fletcher Jones Professor of Geology California Institute of Technology

John Grotzinger is a field geologist interested in the co-evolution of surficial environments and life on Earth and Mars. His research addresses the chemical development of the early oceans and atmosphere, and the environmental context of early evolution. Field mapping studies are the starting point for more topical laboratory-based studies involving geochemical, paleontological, and geochronological techniques.

Currently, his research is focused on the reconstruction of environmental conditions associated with the Cambrian radiation of animals in Oman, Namibia and Siberia. In 2004, he served as a member of both the Geology and Long Term Planning Groups for the Mars Exploration Rover mission.