

A photograph of the Phoenix Mars lander on the surface of Mars. The lander's robotic arm is extended, holding a scoop. The background shows the reddish, rocky terrain of Mars under a hazy, orange sky. The lander's solar panels are visible in the lower-left corner.

Phoenix

Surface Phase Overview

Barry Goldstein

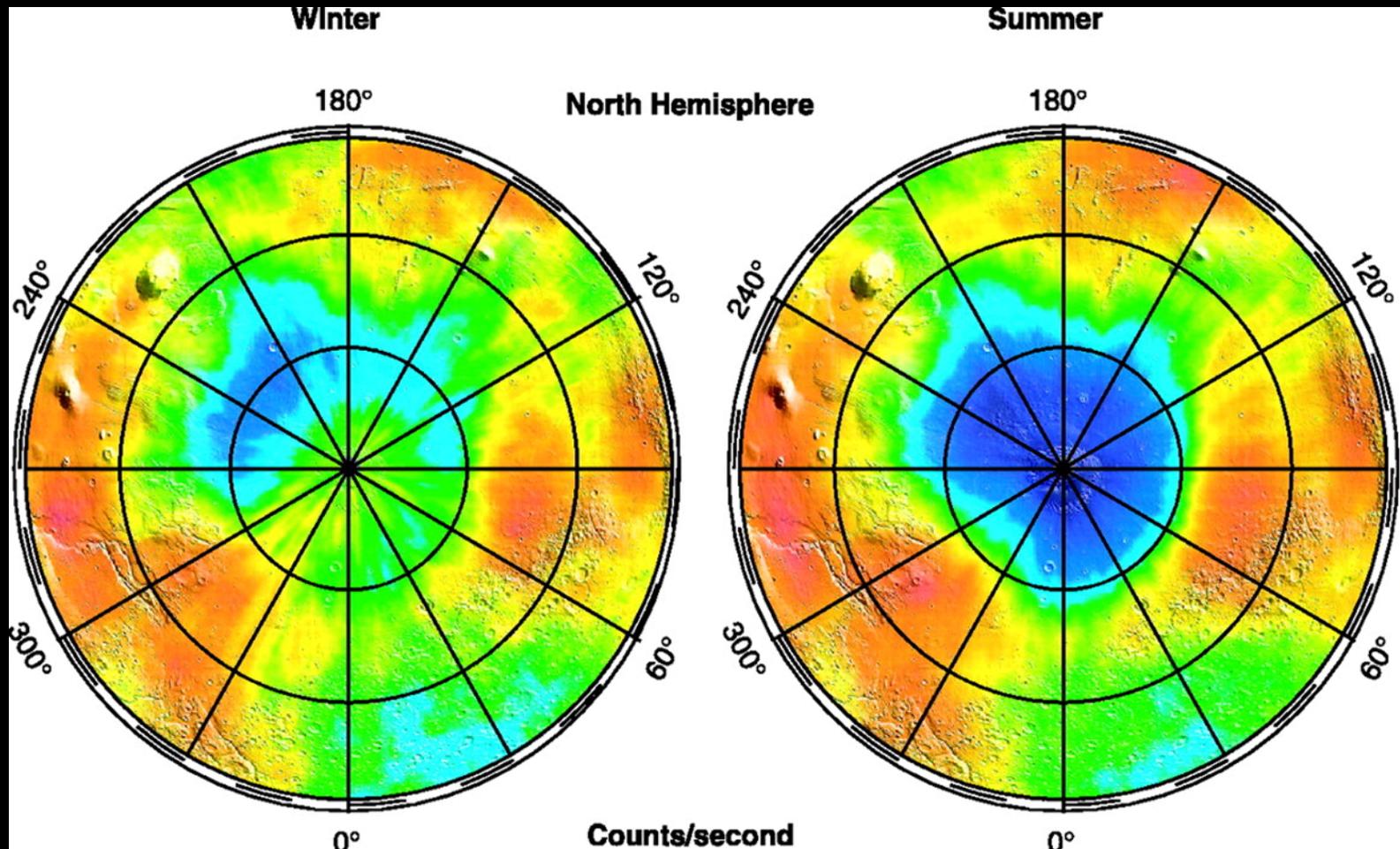
Project Manager

Jet Propulsion Laboratory, California Institute of Technology

(c) 2009 California Institute of Technology. Government sponsorship acknowledged

Phoenix Was Conceived to Respond to the Discovery by Odyssey in 2003

A Large Body of Ice Water at the Poles





The Big Questions?

- What happened to the Martian water?

Phoenix will be the first mission to touch and examine water on Mars

- Is there biological potential at the northern polar region of Mars?

Three components necessary:

Water → Did the ice melt?

Food → Are there organics?

Energy → If at the surface/sun

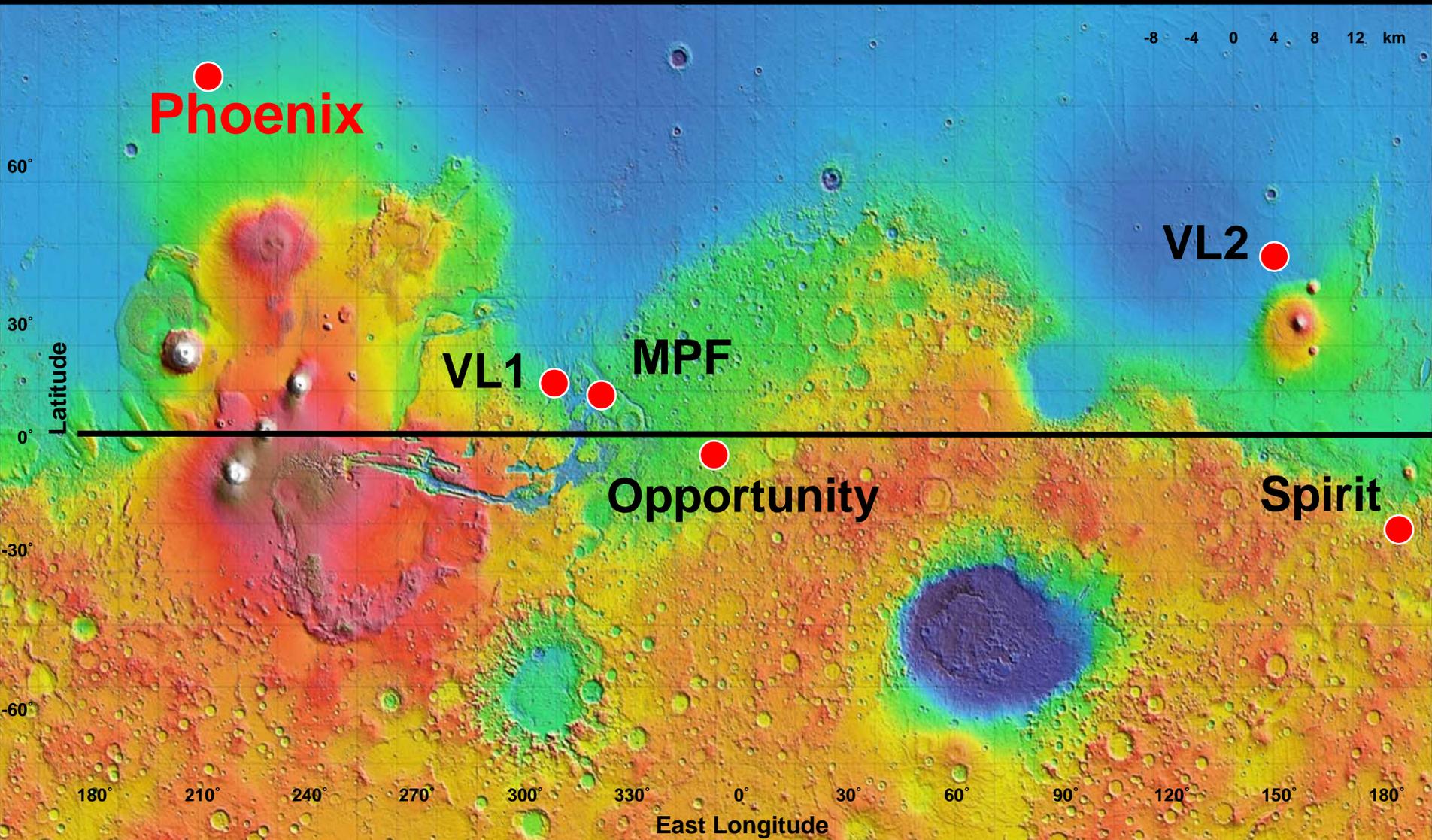
- Do the poles indicate global climate change?

Global climate change is always dominated by polar processes



Ancient Mars?

Phoenix Landing Site Is Much Farther North Relative to the Other Landers





Phoenix Landing Site Latitude and Longitude If It Were on Earth

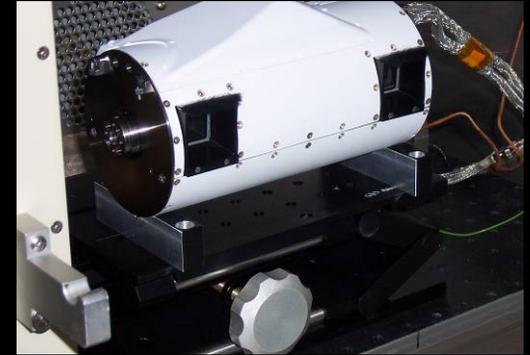




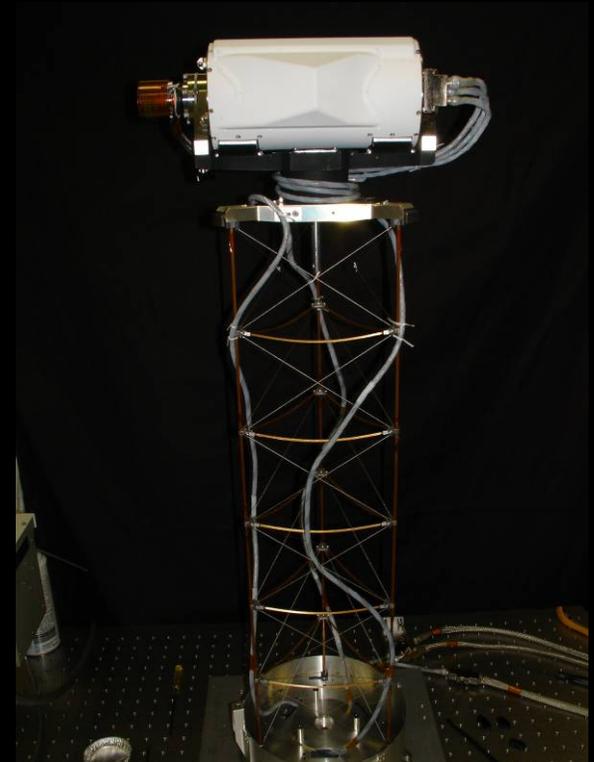
Surface Stereo Imager (SSI)

University of Arizona

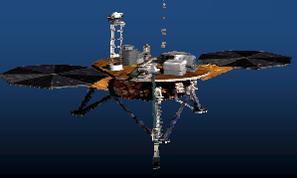
- Perched about 7 feet above ground and as far apart as a pair of human eyes, the two cameras will see in all directions with the same resolution as human eyes
- One mega pixel camera



SSI Sensor Head



SSI Sensor Head & Mast



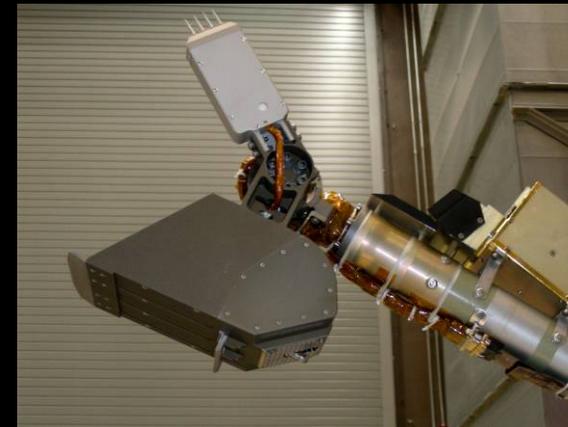
Robotic Arm

JPL

- Over 7 foot reach, four degree of freedom sampling arm
- Scoop contains blades, ripper-tines and Icy-Soil Acquisition Device (ISAD)
 - Motor driven drill bit to acquire hard surface soil/ice
- Holds Robotic Arm Camera (RAC)
 - Max Plank Institute, Germany
 - Observes trench, documents sample
- Positions Thermo-Electric Conductivity Probe (Part of MECA)



Flight Arm on Bio-barrier plate



**Flight Scoop,
ISAD, TECP**



RAC



Thermal and Evolved Gas Analyzer (TEGA)

University of Arizona

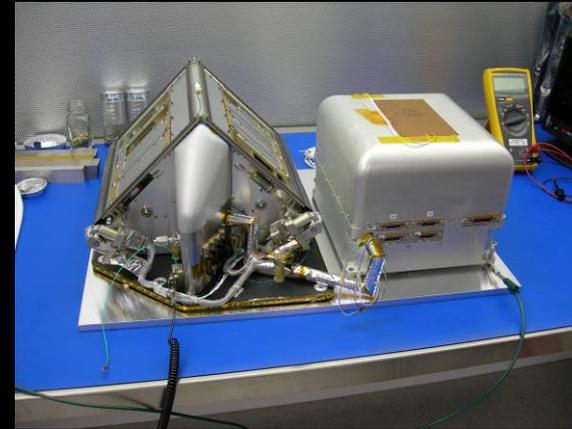
Two components:

Thermal Analyzer

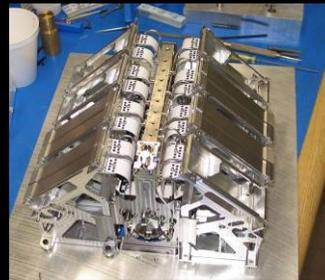
- Robotic arm delivers samples to 8 Small Ovens heated to 1000 c
- Detects phase transitions from solid to liquid to gas
- Documents ice and other volatiles bound to minerals
- Gases Directed to the Mass Spectrometer

Evolved Gas Analyzer

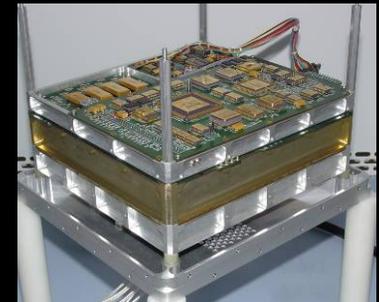
- Mass Spectrometer looking at the constituents of the gases from the TA
- Detects Organic compounds
- Can also measure atmospheric humidity



Flight TEGA

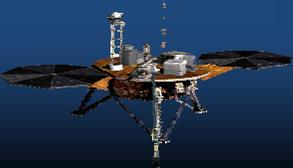


Thermal Analyzer



Mass Spectrometer





Microscopy, Electrochemistry & Conductivity Analyzer (MECA)

JPL

Multiple Instrument Package:

- Four tools to examine the soil
- What a gardener or a farmer might do in a soil test + more

Wet Chemistry Cells

- 4 teacup-size beakers each used only once
- Samples from the Mars surface and 3 lower depths delivered and mixed with water
- Measure electrochemistry of delivered soil samples

Two Microscopes

- Optical Microscope
 - 2 μm resolution
- Atomic Force Microscope
 - 0.1 μm resolution — 1/100 of human hair

Thermo-Electric Conductivity Probe

- A Four-spike fork at the end of the robotic arm inserted into regolith for thermal and electric conductivity measurement

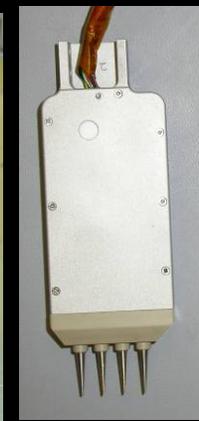


Wet Chemistry Cell
(1 of 4)

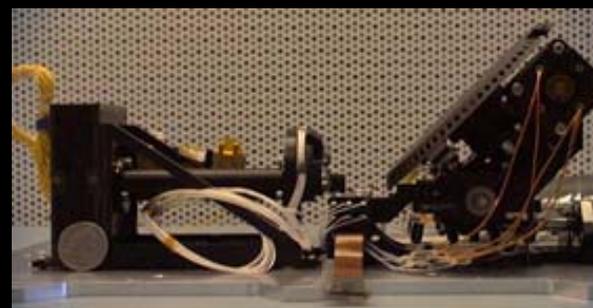


MECA Assembly

(Sample Port Upper Left)



Flight TECP



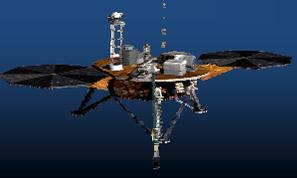
Optical Microscope With
Sample Carousel



Optical Microscope



AFM Sensing Head



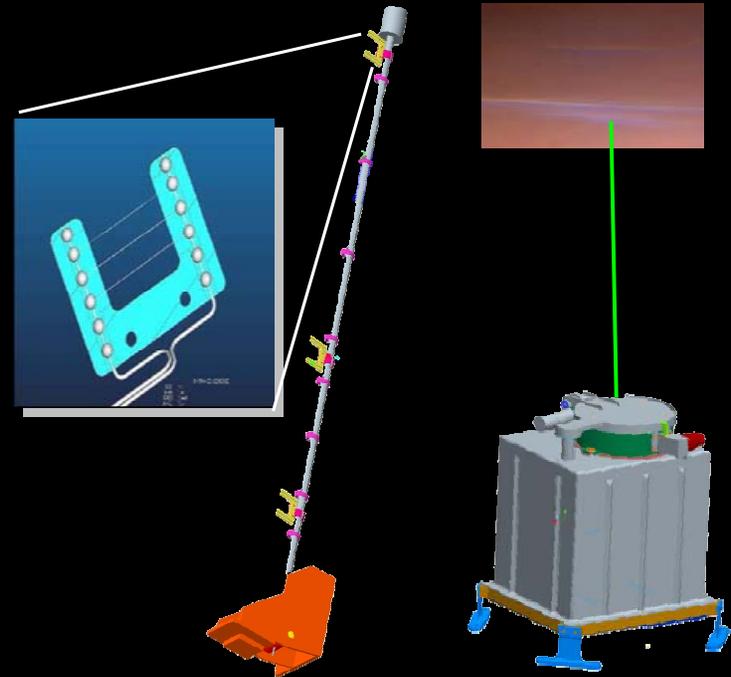
Meteorological Station (MET)

Canadian Space Agency



Tell-Tale

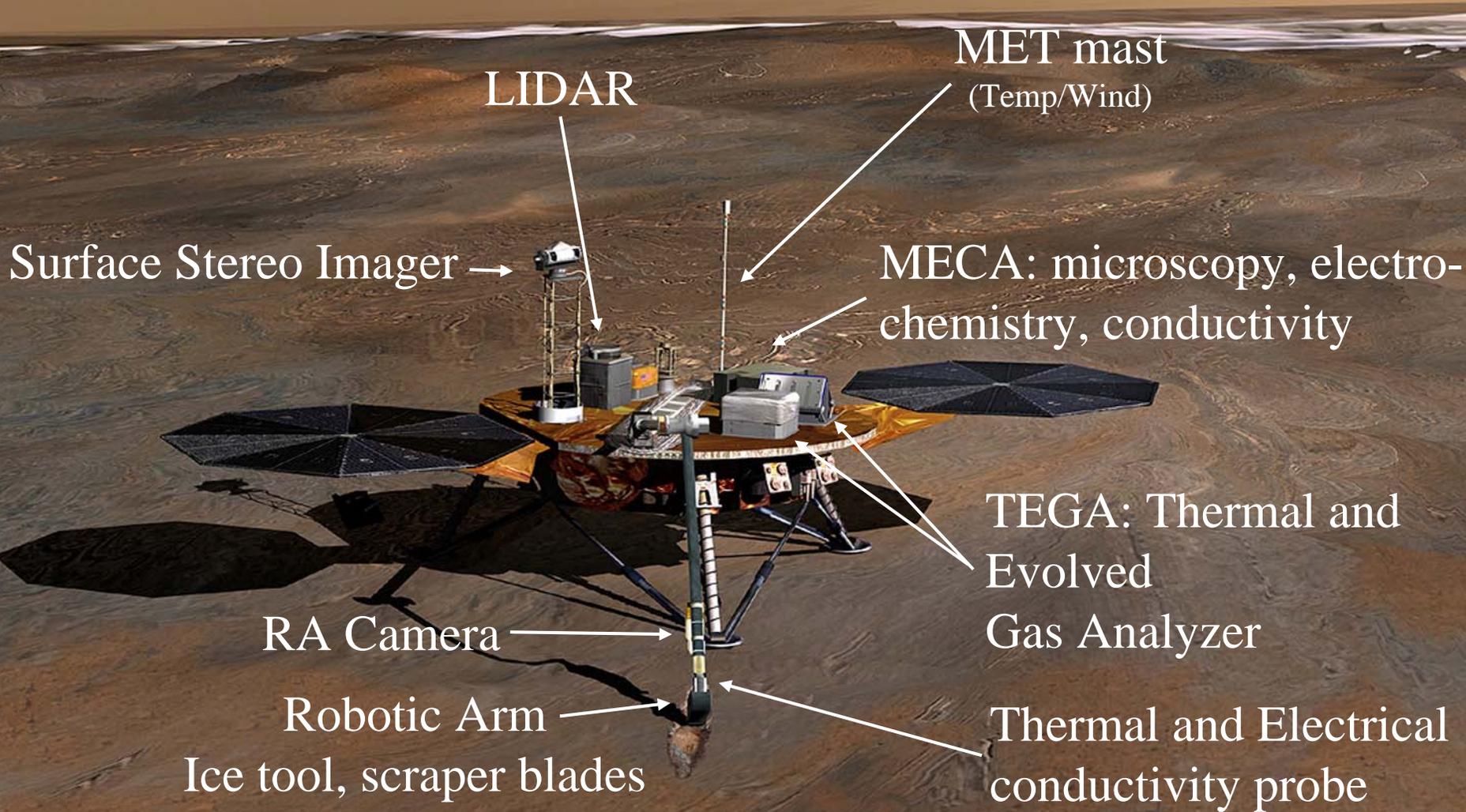
- 1.2 meter mast with three positioned temperature sensors
+/- 0.3°C resolution
- Upward looking LIDAR to detect Martian clouds atmospheric boundary layers
Can view up to 20 km altitude
- Pressure sensor
Mounted with instrument electronics
Finish Meteorological Institute
- Passive “Tell-Tale” wind sensor
Mounted on top of mast
University of Copenhagen

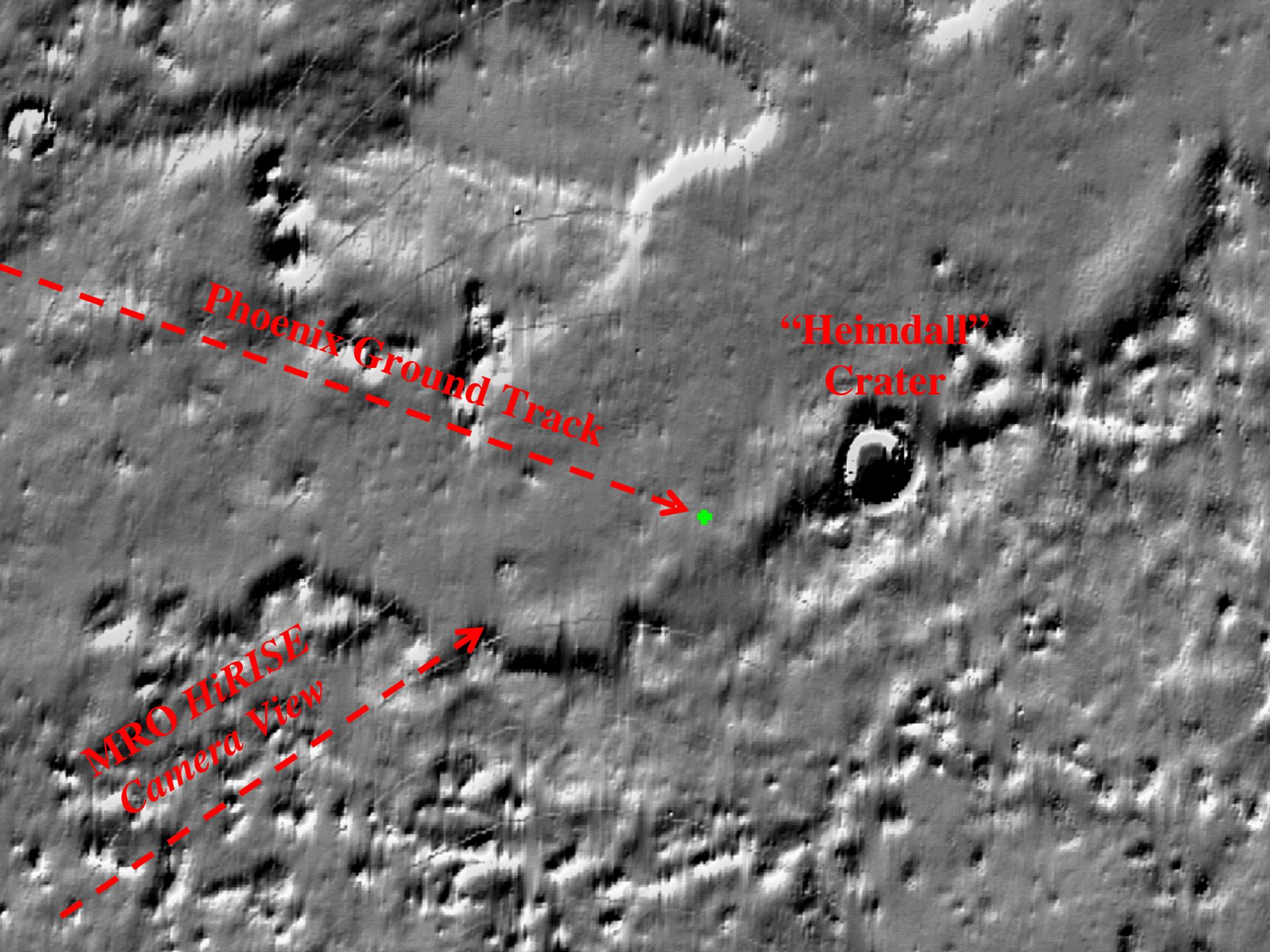


LIDAR Sensor
Head &
Electronics



The Phoenix Landed Payload





Phoenix Ground Track

**"Heimdall"
Crater**

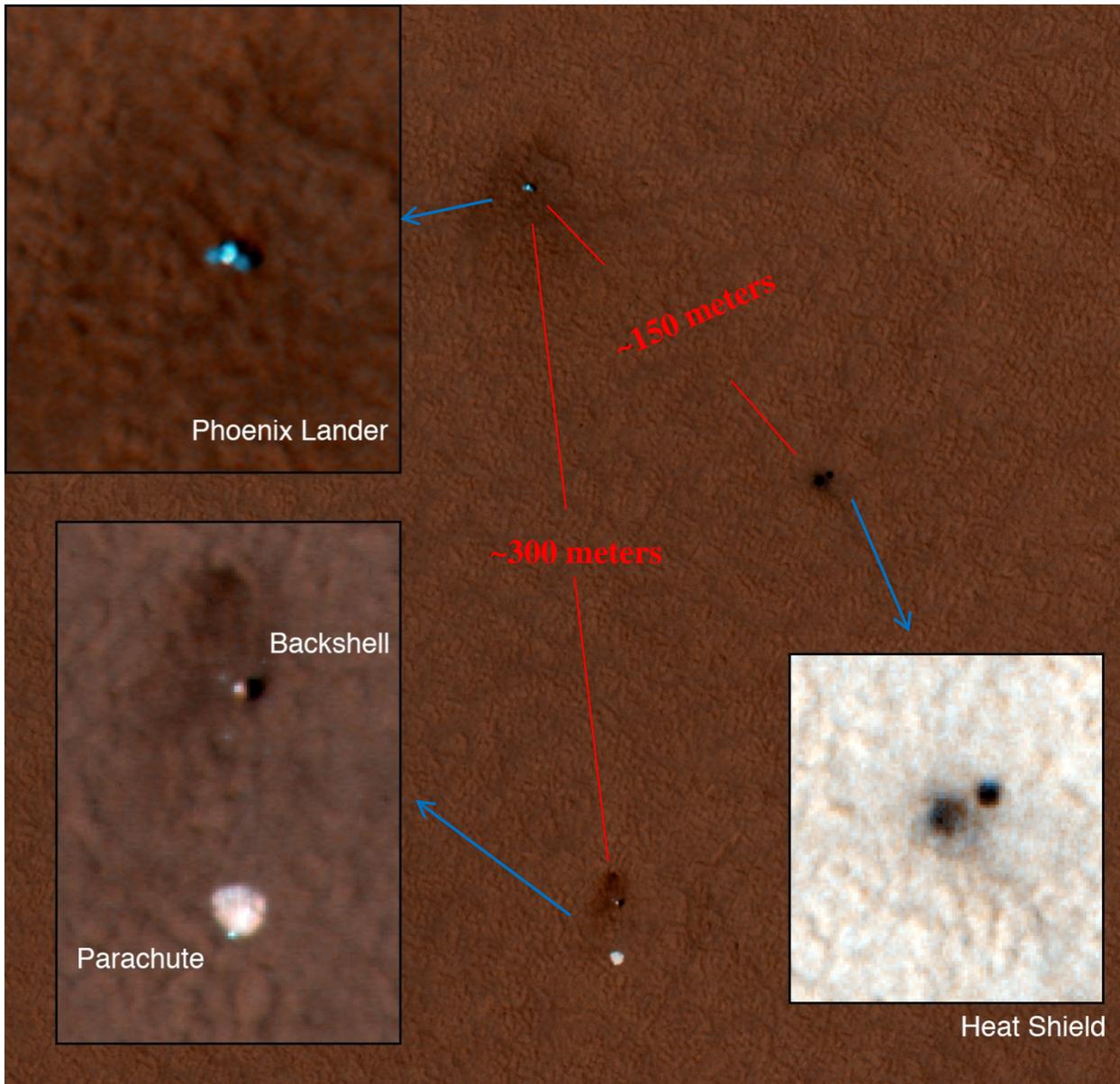
**MRO HiRISE
Camera View**



We landed 22 km away from the rim!



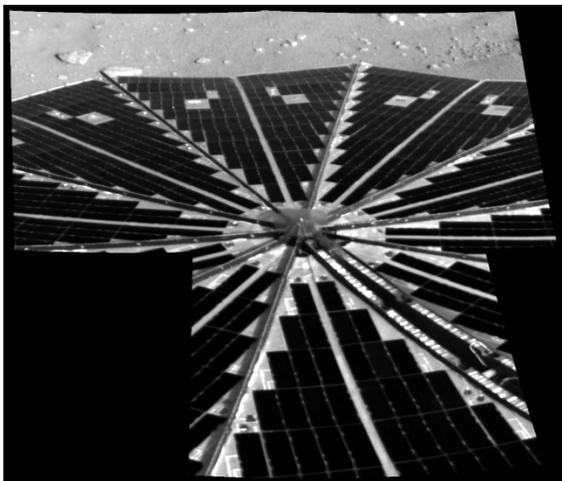
Family Portrait





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Phoenix
Sol-0



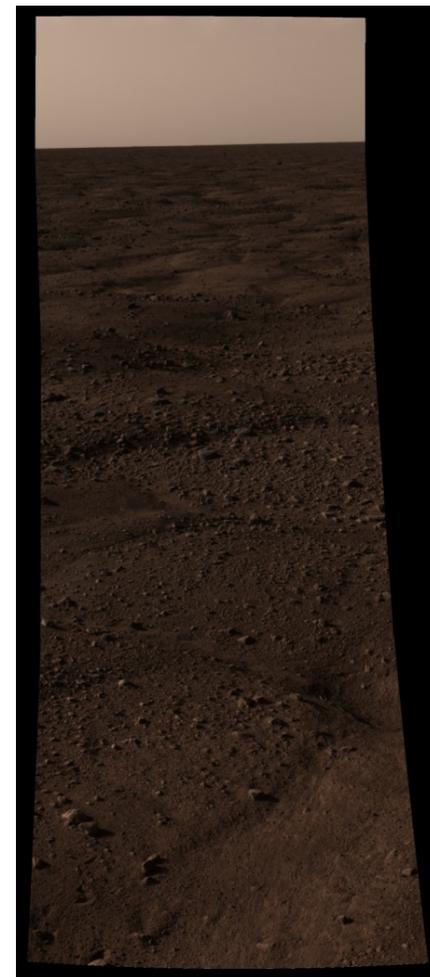
Solar Array Deployed



**RA Bio-
Barrier/MET
Mast (deployed)**



Footpad (very little soil)

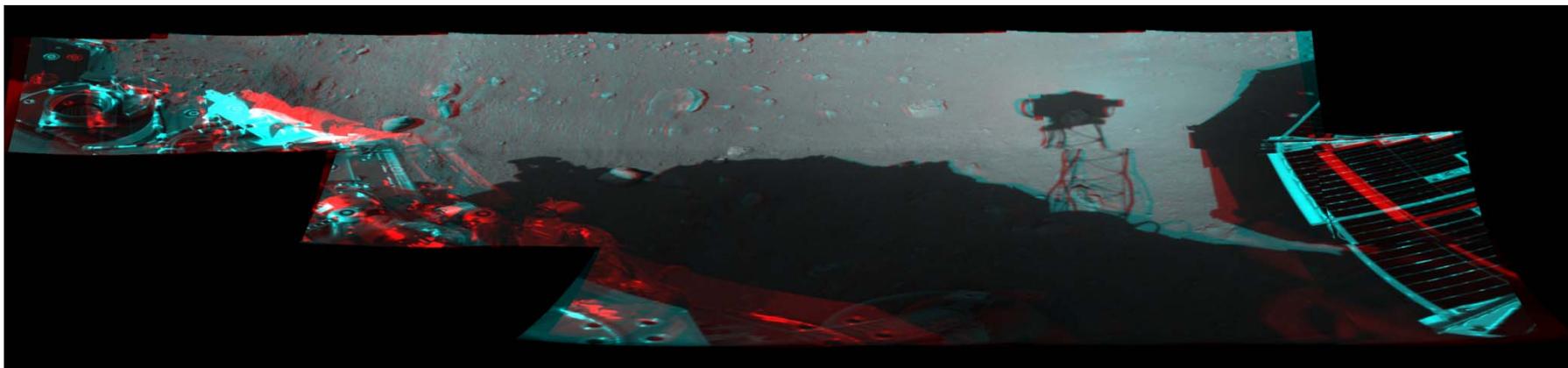


**Horizon
Postcard**



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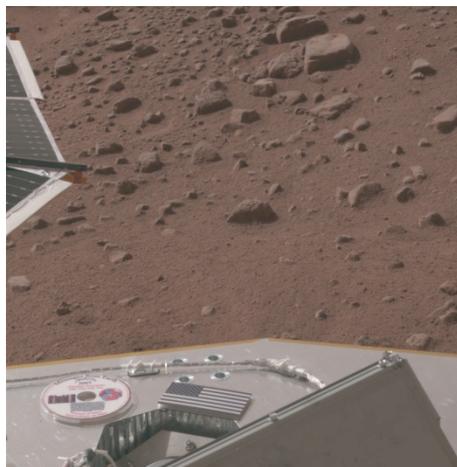
Phoenix Sol-1



Robotic Arm Workspace (SSI Shadow)



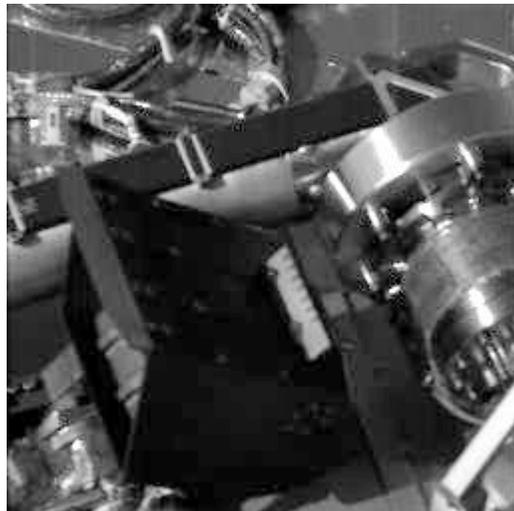
“Tell Tale” on top of MET Mast



Lone S/C Logo



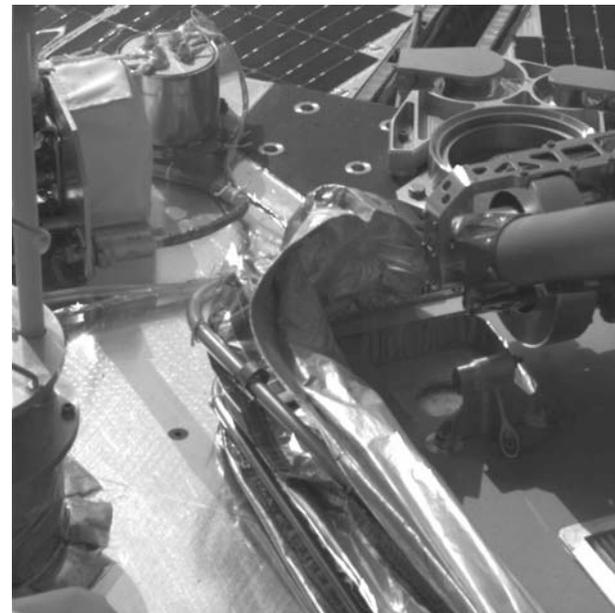
**South of Lander
(Backshell Parachute?)**



Wrist Deployment



RAC High Above The Deck

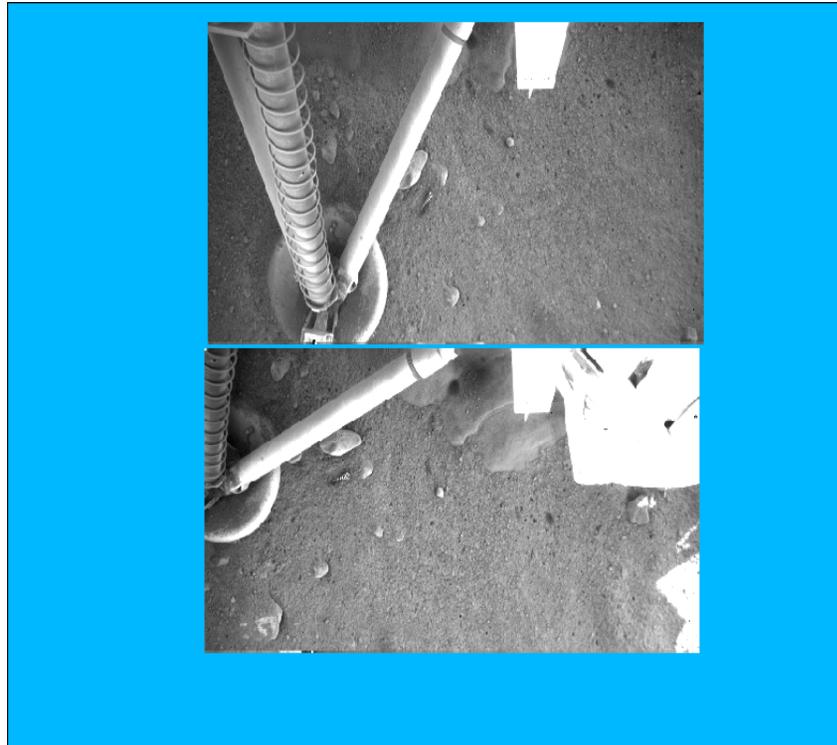


Elbow Deployment

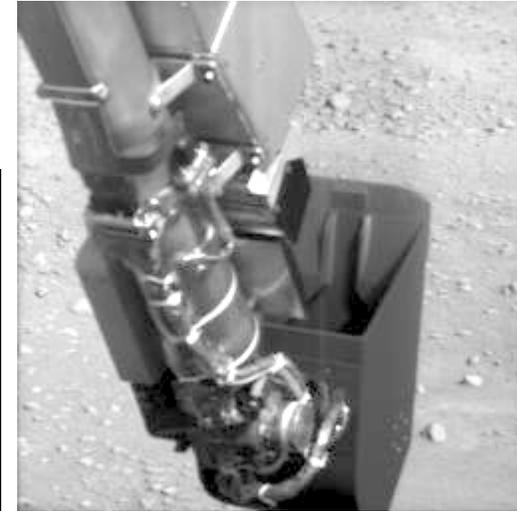
Deployment of Robotic Arm



**LIDAR cover deployed
First Data**



**RAC Footpad Image Possible
Ice and "spring"**



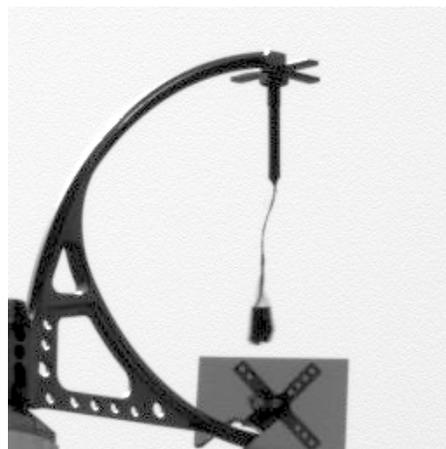
Business End Of Arm

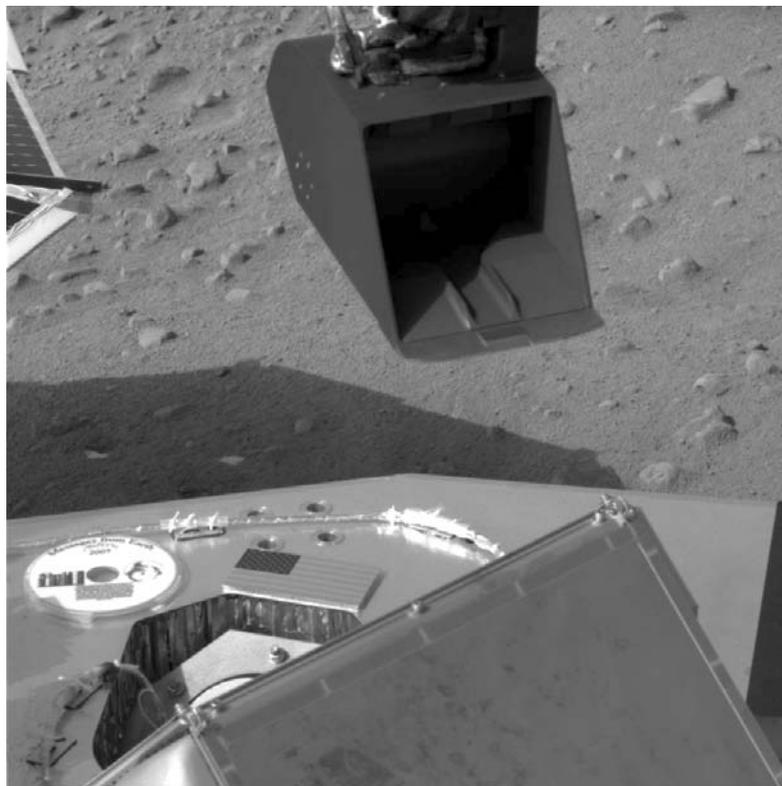


“Holy Cow”



**Tell Tale
Movie**





Arm traversing to pay-dirt



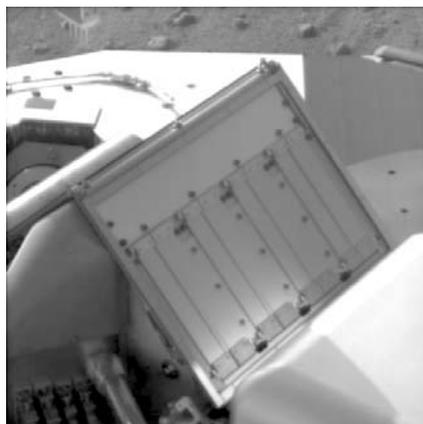
**Scoop Touches Mars
("One Small Step")**



First Martian Dig



Martian Soil In RA Scoop



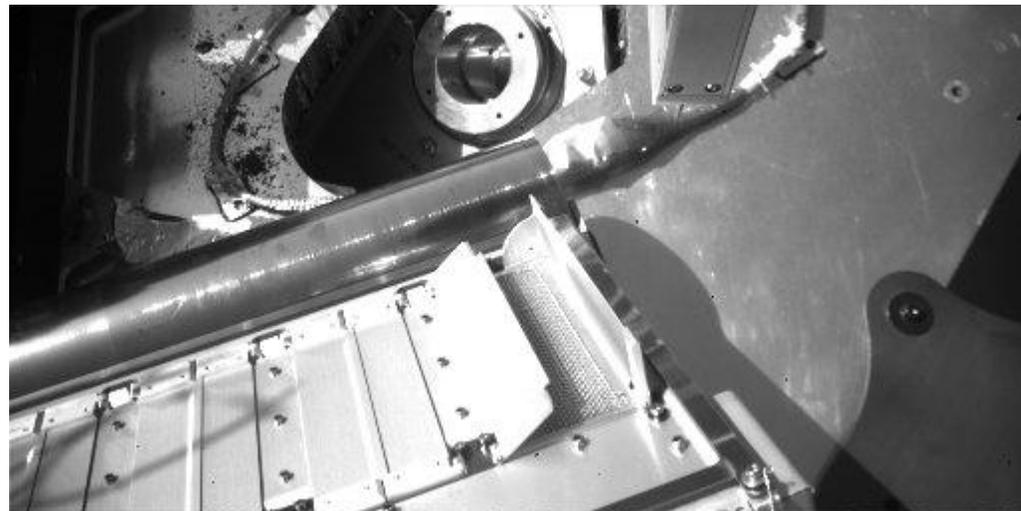
**TEGA Cover Side One
Deployed**



**TEGA Cover Side two deployed (but
needs tightening)**



**RA Scoop over partially
opened TEGA door**



Cover tightened, however....



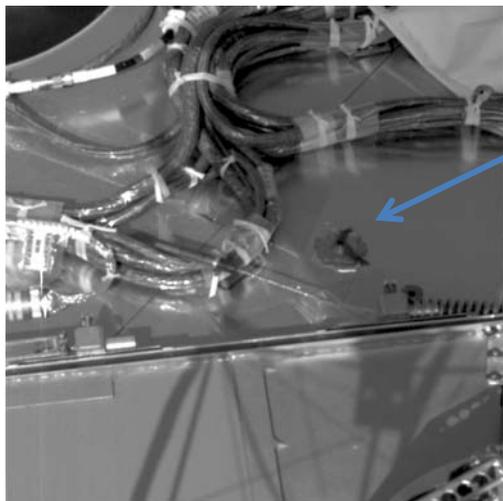
“Clumpy” Sample To Deliver To TEGA



Sample Delivered, no indication of any soil in ovens!

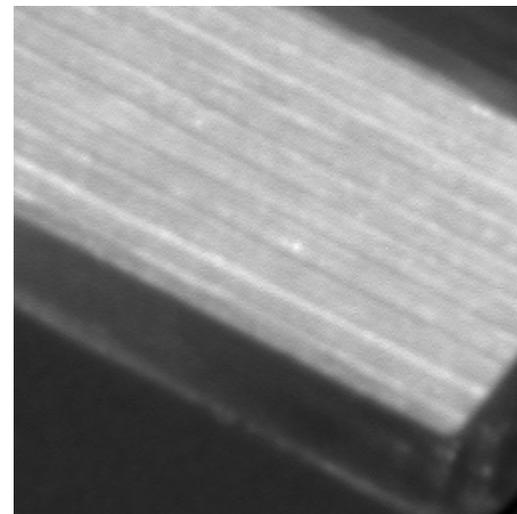


Phoenix Sol-13

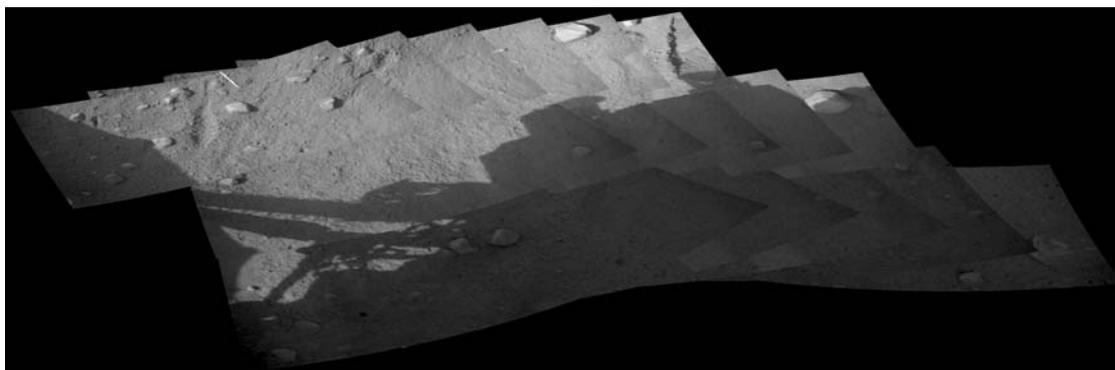


Missing Spring!
(from Sol-4)

Spent Sol
Shaking TEGA
Cell



“Organic Free Blank”

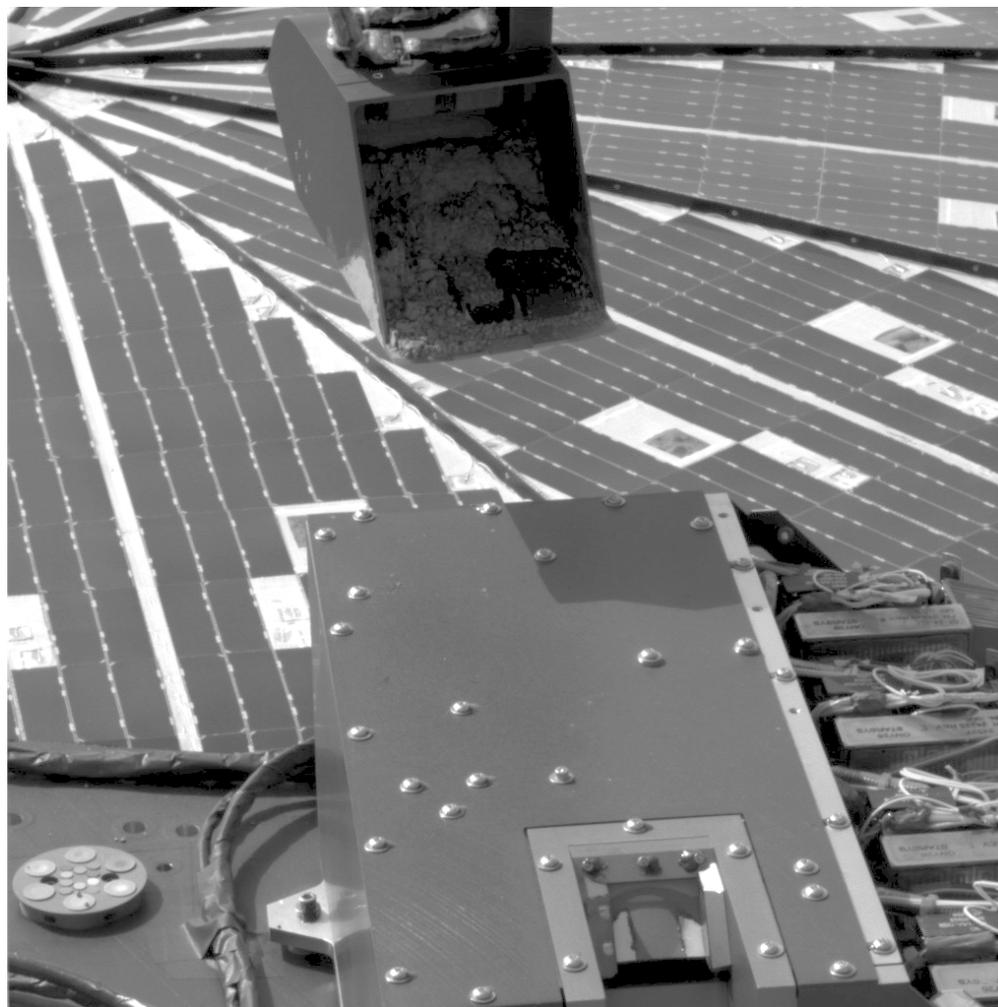


RAC “Snow Queen” Mosaic

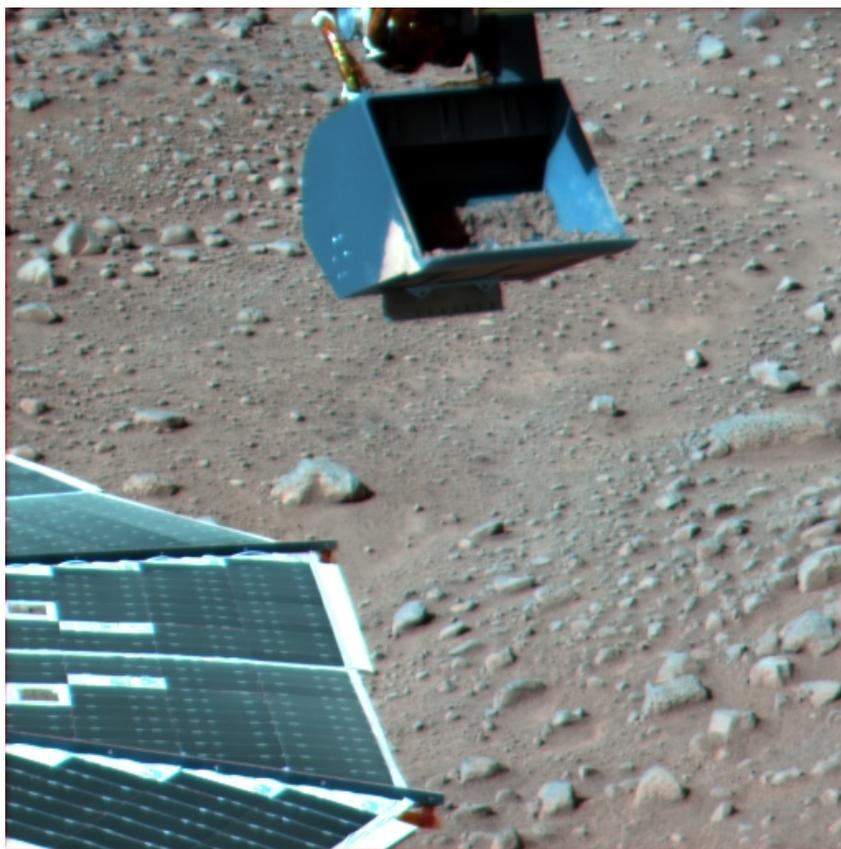


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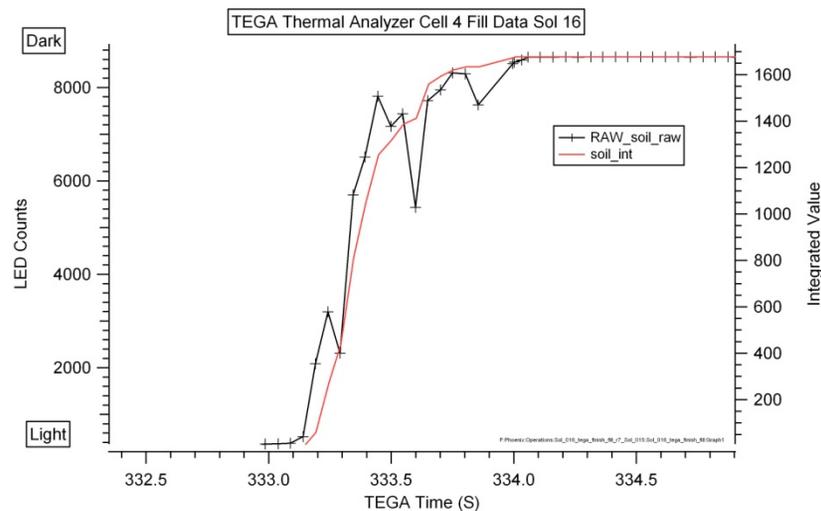
Phoenix Sol-15



New Delivery Technique RASP “Sprinkle”

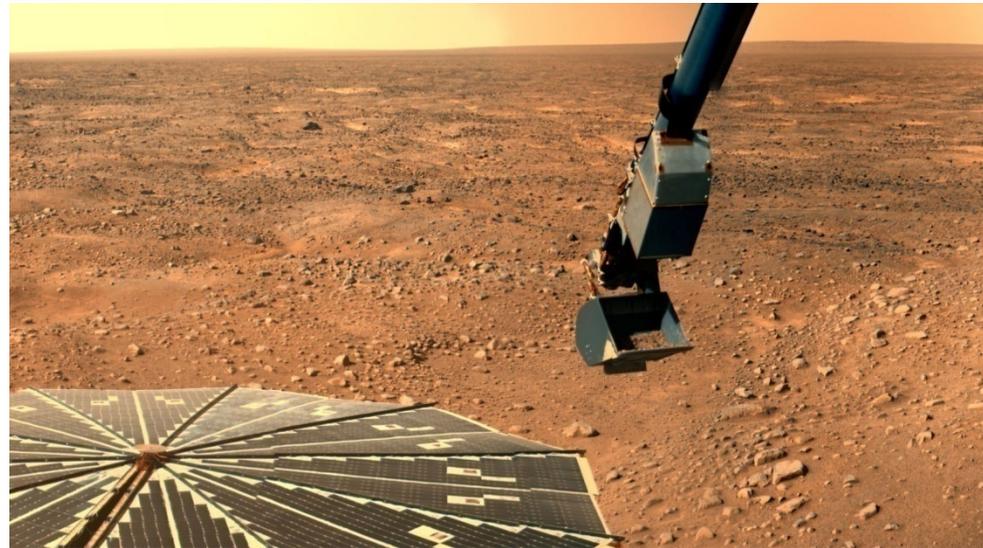


**Sample Collected For Optical
Micro-Scope**

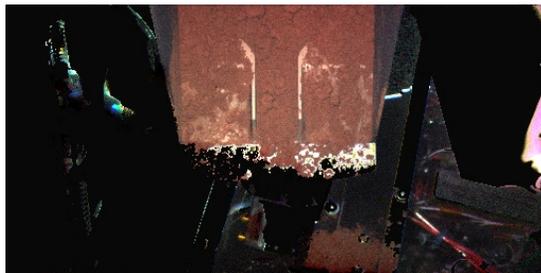


TEGA Shake SURPRISE!

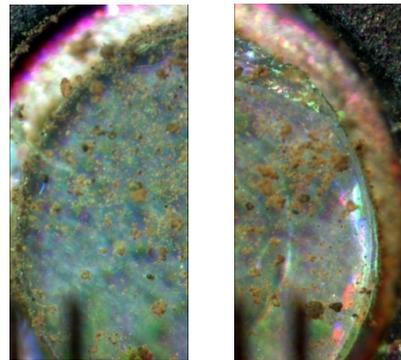
**Last Shake Produced A
Sample!**



Part Of Mission Success Panorama



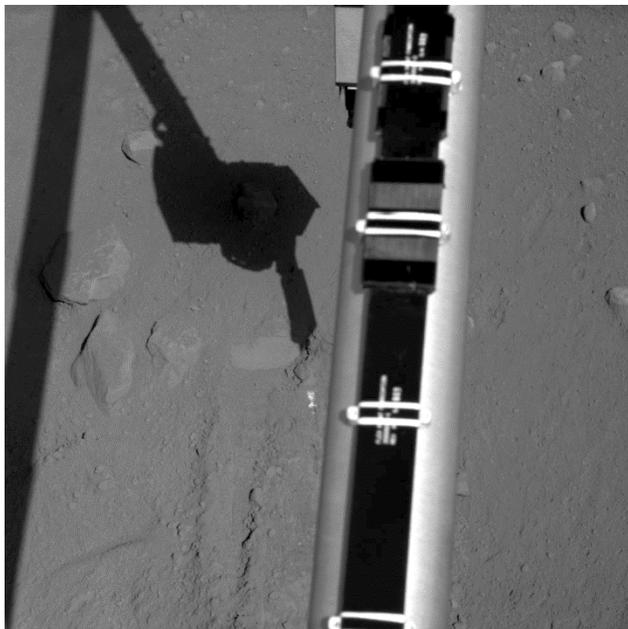
Optical Microscope Sample



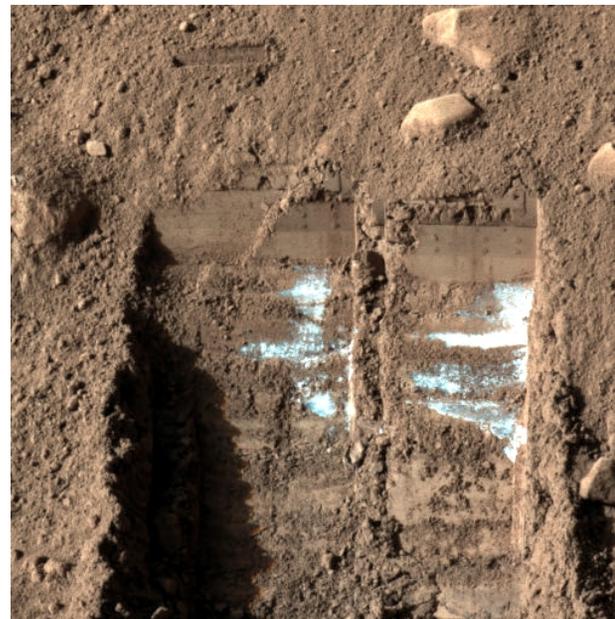
OM Sample Images



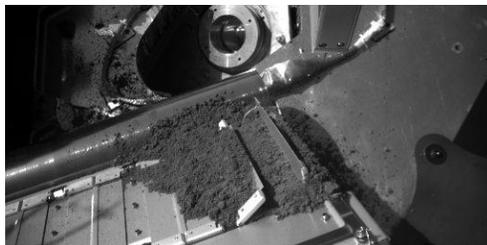
Optical Microscope Sprinkle



Digging For Ice



**Sol-18 Digging Results
("Dodo-Goldilocks")**



Before



After

TEGA Cell

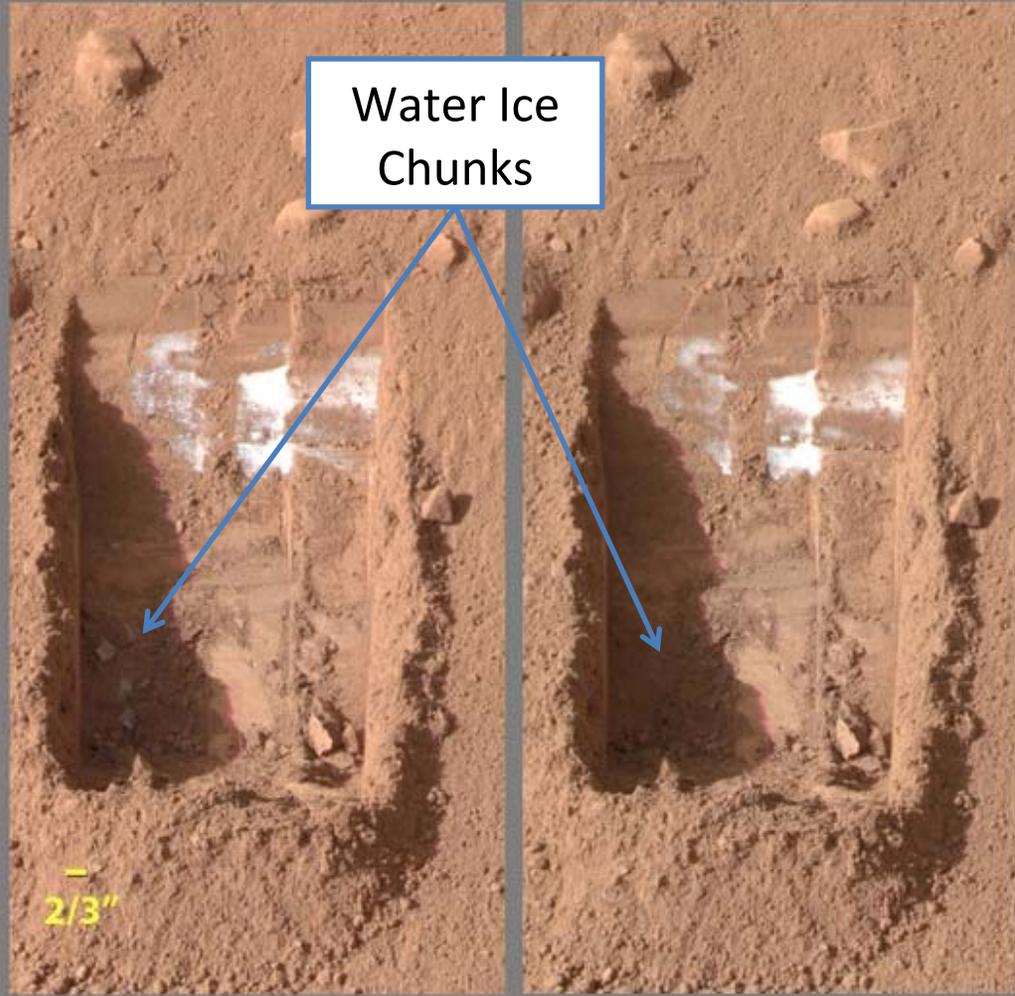
**First TEGA DSC
(Low Temperature)
Run This Sol**



Sol 20

Sol 24

Water Ice
Chunks



Water Ice Confirmed!!

Sublimation of ice chunks over 4 sol period consistent with water at measured temperatures and pressures



Not All News Is Good



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Phoenix
Sol-39
7/4/08



From Pat Winkler



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Sol-41



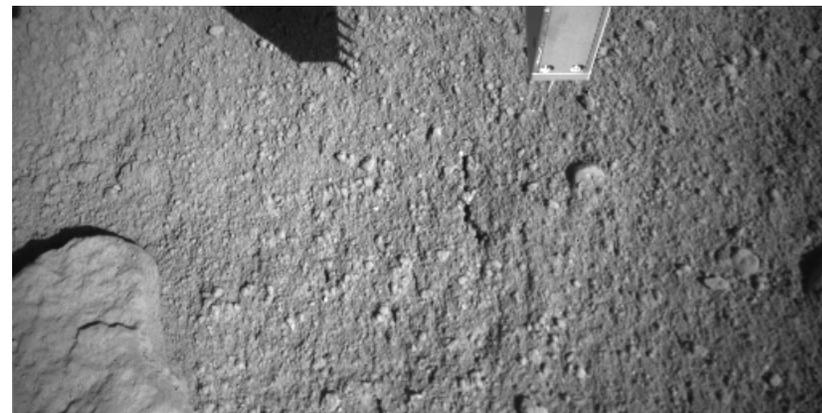
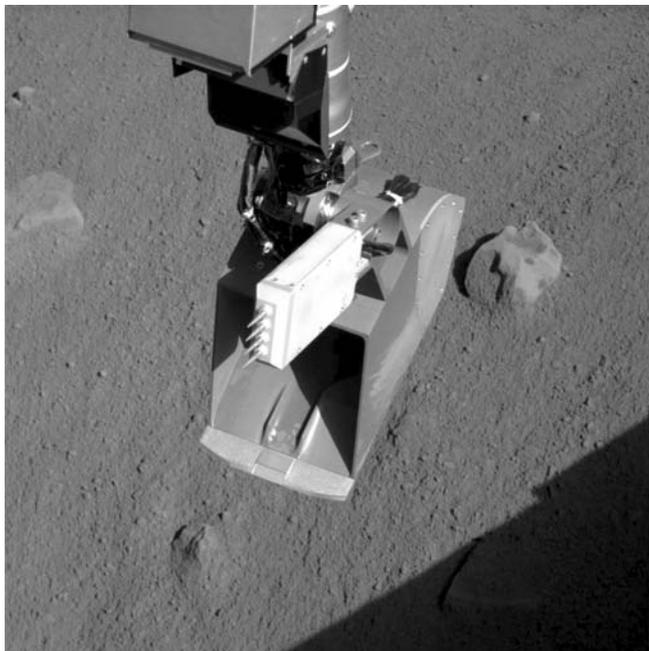
Second Wet
Chemistry Lab
Acquisition
And Delivery



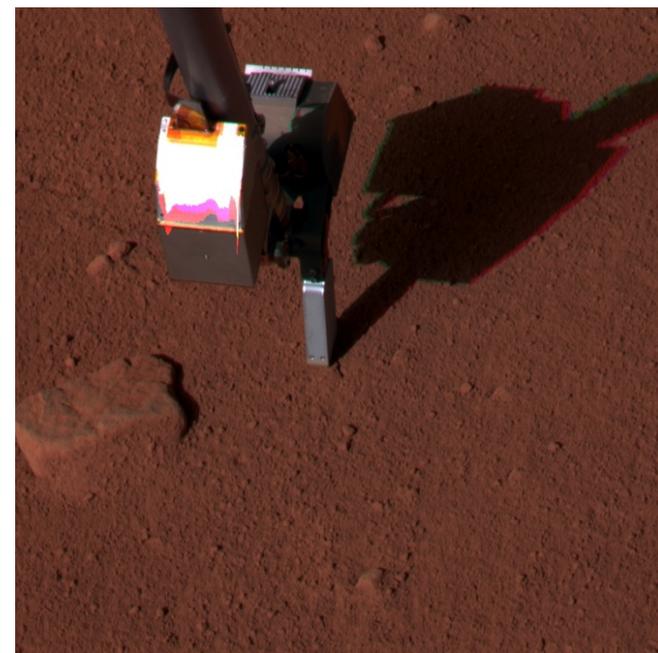
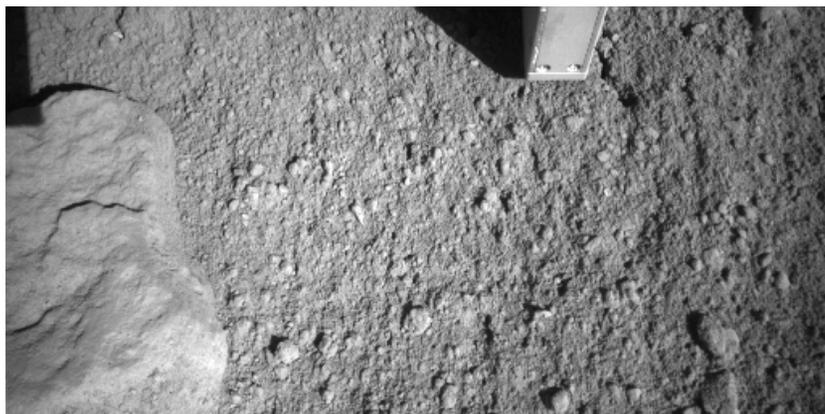
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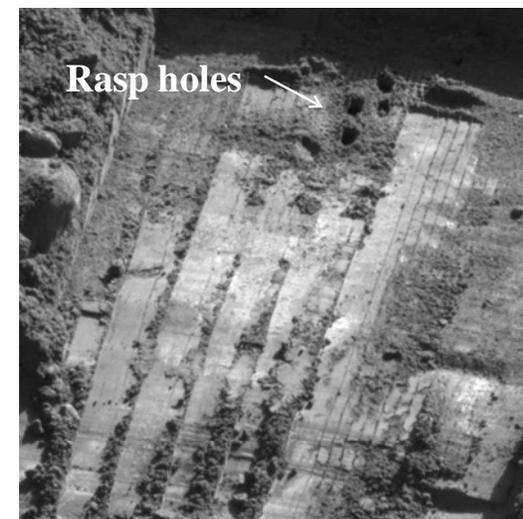
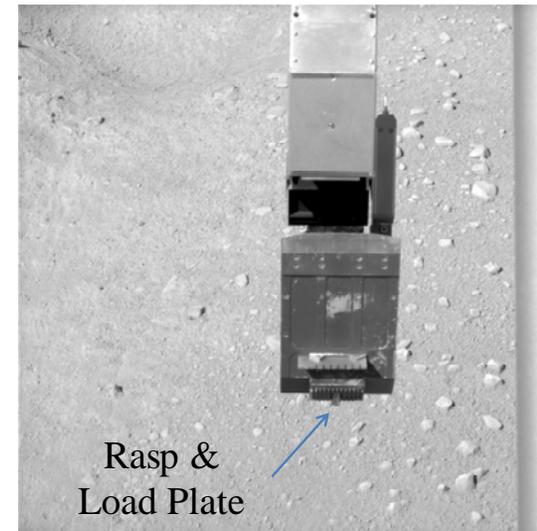
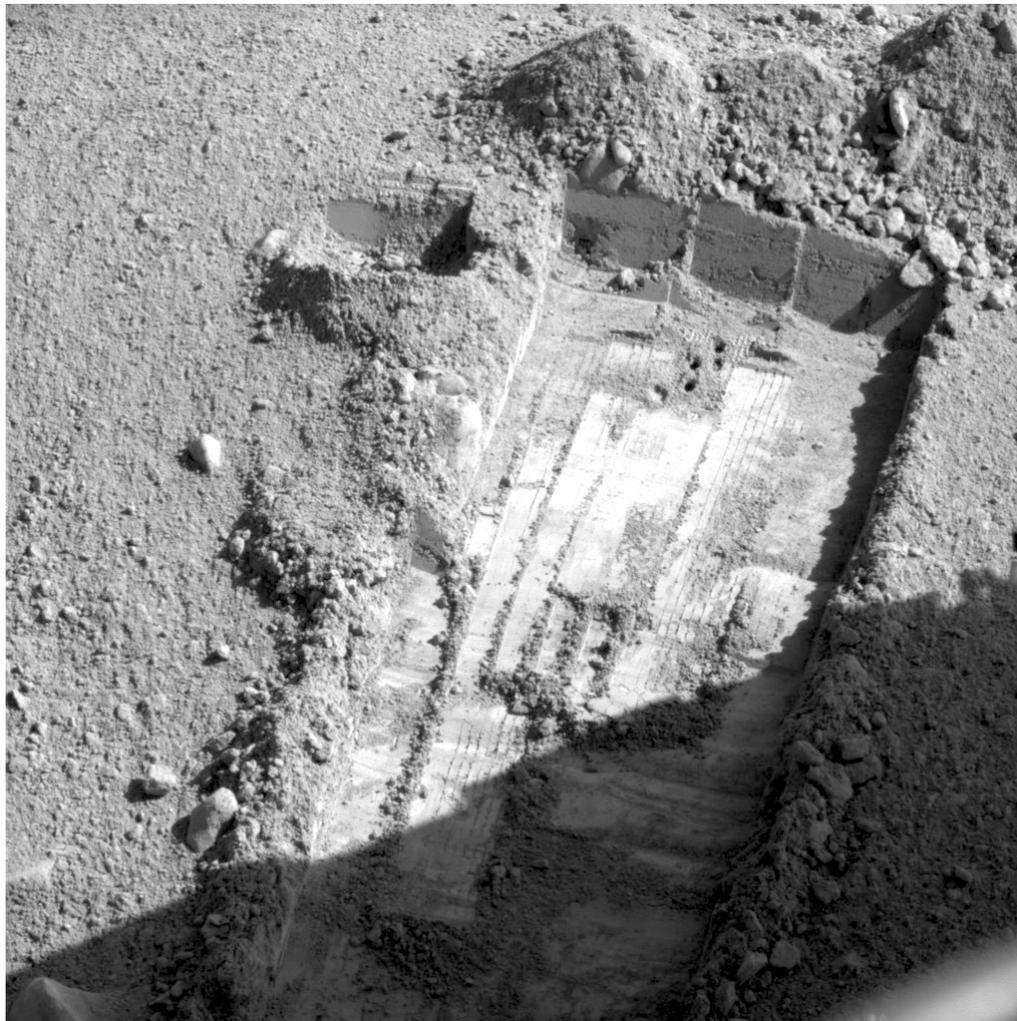
Phoenix

Sol-46



TECP In Soil
(first Time)

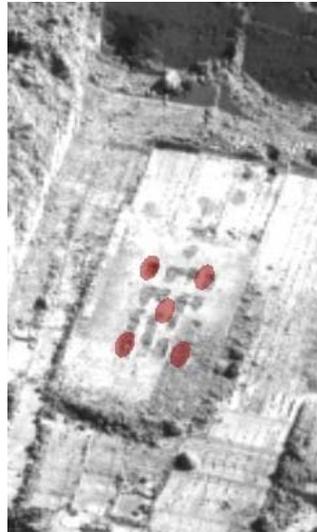




First Rasing On Mars

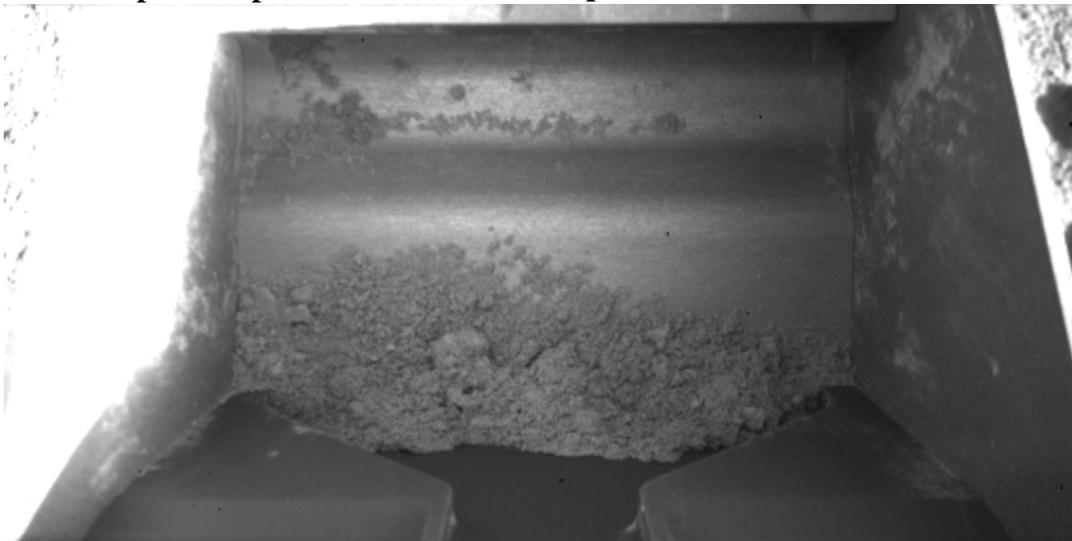


4x4 Rasp of sample

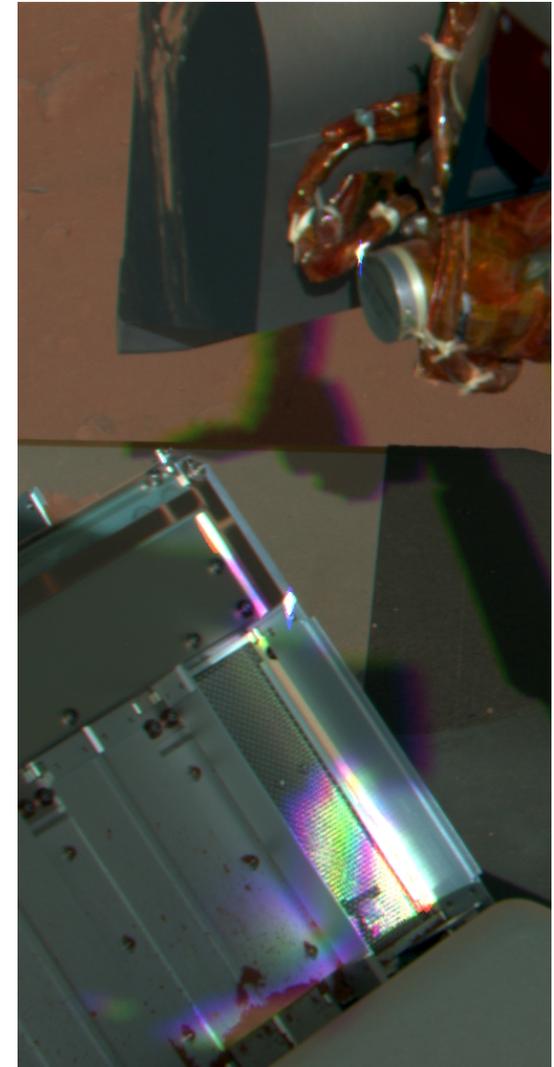


4x4 vs. aim point

Attempt At
Icy Soil
Grab and
deliver to
TEGA



Scoop before & after TEGA delivery

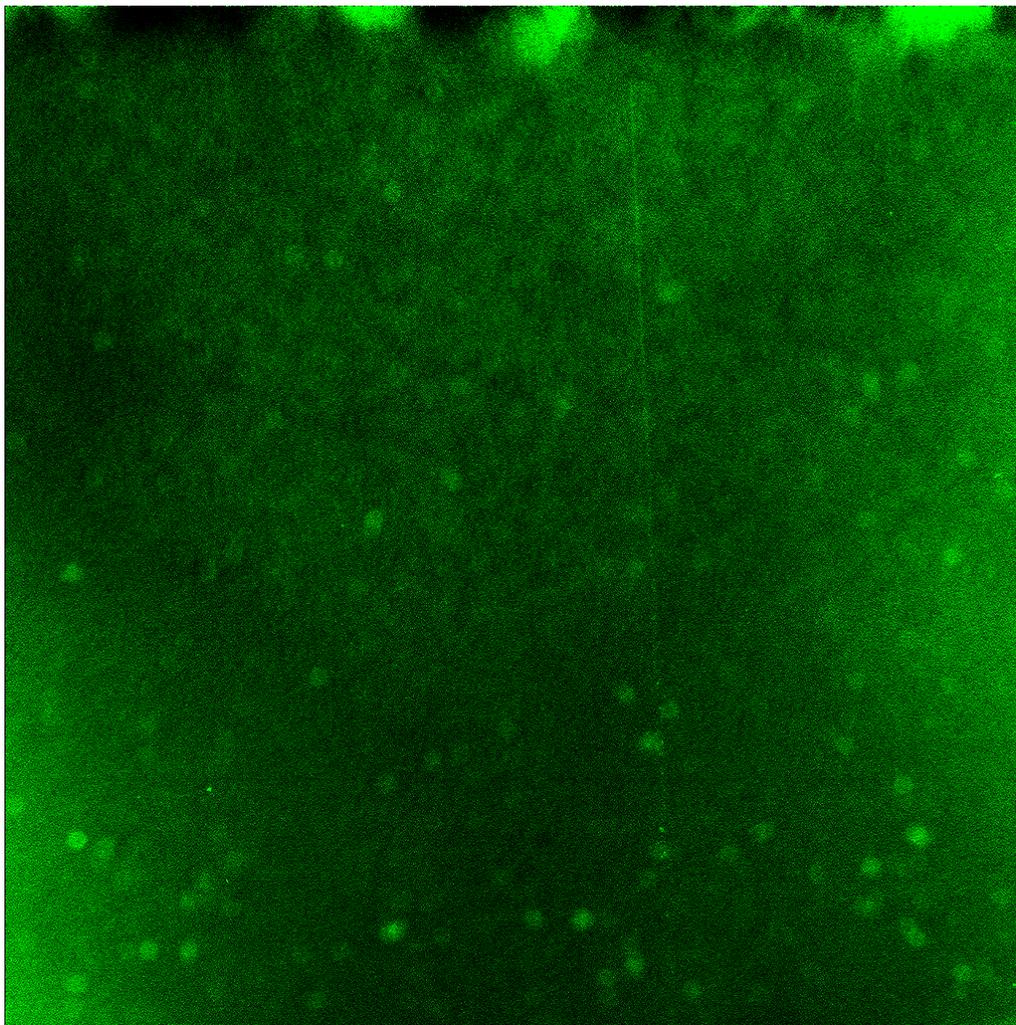


Scoop & TEGA after delivery



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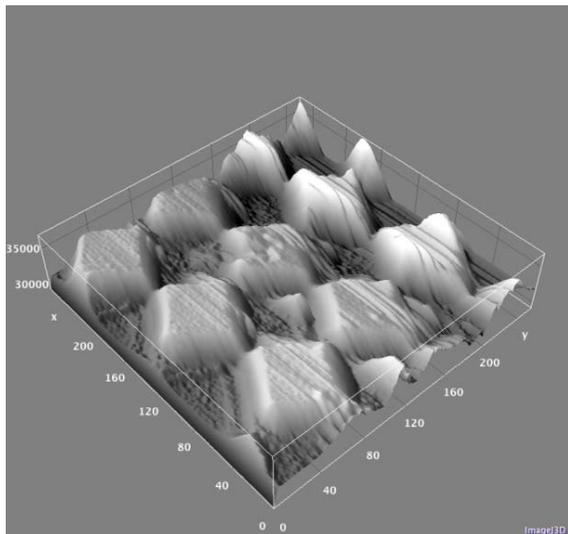
Phoenix
Sol-61



Laser Light Show On Mars



"Wicked Witch" announces water discovered (again).



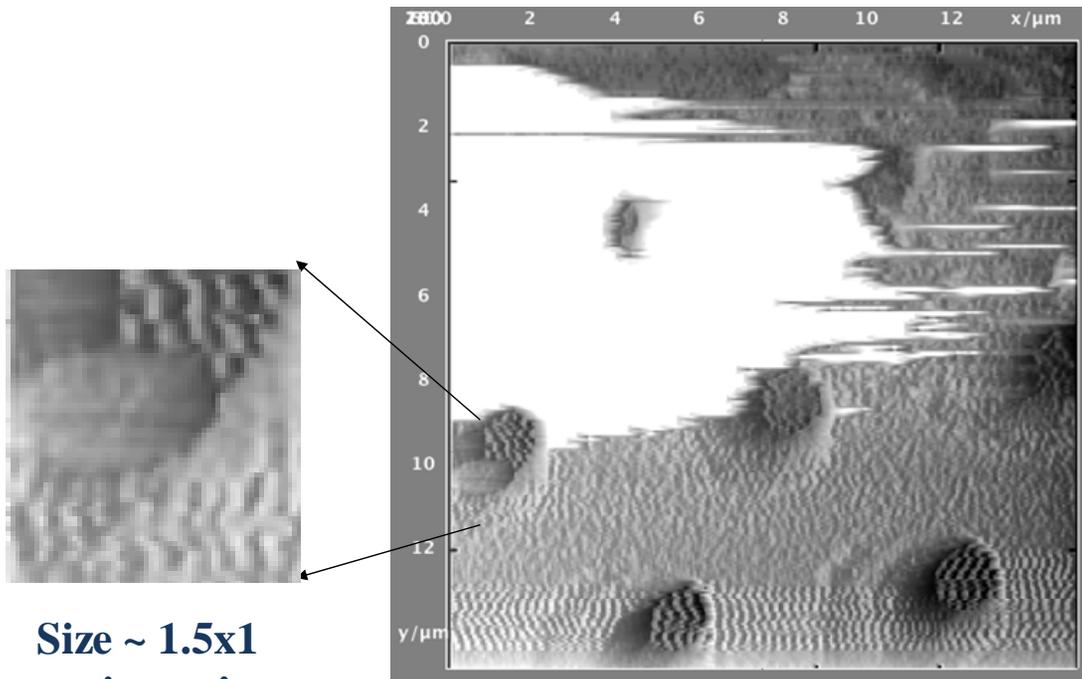
Atomic Force Microscope calibration target at full resolution



TEGA Cell-0 Sample Site



TEGA Cell-0 Delivery



**Size ~ 1.5x1
microns!**

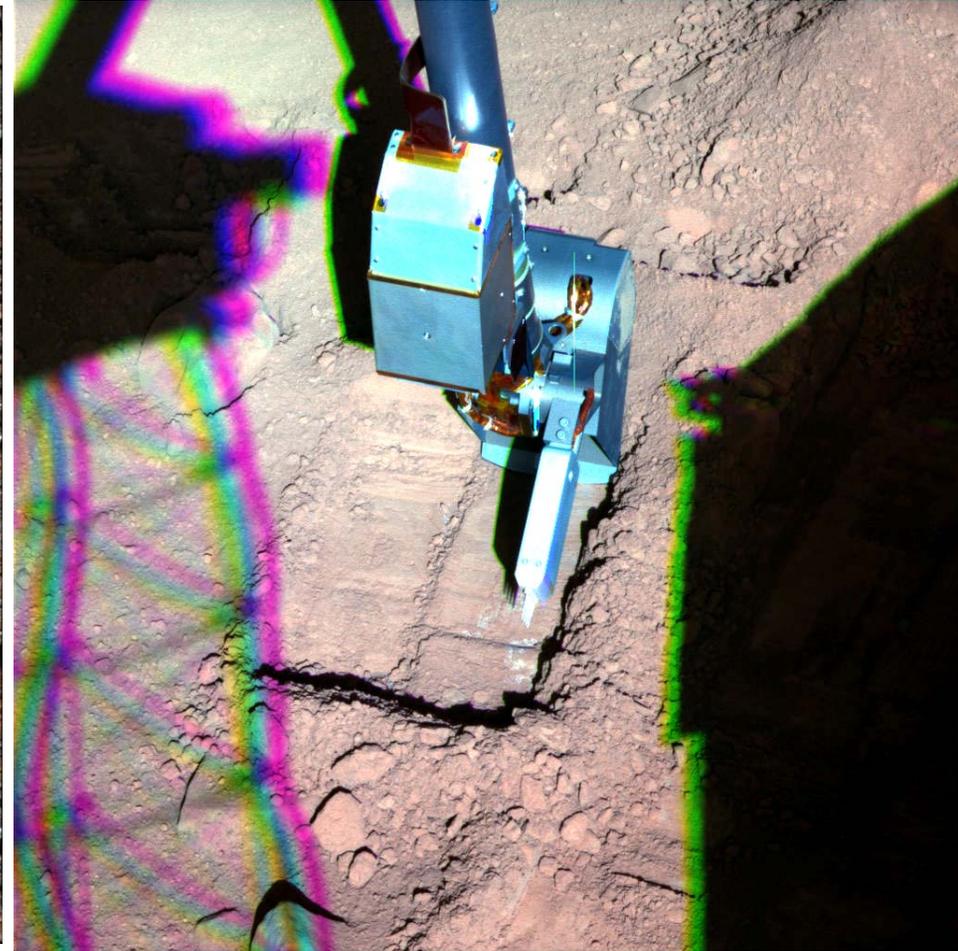
First Atomic Force
Microscope Image
of Martian Grain



Neverland & Headless



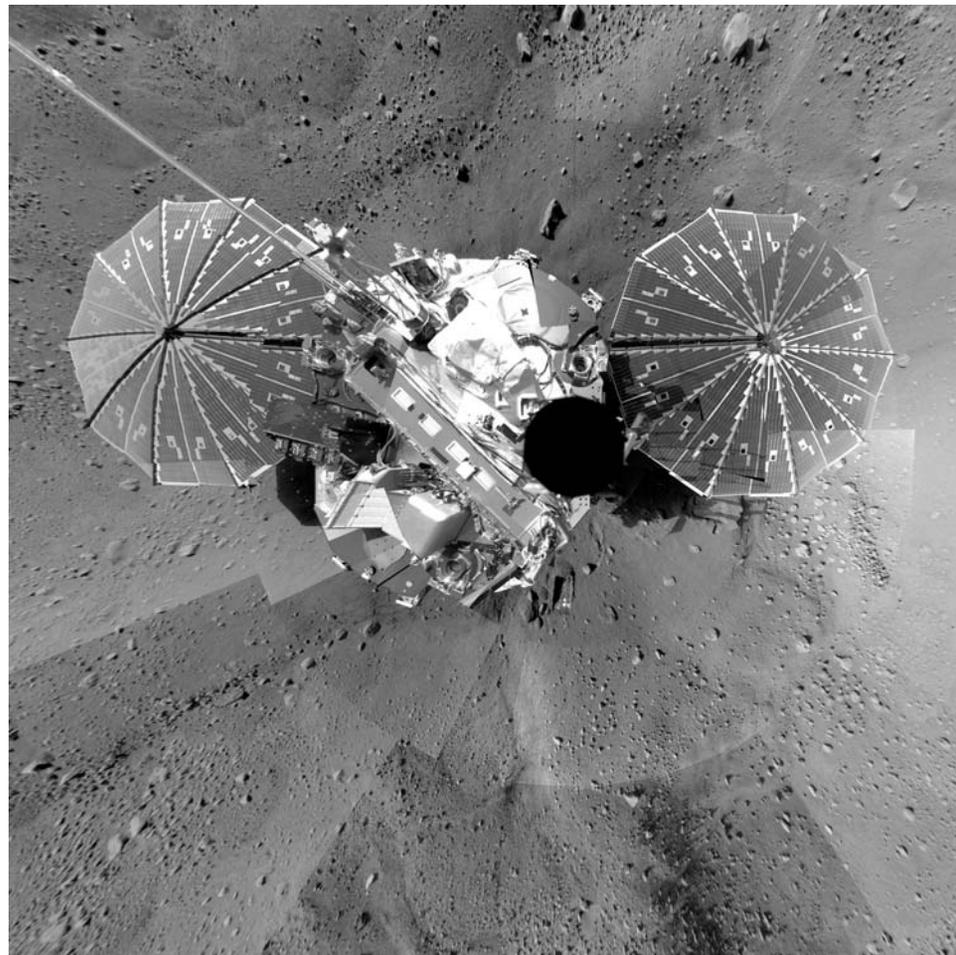
Frost Forming



Burned Alive
Sample Acquisition



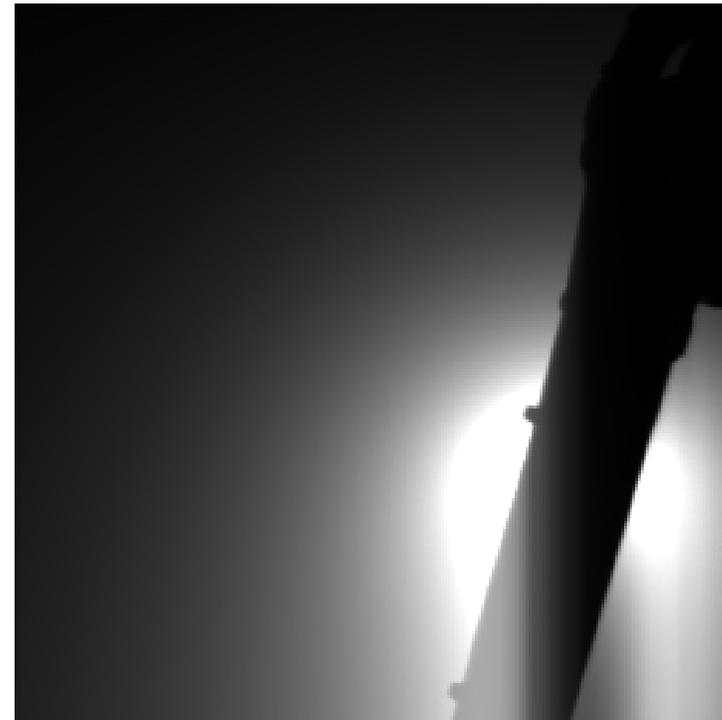
Frost On
Tell-Tale
Mirror



Polar
Projection



Sunrise



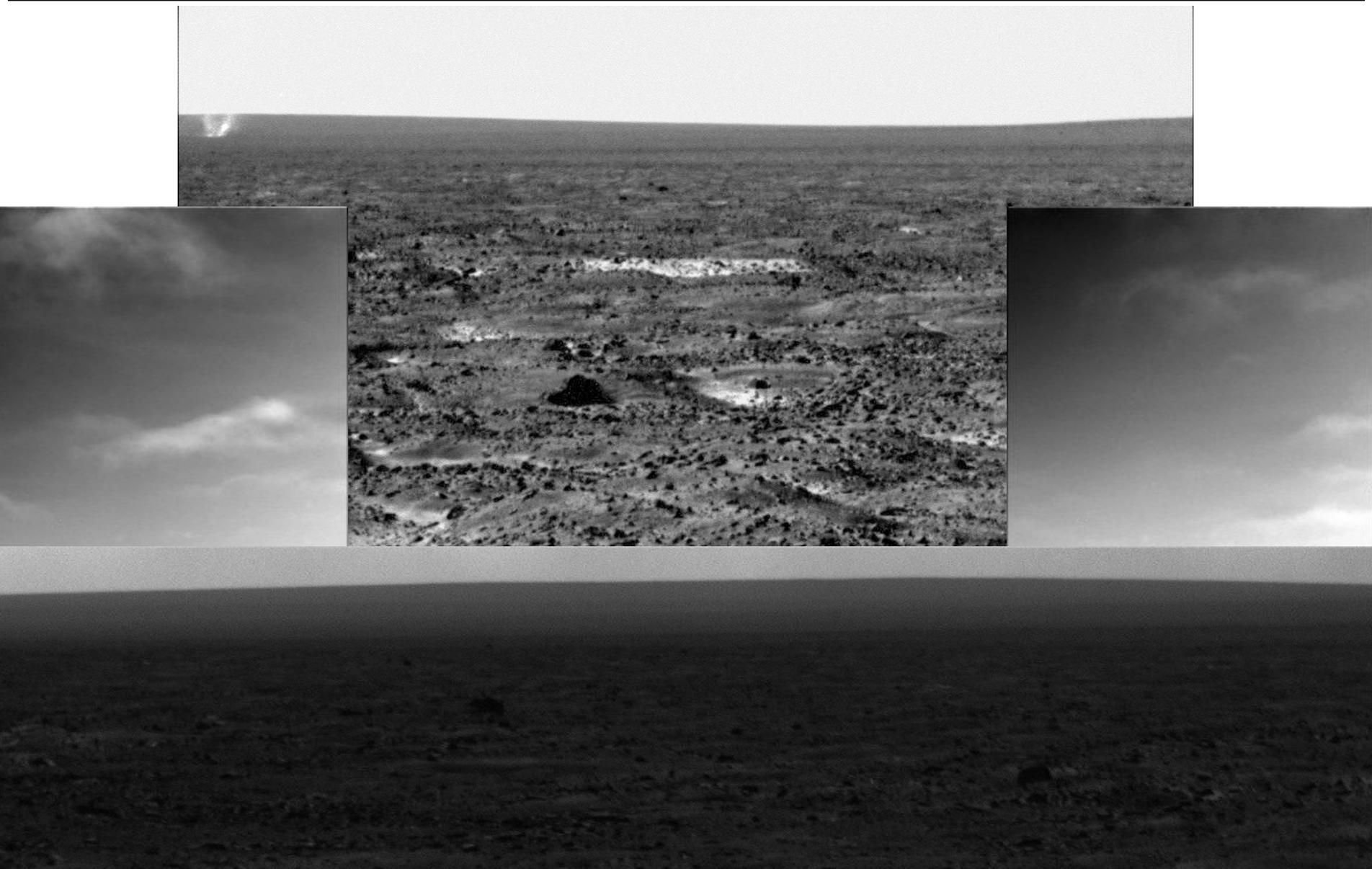
“RA Eclipse”

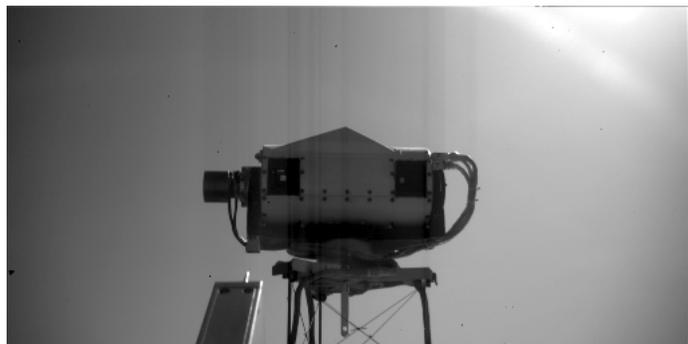


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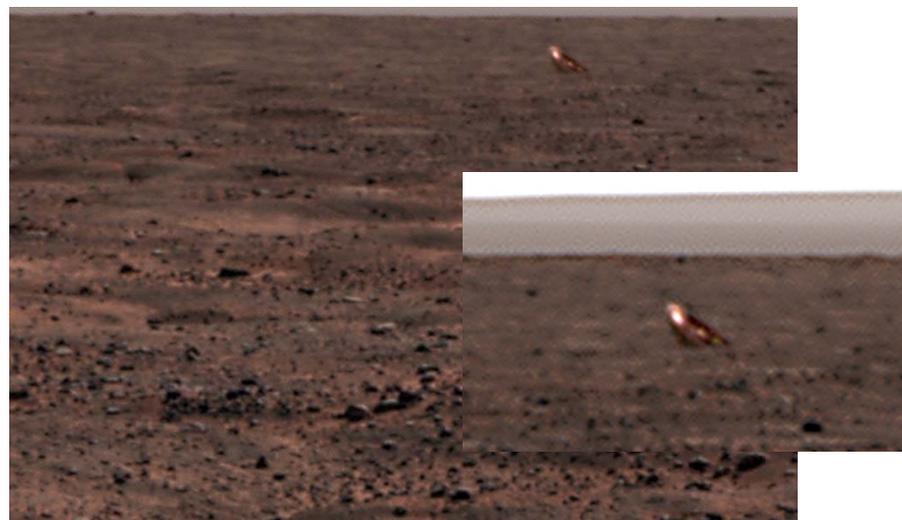


Sol-106/ Sol-109

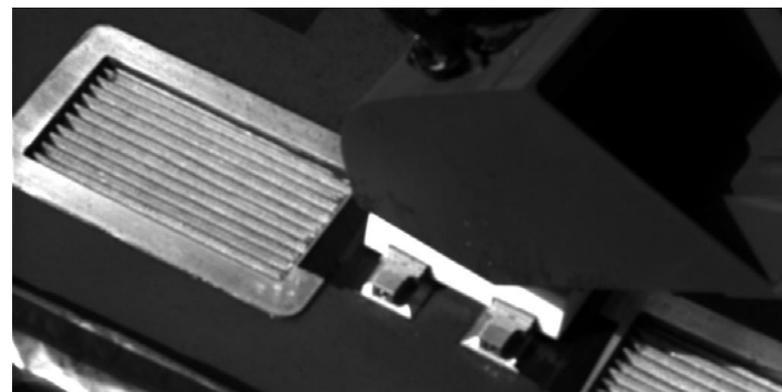
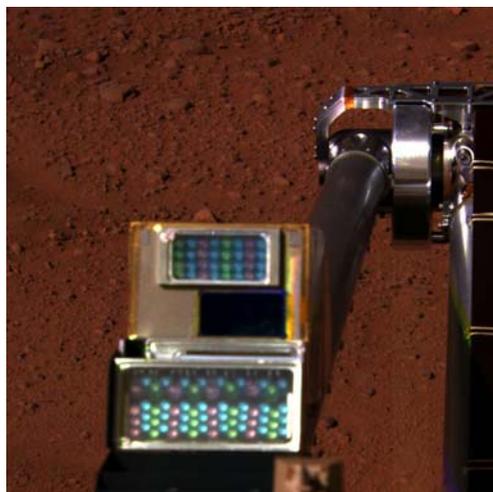




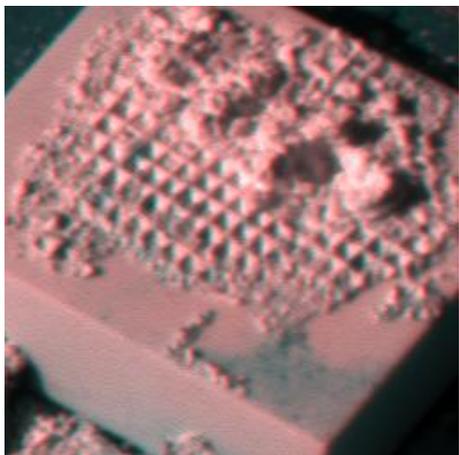
Camera's photo's
of each other



Backshell



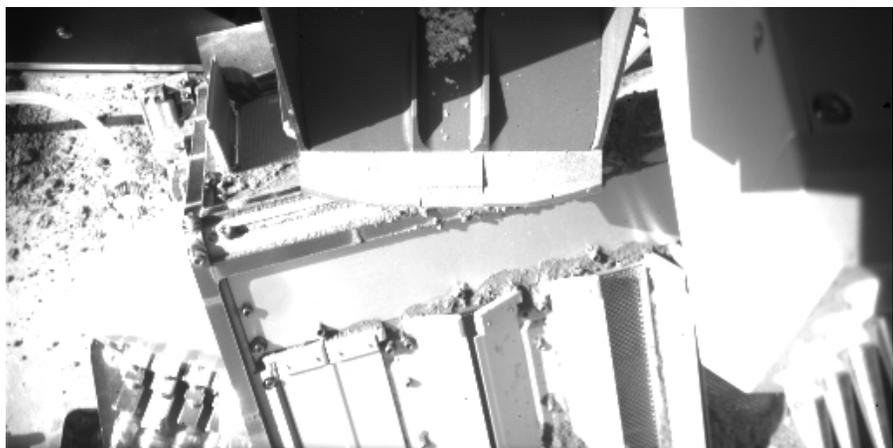
OFT Touch Test



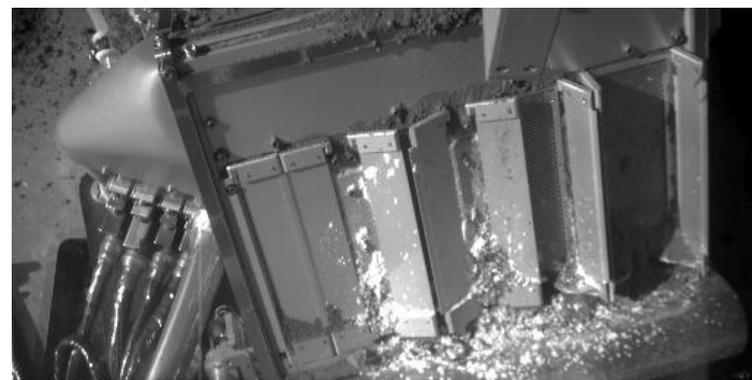
Organic Free Blank Post RASP



Organic Free Blank material in scoop



Wind blows material during delivery`



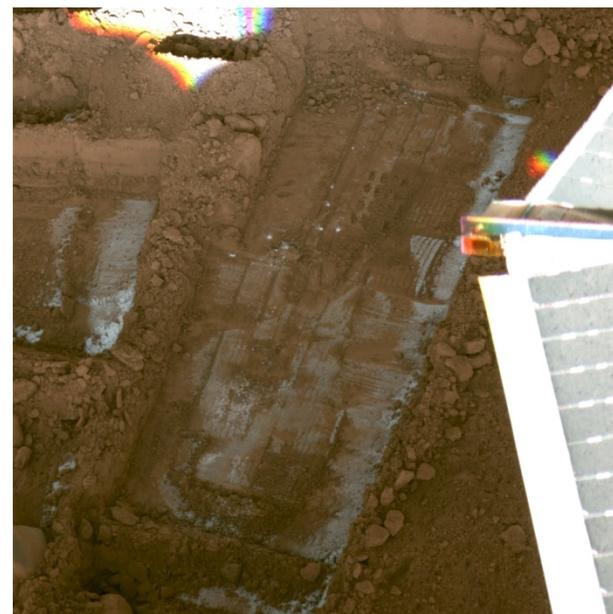
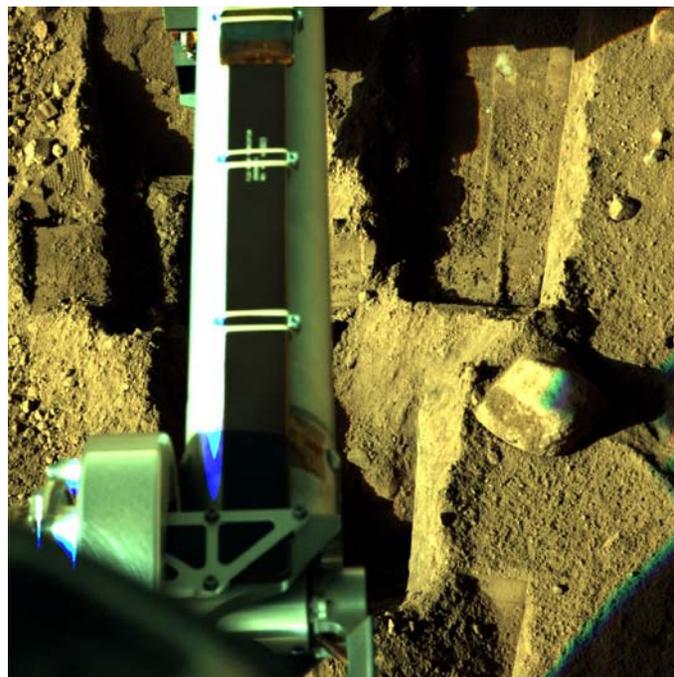
Residual on TEGA



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Phoenix

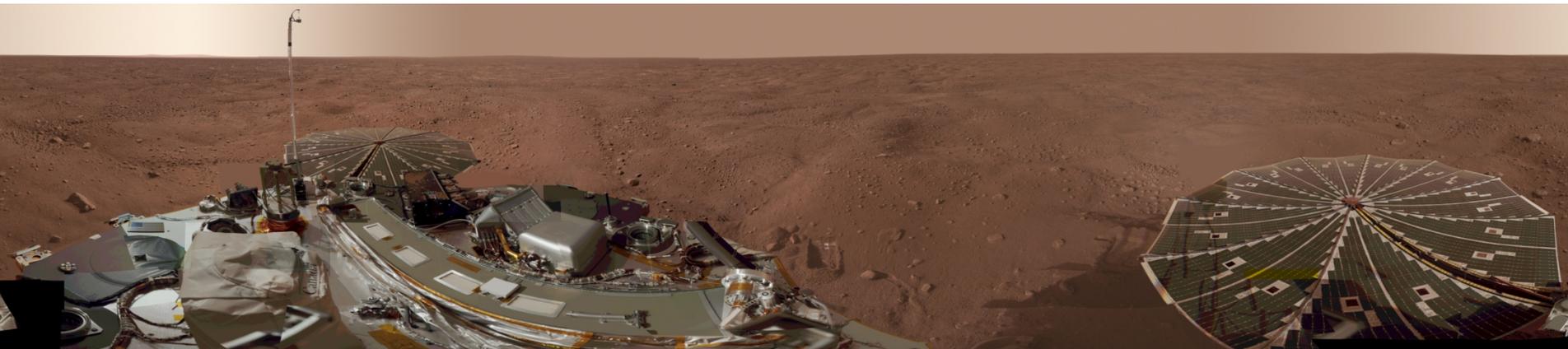
Sol-140



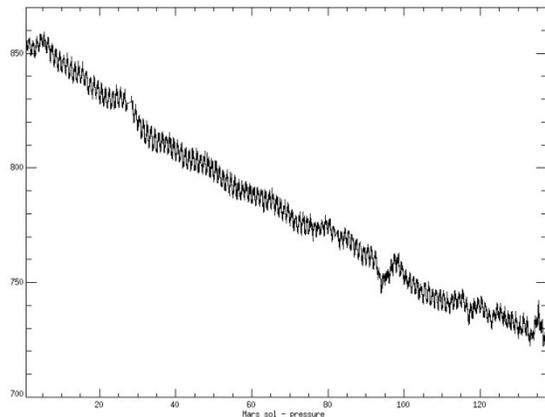


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Phoenix Favorites



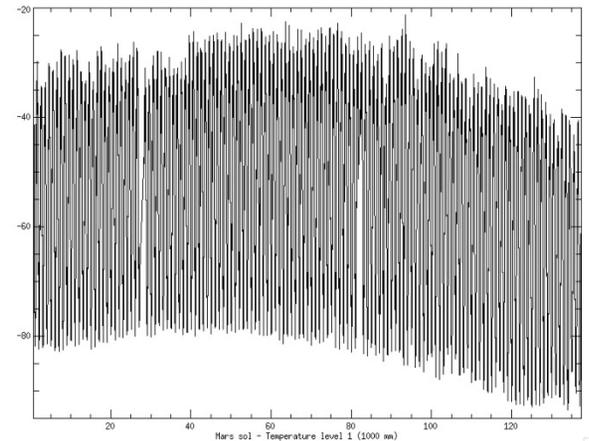
“Around Midnight”



All Sol Pressure

“Work-Space”

CO₂ Condensing in southern hemisphere seen as a consistent small decay in the daily atmospheric pressure.



All Sol Temperature