Instrumentation on the Phoenix Mission:

Unexpected Consequences

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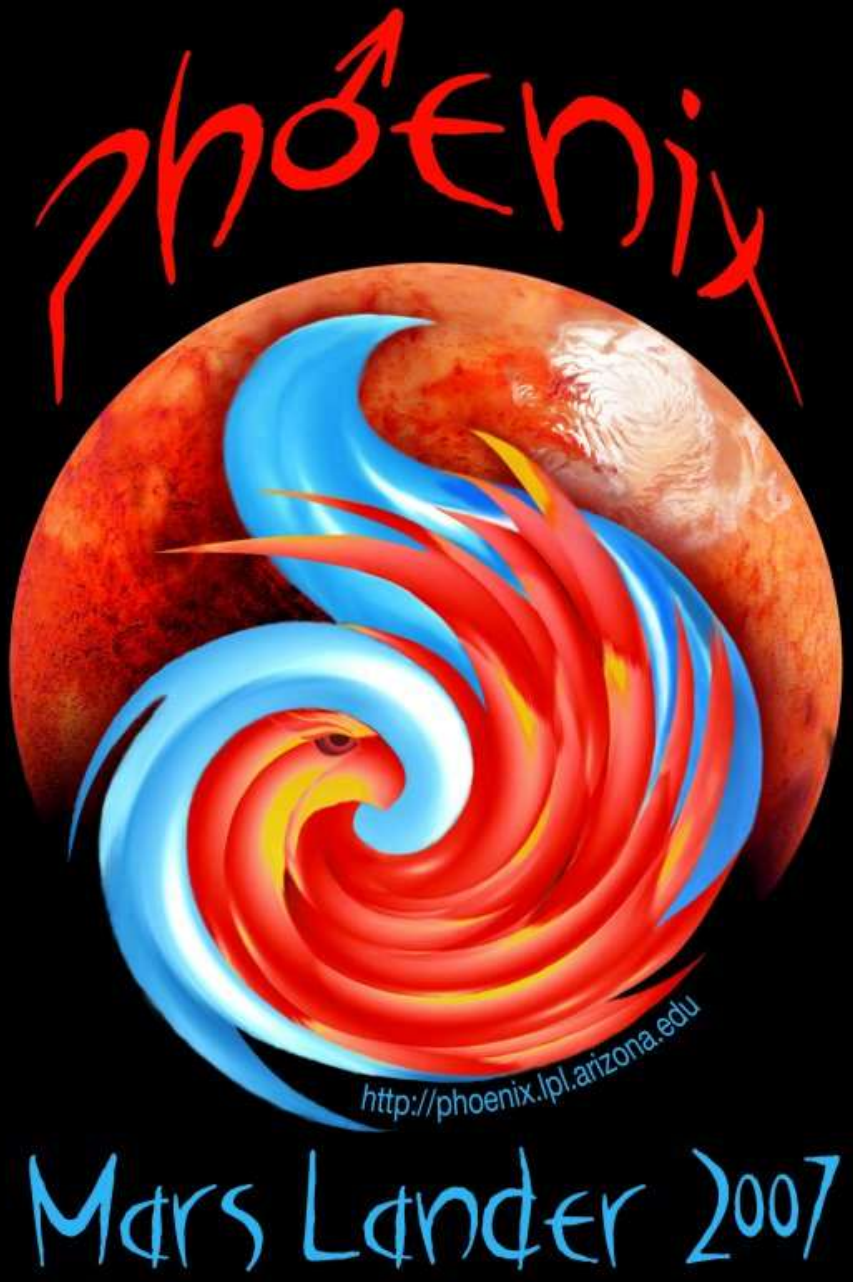

International Workshop on
Instrumentation for Planetary Missions
October, 2012

Surface Operations Team in Tucson

UA + JPL + Locheed Martin + CSA

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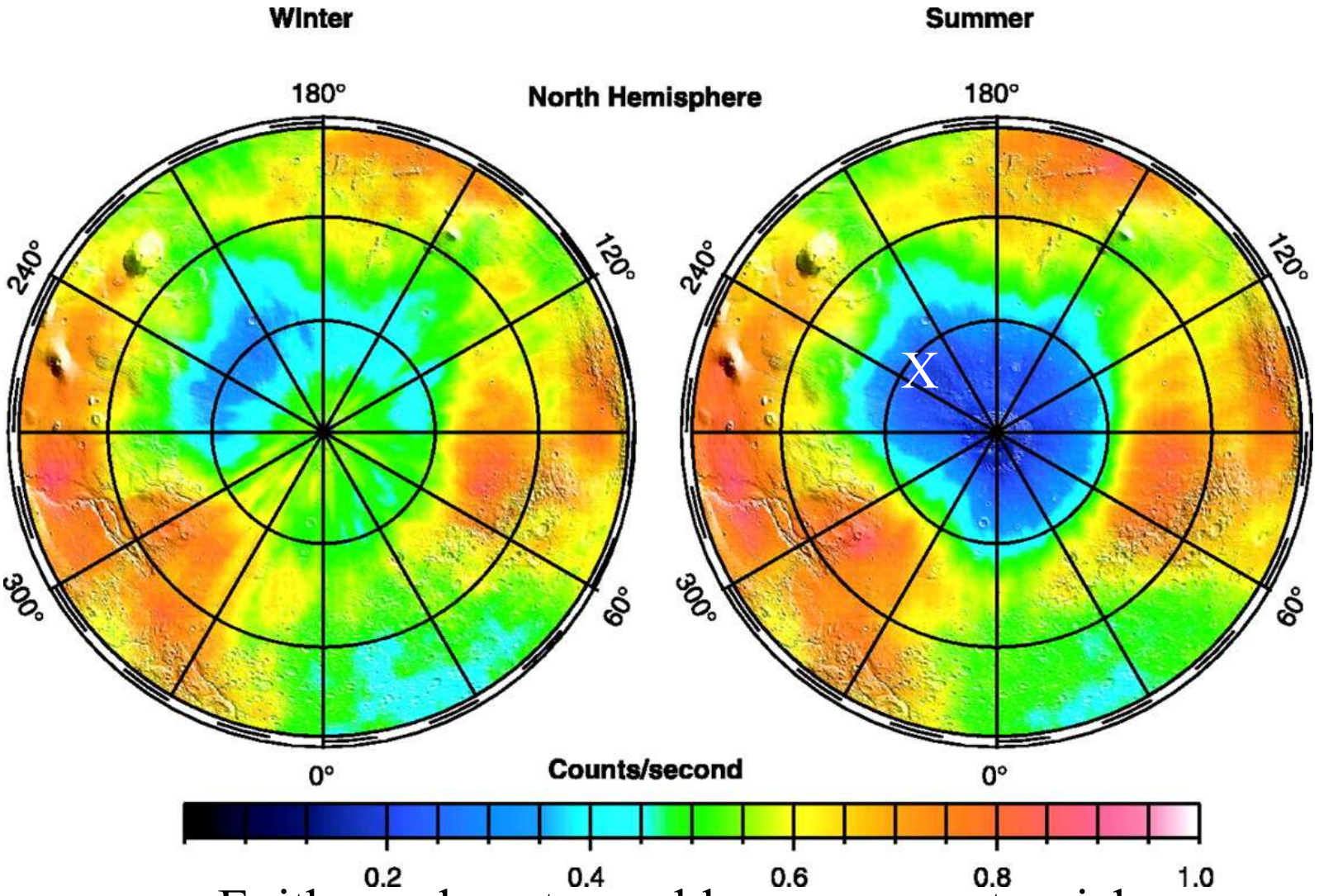
Launch August 4, 2007
USAF
ULA
DELTA

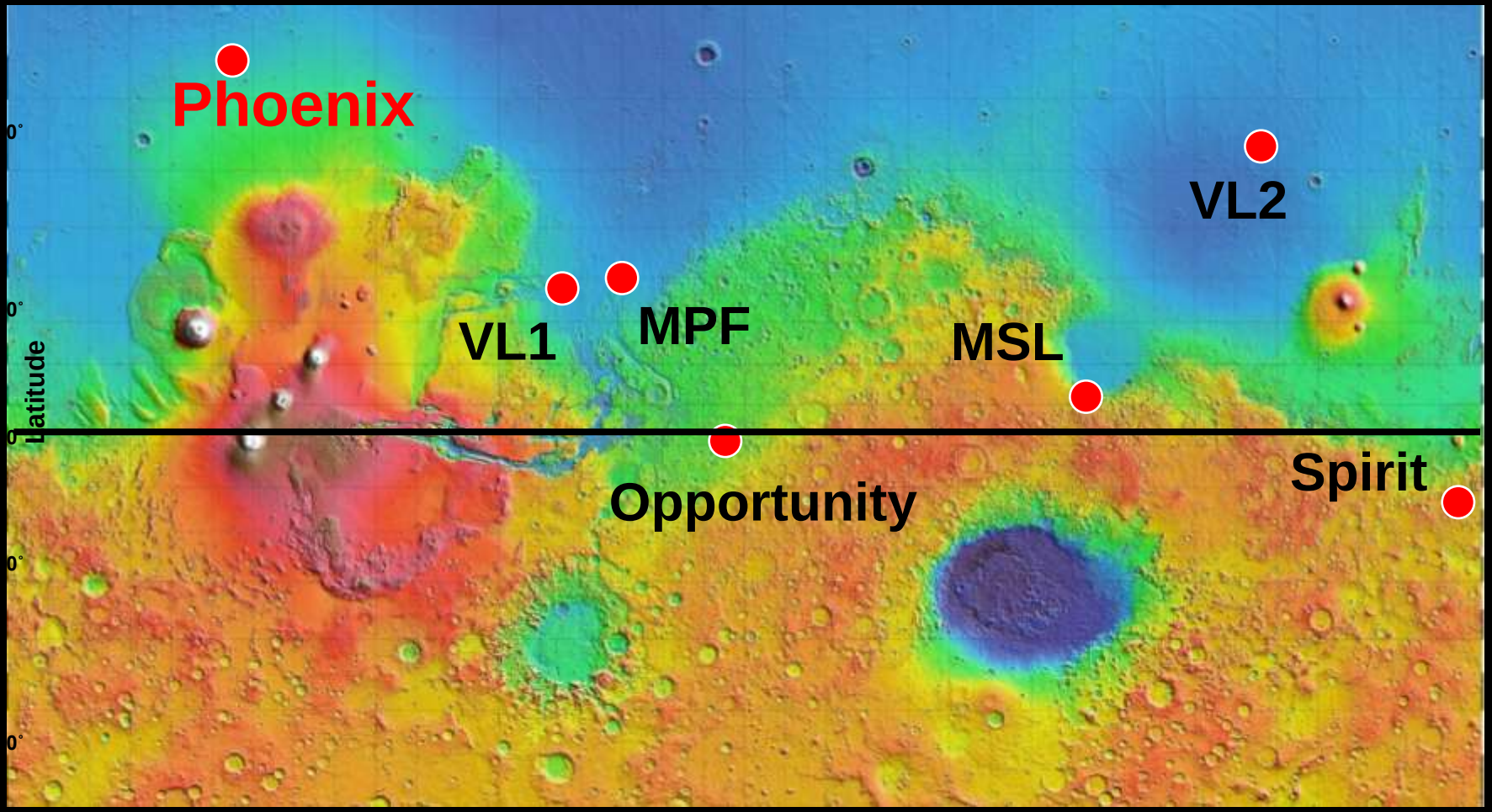
Science (June 27, 2003) Results from Odyssey



Epithermal neutrons: blue means water rich

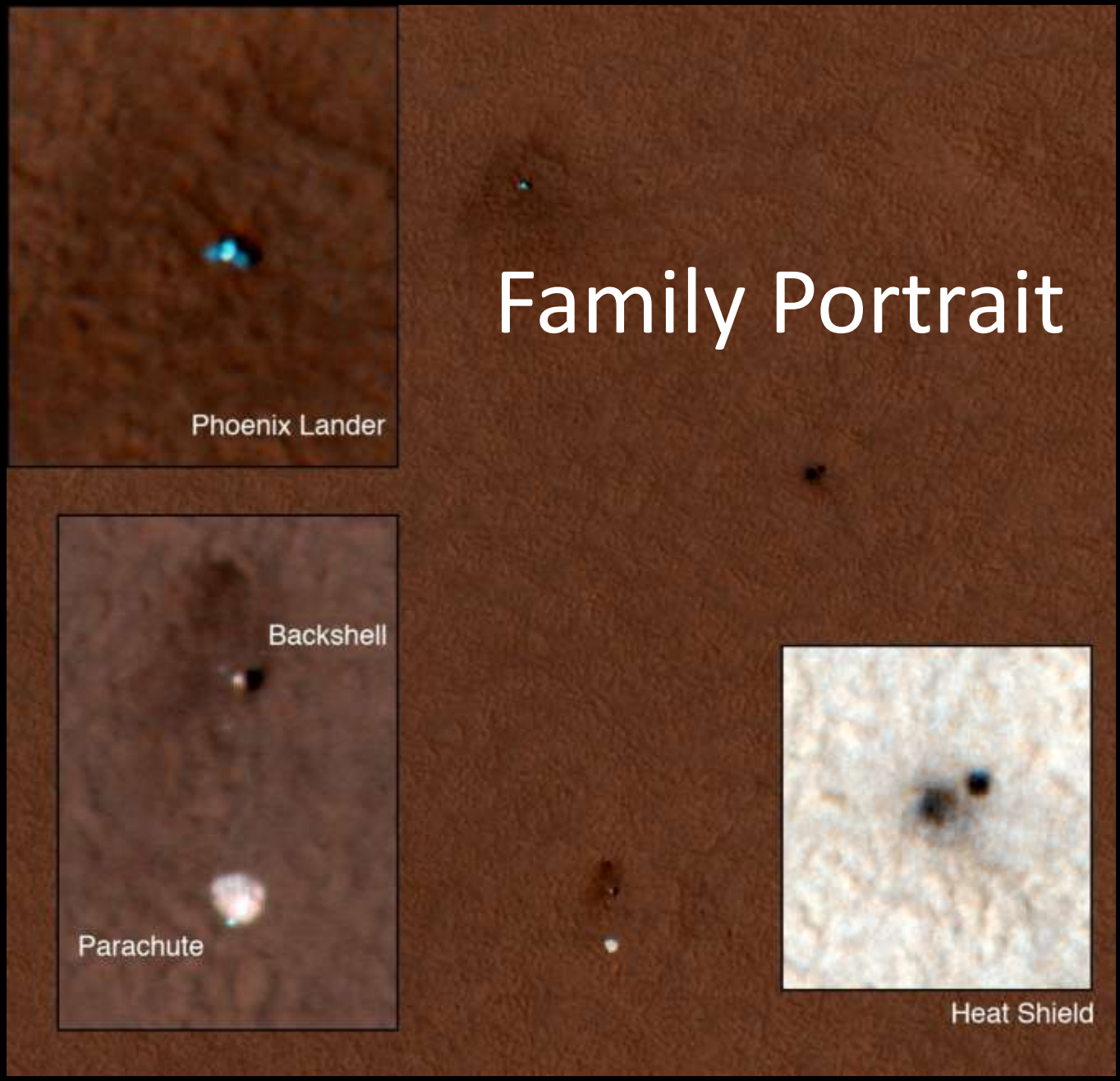

To: Peter and the Phoenix Team
Happy Holloween!!
From Alfred and the HiRISE Team

Phoenix Landing Site Is Farther North Relative to the Other Landers

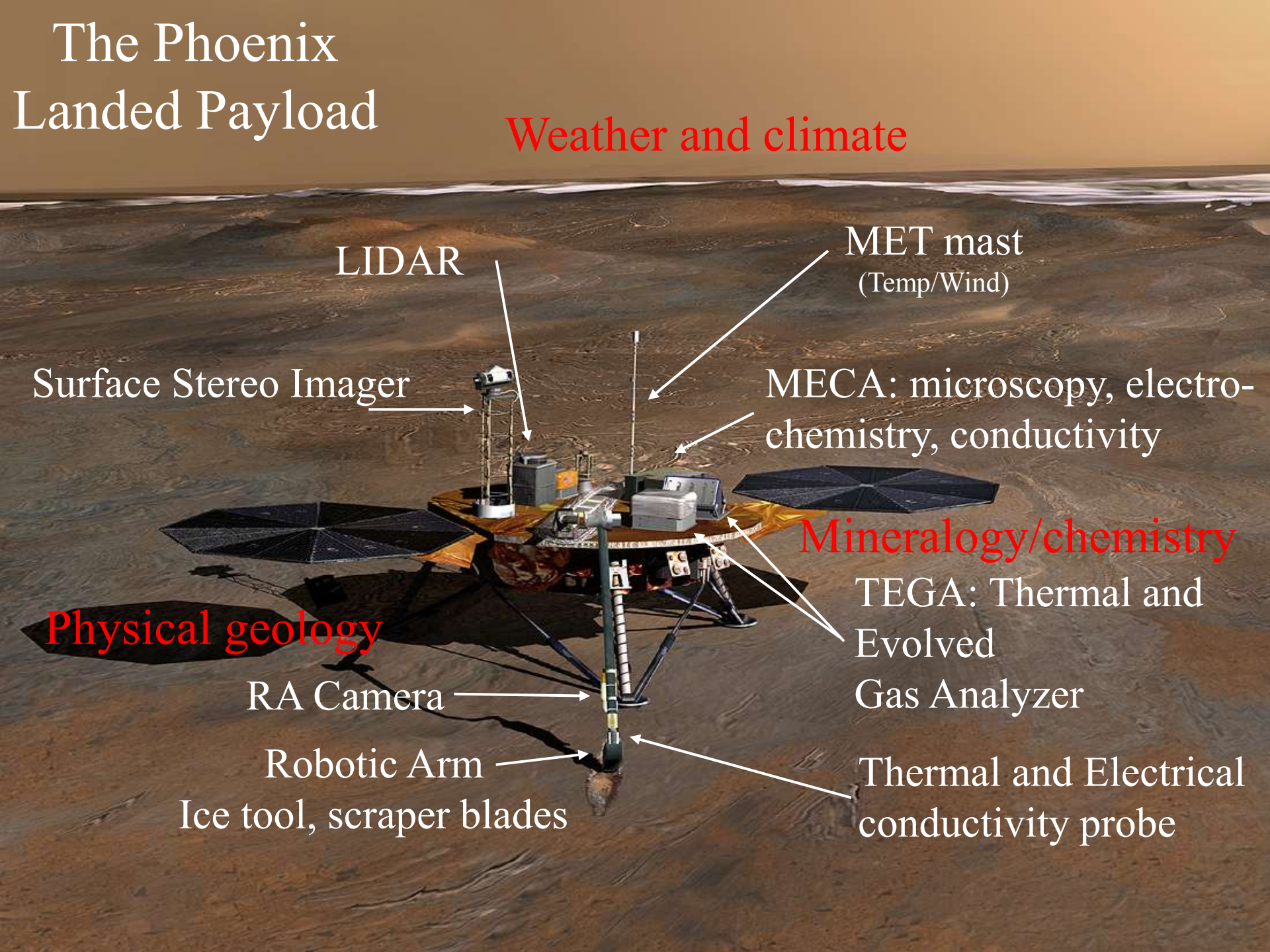


Phoenix: May 25, 2008

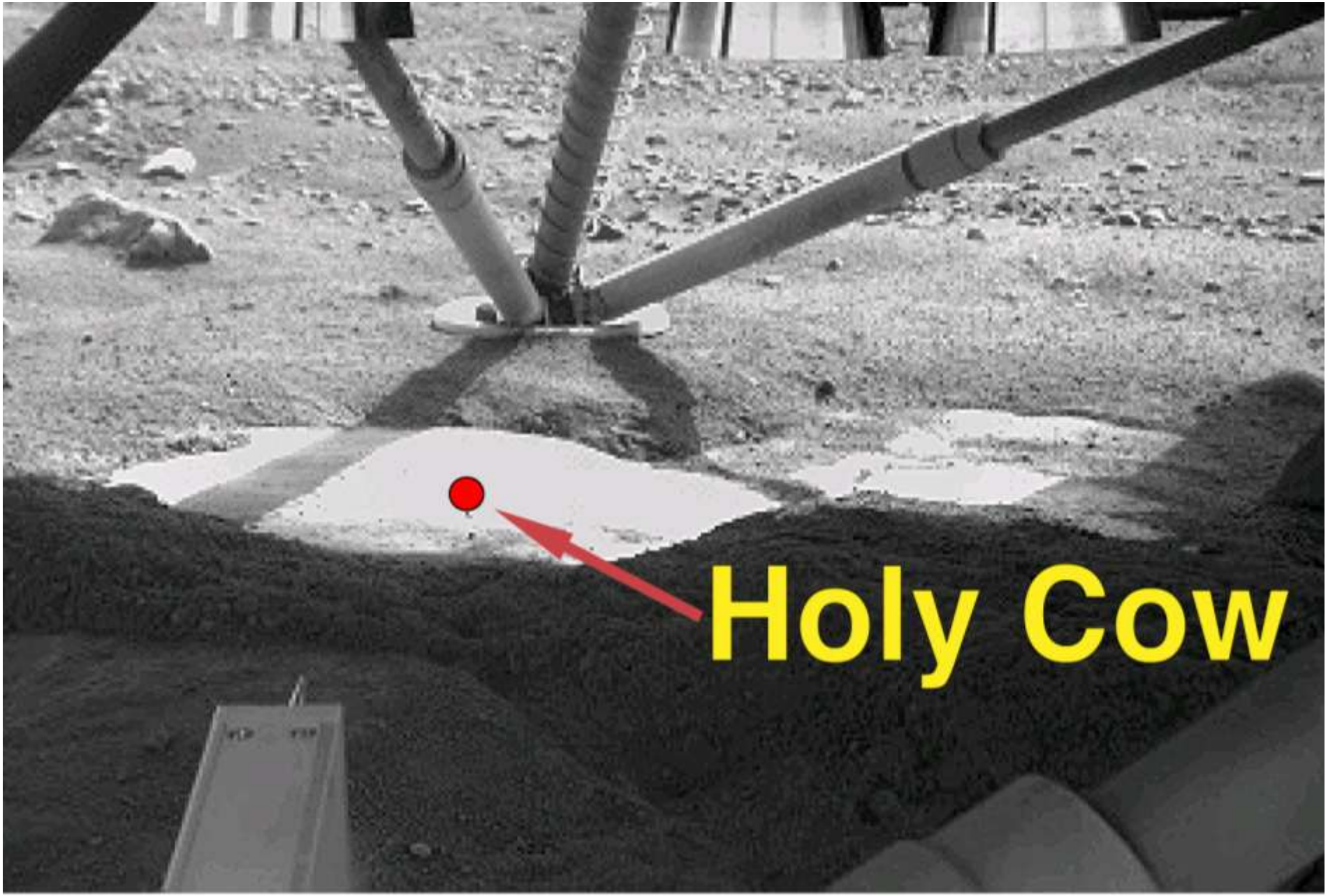
Family Portrait



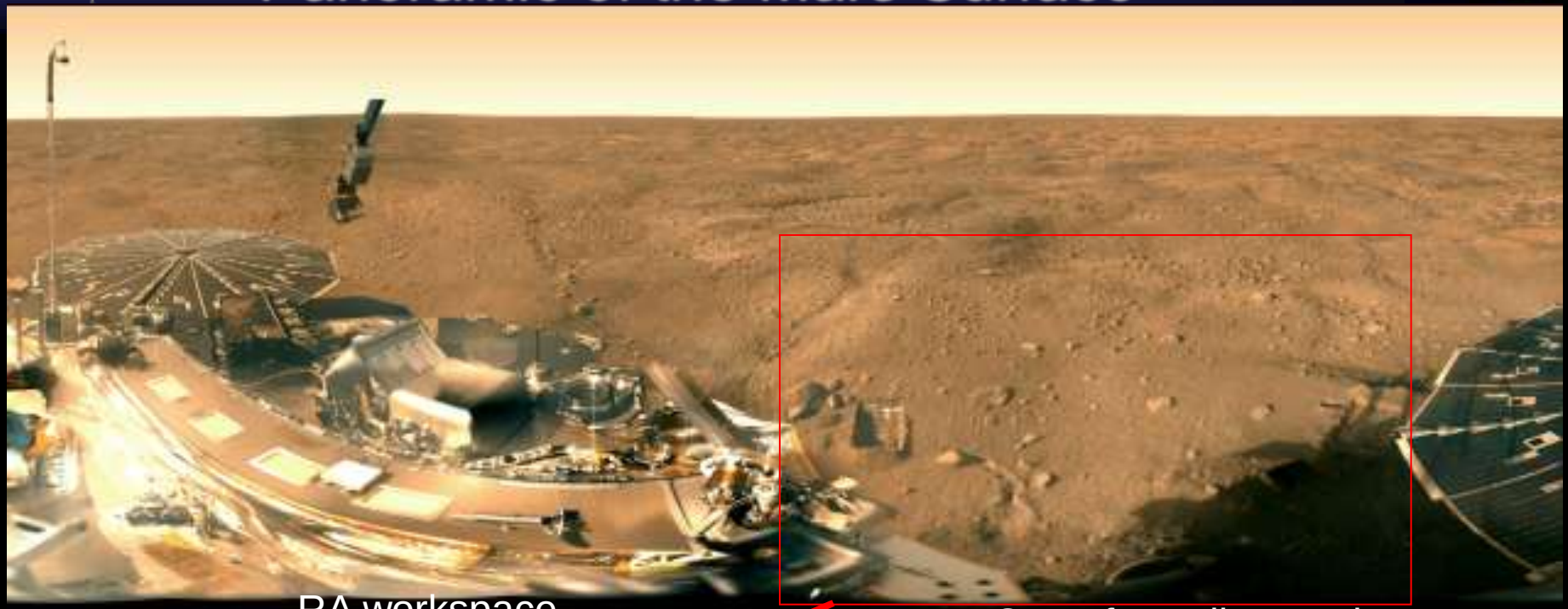
Payload On Lander


The Phoenix
Landed Payload
Weather and climate
LIDAR
MET mast
(Temp/Wind)
Surface Stereo Imager
MECA: microscopy, electro-
chemistry, conductivity
Mineralogy/chemistry
TEGA: Thermal and
Evolved
Gas Analyzer
Physical geology
RA Camera
Robotic Arm
Ice tool, scraper blades
Thermal and Electrical
conductivity probe

“Holy Cow”—Ice Exposed by Thrusters Under Lander

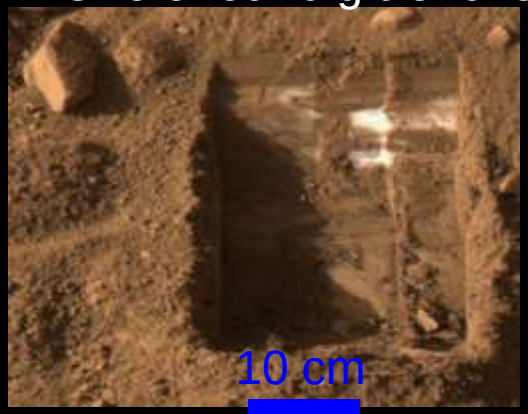


Panoramic of the Mars Surface



RA workspace

One of our dig trenches



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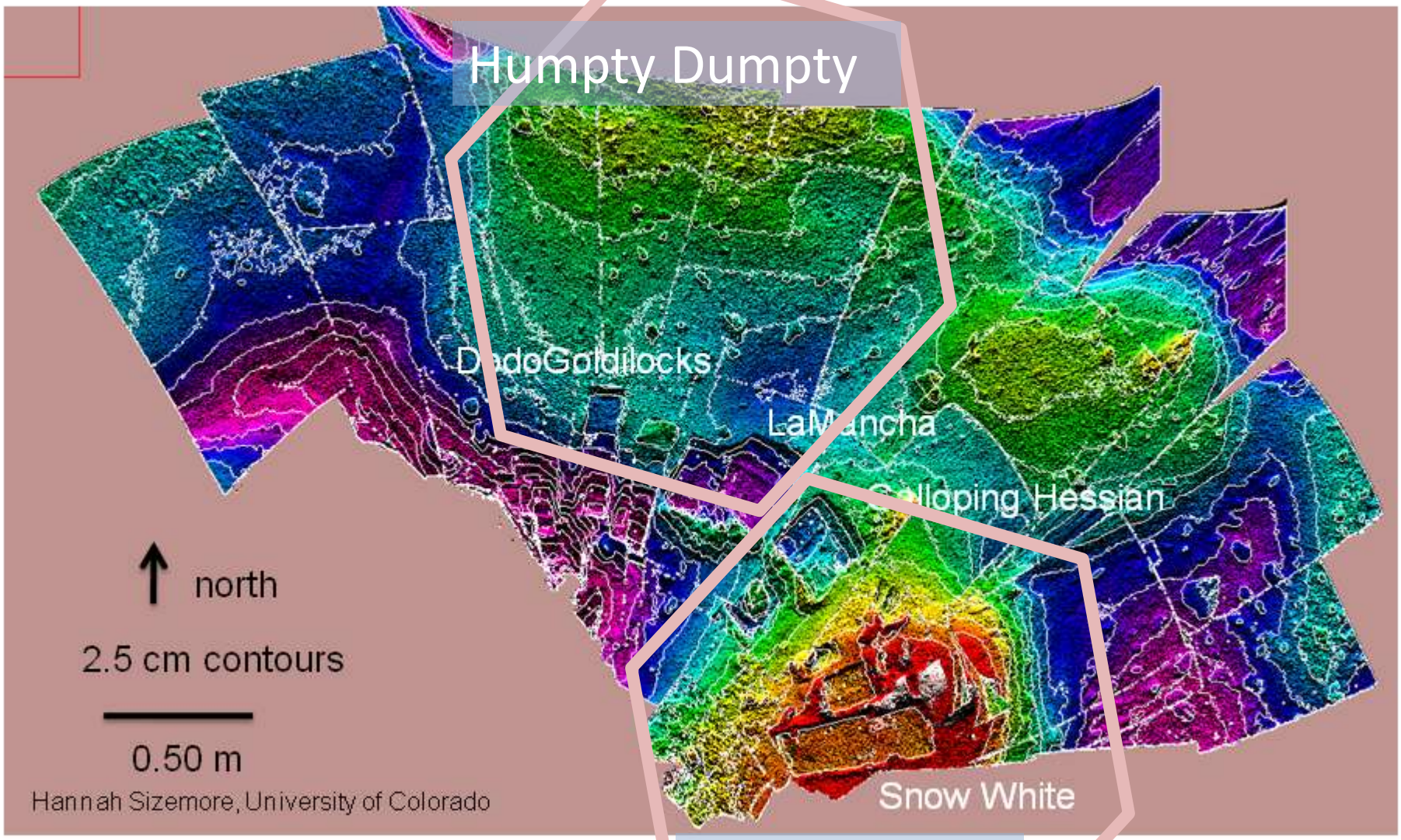
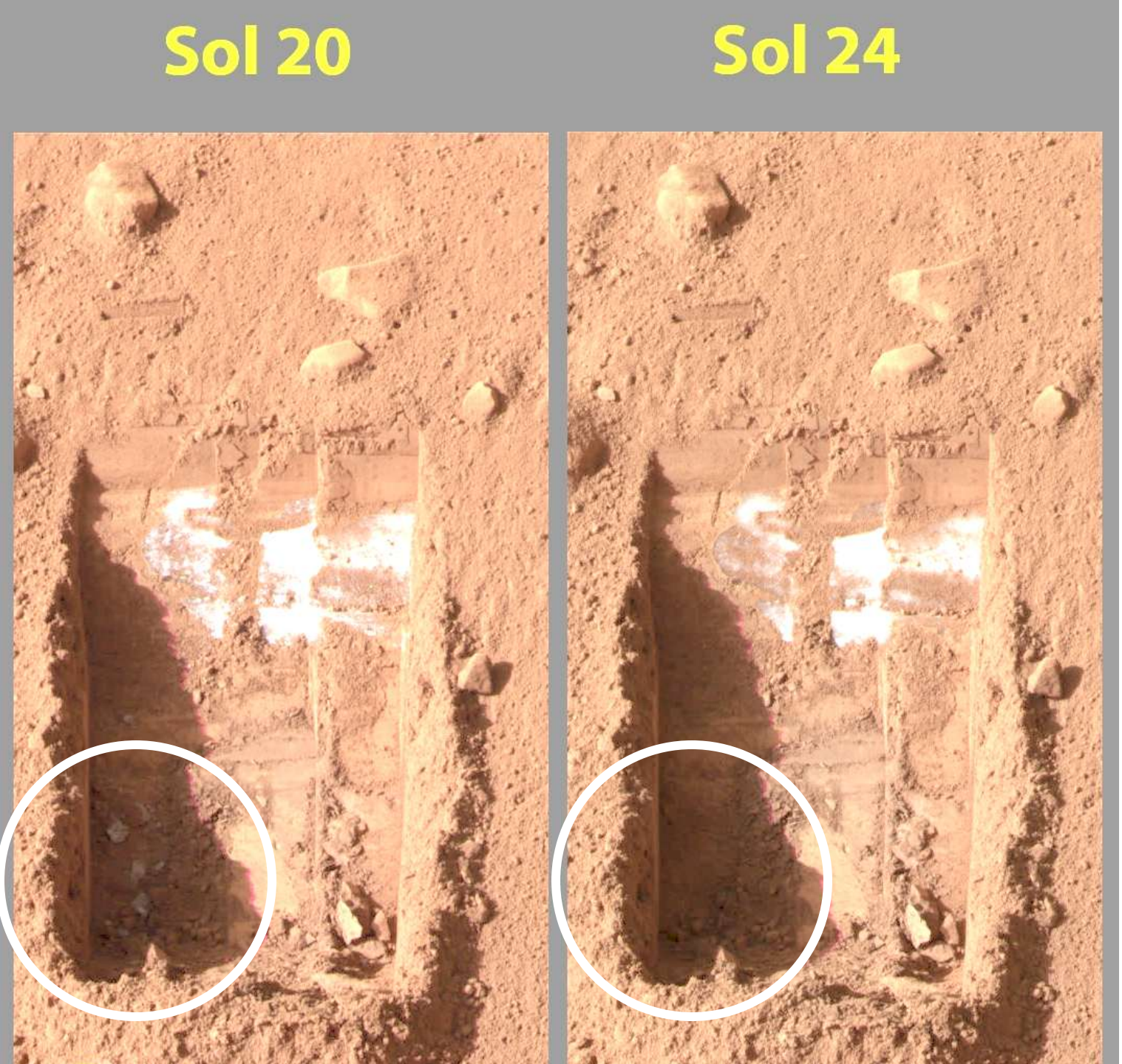
Topographic Map of Polygons and Robotic Arm Work Space





Ice
Chunks
Sublime

Headless Before/After Dragging

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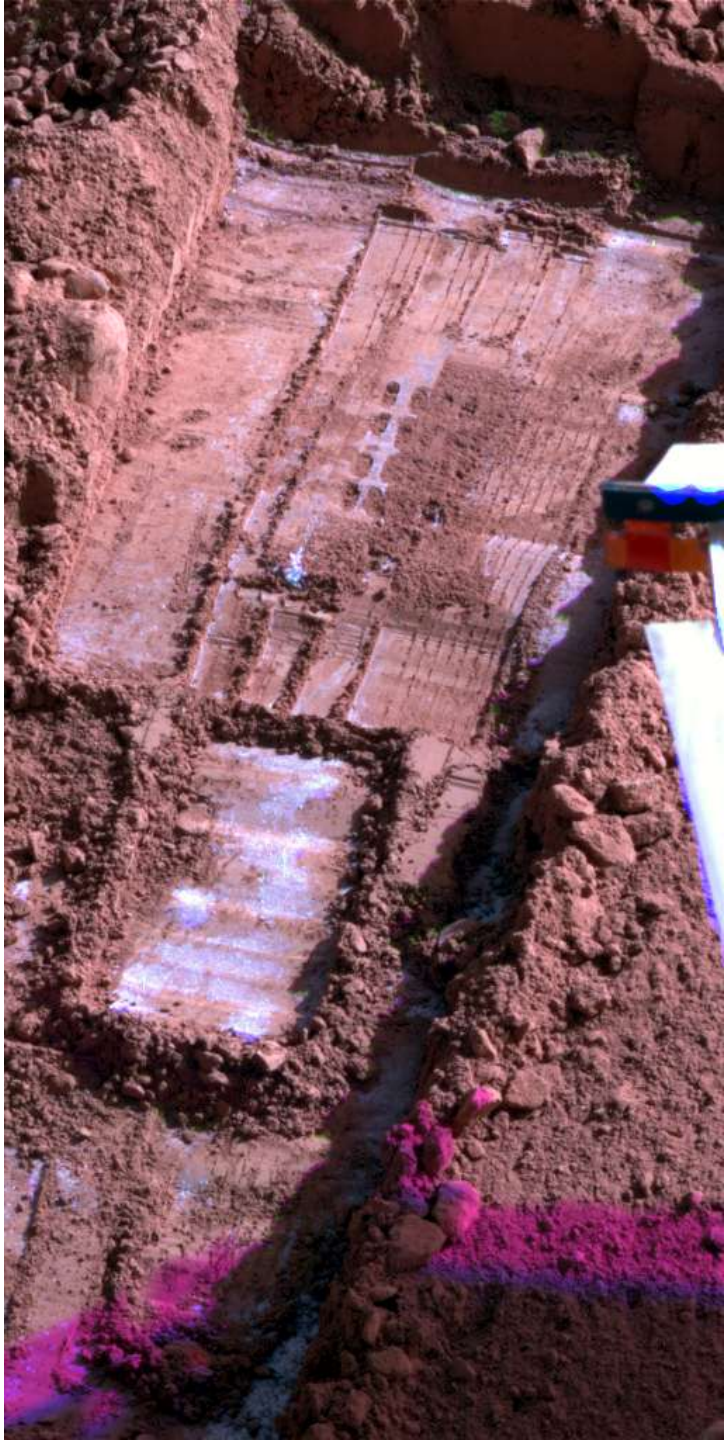
Ice Properties

- Polygons 2-3 m in size implying a soil-ice mixture
  - Form by thermal contraction
  - Currently active
- Hard ice layer 5-15 cm beneath the surface
  - Deeper in troughs
  - Validates orbital measurements and interpretations
  - Validates vapor diffusion models
    - Give confidence to models of the entire polar region
  - Rocks depress the ice table as predicted



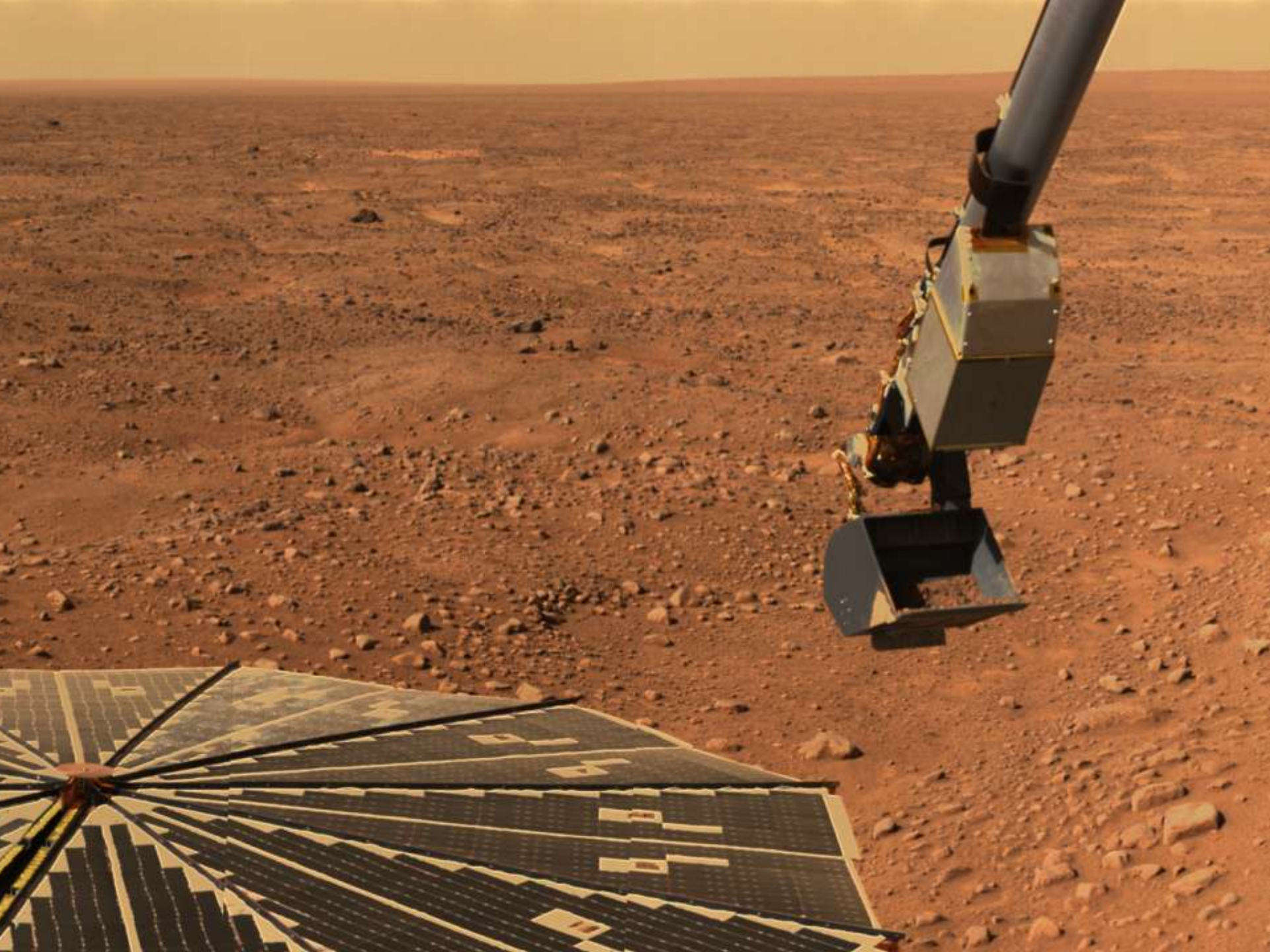
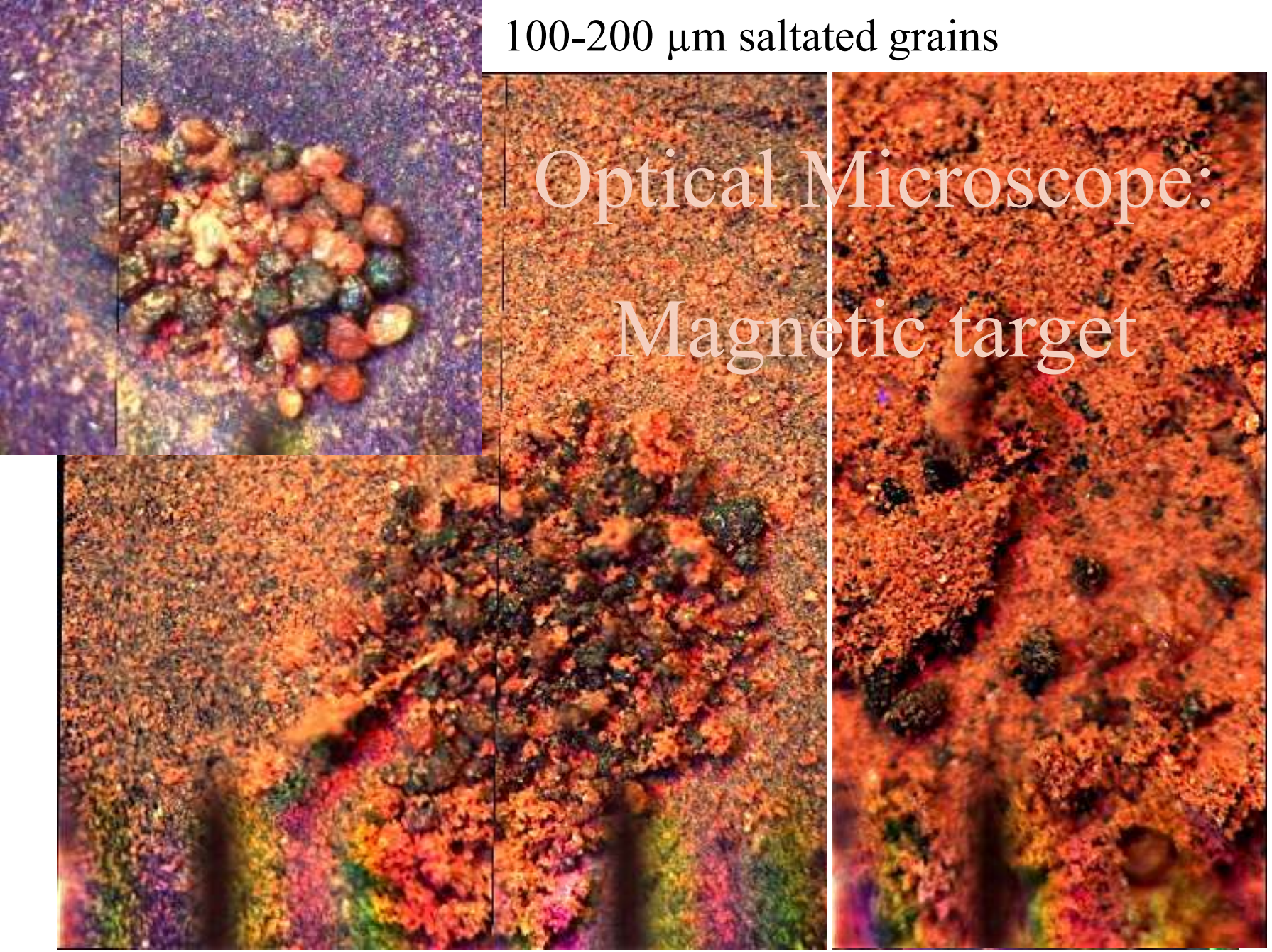


Image of Scoop
Notice Icy Soil (very lumpy)

Partially Open Doors and Sticky Soil Force a 4 Day Delay for the first TEGA Sample


100-200 μm saltated grains
Optical Microscope:
Magnetic target
Silt/Clay-sized material, very sticky

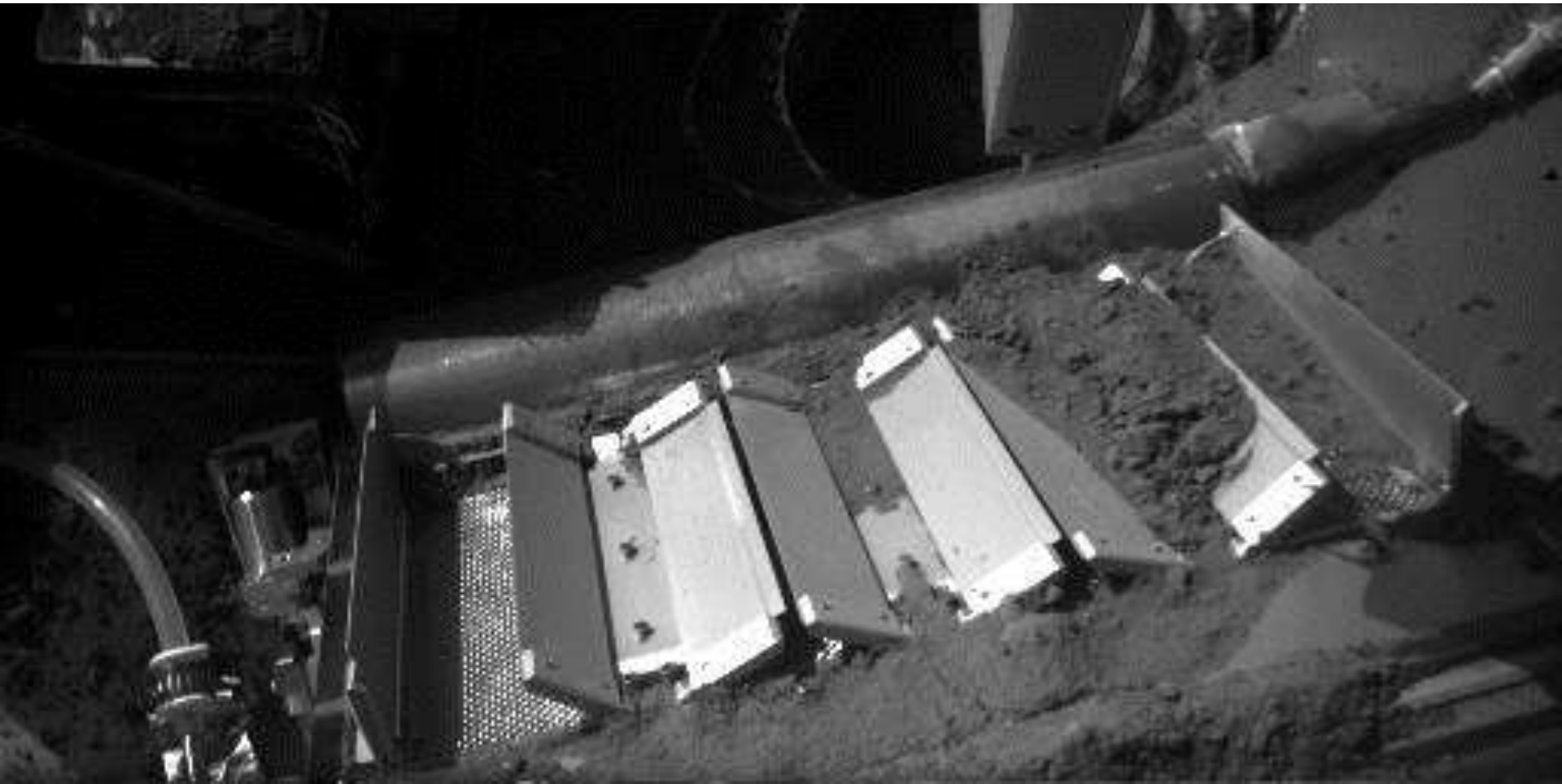
TEGA Struggled to Fill its Ovens

Identified ice at bottom of Snow White

Sulfates not identified

5% Ca-carbonate

Other aqueous minerals



More Frustration

- Organic-free blank
  - Glassy material that was heated to high temperatures
  - Protected throughout cruise inside the robotic arm biobarrier
- Sample obtained by rasping pieces inside the scoop
- Sample lost during final delivery by a gust of wind

MECA Wet Chemistry

pH = 7.7 ±0.5, alkaline and controlled by Ca-carbonate

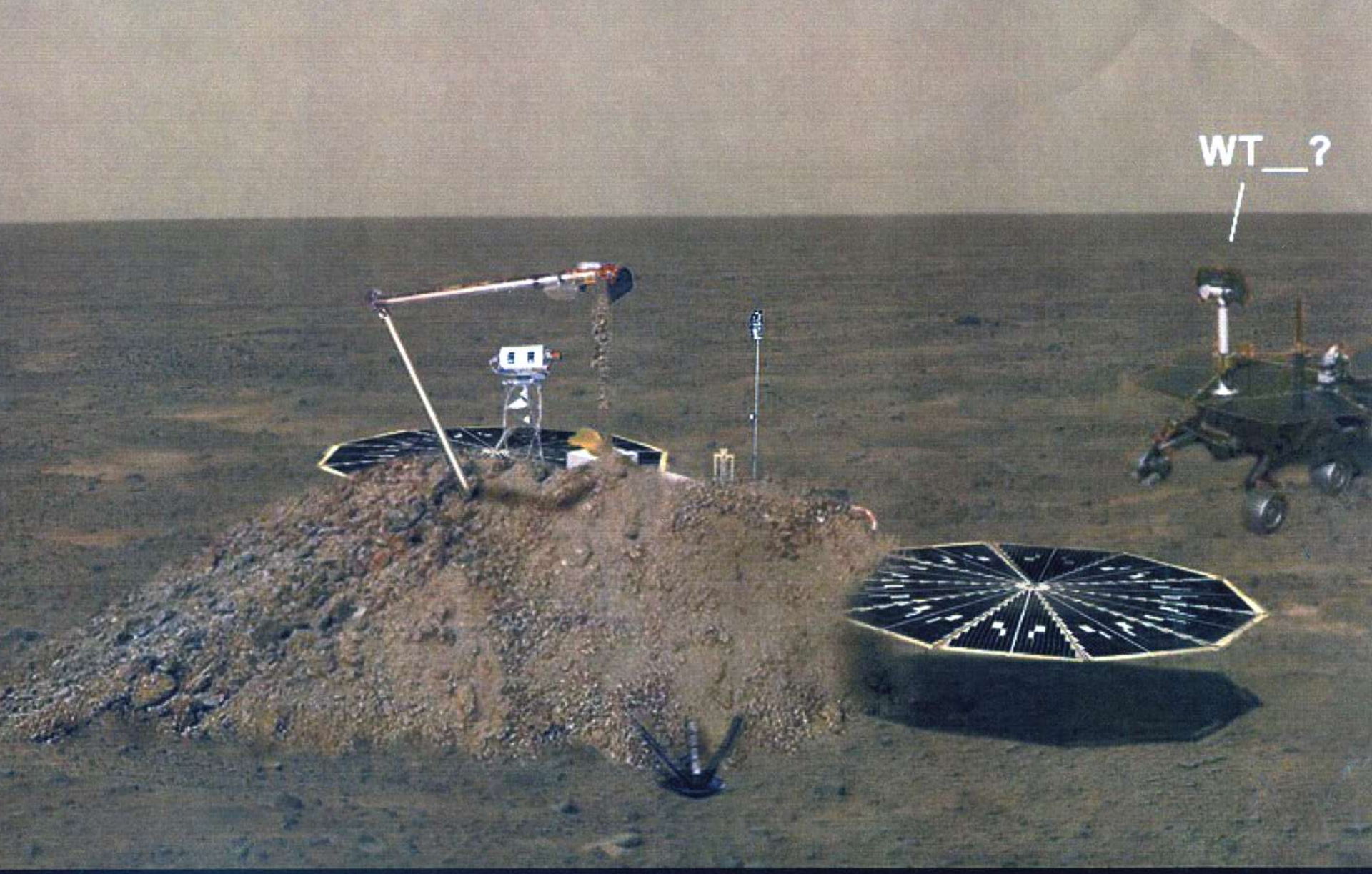
0.5% perchlorate, probably Mg perchlorate

Tiny amount of salts: K, Cl, Na

MECA Serindipity

- Of all the Ion Specific Detectors only one could detect nitrates
- By chance, it was even more sensitive to perchlorates altho no one thought for a moment that they would exist on Mars
- The failure of the 4^{th} wet chemistry cell to receive its sample due to the clumpy soil factor gave us a useful empty cell calibration

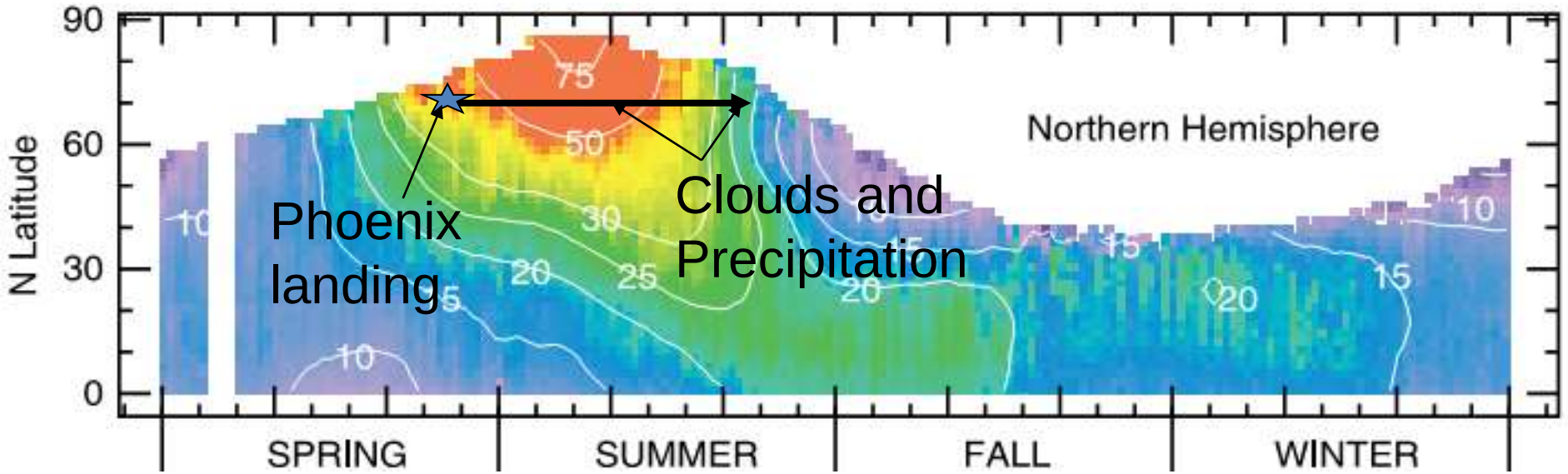
Later in the Mission the Lander was Cluttered with Samples that had Missed their intended Targets

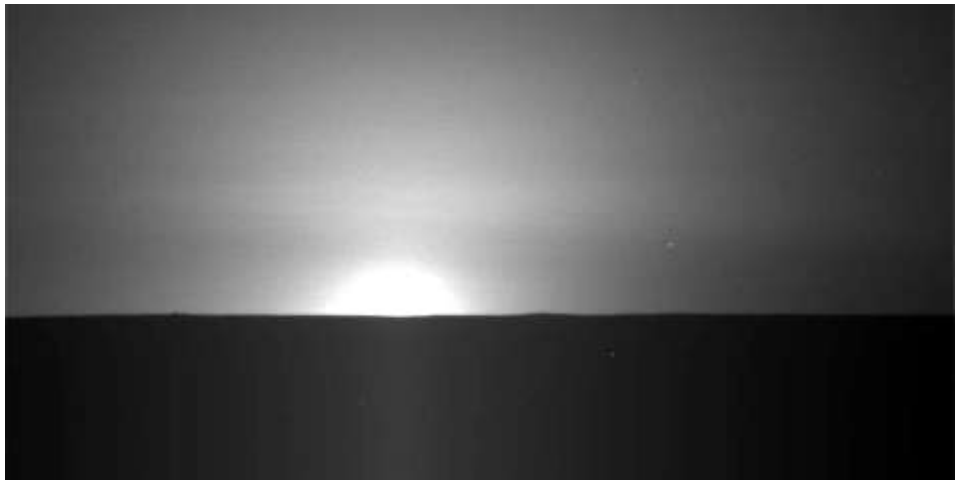


Phoenix attempts another sample delivery!

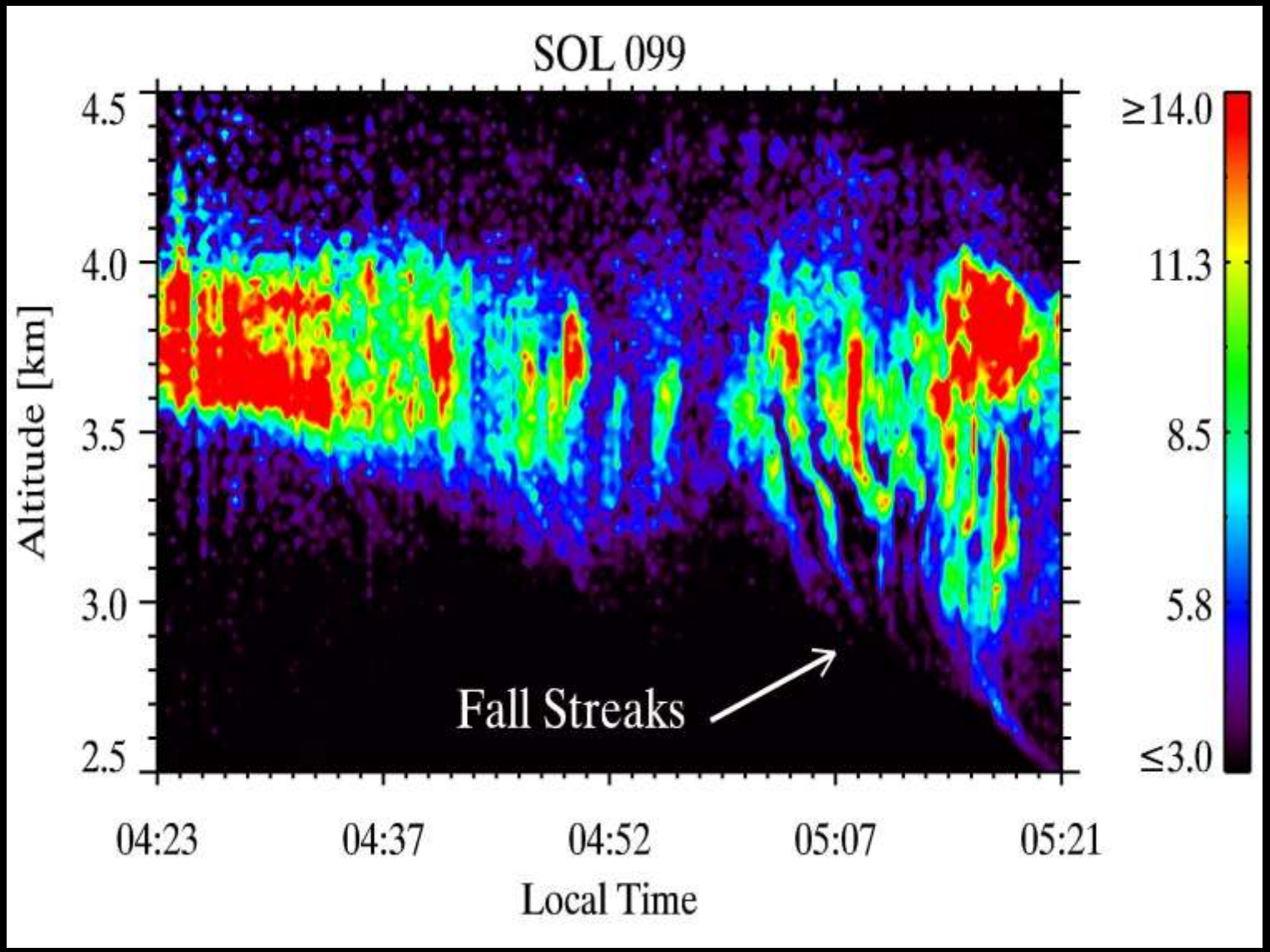
Mid- to Late-Summer Weather
Mission Timed to Maximum Water Vapor

Water Vapor (pr-μm), Smith et al., TES data



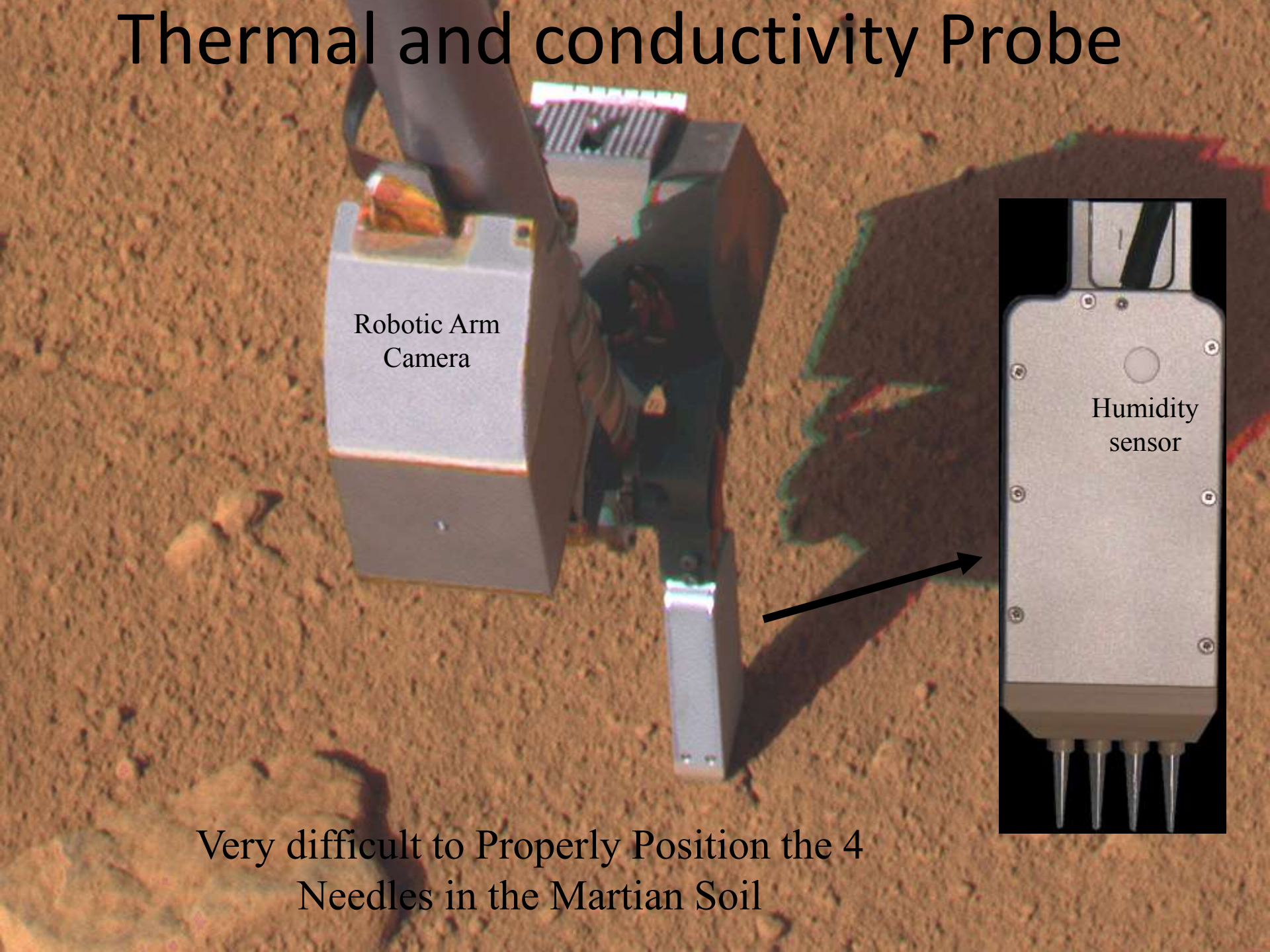


But the first hints of Snow Came after the Primary Mission




Fall Streaks
http://australiasevereweather.com/

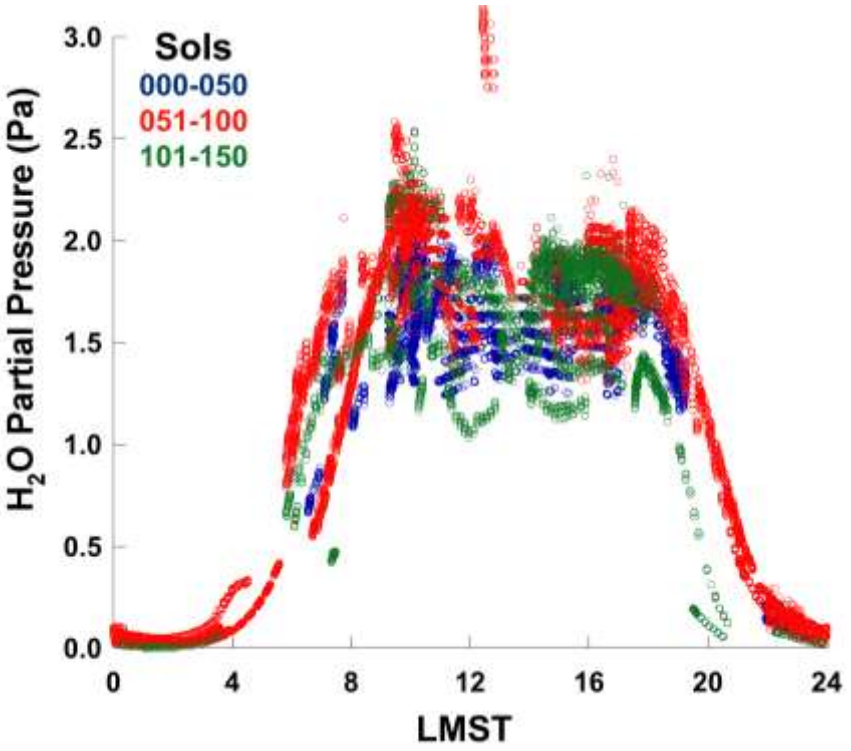
Thermal and conductivity Probe

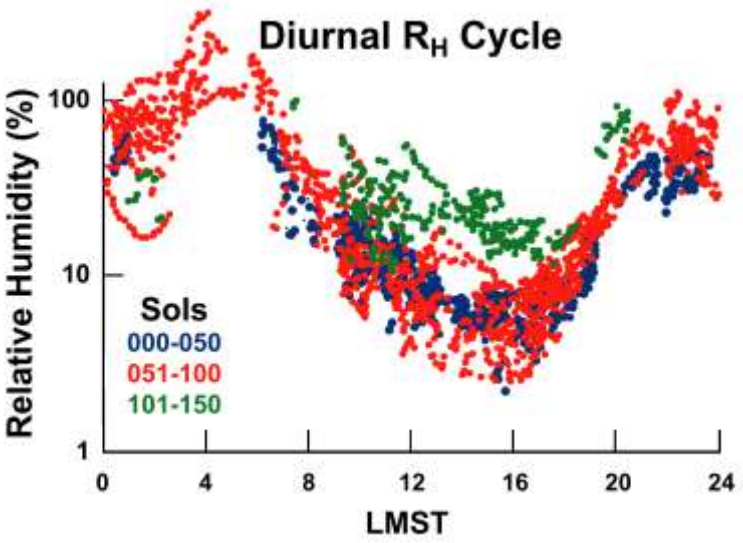


Very difficult to Properly Position the 4 Needles in the Martian Soil

Humidity

- Partial pressure of H_20 about 1.8 Pa during the day
- Drops to nearly zero at night as the atmosphere cools and releases its water vapor into the soil
- Daytime RH peaks at 15%, saturates at night





Conclusions

- Do not pretend that you know what conditions that you will encounter
  - Don't believe all the reasonable operational plans that convinced proposal reviewers that you are prepared for your mission
  - Phoenix practiced with a range of soil types, none of which had any resemblance to the soil that we dug into
  - It was only by chance that we were able to discover perchlorates
- OSIRIS-Rex is preparing to touch an asteroid later this decade and gather a sample in the process
  - What sort of surface will they encounter??
  - Are there safe areas for sampling?
  - I encourage them to prepare for the worst and not assume that each phase of the mission will be as planned in Phase B
- On the other hand, it is vital to prepare for resounding success! That is why we devote ourselves to missions of exploration

The Phoenix Mission:

Entered “Sleeping Beauty” mode
on Nov. 2, 2008