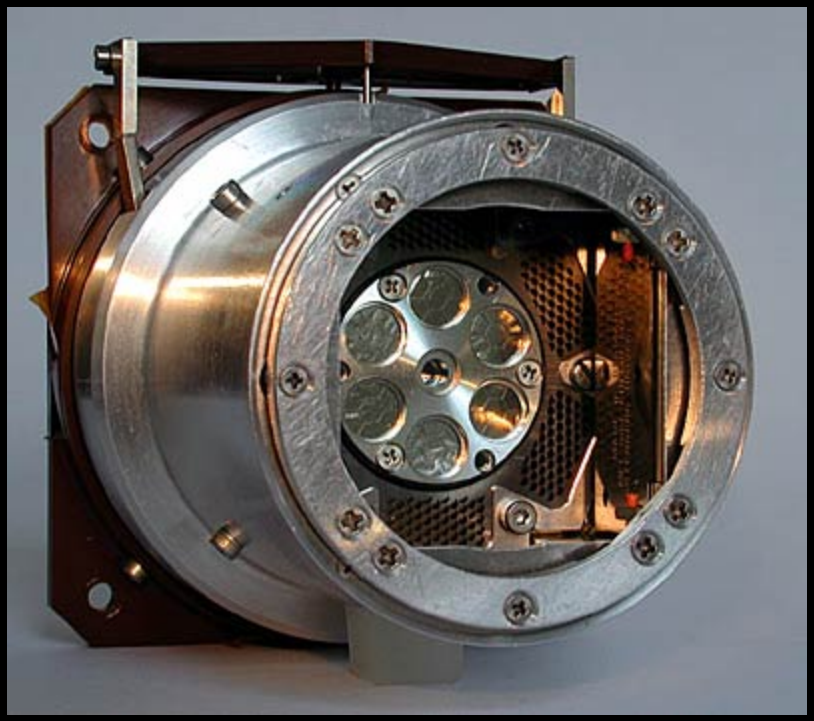

Curiosity on
Mars 2013
NASA


APXS Installation July 2011
Kennedy Space Center



APXS

Alpha Particle X-Ray Spectrometer

Curium 244 – Alpha Source / Plutonium 240 Decay Gamma Source

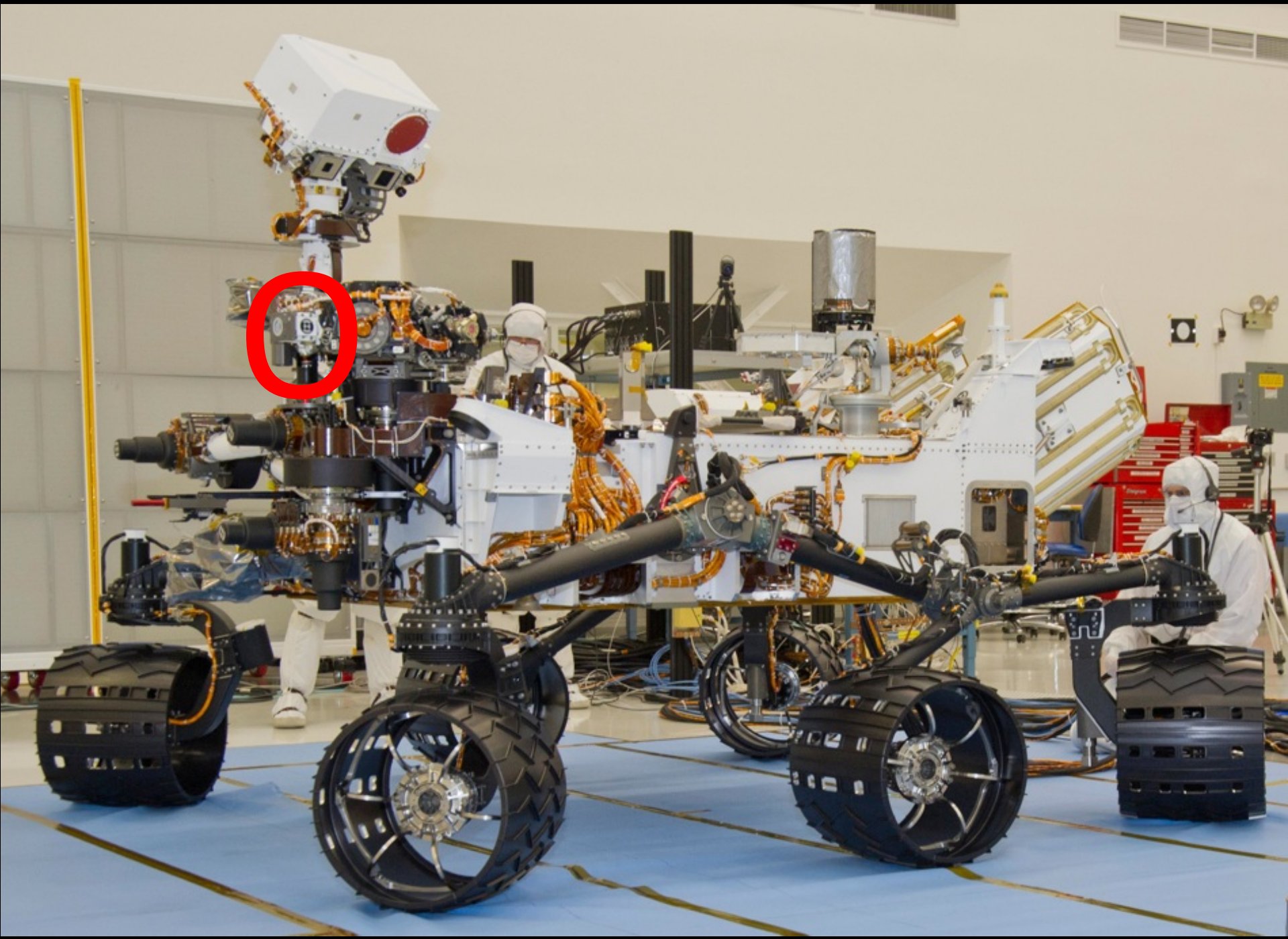
PIXE Principle – Particle Induced X-Ray Emissions and Lower Energy Emissions

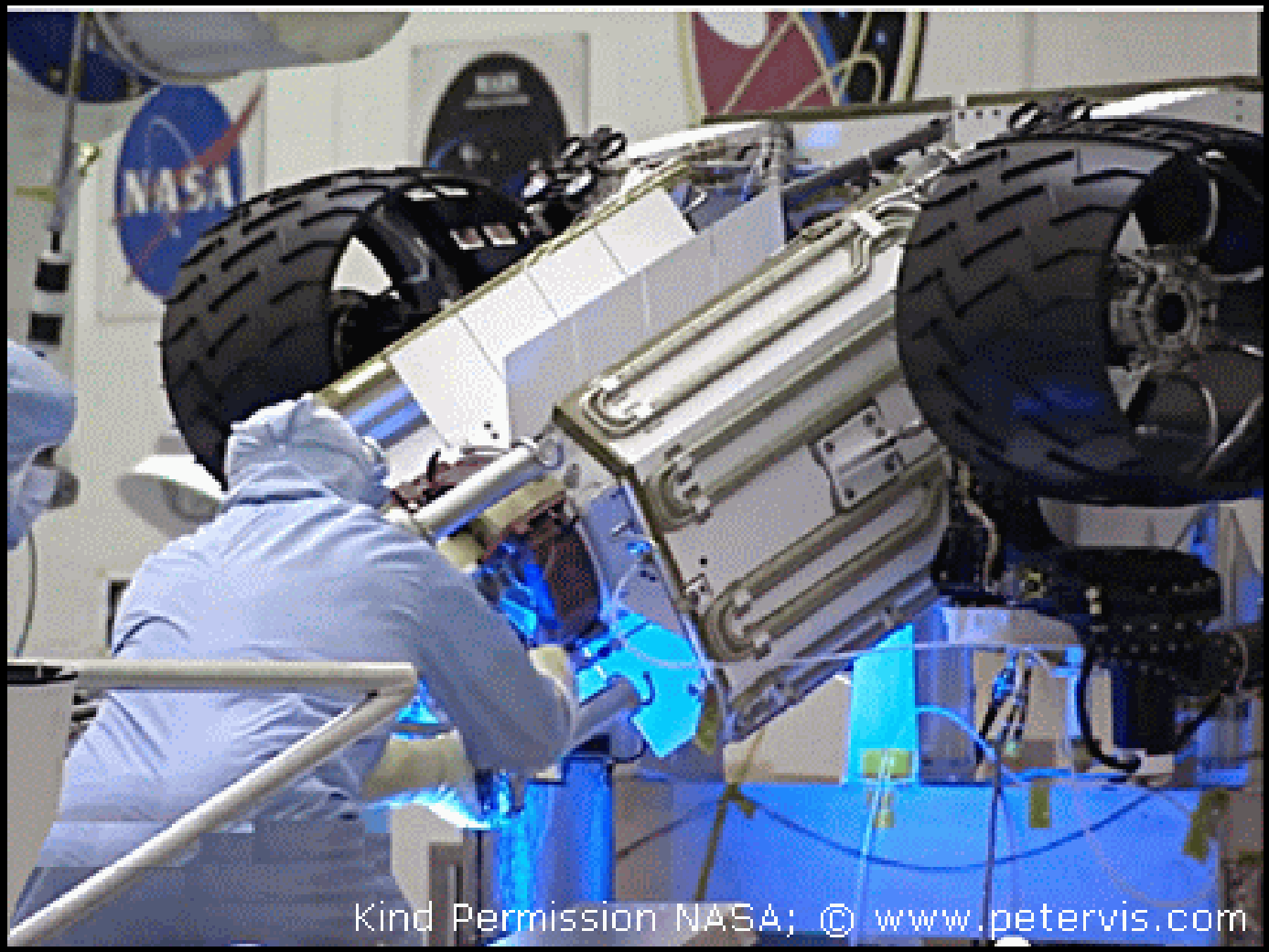
The APXS PIXE Principle

PIXE relies upon the fact that fast moving alpha particles can knock electrons from the lowest energy levels of atoms right out of the atom itself.

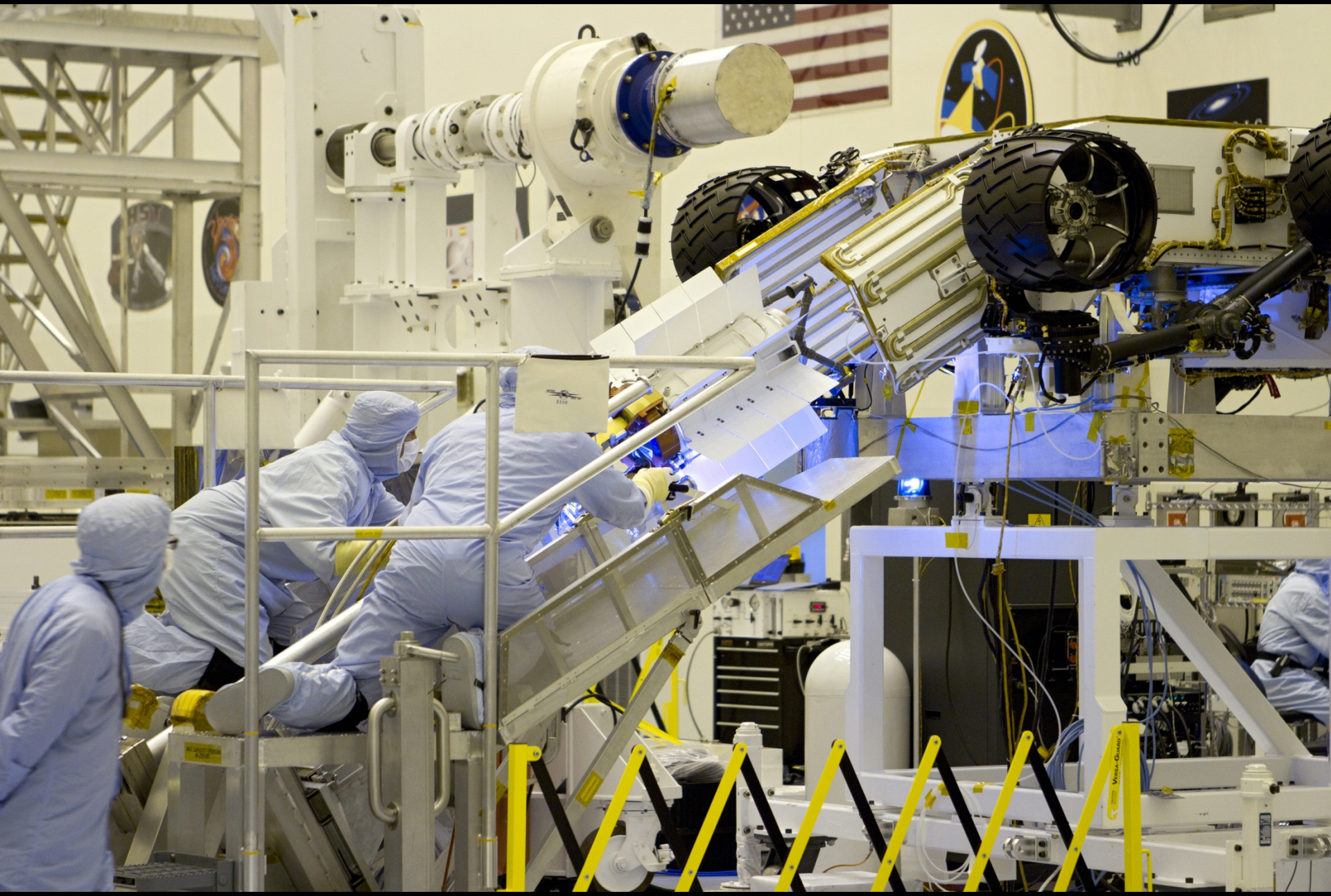
This leaves an atom with an unstable configuration of electrons, and one of the electrons in the high energy levels of the atom will now drop down to the low level one, emitting an X-ray as it does so.

APXS has a detector to capture these X-rays and we can determine the elements in the sample by looking at the energy of the X-rays – each element emits X-rays with very specific energies, an energy signature if you like. PIXE is good for detecting lighter elements, essentially sodium through to calcium.





Loading the MMRTG



Curiosity's Power Source
The New Multimission Radioisotope Thermoelectric Generator

10.6 Pounds of PU-238 in 32 Cubes
(Half Life 87.7 y)
Alpha Emitter
Solid State Thermoelectric Conversion
Provided by DOE
Manufactured by Hamilton Sundstrand

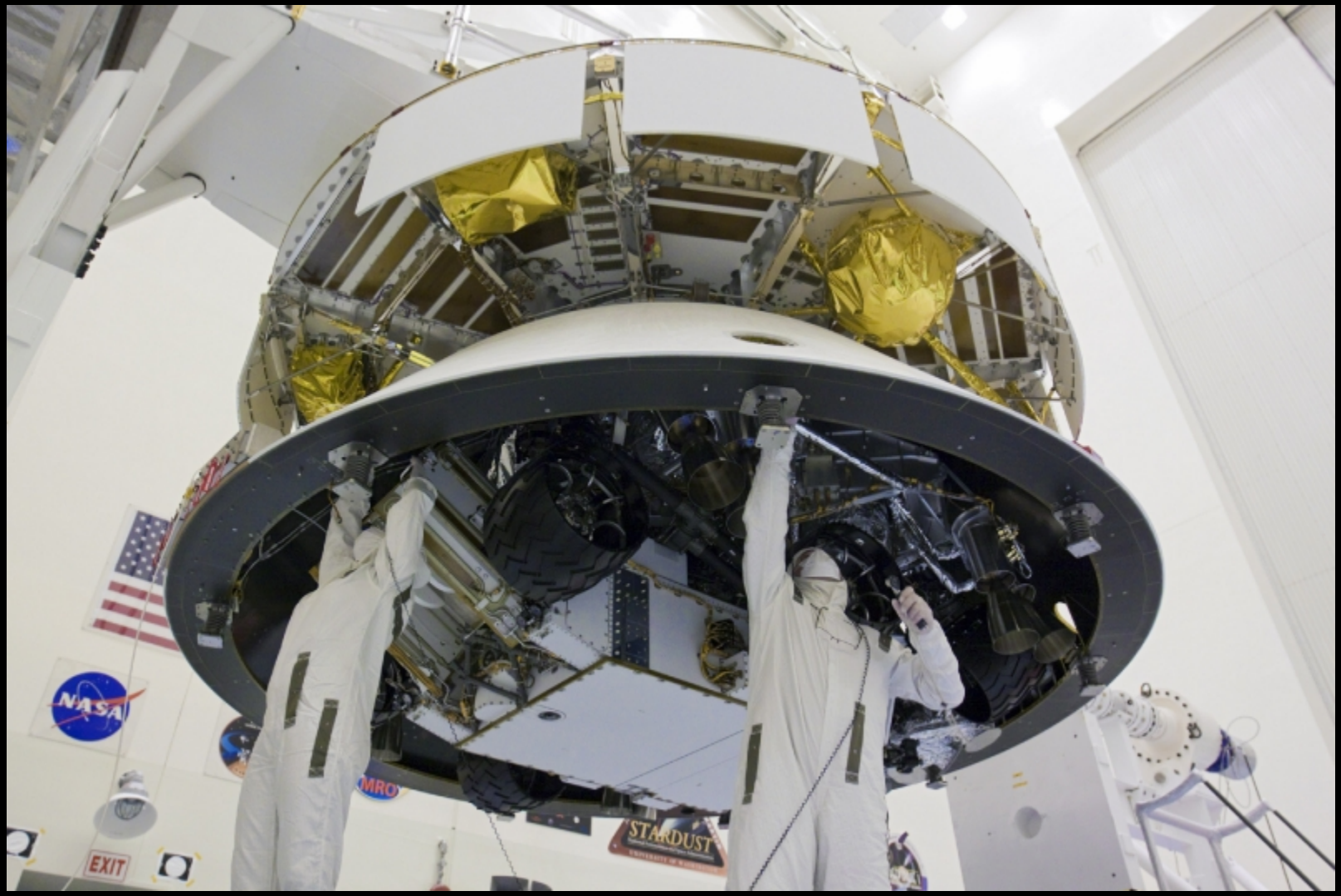
P238 Pellet In Production

Generation Capacity is 125 Watts electrical energy
From 2000 watts of heat energy
2.6 KWH electrical energy/day

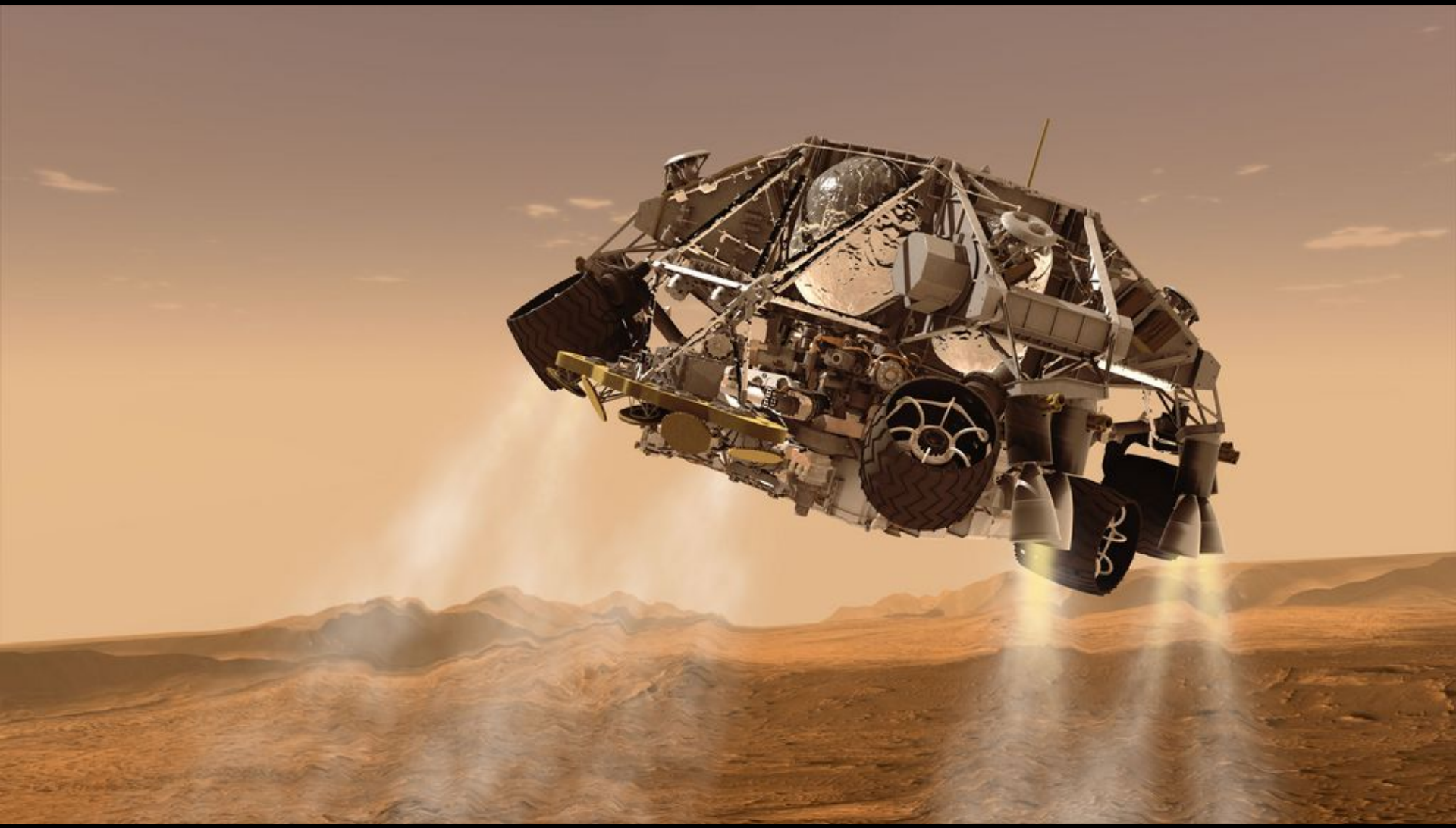
Thermal heat used to warm electronics bay
Excess heat radiated to atmosphere

Two rechargeable Lithium-ion batteries having capacity 42 amp-hours
To provide extra power to the rover when the demand exceeds the RTG's output capacity

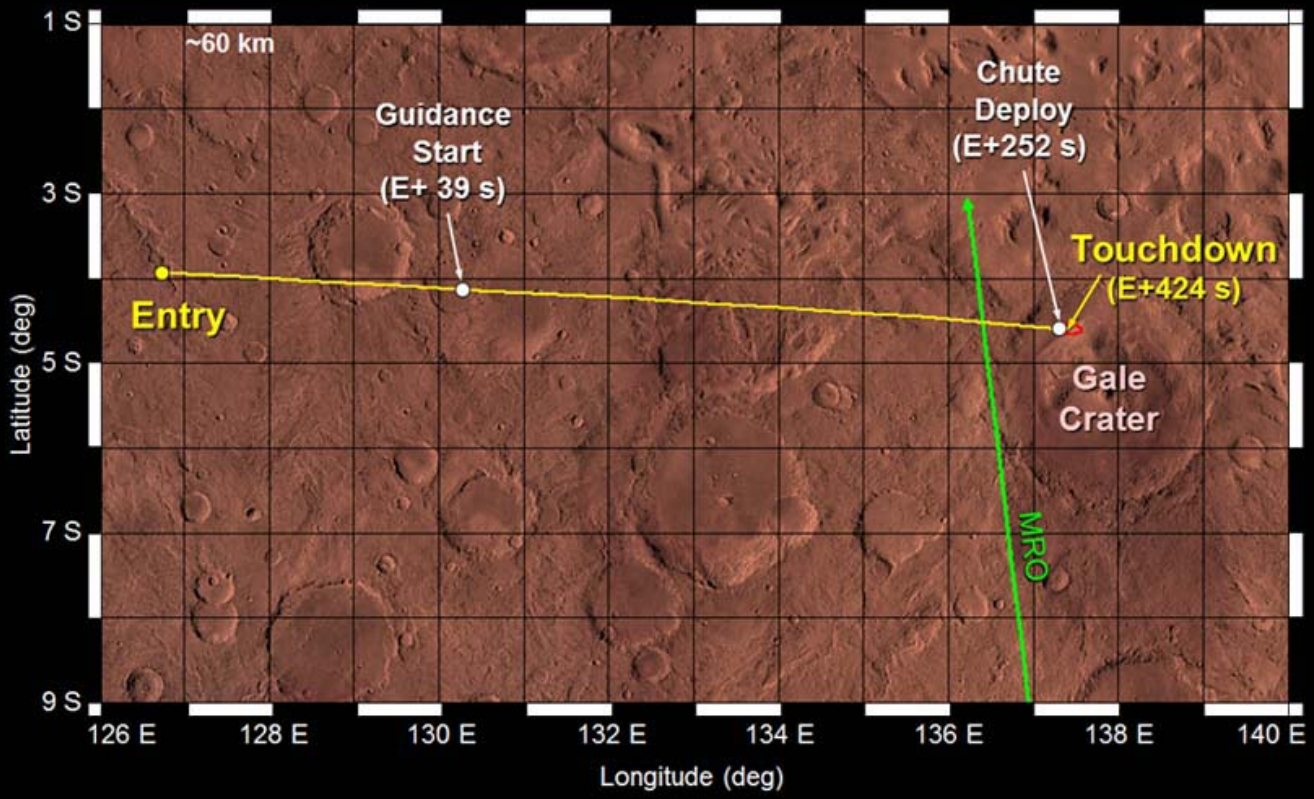

242
CAUTION !
Helium Tanks under High Pressure

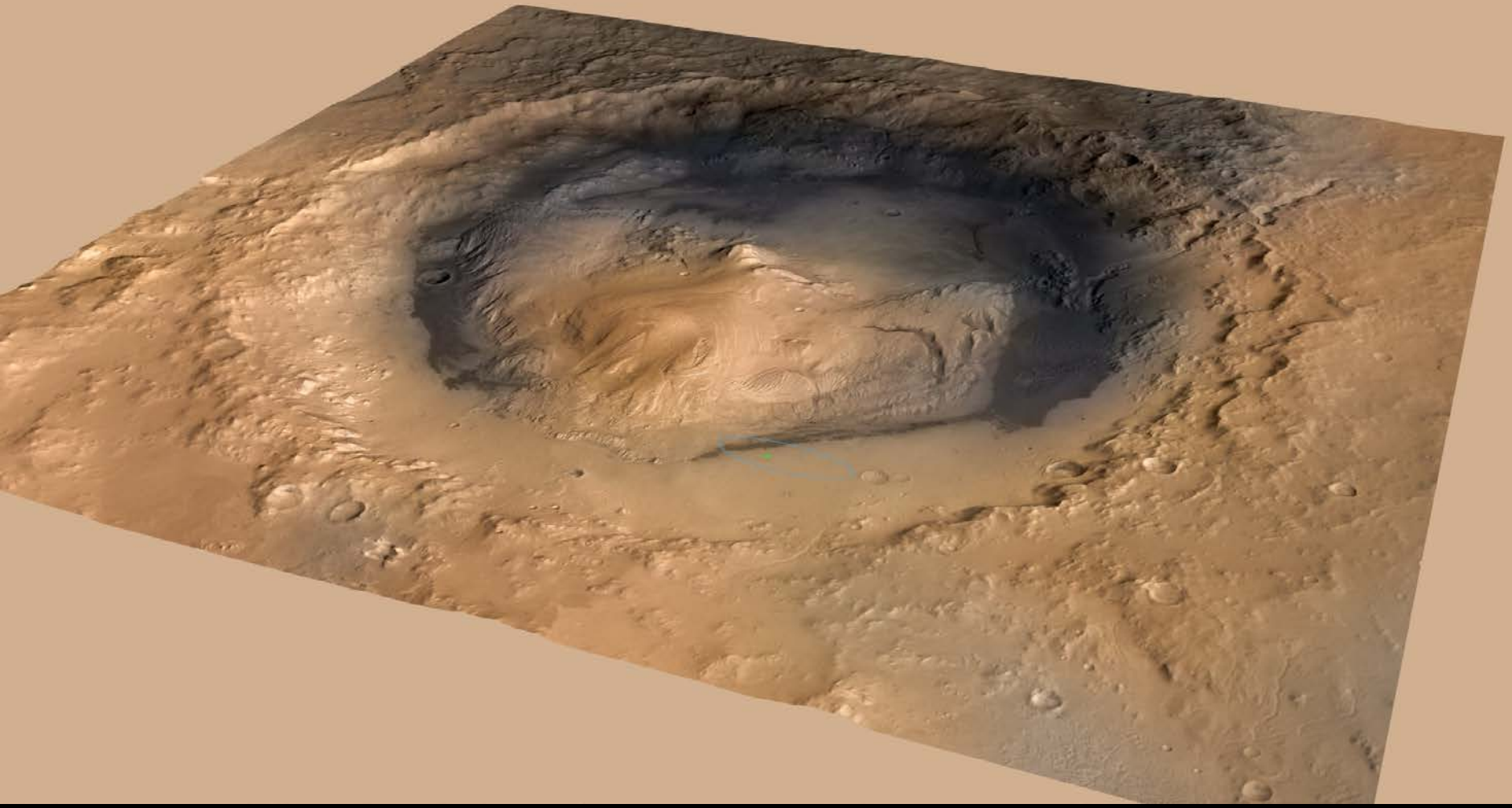

NASA
MRO
STARDUST
EXIT

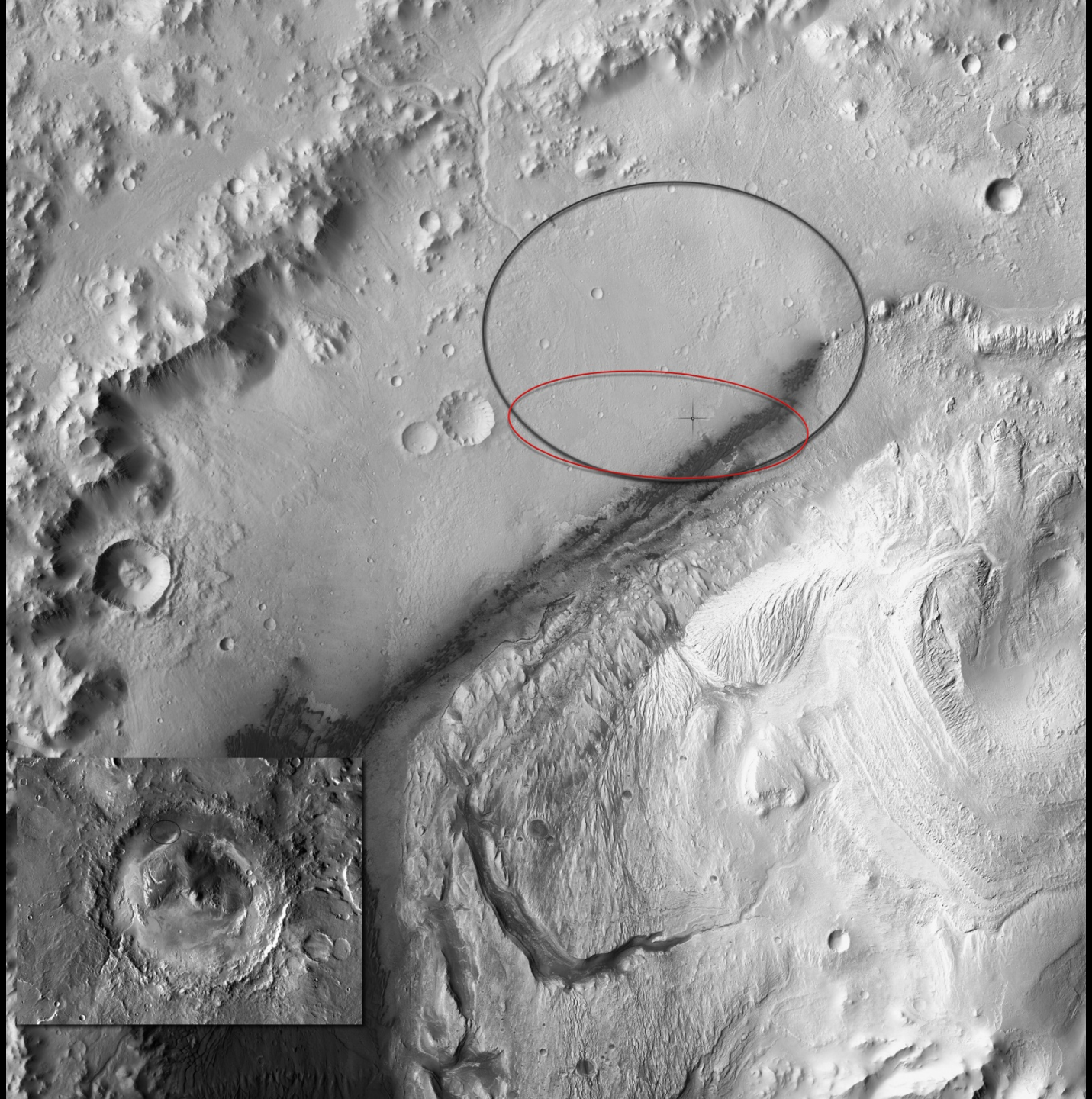

Curiosity Launch 26 November 2011

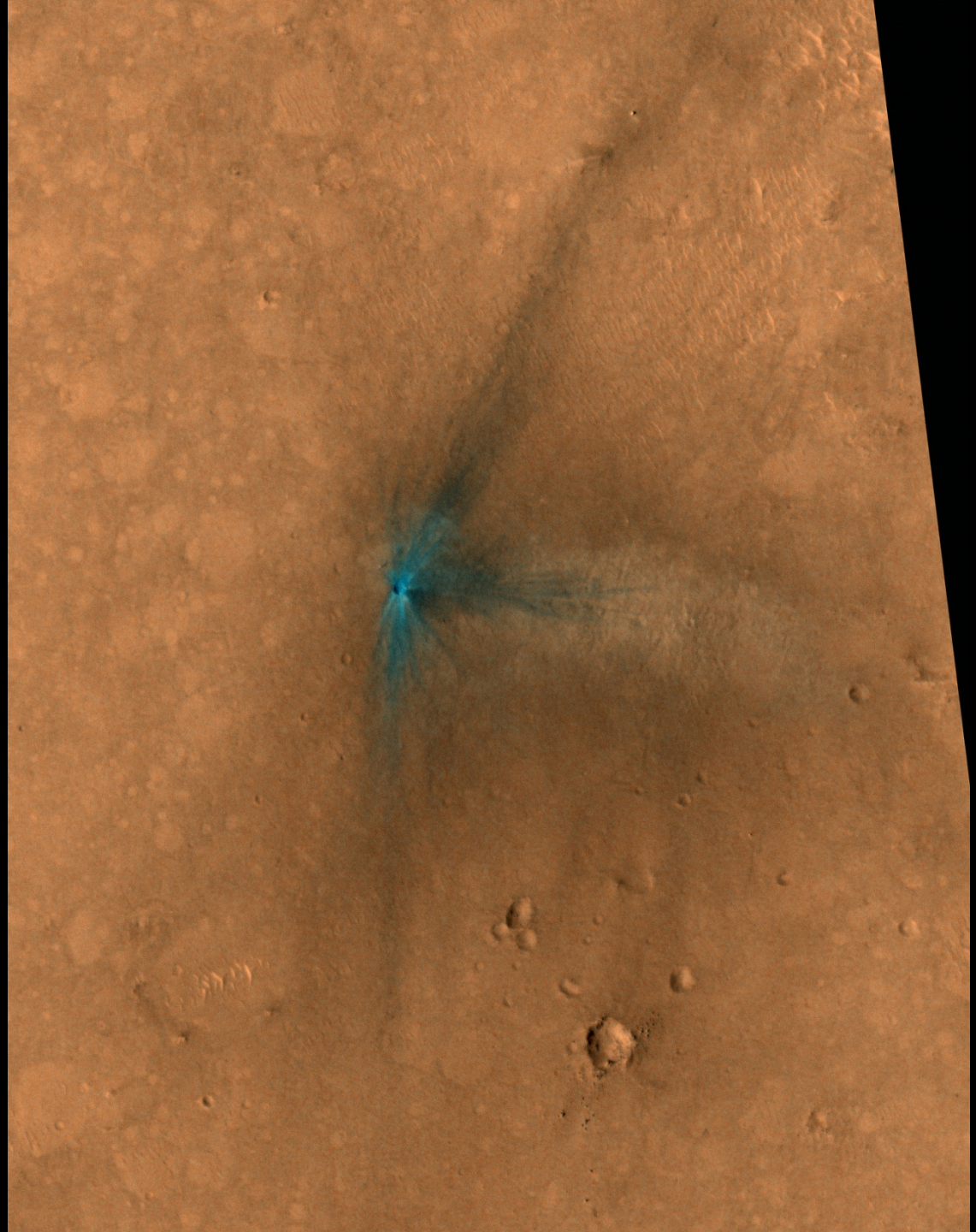


Dropping in on Mars in High-Res


1 S
3 S
5 S
7 S
9 S
Latitude (deg)
126 E
128 E
130 E
132 E
134 E
136 E
138 E
140 E
Longitude (deg)
~60 km
Guidance
Start
(E+ 39 s)
Chute
Deploy
(E+252 s)
Touchdown
(E+424 s)
Entry
Gale
Crater
MRO

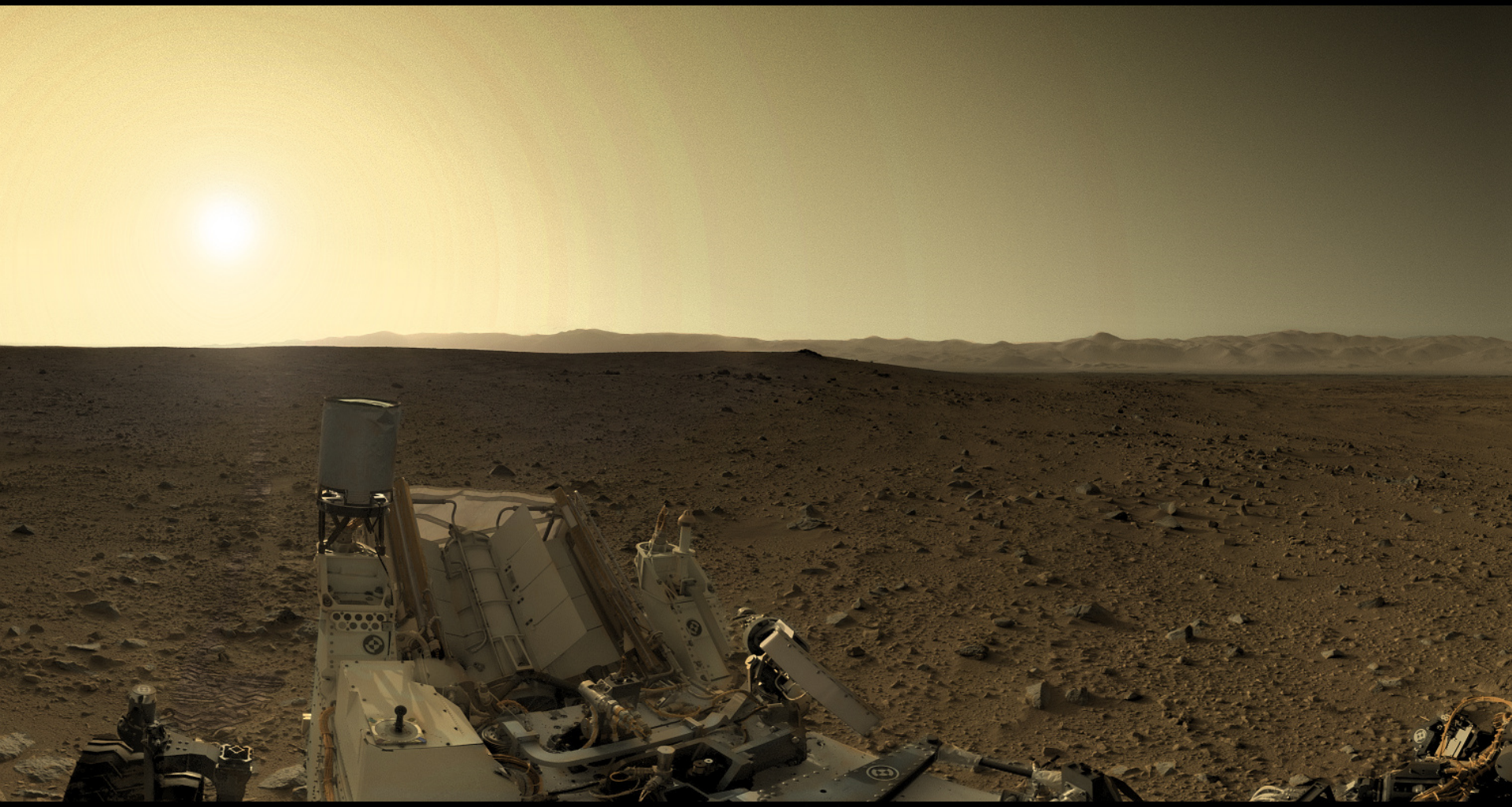




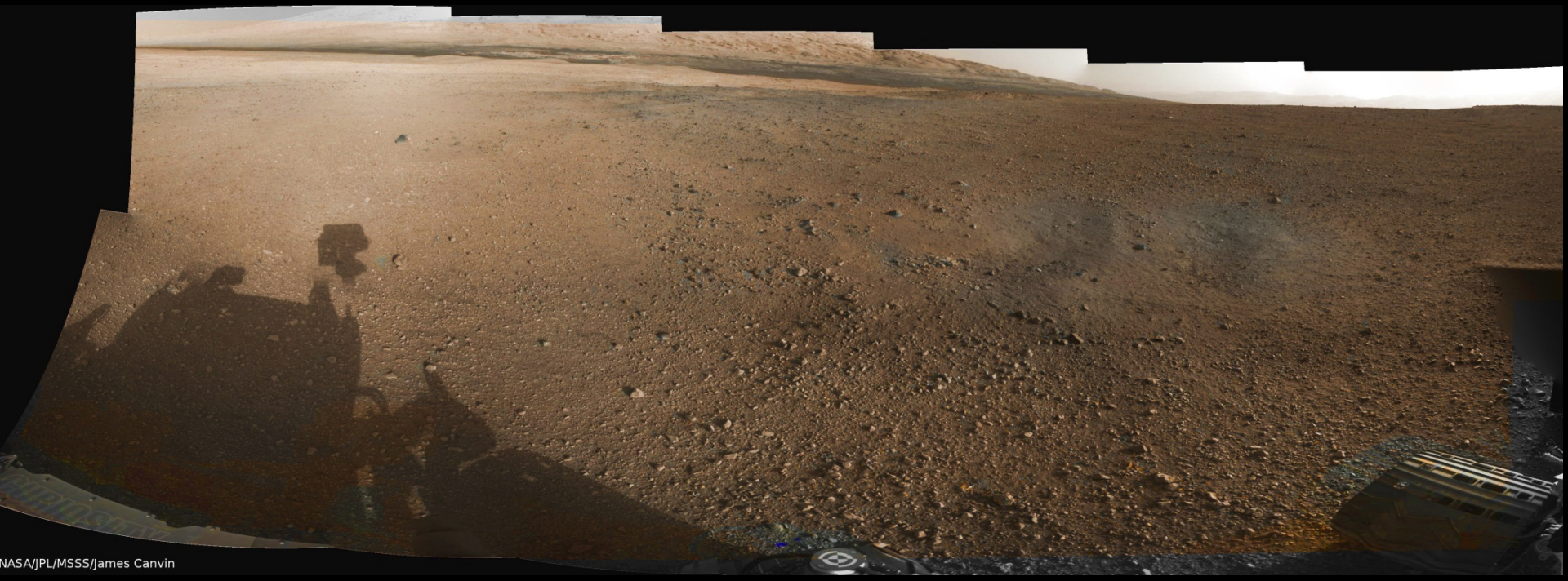


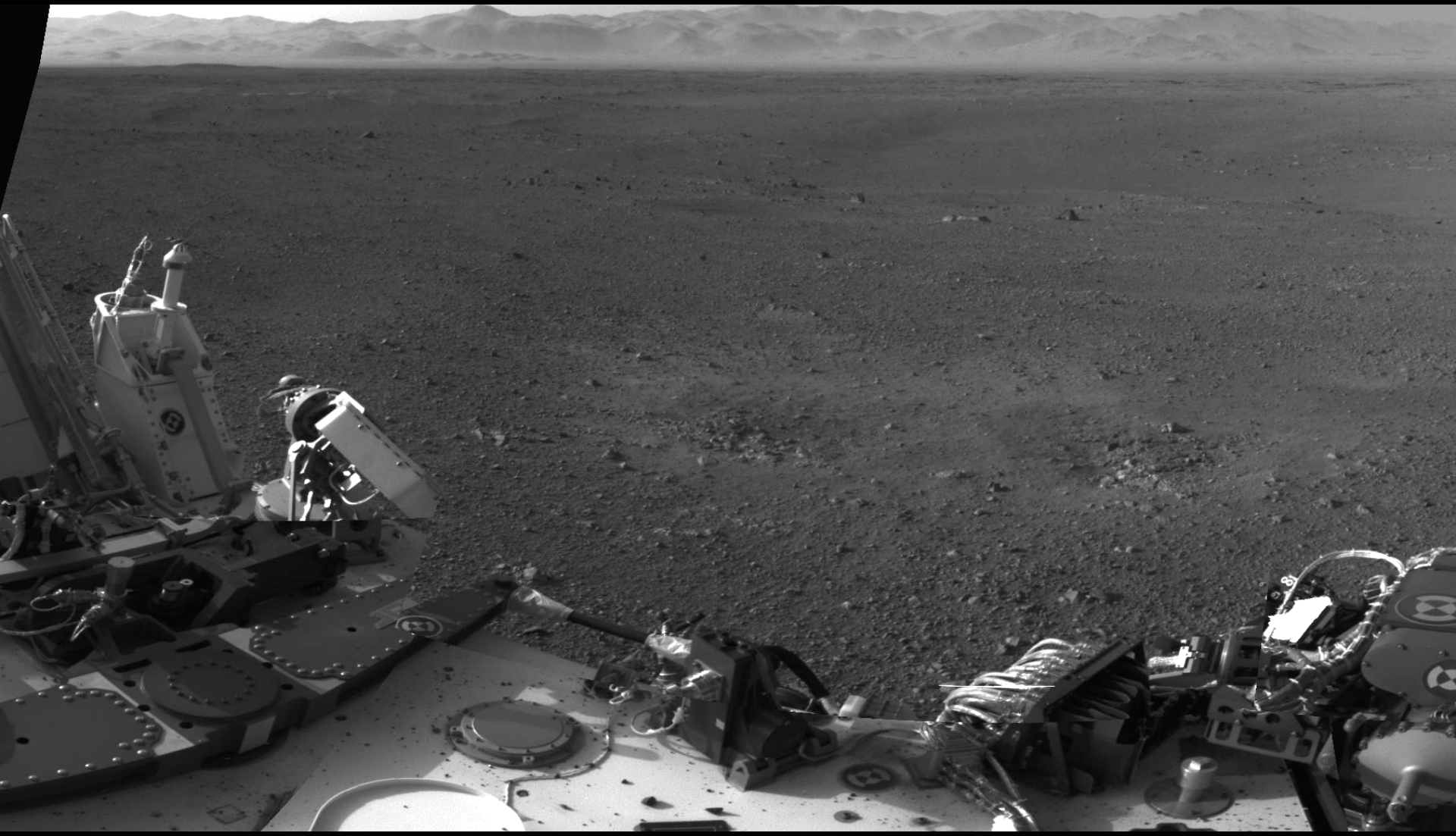
To Mount Sharp….
…but First a Detour

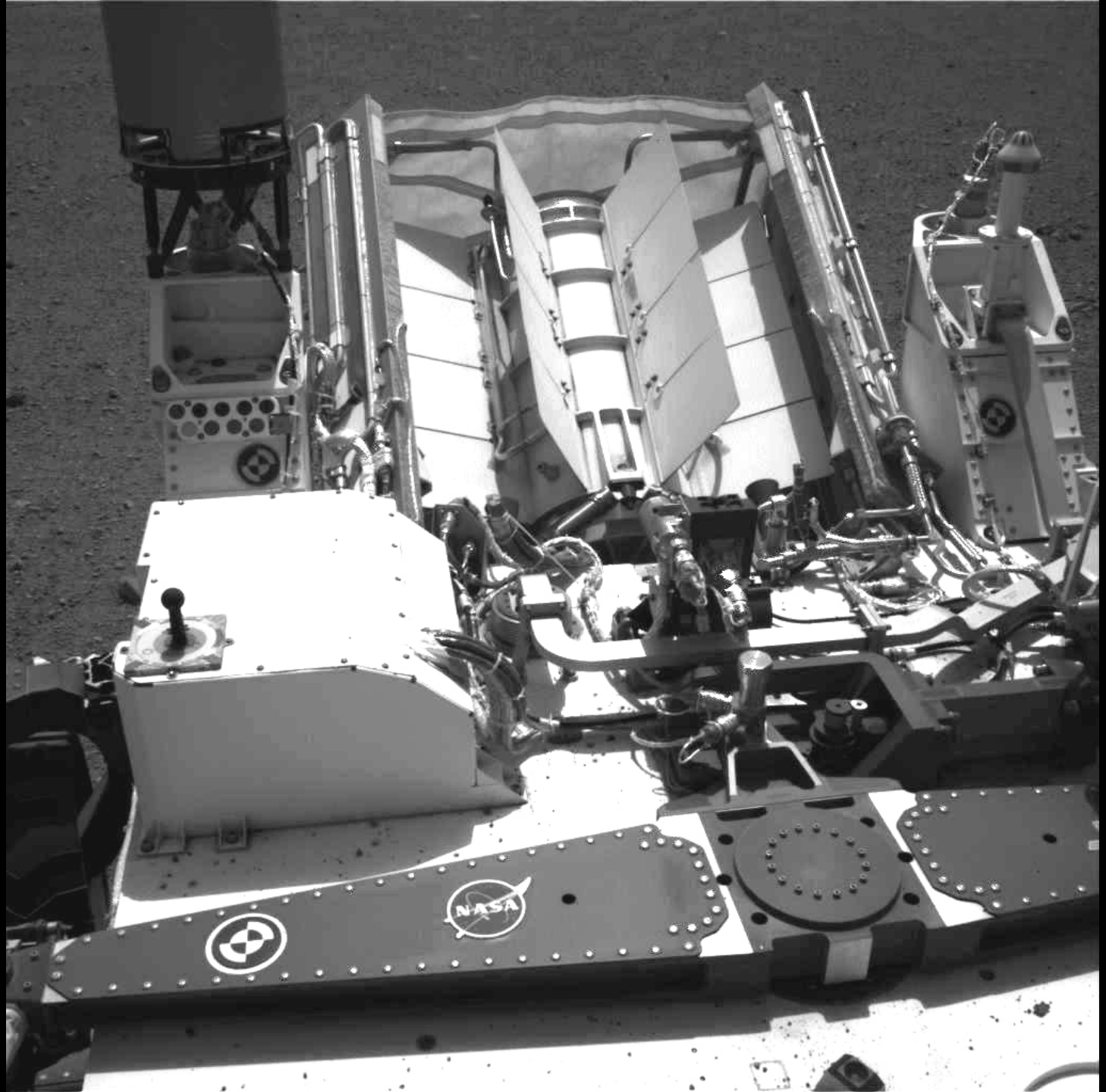
To Rocknest and Gleneg….

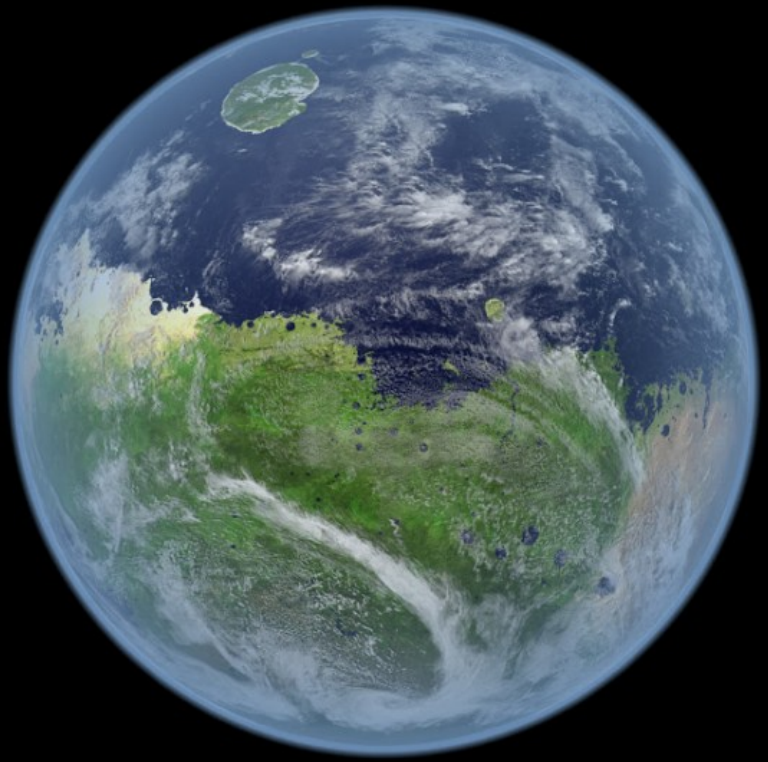


Late afternoon at Gale - Sol 49 - NASA/JPL-Caltech/D.Bouic - www.db-prods.net


NASA/JPL/MSSS/James Canvin



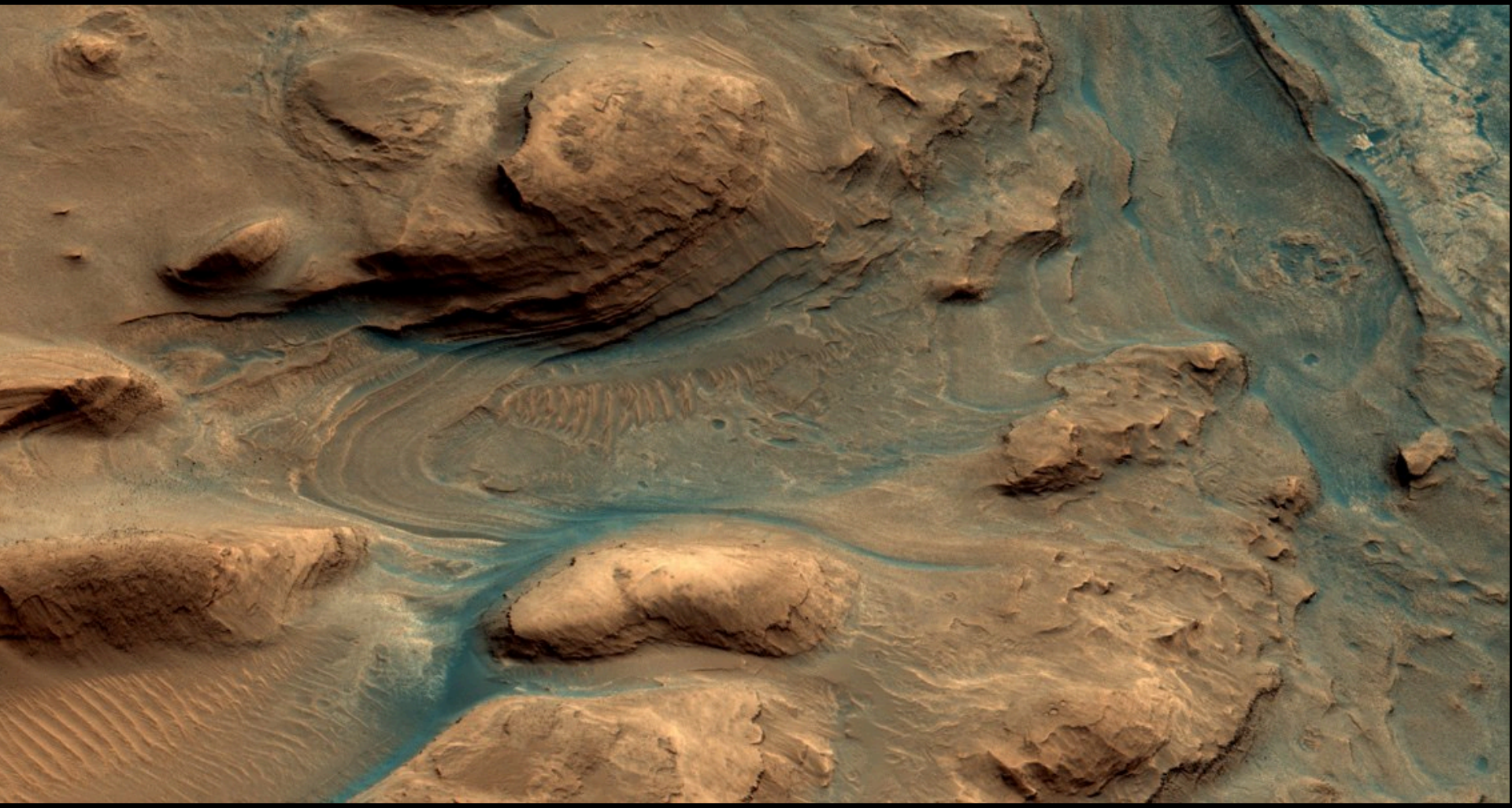

NASA



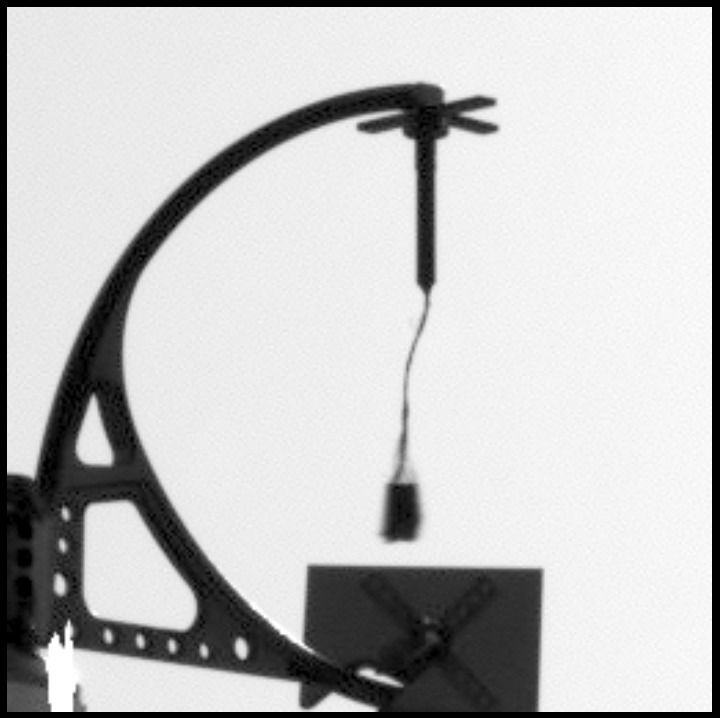
What Curiosity is Searching For

H_2O

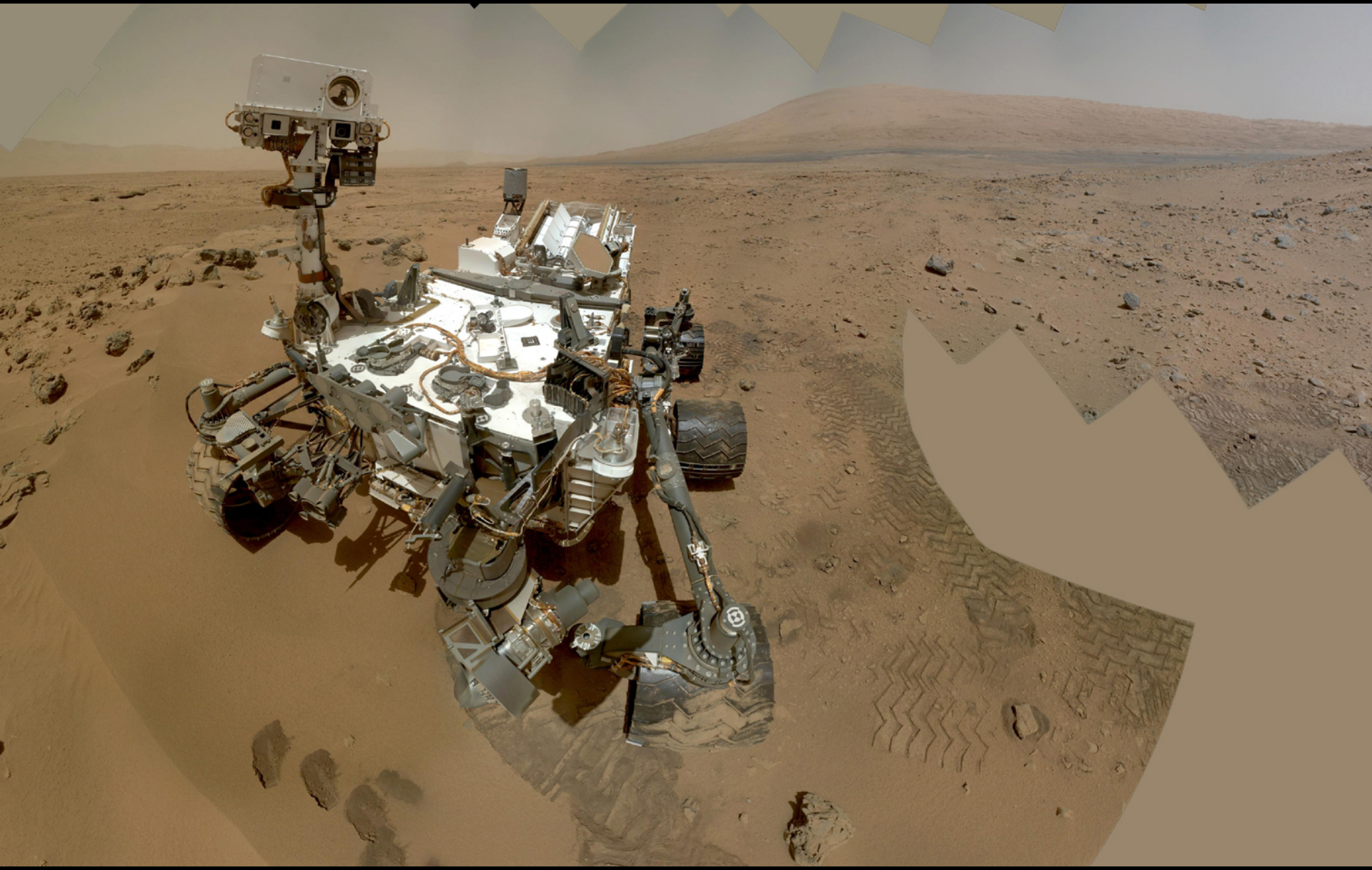
Past and Present

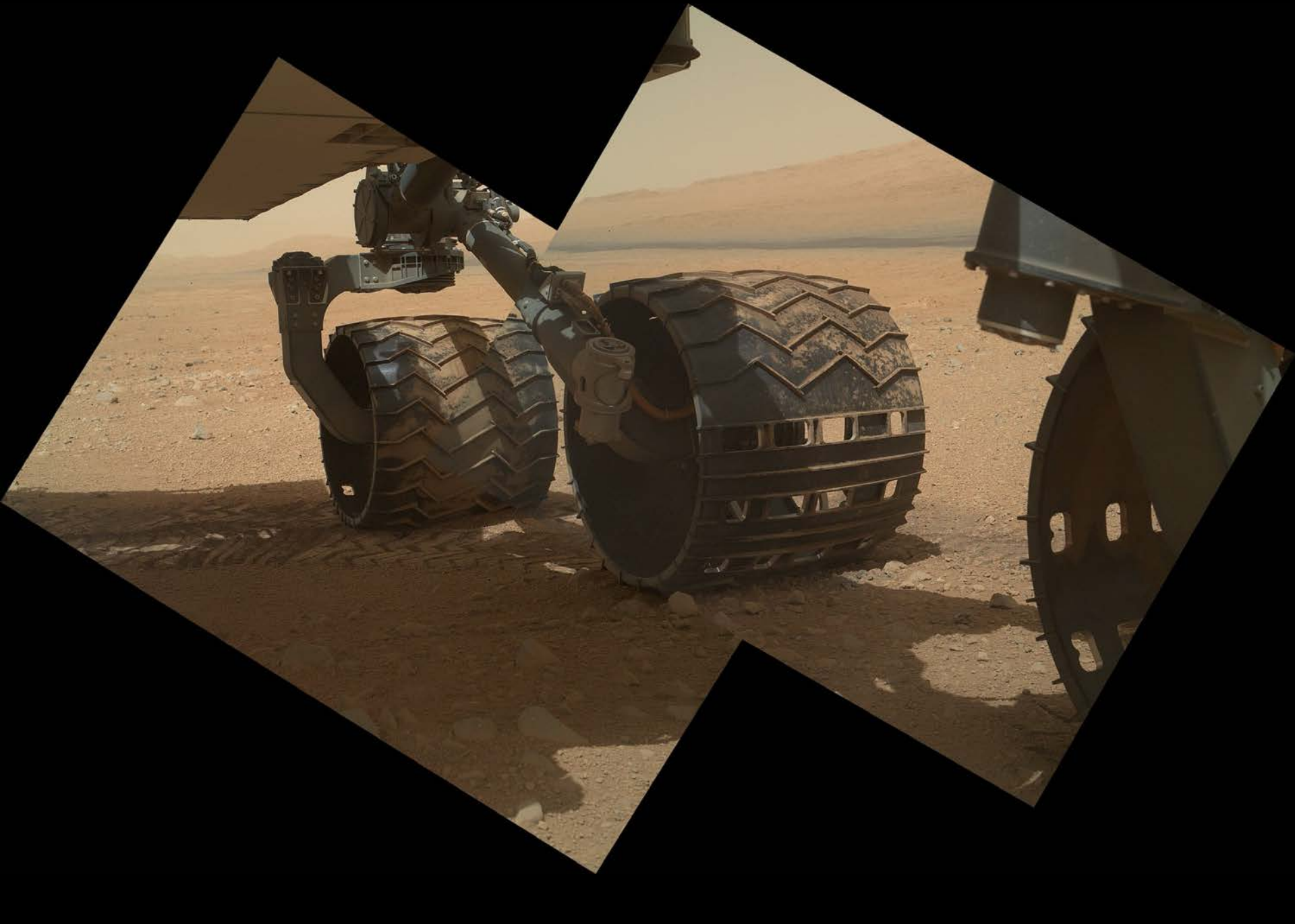


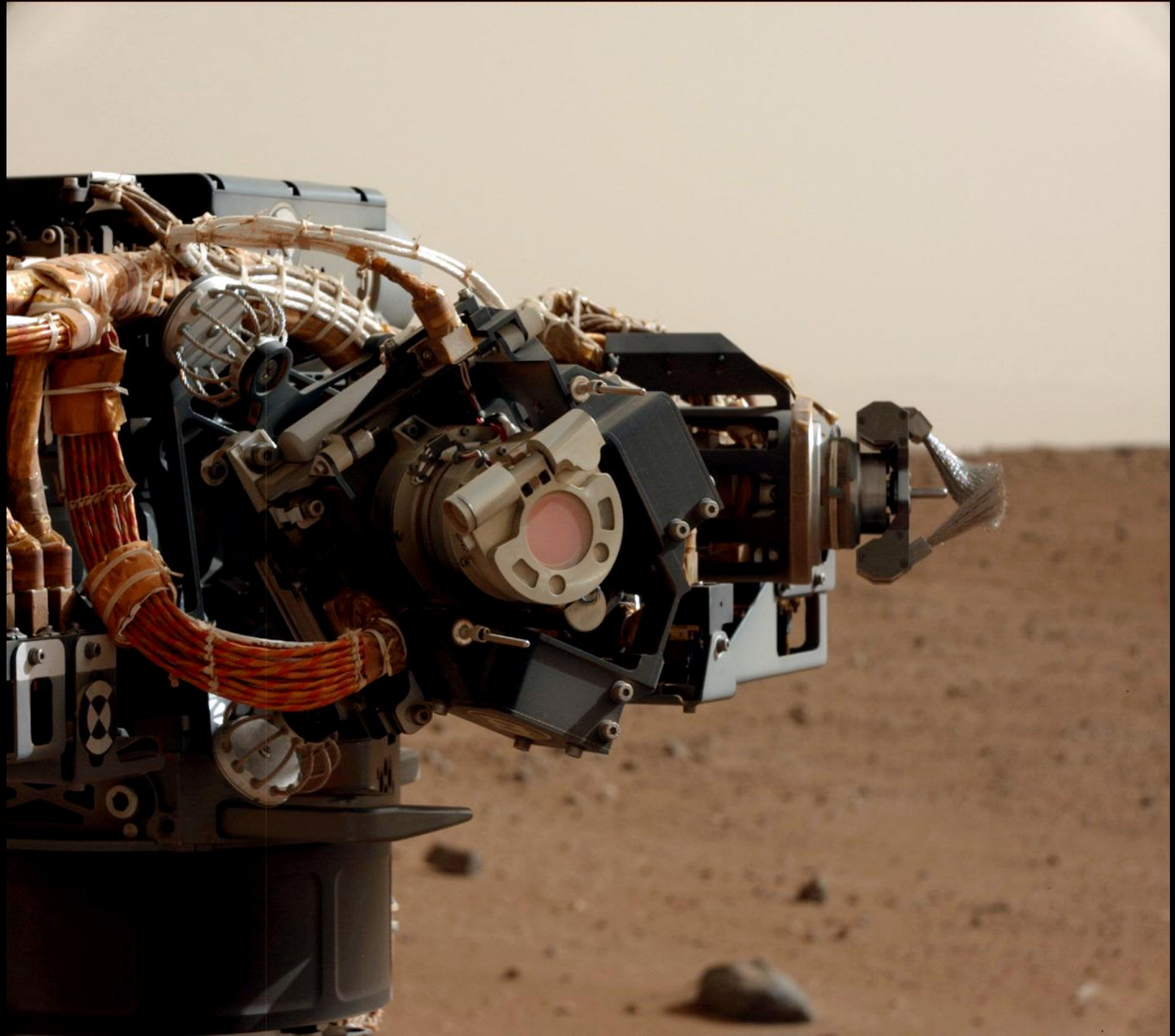
The two forces that have shaped Mars
Aqueous and Aeolian

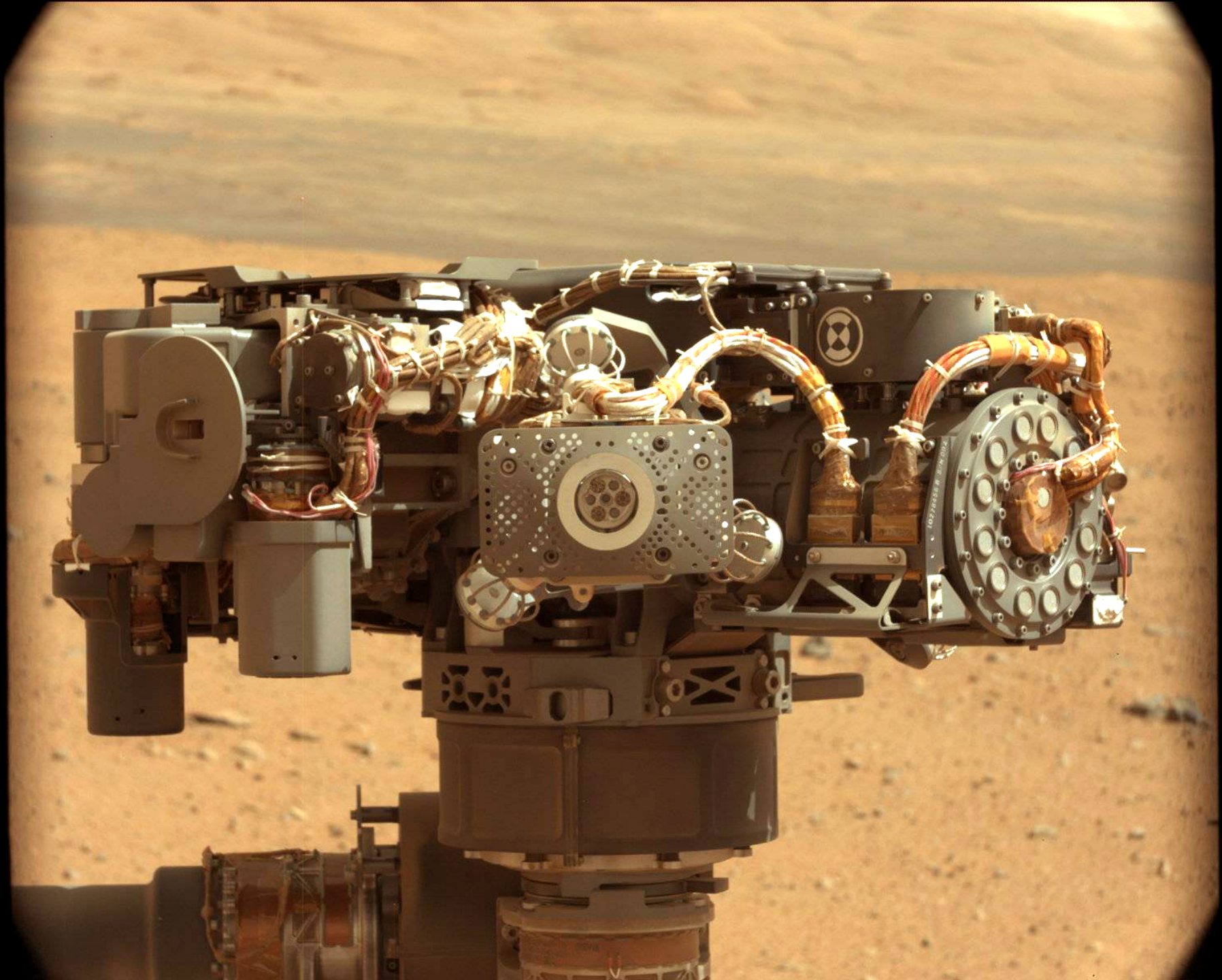


Wind and Water on Mars

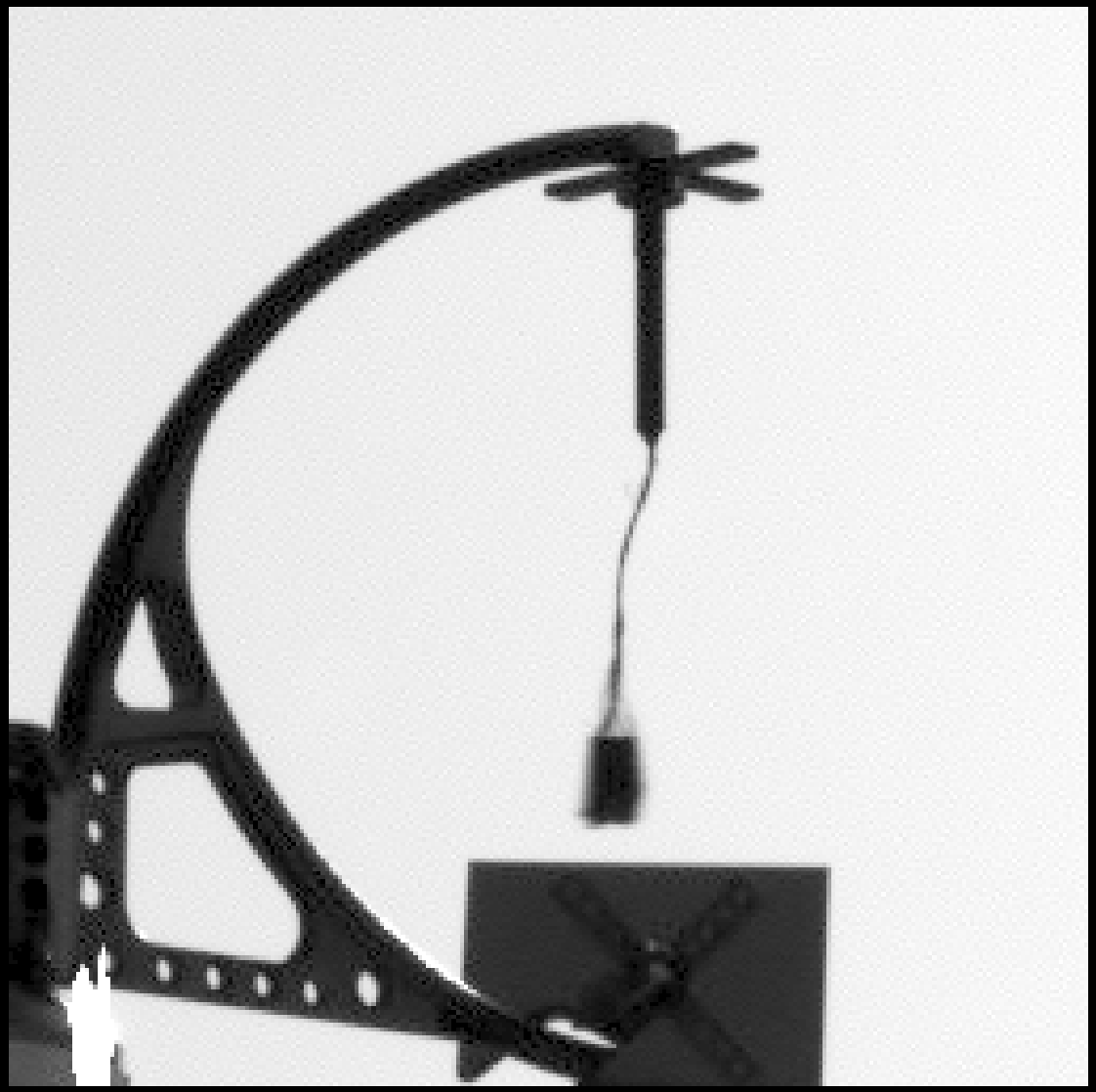


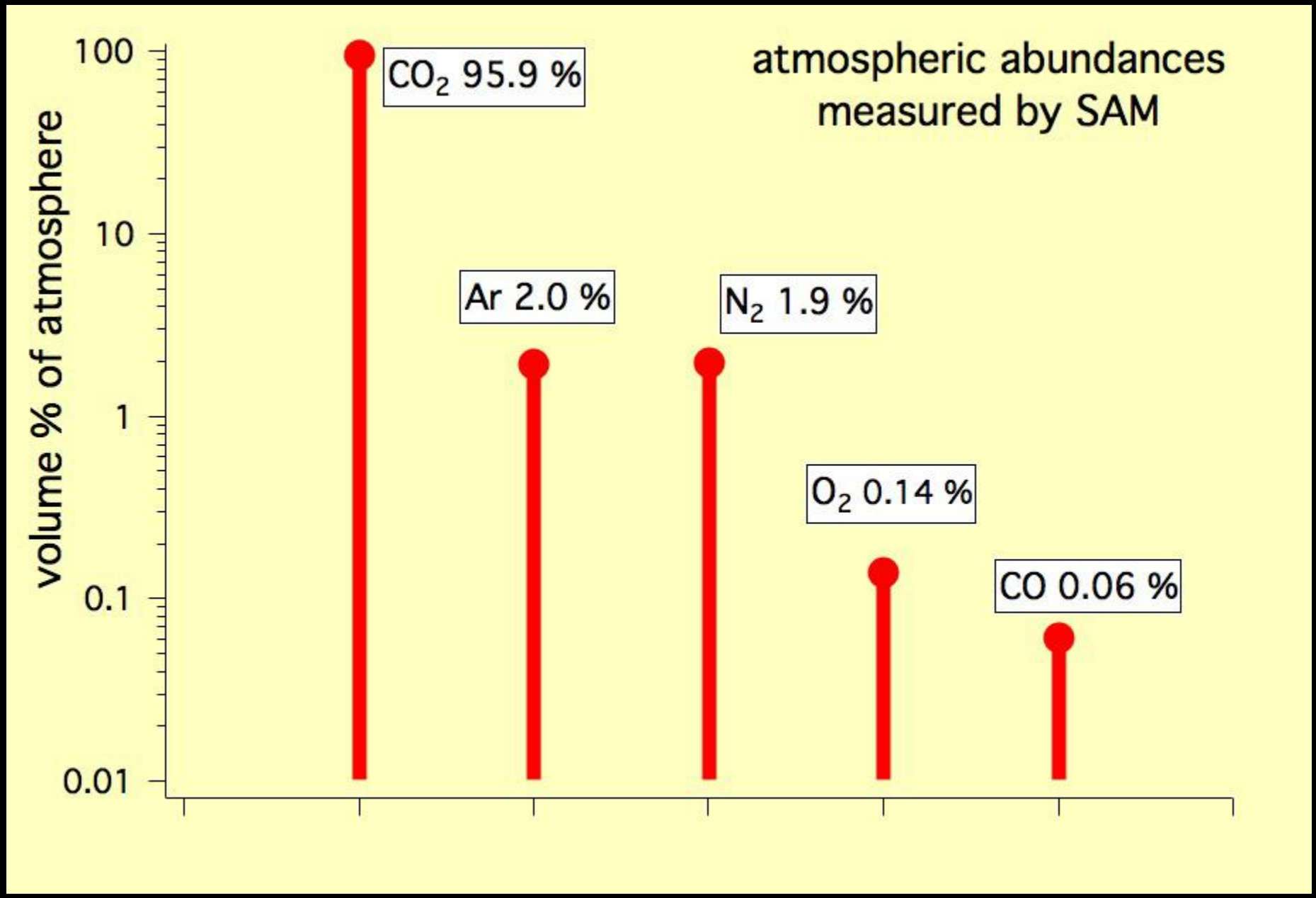




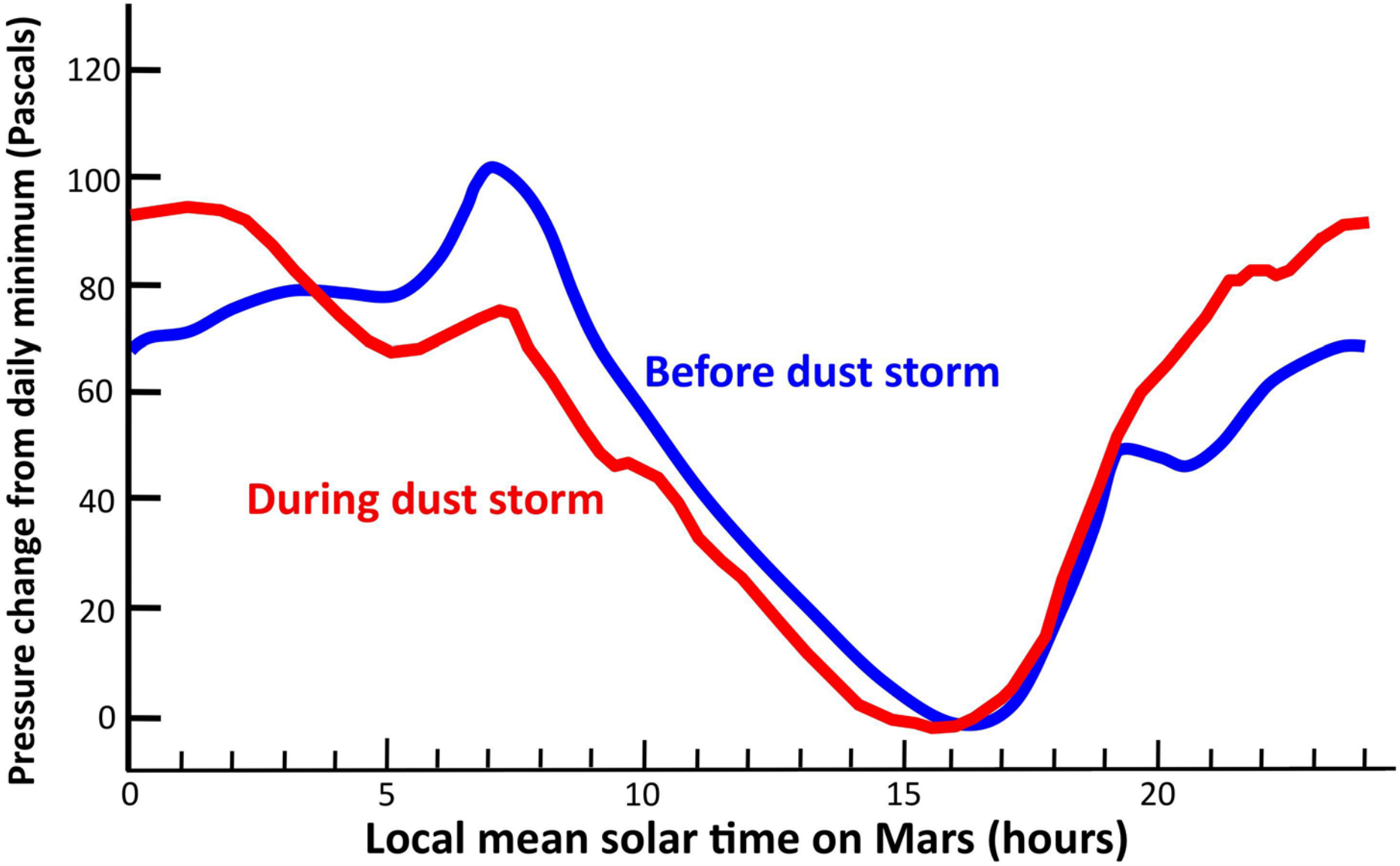


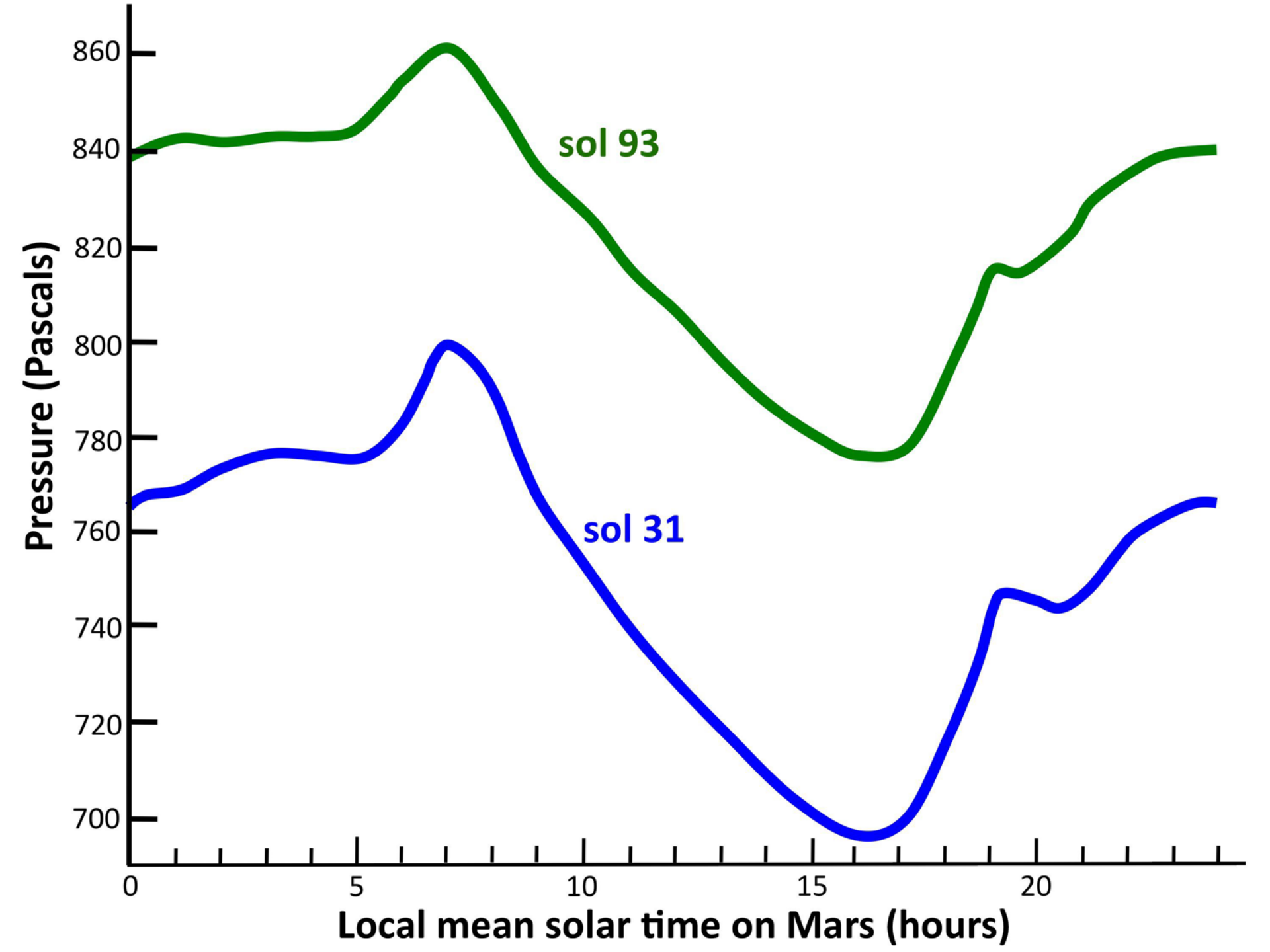

Mars Weather
August 21, 2012
Gale Crater
Temp Hi: +28 F
Temp Lo: -103 F
Wind: Gusty
55.5 MPH NW
Pressure:
0.690-0.775 ATM




atmospheric abundances
measured by SAM
volume % of atmosphere
100
10
1
0.1
0.01
CO2 95.9 %
Ar 2.0 %
N2 1.9 %
O2 0.14 %
CO 0.06 %

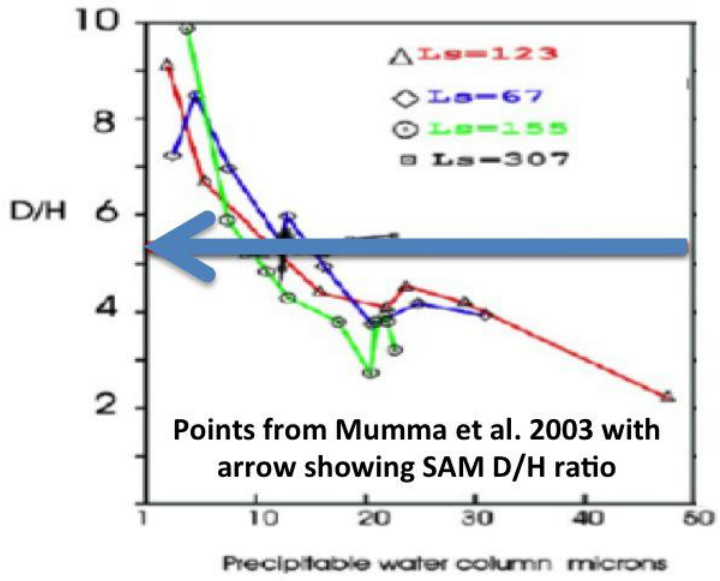
Typical REMS pressures before and during the dust storm




860
840
820
800
780
760
740
720
700
Pressure (Pascals)
sol 93
sol 31
0
5
10
15
20
Local mean solar time on Mars (hours)

First detection of deuterium to hydrogen ratio on the surface of Mars shows water released from Rocknest samples is much heavier than that in the Earth's oceans

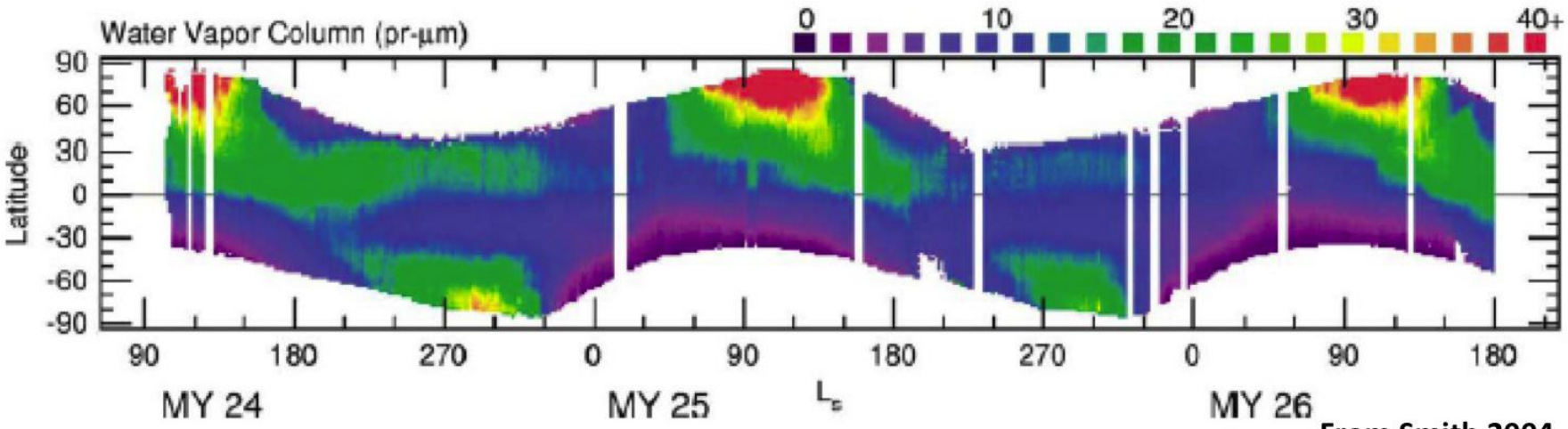
Similar to D/H in the Mars atmosphere



Points from Mumma et al. 2003 with arrow showing SAM D/H ratio

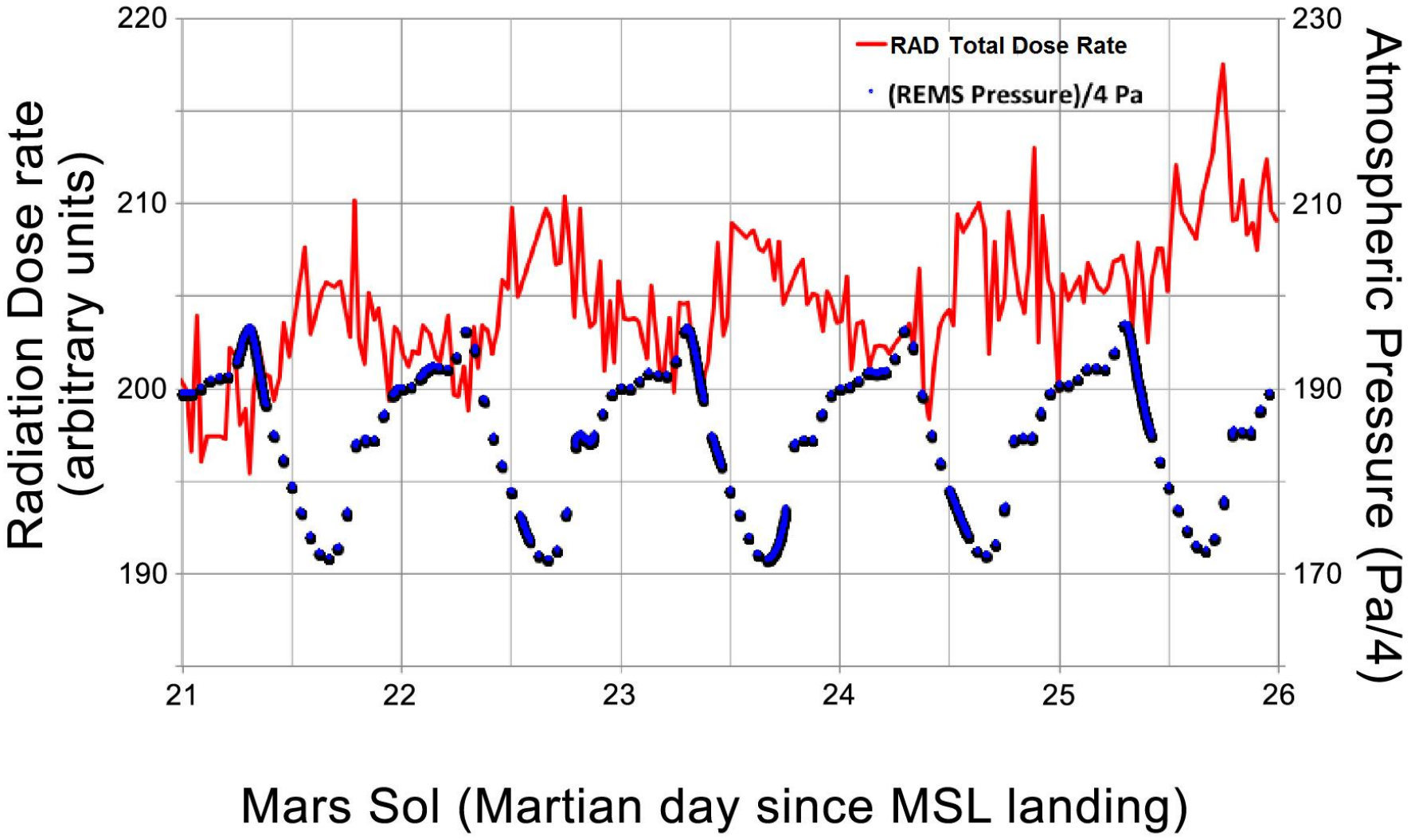
The deuterium to hydrogen isotope ratio (D/H) is used to help understand the extent of atmospheric escape and the change from early environments

D/H in atmosphere varies with season (left) as does the water amount in the atmosphere (below)

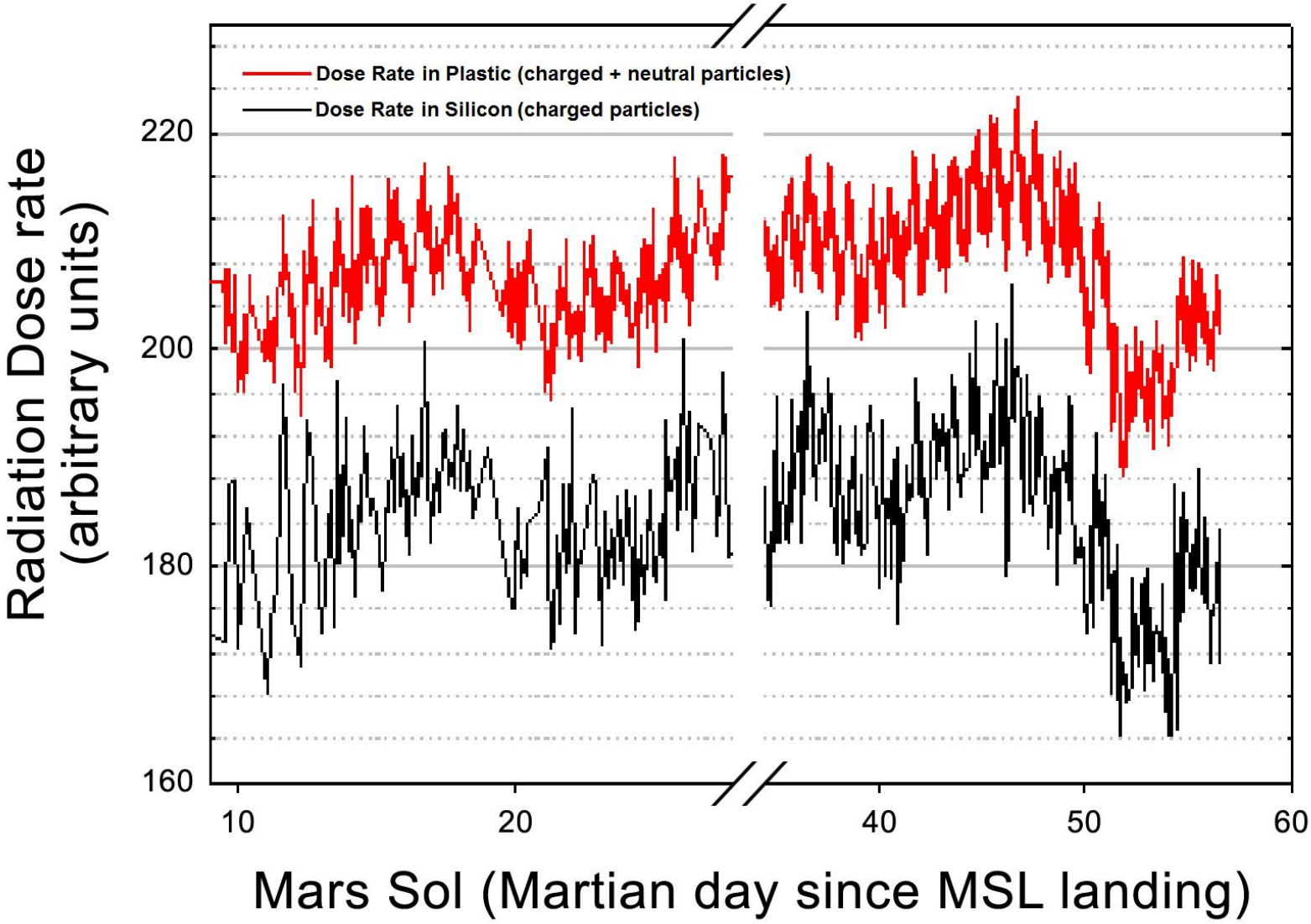


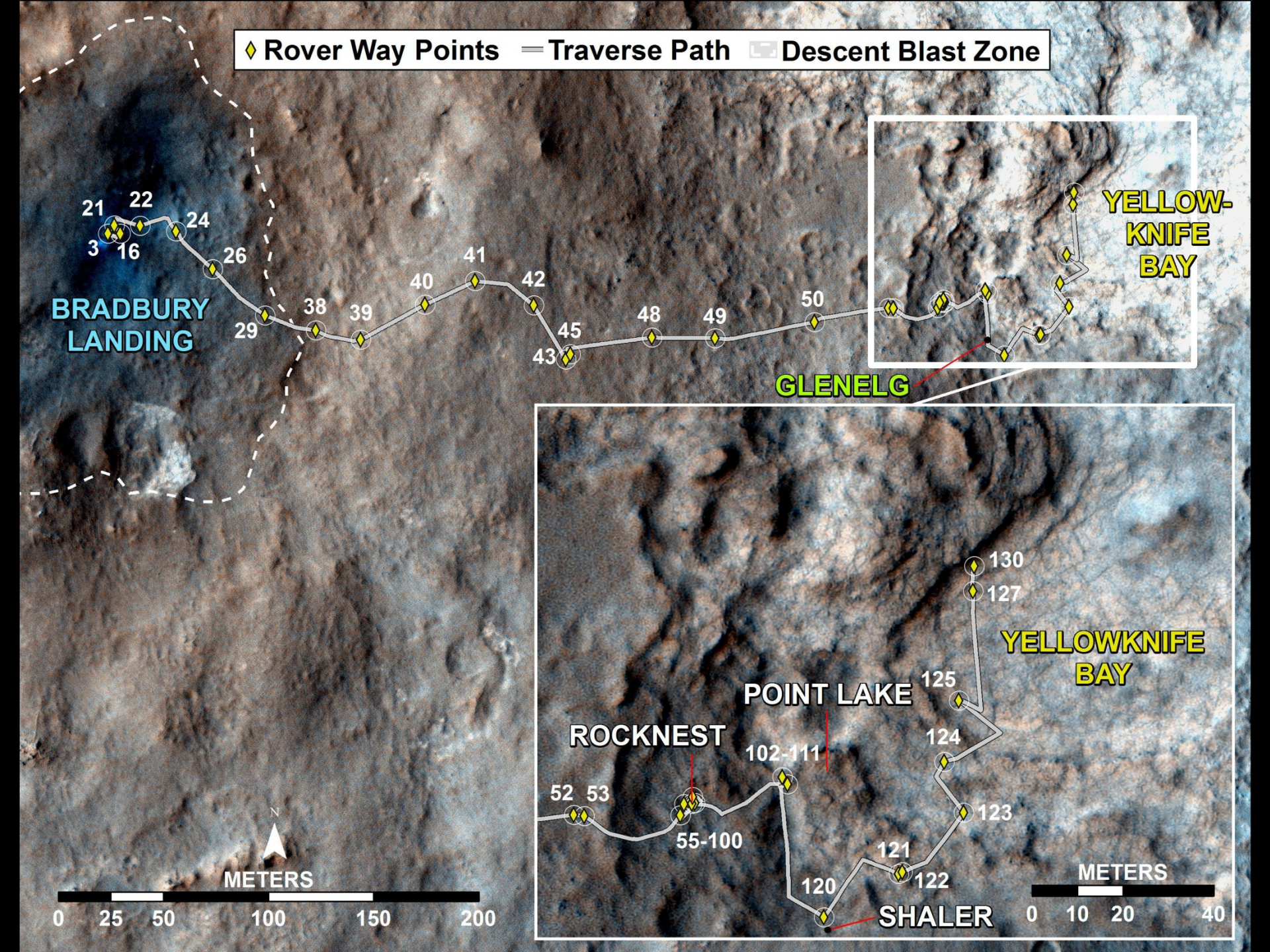
From Smith 2004

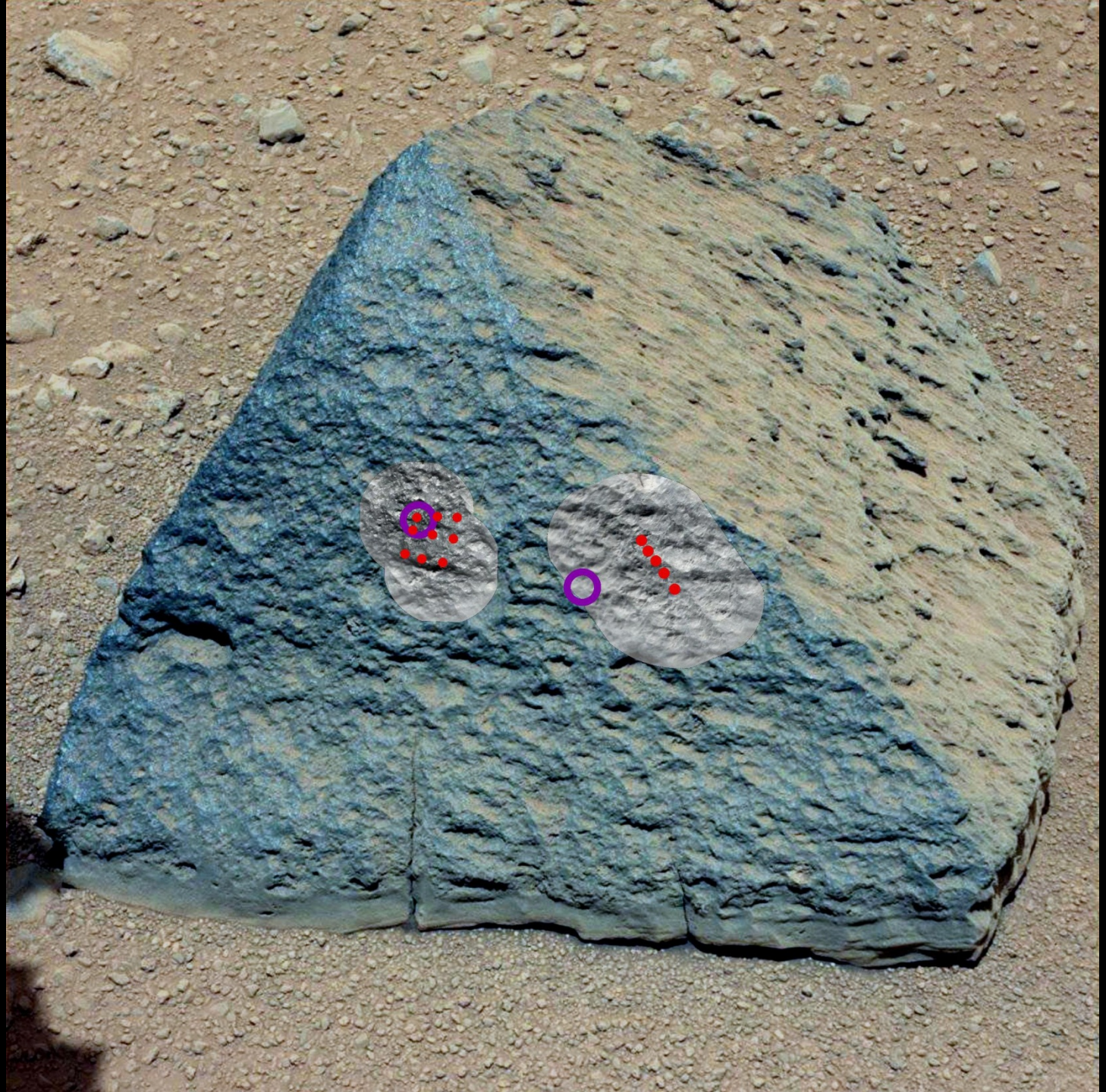
Daily Variation of Radiation Dose on the Mars Surface

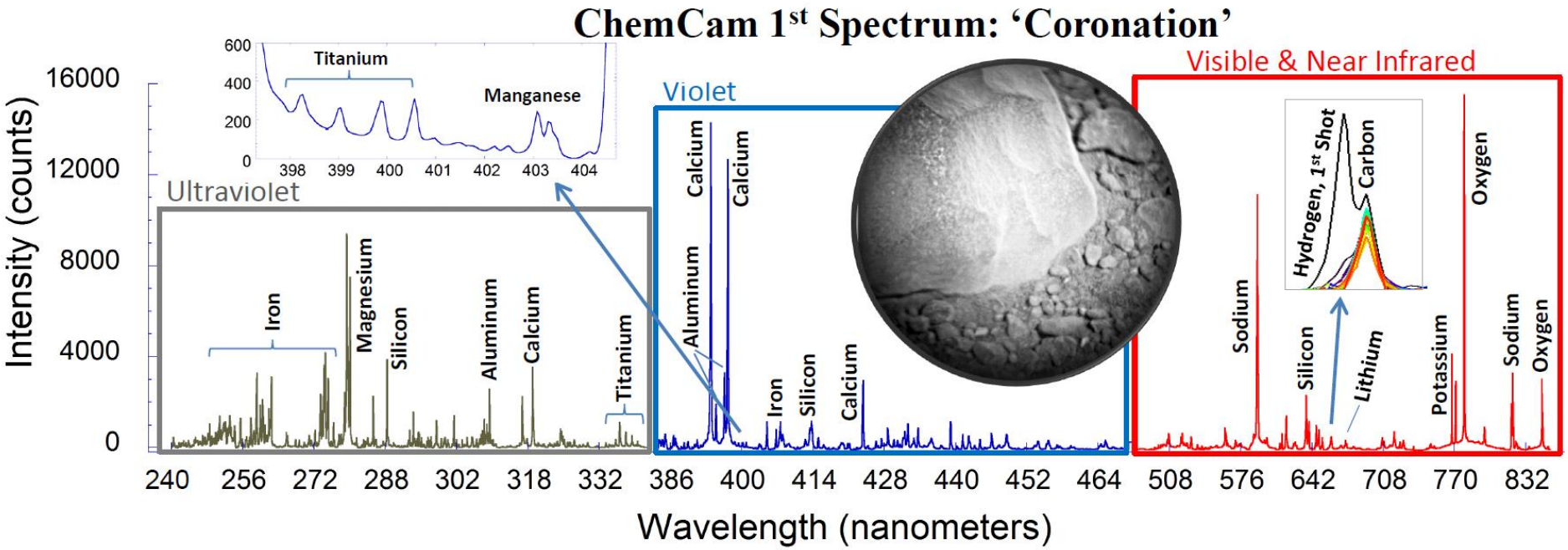


Longer Term Variations Due to Solar & Heliospheric Rotation

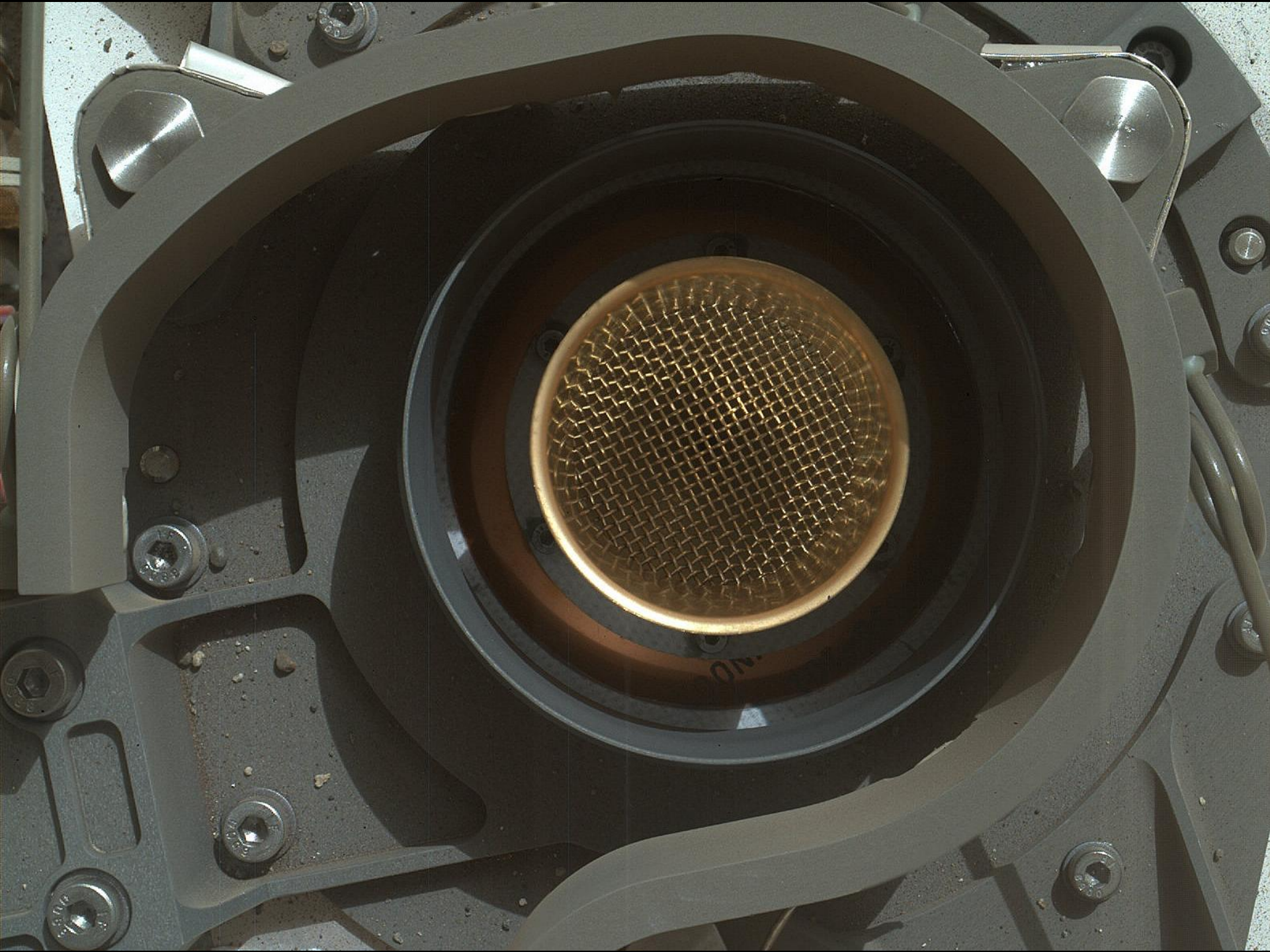


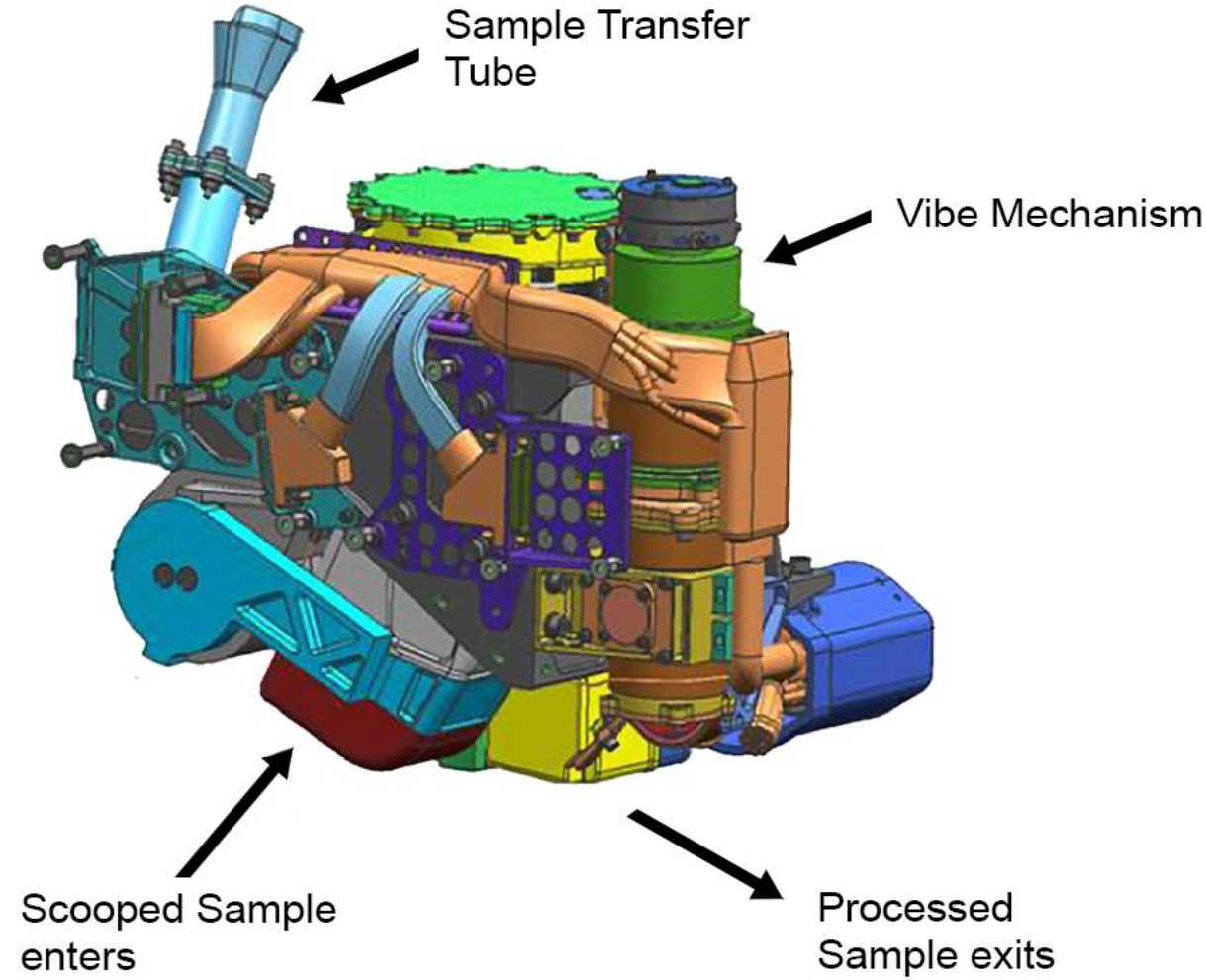

Rover Way Points
Traverse Path
Descent Blast Zone
BRADBURY LANDING
21
22
24
3
16
26
29
38
39
40
41
42
43
45
48
49
50
YELLOW-KNIFE BAY
GLENELG
130
127
YELLOWKNIFE BAY
125
POINT LAKE
ROCKNEST
124
102-111
52
53
55-100
123
121
122
120
SHALER
N
METERS
0 25 50 100 150 200
METERS
0 10 20 40

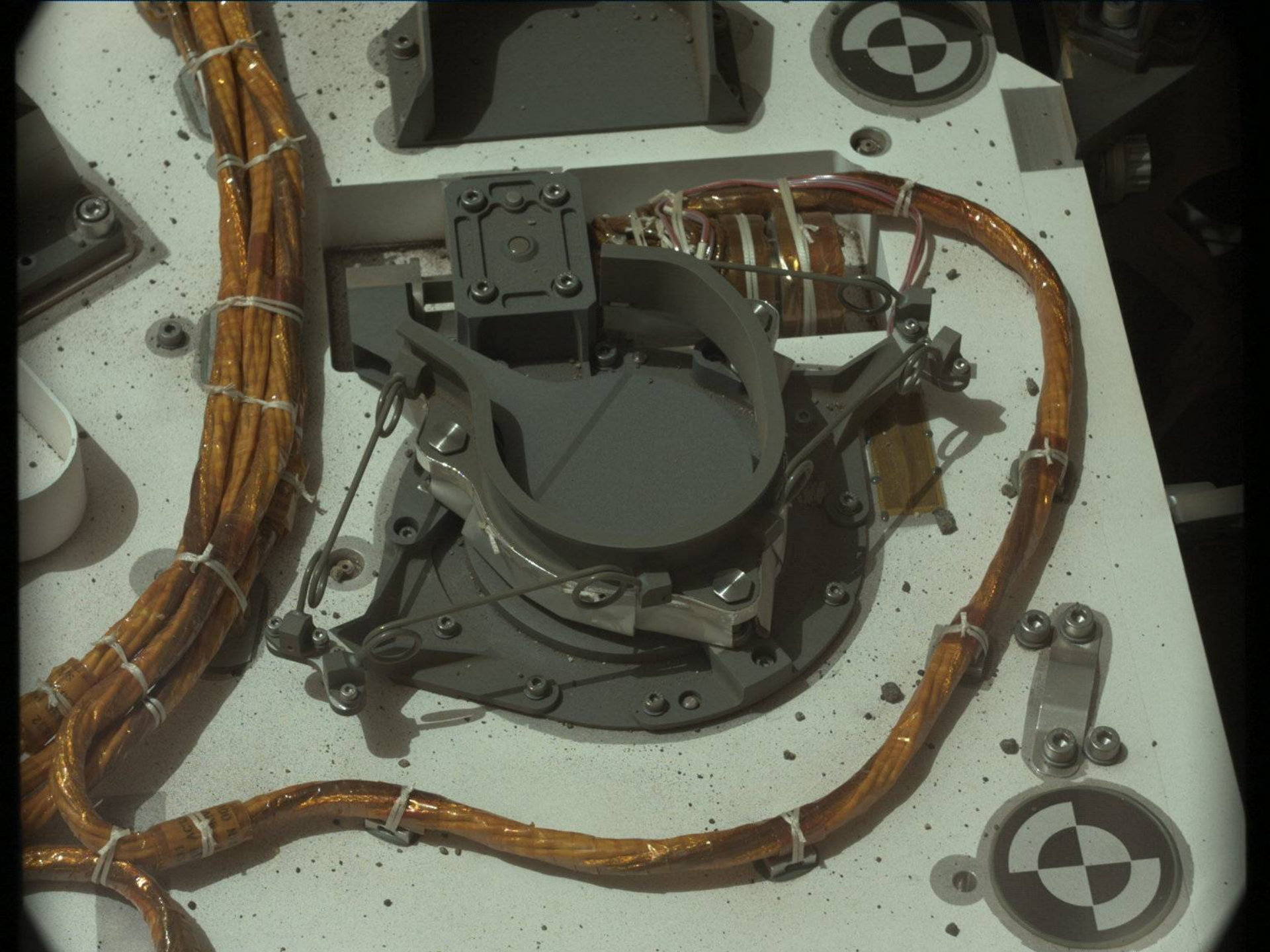



ChemCam 1st Spectrum: 'Coronation'
Visible & Near Infrared
Violet
Ultraviolet
Titanium
Manganese
Intensity (counts)
Wavelength (nanometers)
Iron
Magnesium
Silicon
Aluminum
Calcium
Titanium
Aluminum
Calcium
Calcium
Iron
Silicon
Calcium
Sodium
Hydrogen, 1st Shot
Carbon
Oxygen
Silicon
Lithium
Potassium
Sodium
Oxygen

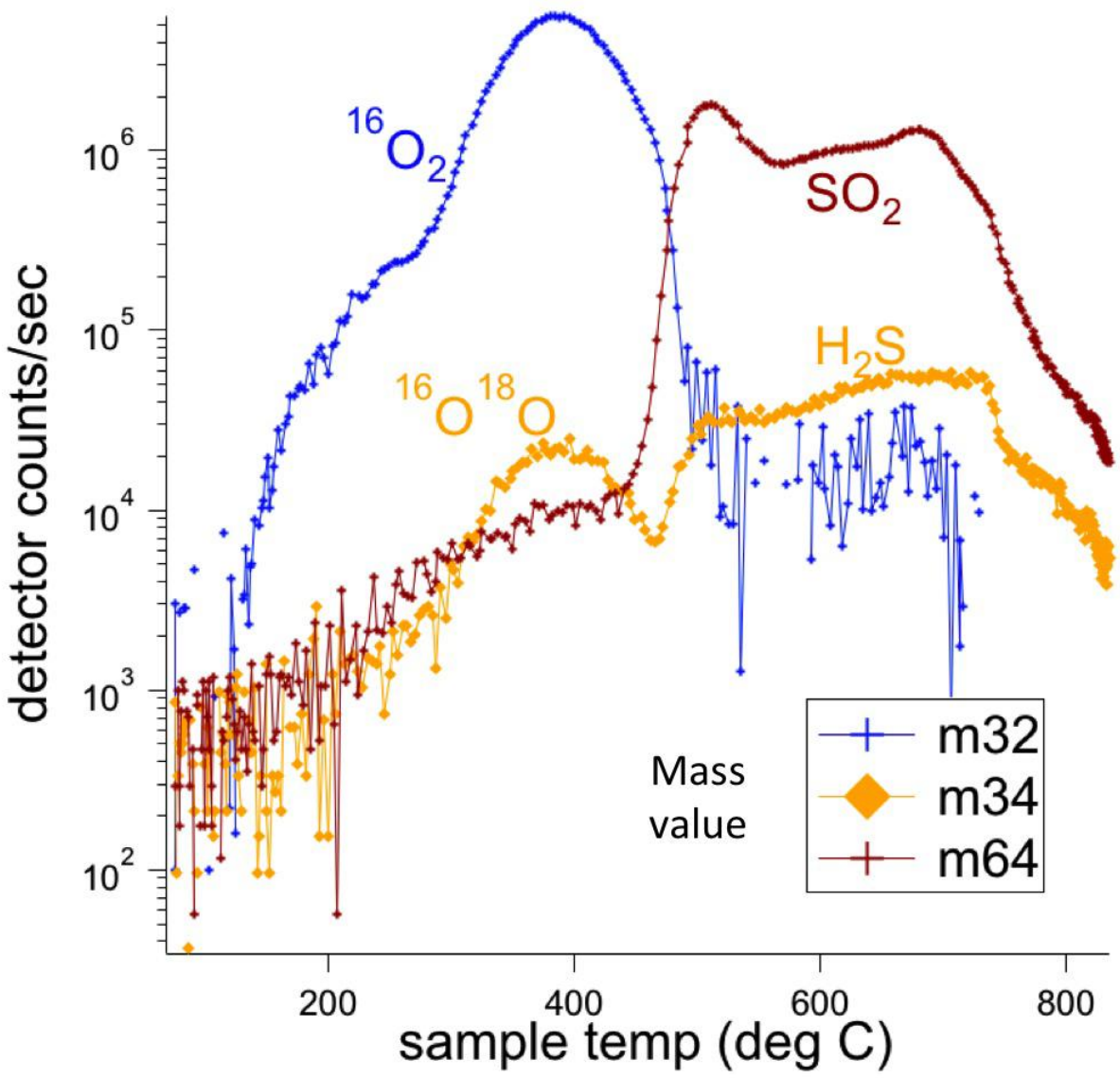
Layering at Rocknest




Sample Transfer Tube
Vibe Mechanism
Scooped Sample enters
Processed Sample exits



Oxygen and Sulfur compounds from Rocknest samples



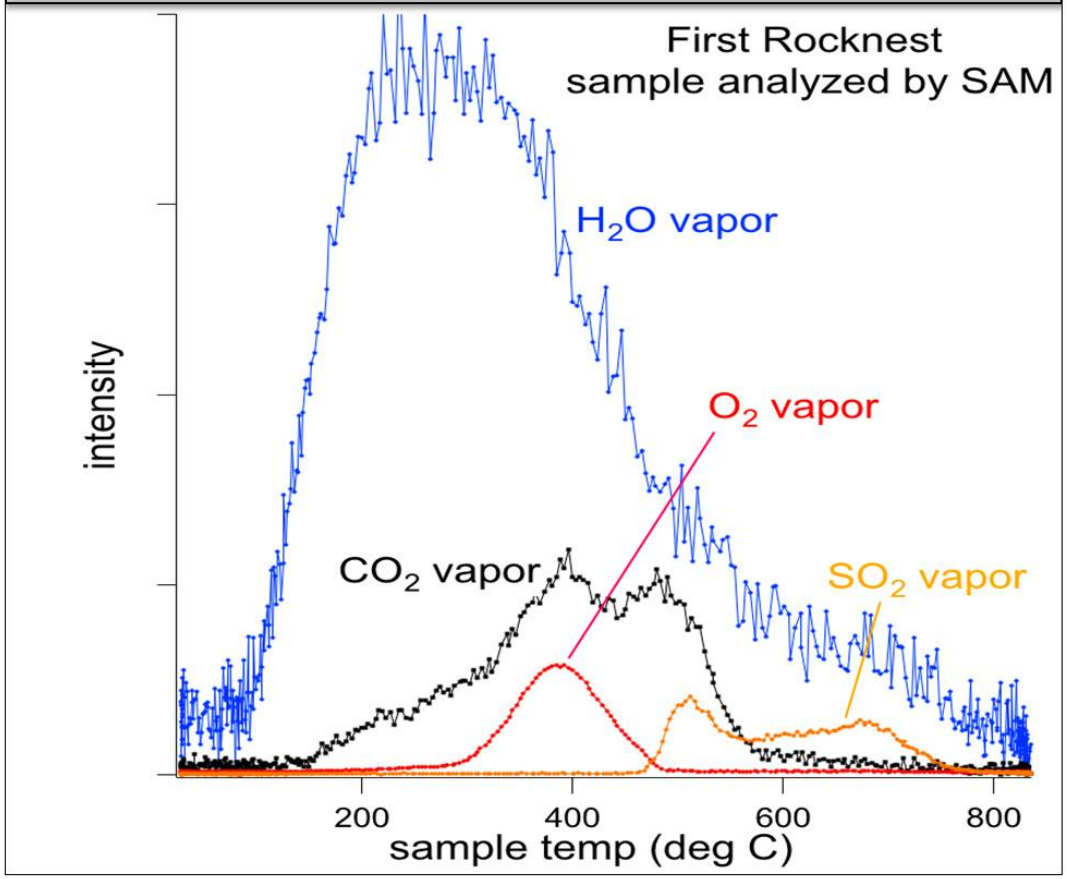
Oxygen released may be from decomposition of a perchlorate such as Ca $(ClO_4)_2$

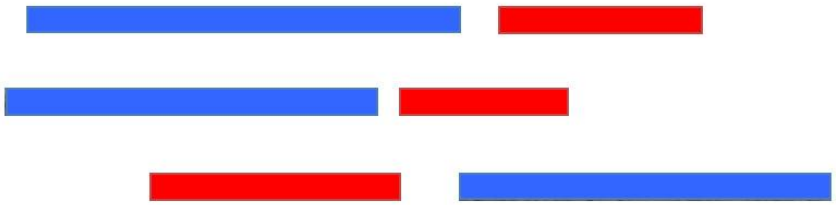
Similar chemicals were observed by the Phoenix polar lander

Higher temperature S containing compounds suggest the presence of sulfates or sulfides

Variety of gases released from Rocknest samples

Major gases released on heating



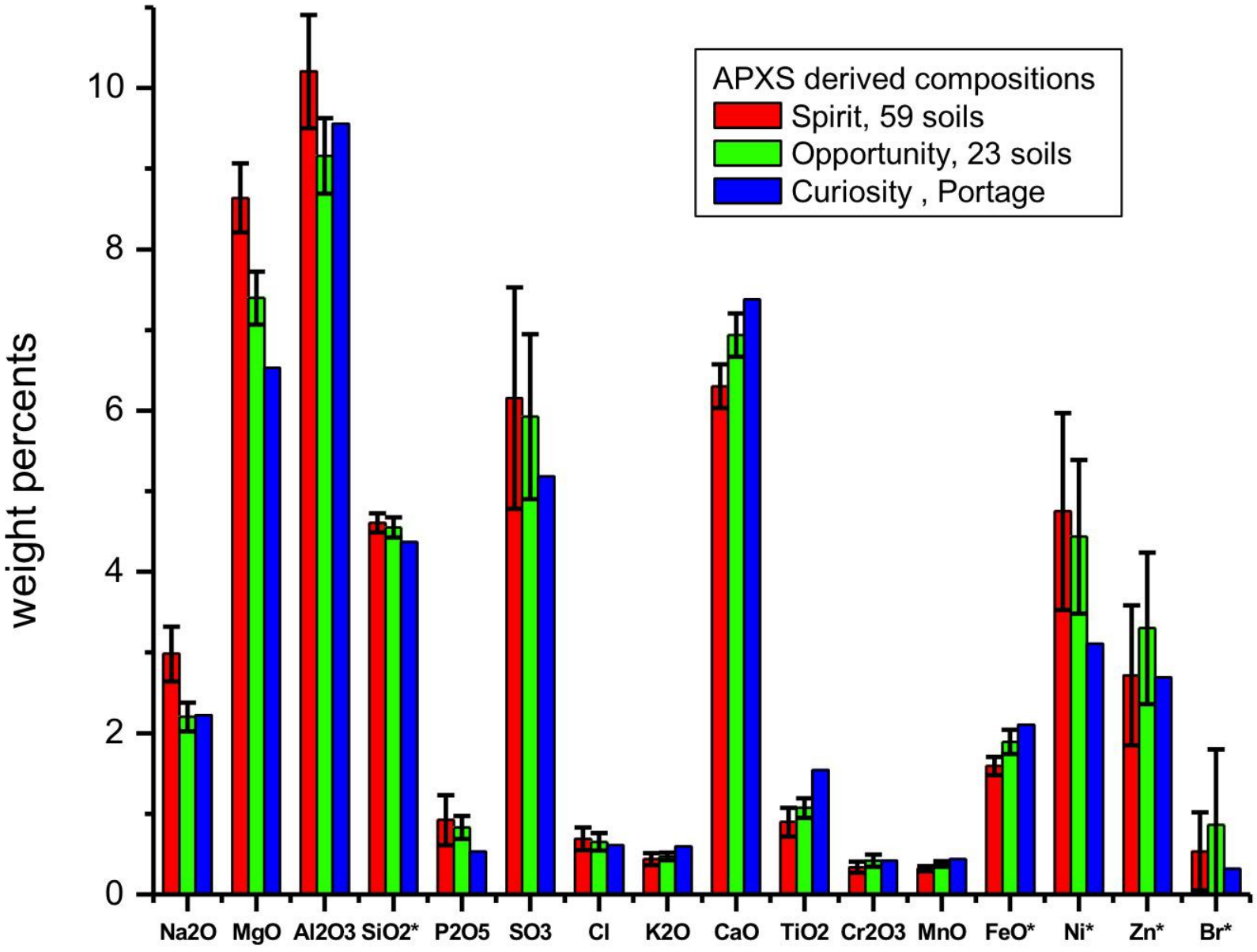


Gases detected by SAM include water (a few percent), and lesser amounts of carbon dioxide, oxygen, and sulfur dioxide

SAM experiment types

- Gas composition
- Isotopes in light elements
- Specific search for organics

For three separate experiments
Red bar - sample temperature for gas sent to TLS
Blue bar – sample temperature for gas sent to GC


APXS derived compositions
Spirit, 59 soils
Opportunity, 23 soils
Curiosity , Portage
weight percents
0
2
4
6
8
10
Na2O
MgO
Al2O3
SiO2*
P2O5
SO3
Cl
K2O
CaO
TiO2
Cr2O3
MnO
FeO*
Ni*
Zn*
Br*

Destination 2013: Mt. Sharp