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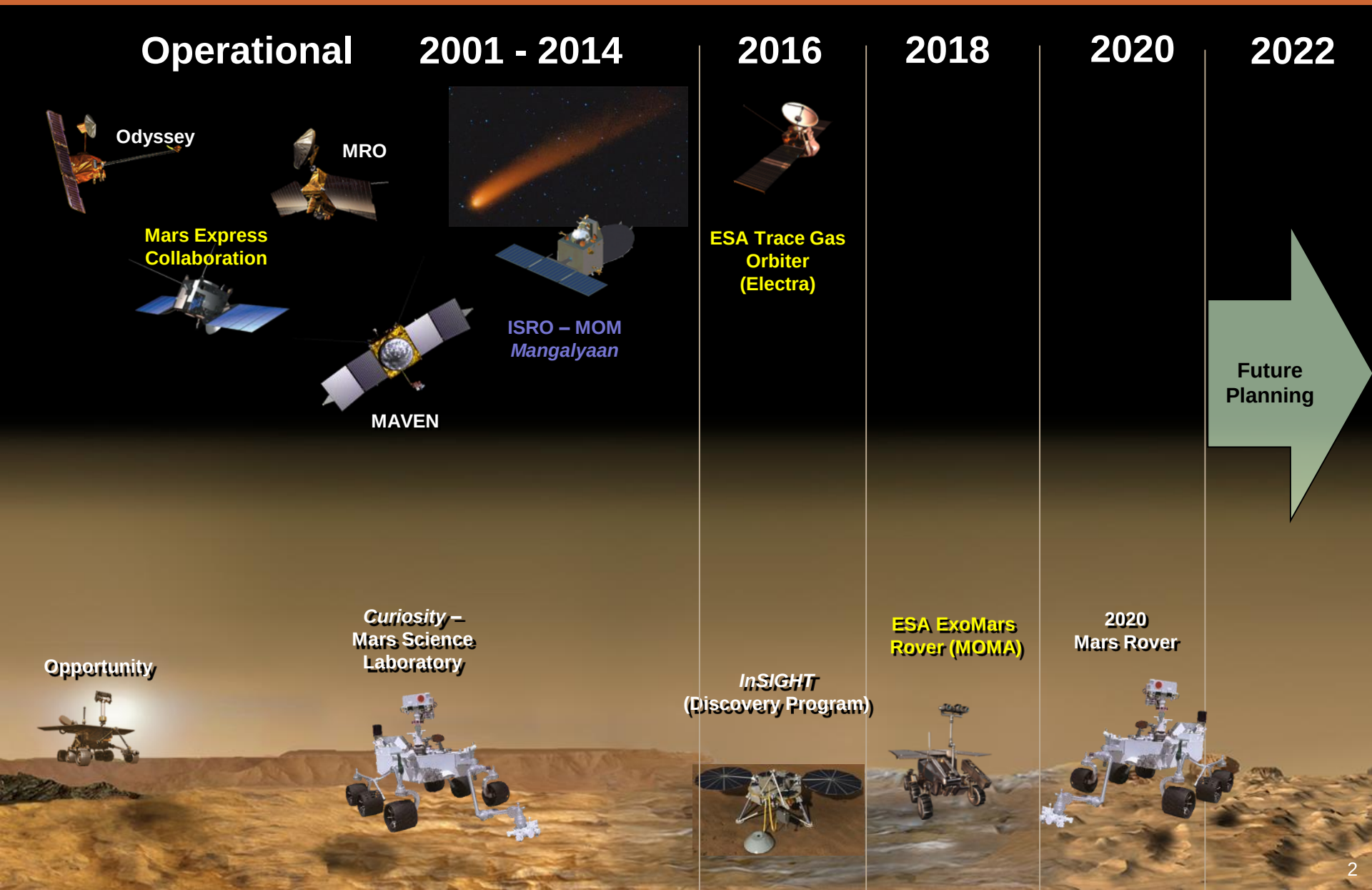
Michael Meyer, Lead Scientist
Mars Exploration Program, HQ

MEPAG
Feb. 2015

Mars Exploration



Events

- ✓ ***Status of Mars Missions***
  - ODY, MER-B, MRO, MEX/NASA, MSL extended missions being implemented
  - MAVEN and MOM in their science orbits around Mars and conducting their prime science missions (reports on Day 2)
  - All Mars missions survived Comet Siding Spring encounter with Mars!
- ✓ ***Science Highlights***
  - Comet Siding Spring observations and impacts on Mars atmosphere
  - *Curiosity* on slopes of Mt. Sharp, drilling away
  - *Opportunity* examines rock diversity on Endeavour Crater rim; nearing marathon run.
  - Odyssey getting a look at the morning/evening atmosphere at their new local time
- ***Progress being made on Landing Site Observations*** *(see talks on Day 2)*
- ***Many science presentations at DPS, GSA, and AGU***
- ***Looking Ahead***
  - ISRO-NASA Mars Working Group met face to face in Bangalore
  - Face to Face MEPAG meeting on Feb. 24-25, 2015, Pasadena area.
  - LPSC coming up on March 15-20
  - FY17 Budget in work

Comet Siding Spring Highlights (observed at Mars)

- **All spacecraft survived with no apparent damage!**
- **Comet:**
  - **First-ever imaging of the nucleus of a long-period comet:**
    - MRO HiRISE: nucleus ≤ 1 km in diameter, may be ≤ 500 m (pixelated bright area)
    - Rotation and diameter determinations complicated by bright jets and "half-moon" phase
      - But nucleus is smaller than expected and it is rotating!
  - **Composition**:
    - MAVEN IUVS and NGIMS: First ever determination of metals in dust from an Oort Cloud comet.
- **Interaction with Mars:**
  - **Meteors did enter Mars atmosphere!**
    - Temporary detection of metal ions in substantial quantity
    - Temporary, but significant, ionospheric enhancement seen near ~100 km altitude (too deep for molecular penetration)
    - Rovers did not attempt to see meteor shower which would have been at twilight.
  - **How many meteors entered Mars atmosphere?**
    - Seems to have been a lot of material
    - Note: Even at an estimated fluence of 1 particle/km^2 Mars would have intercepted millions of meteors (> 1 metric ton) with a probability of spacecraft impact of only 10^{-5}.

Scale: ~ 1.6-cm wide brushed area

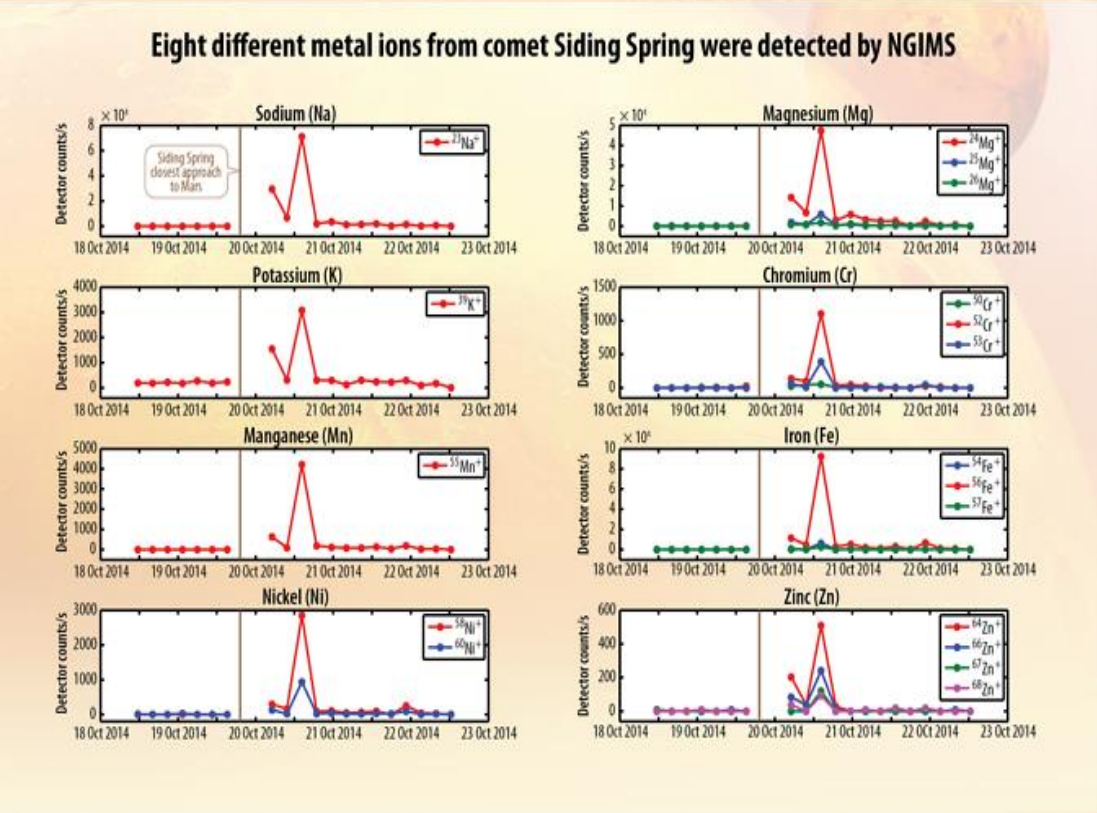
Scale: ~ 6-cm wide brushed area

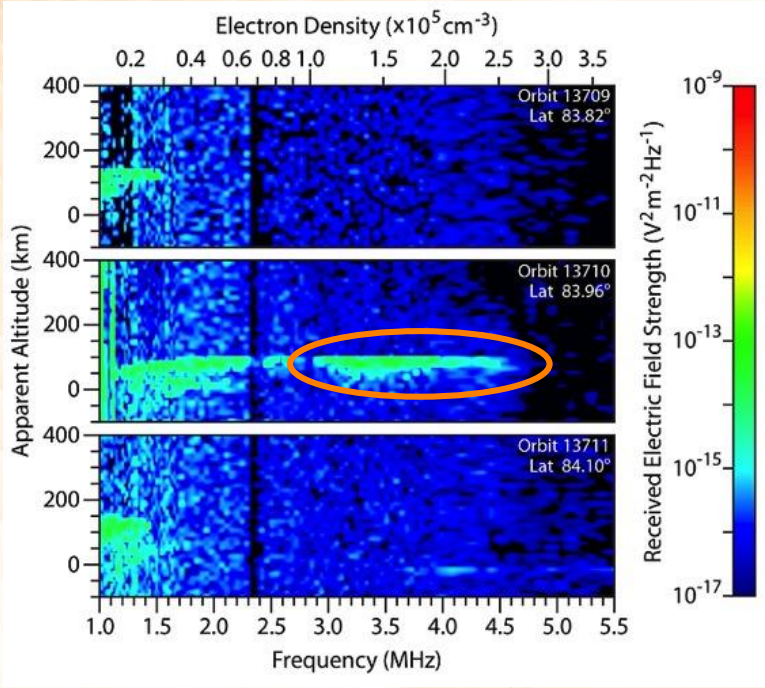
More heavily damaged left wheel

Comet /2013 A1 Siding Spring: Comet Dust in the Mars Atmosphere (see MAVEN presentation)

MAVEN IUVS & NGIMS:
Metallic signatures of Comet Dust in the Mars Atmosphere

MEX MARSIS & MRO SHARAD:
Comet-induced Ionization in the Mars Atmosphere

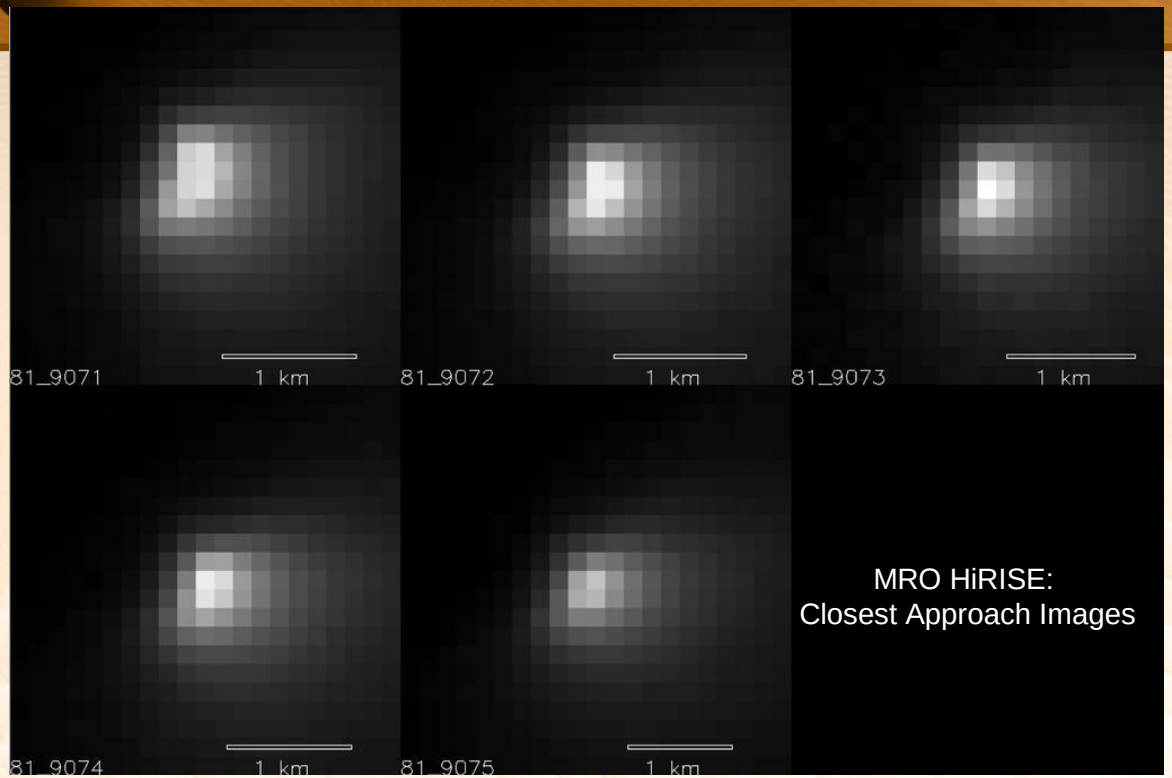




MAVEN NGIMS: In situ metal detection (~175 km)

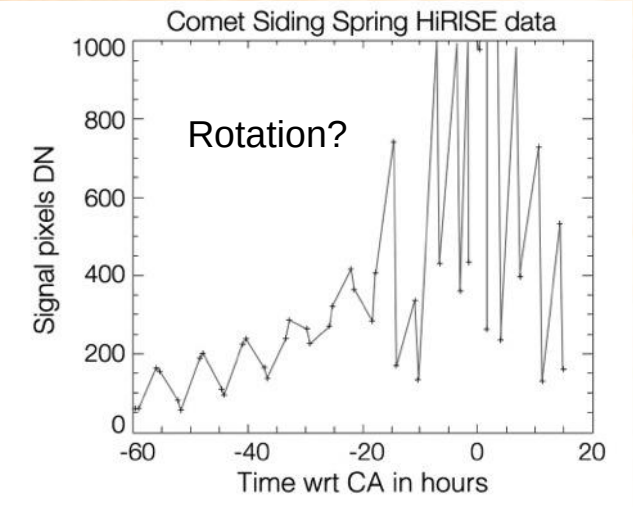
MEX MARSIS: Transient Ionospheric Layer at ~100 km

Comet /2013 A1 Siding Spring: Nucleus & Inner Coma



MRO HiRISE:

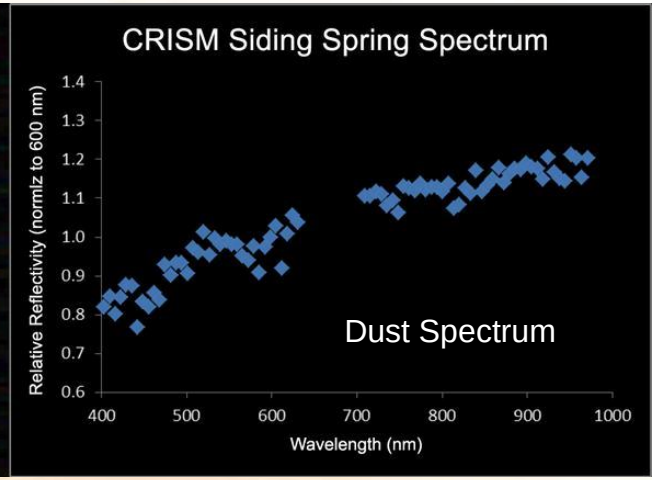
Brightness variation during CSS Encounter



MRO CRISM:

Left: Comet Siding Spring Color Composite From Closest Approach (CA) Images

Right: Composite Spectrum of CSS Reflecting Dust

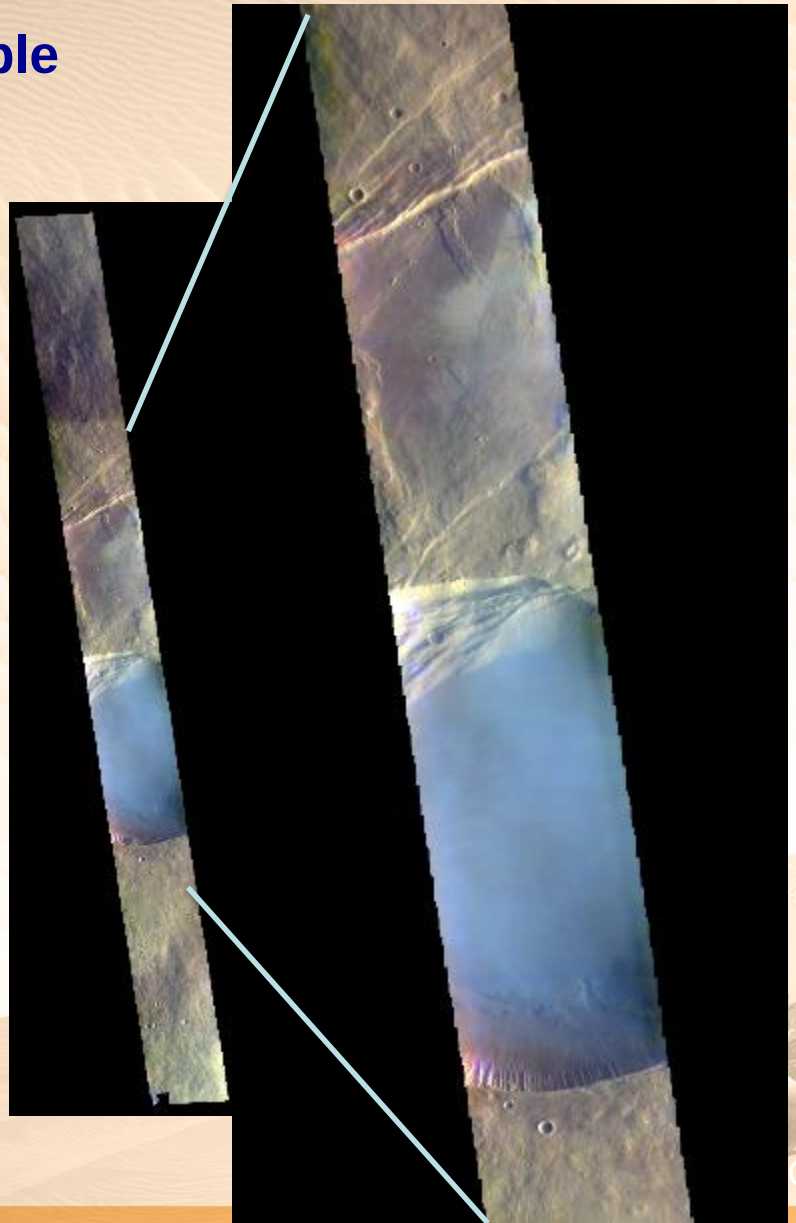


THEMIS Morning Day-Side Visible Images of Water-Ice Clouds

Recent THEMIS data provide a preview of the morning day-side orbit geometry that Odyssey will be in for much of the upcoming Extended Mission 6.

This enhanced visible color image shows water-ice clouds that formed overnight lingering in the caldera of Pavonis Mons, near the Martian equator.

Image width 18 km.
Image acquired Sep. 4, 2014.



Landing Sites

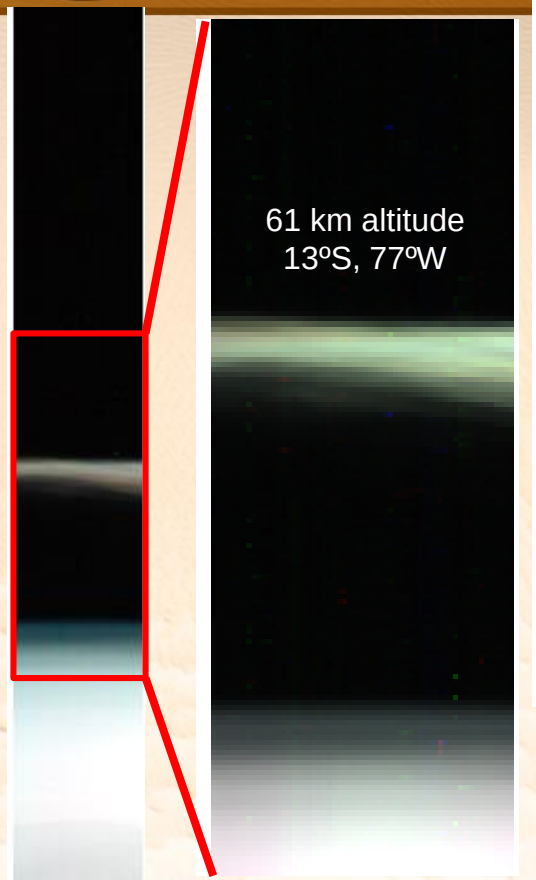
MRO

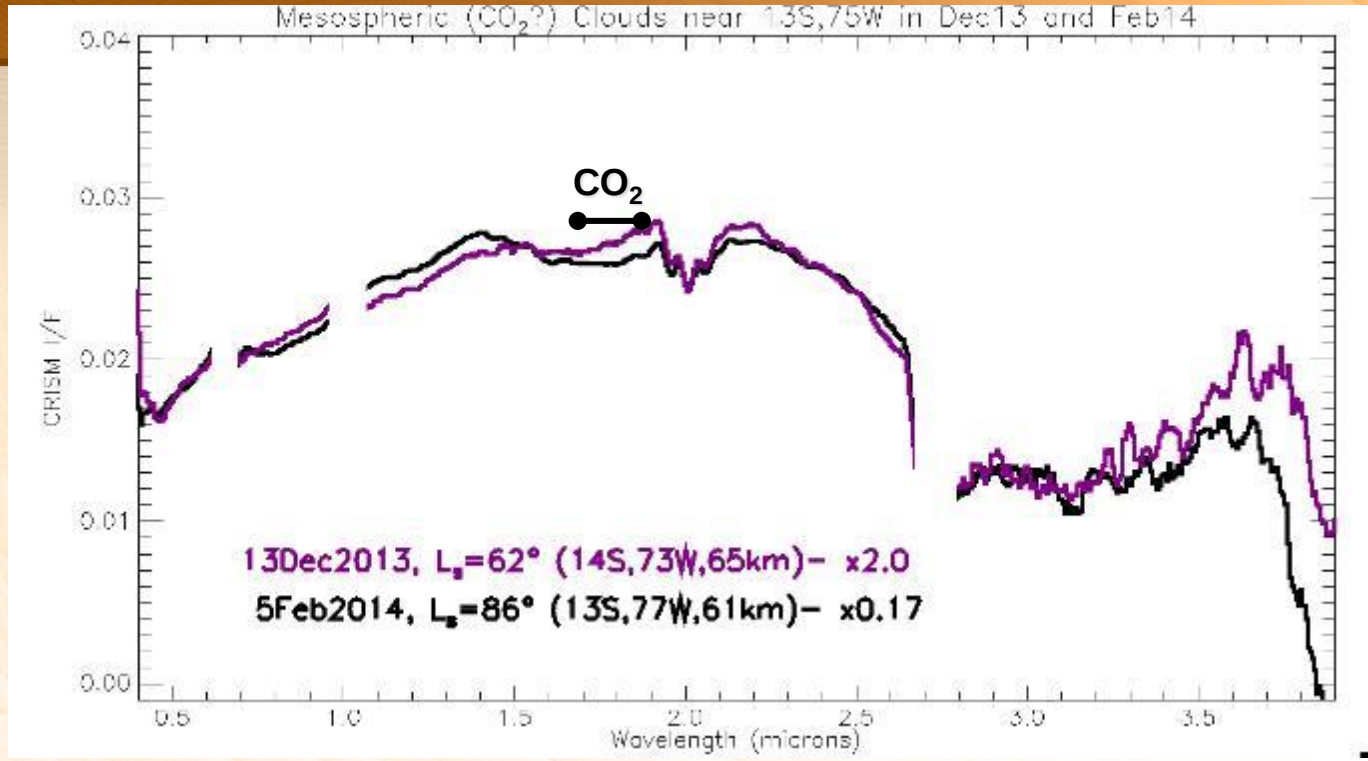
Scale: ~ 1.6-cm wide brushed area *Scale: ~ 6-cm wide brushed area*

- MRO has satisfied >50% of all current landing site characterization requests for InSight, 2018 ExoMars, & 2020 Mars rover
- Pace of MRO data acquisition for landing site characterization was slowed temporarily due to Comet Siding Spring activities and November "no roll" period. MRO now back to observing with nominal ±30˚ rolls

- **Site Selection Activities: InSight, ExoMars, 2020 Mars Rover, Humans to Mars**
  - See specific presentations, many on Day 2.
  - 2020 *Second* Landing Site Workshop scheduled for first week in August 2015
  - Site proposers were asked to identify "regions of interest" for their site to aid 2020 Project assessment of operability.
    - May also benefit studies of landing site configuration for humans

High Altitude CO_2 Ice Clouds on Mars



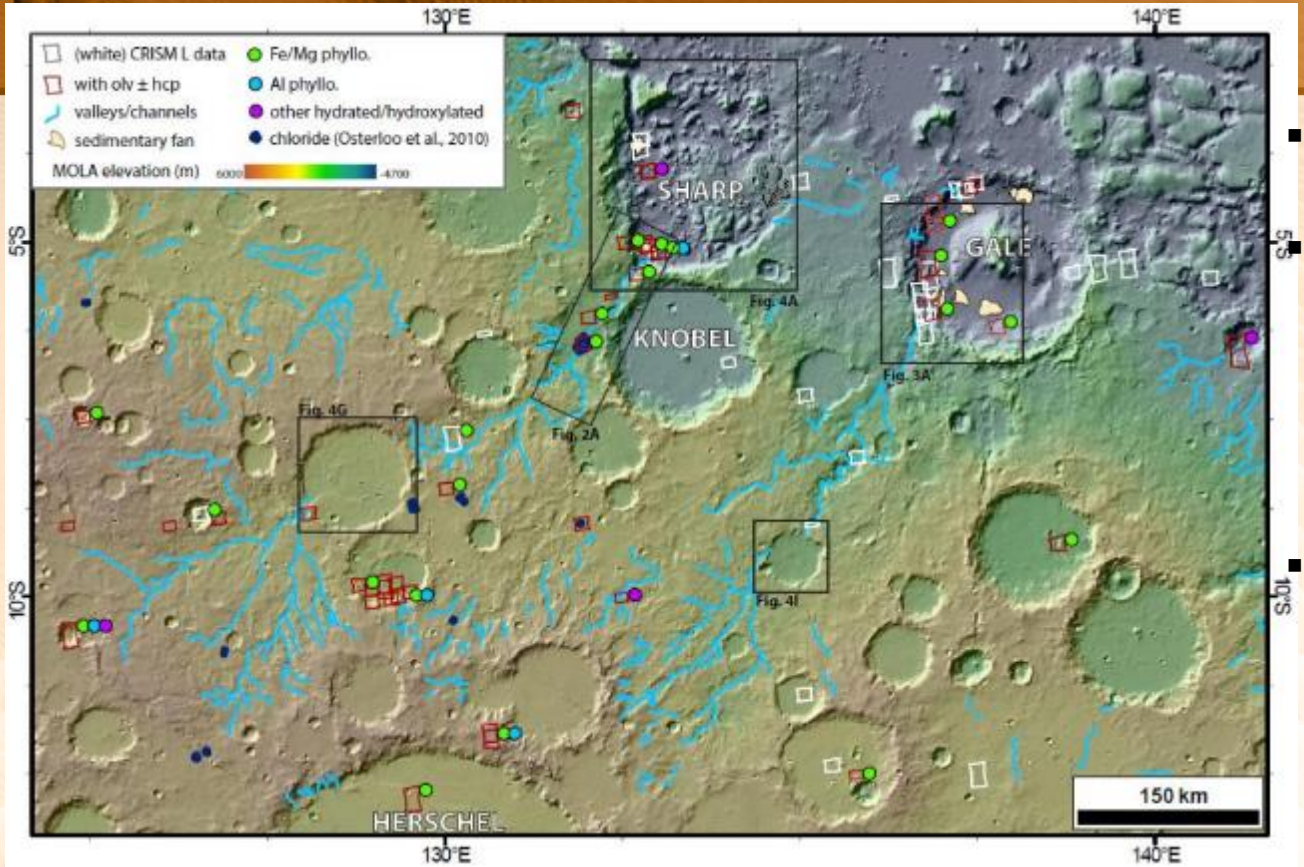


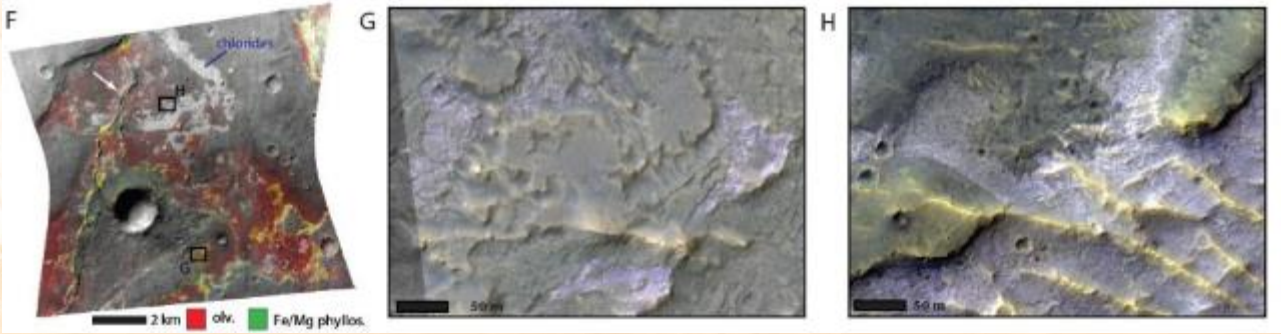
Left: False color limb scan (R= 2.53, G=1.51, B=1.08 µm)

Above: stretched using CO_2 bands (R=2.14, G=2.00, B=1.87 µm)

- **Mission/instrument:** MRO/CRISM
- **Finding:** Rare, high altitude CO_2 ice clouds occur in Mars' northern equatorial region of during northern summer/fall.
- **Importance:** CO_2 ice clouds like these are thought to have had a strong influence on climate early in Mars' history.
- **Reference:** Clancy, R. T., et al. (2014). CRISM Limb Observations of Mars Mesospheric Ice Clouds: Two New Results. Lunar and Plan. Sci. Conf. Abstract #1006.

Minerals in Watersheds Around Gale Crater



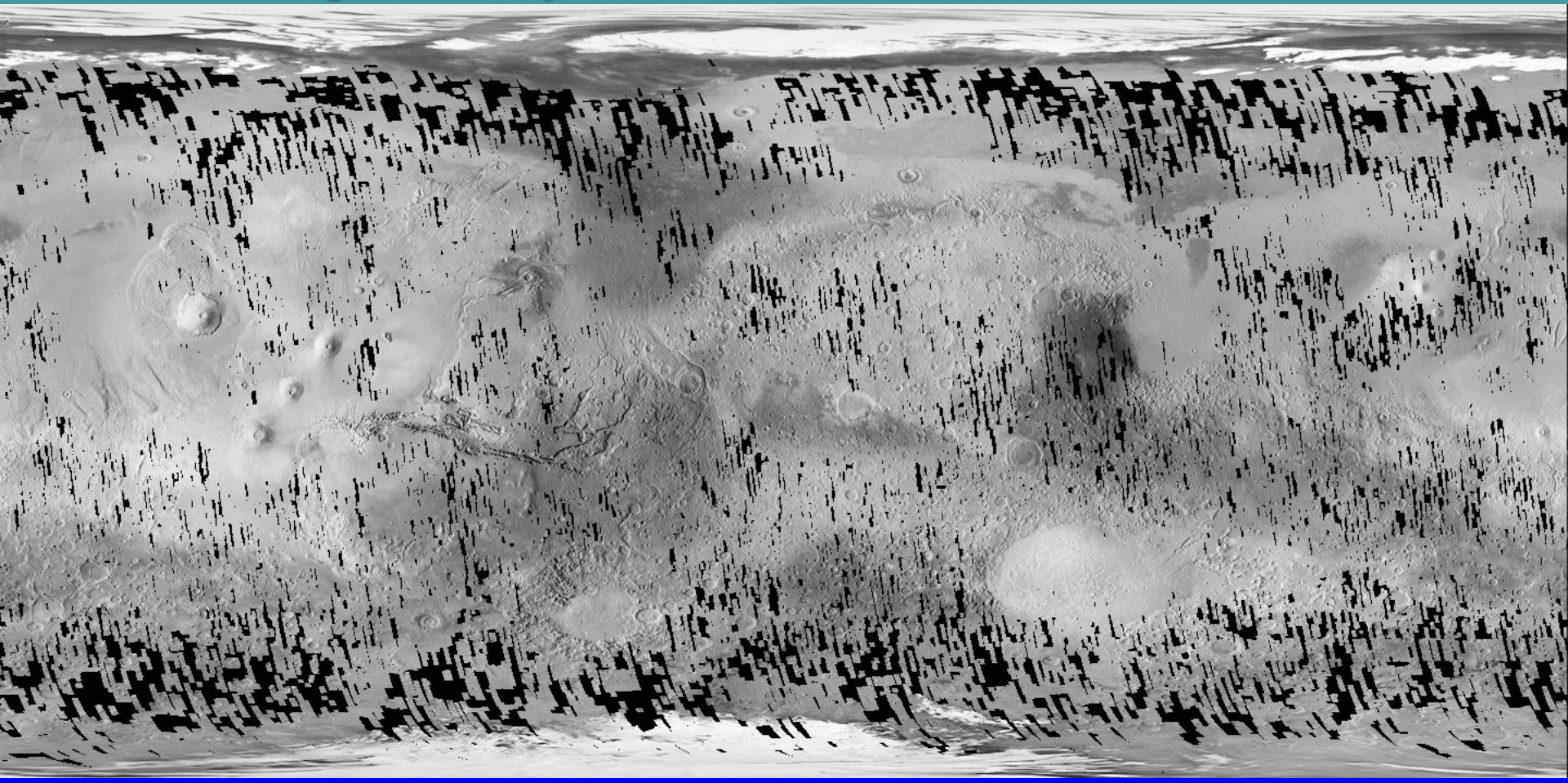


- **Mission/instrument:** MRO/CRISM
- **Finding:** Gale and surrounding craters host similar bedrock mineralogy and altered clay deposits on their floors, but vary in evaporate salt content.
- **Importance:** Fluvial processes emplaced detrital clay minerals. As Mars dried out, the three craters became hydrologically isolated and salts were left behind nonuniformly. Curiosity will explore this geologic history.

Reference: Ehlmann, B. L., and Buz, J. (2014) Mineralogy and Fluvial History of the Watersheds of Gale, Knobel, and Sharp craters: Context for MSL Curiosity's Exploration, Geophs. Res. Lett., DOI: 10.1002/2014GL062553.

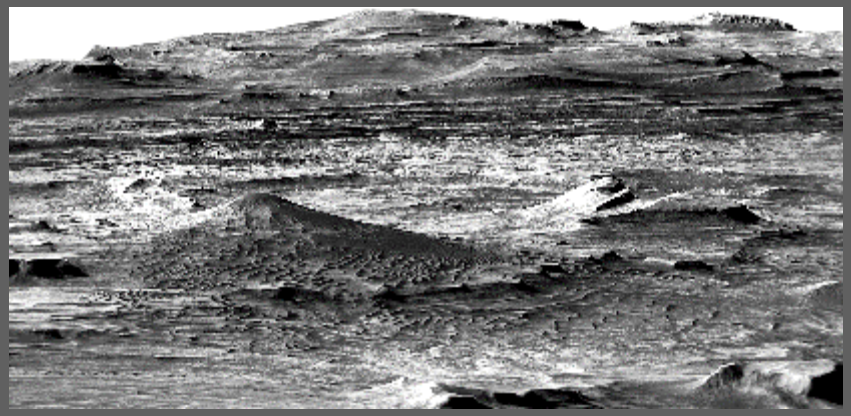
CTX Coverage

Δ Coverage: January 2013 – 2015



CTX has now covered ~94% of Mars

Marsquakes and water-lain sediments in Candor Chasma



Perspective view of the Candor Colles region of west Candor Chasma, Mars. HiRISE image PSP_001641_1735

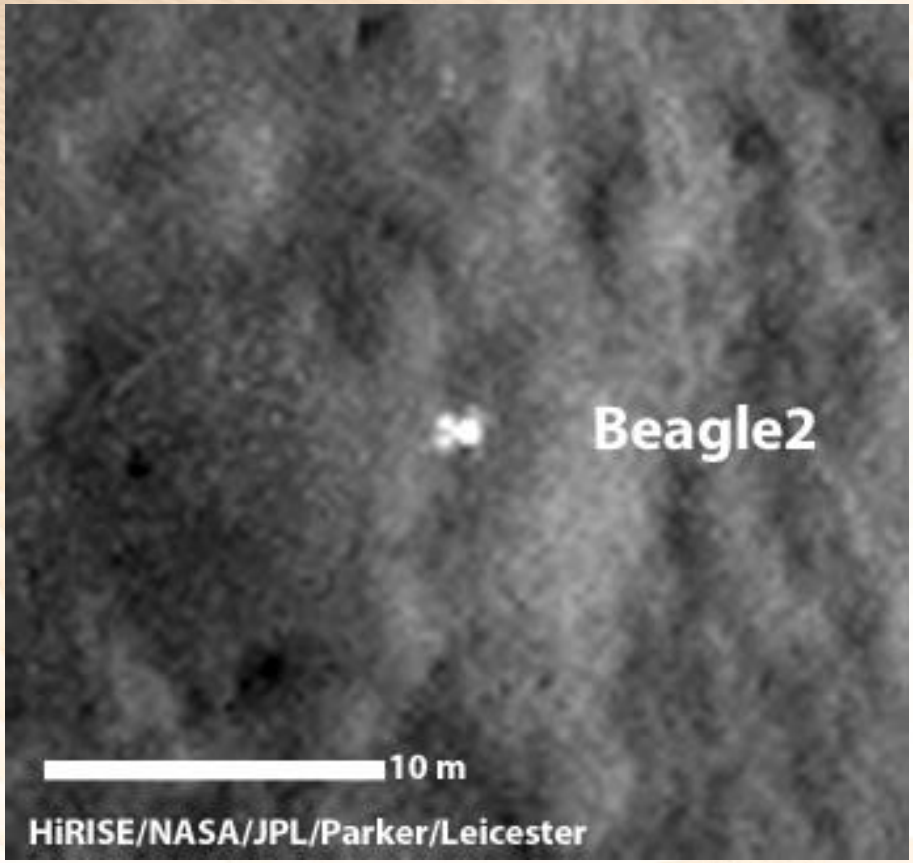
An injectite megapipe (conical hill). Image is ~1 km across. HiRISE image PSP_001641_1735

- Unprecedented high-resolution geologic and structural mapping using HiRISE data has revealed evidence of past marsquakes and water-lain sediments in the west Candor Chasma region of Valles Marineris.
- Orientations of the sediment layers indicate that these rocks formed as sand and dust was blown in by the wind and became trapped in shallow playa lakes.
- Injectite megapipes are also observed. These features formed by underground movement of the water-lain sediments in response to ground shaking (marsquakes) from several large fault zones in the area.
- These injectites served as reservoirs for groundwater and thereby would have hosted potentially habitable environments in the Martian subsurface approximately 3 to 3.5 billion years ago.
- Results published in Okubo, C.H., 2014, Bedrock geologic and structural map through the western Candor Colles region of Mars: U.S. Geological Survey SIM 3309, scale 1:18,000, http://dx.doi.org/10.3133/sim3309.

Beagle-2 Lander Found on Mars

http://www.esa.int/Our_Activities/Space_Science/Mars_Express/Beagle-2_lander_found_on_Mars

- ***The UK-led Beagle-2 Mars lander, which was lost on Mars in late 2003, has been found in images taken by MRO HiRISE***
- ***The lander is seen partially deployed on the surface, showing that the entry, descent and landing sequence worked and it did indeed land on Mars on Christmas Day 2003***
- ***The high resolution images were initially searched by Michael Croon, a former member of the Mars Express operations team at ESA's Space Operations Centre, ESOC, working in parallel with members of the Beagle-2 industrial and scientific teams.***



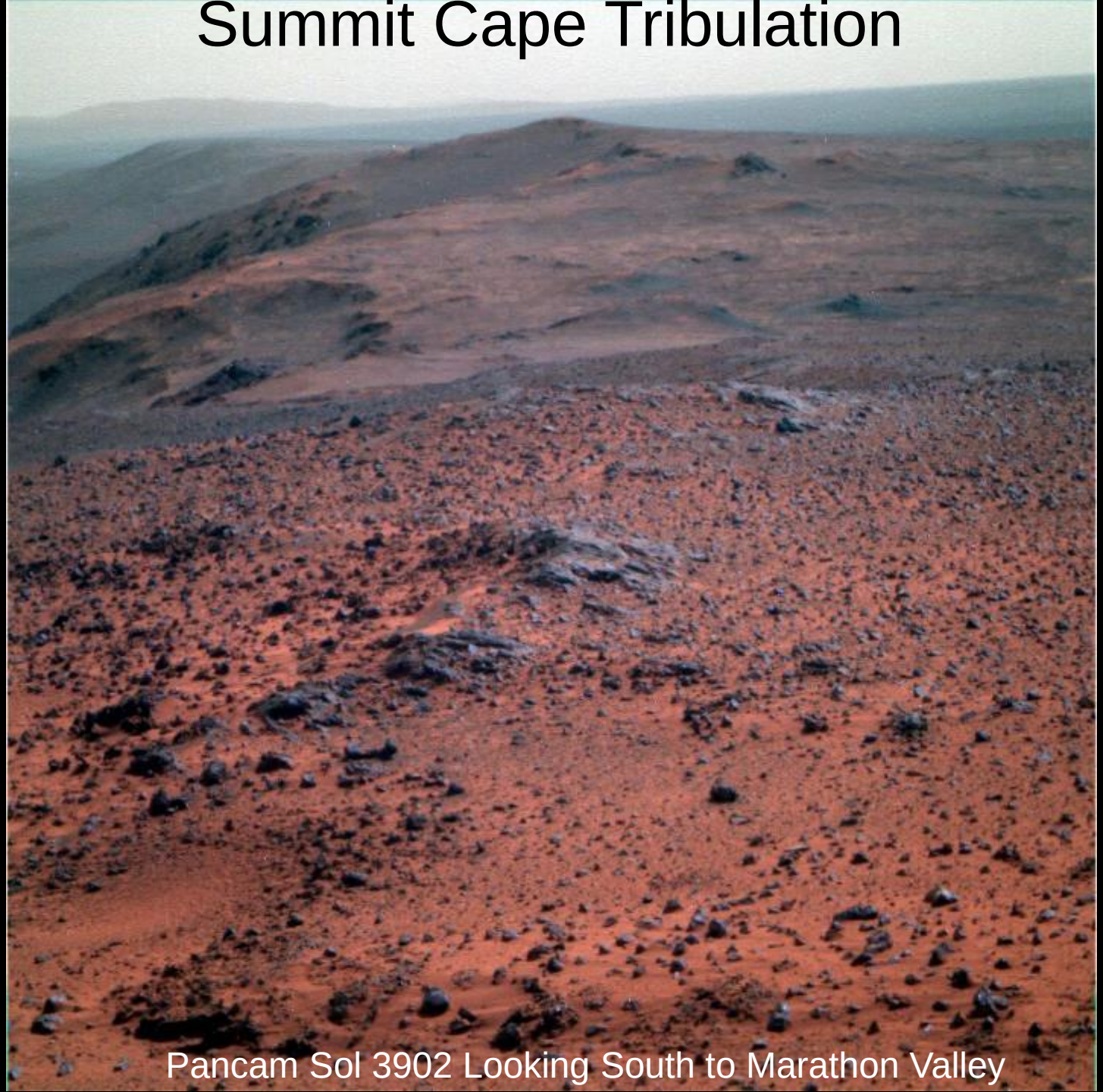
This close-up image shows the lander in a partially deployed configuration, with at most three of the four solar panels open. Beagle-2, lies within its expected landing area at a distance of about 5 km from its center.

Regional Dust Storm

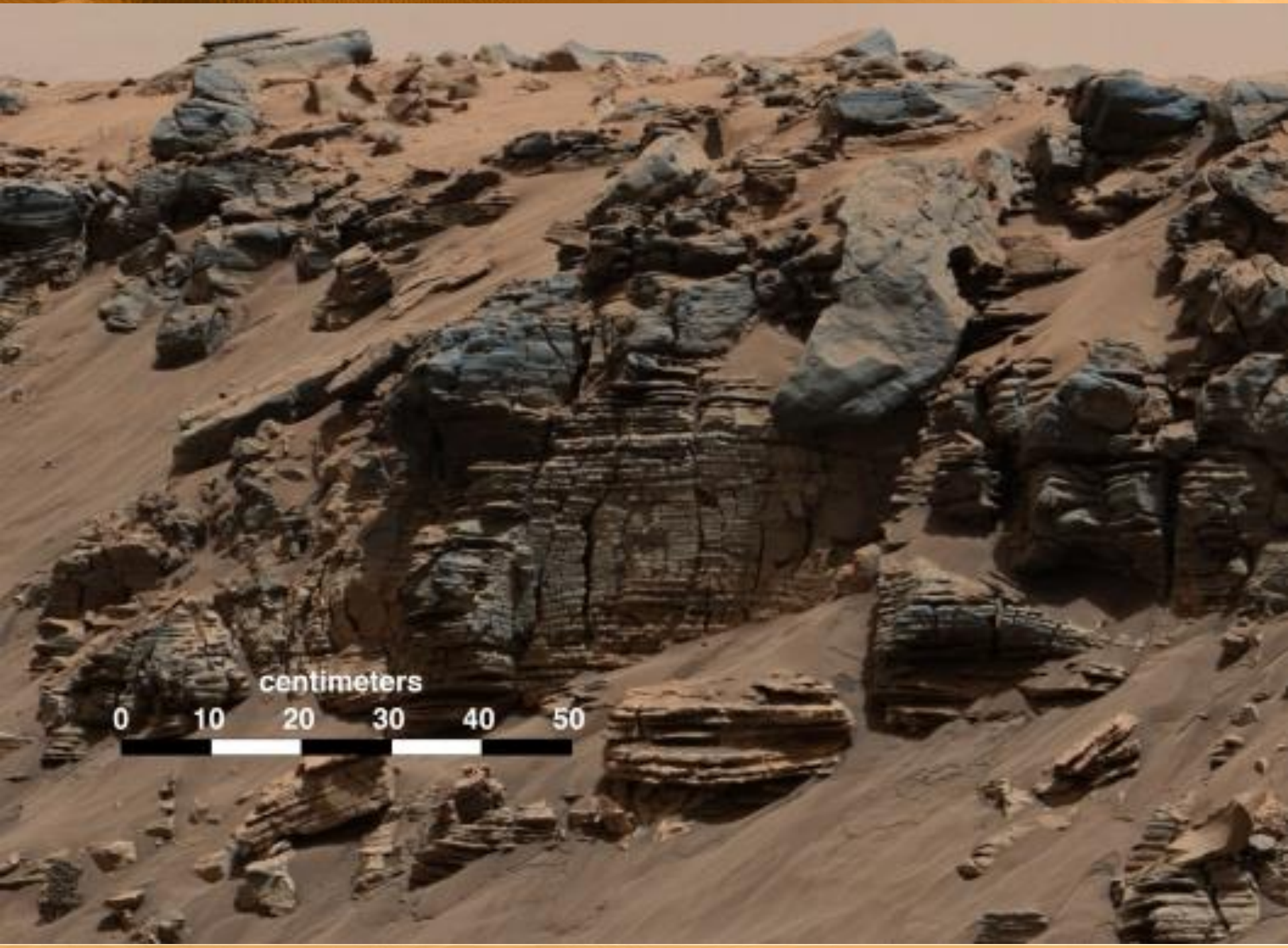
Dust opacity (tau) spiked to >2 on Sol 3823, back down to 1.6 during "A-storm", first of 3 typical dust events during southern spring and summer

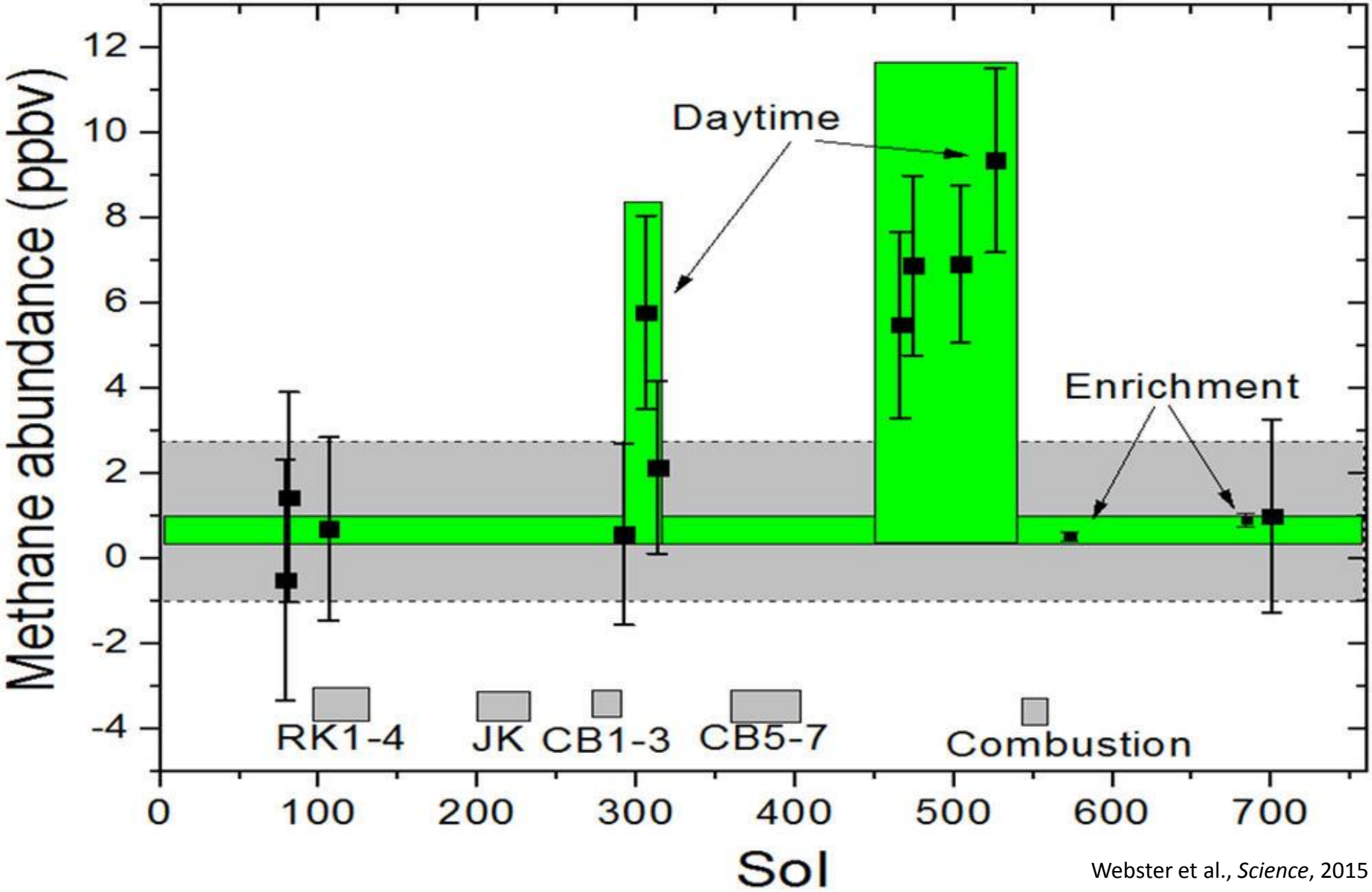
Opportunity
Sol 3911
Sol 3914
Sol 3916
Sol 3918
Sol 3921
Sol 3923
Sol 3936
Sol 3926
Marathon
Valley
Sol 3936
Location
Spirit of
St Louis Crater
42.03 km

Summit Cape Tribulation



Pancam Sol 3902 Looking South to Marathon Valley

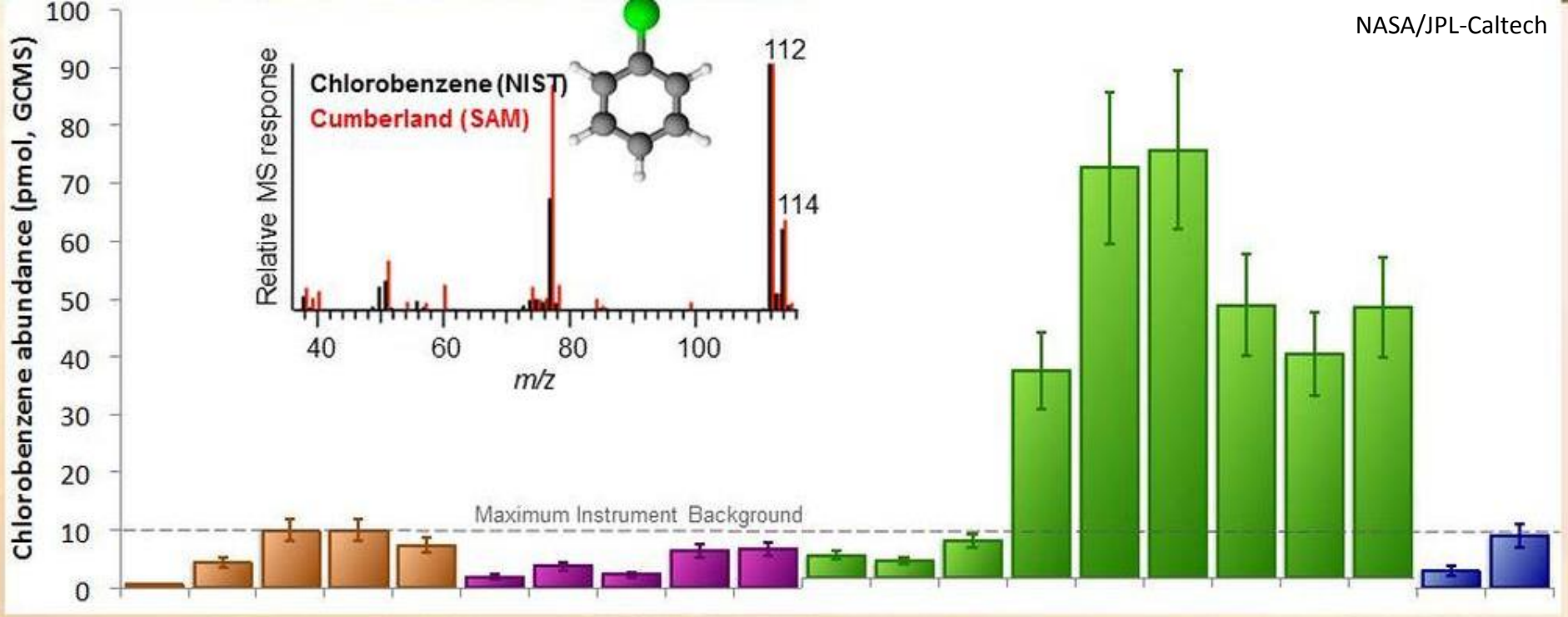

centimeters
0 10 20 30 40 50



Webster et al., *Science*, 2015

Curiosity measured a background methane abundance of 0.7 ppbv and a ten-fold enhancement that lasted ~ 60 sols

NASA/JPL-Caltech



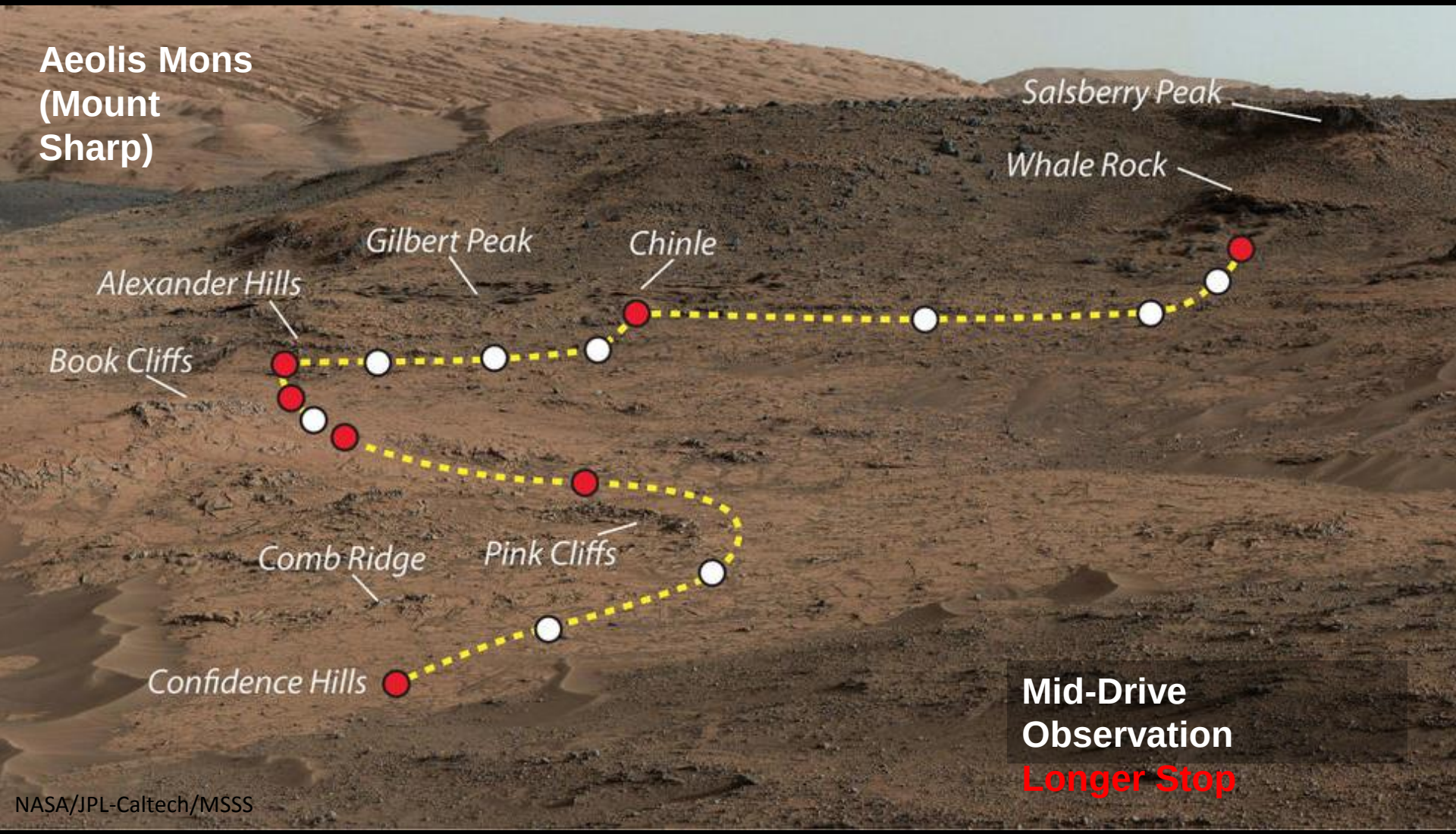
ROCKNEST

JOHN KLEIN

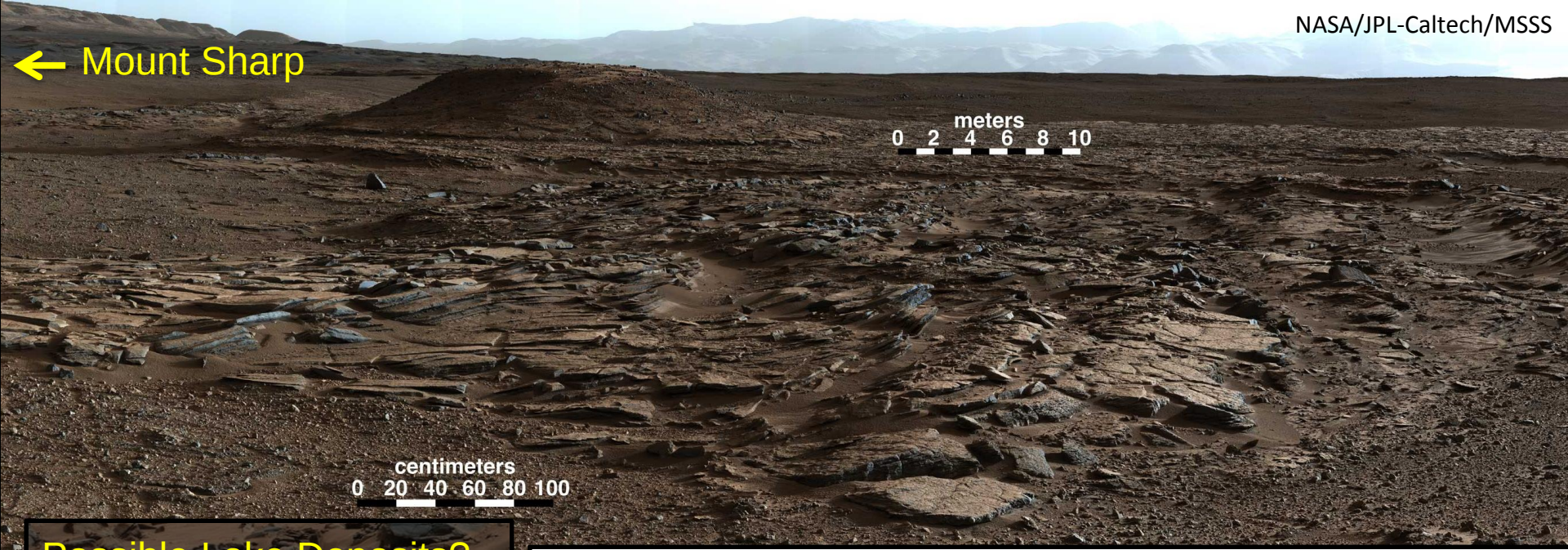
CUMBERLAND

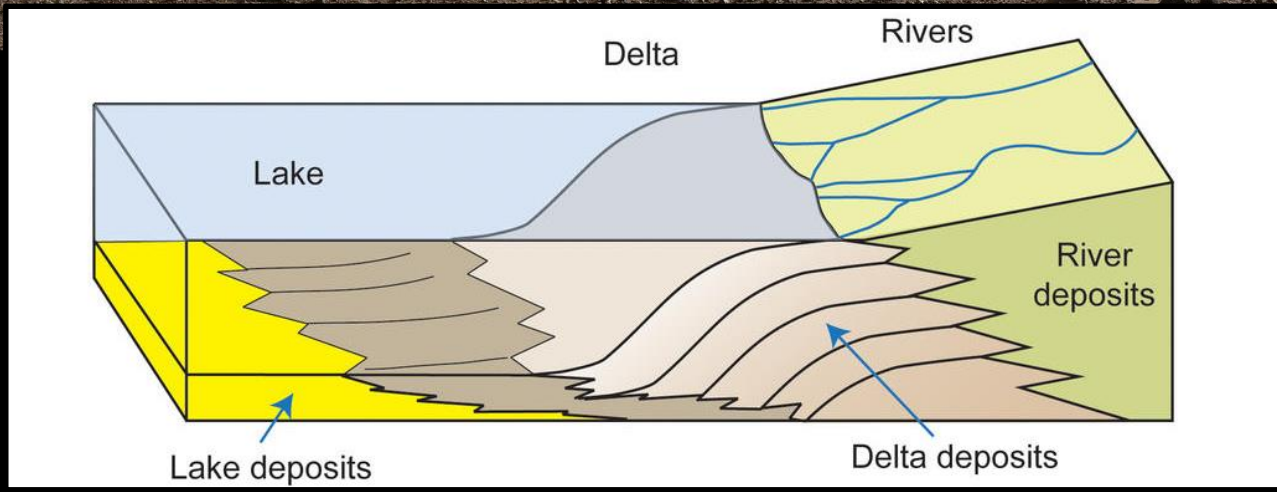
CONFIDENCE HILLS

Chlorobenzene was detected above the instrument background in the Cumberland drilled sample. The chlorine likely is derived from perchlorate in the sedimentary rock.

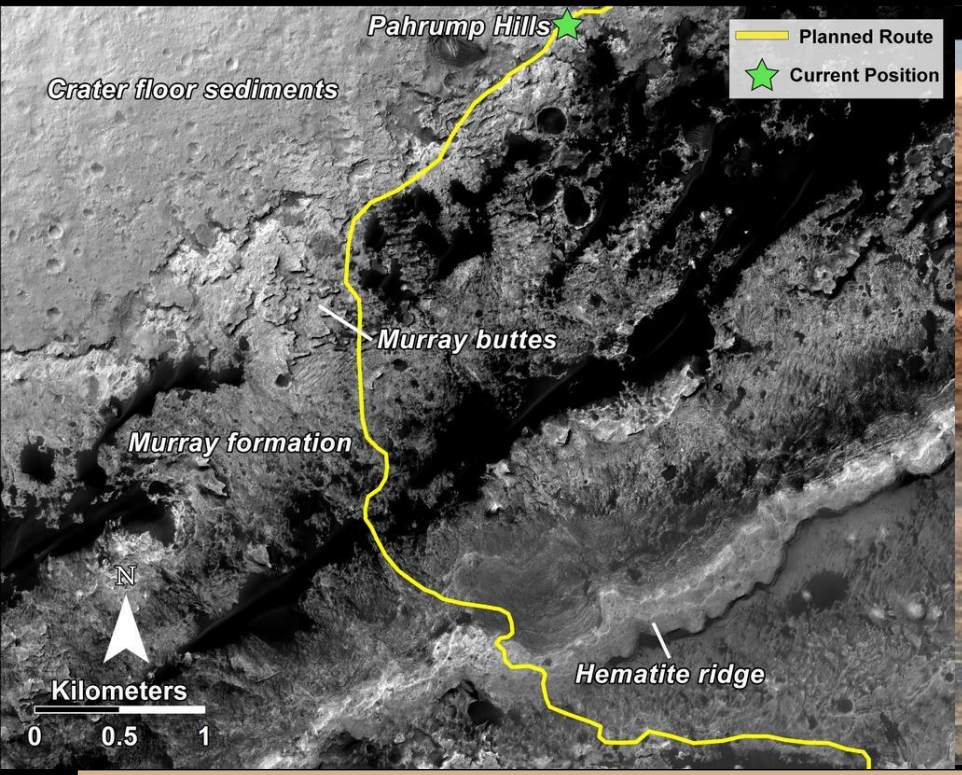


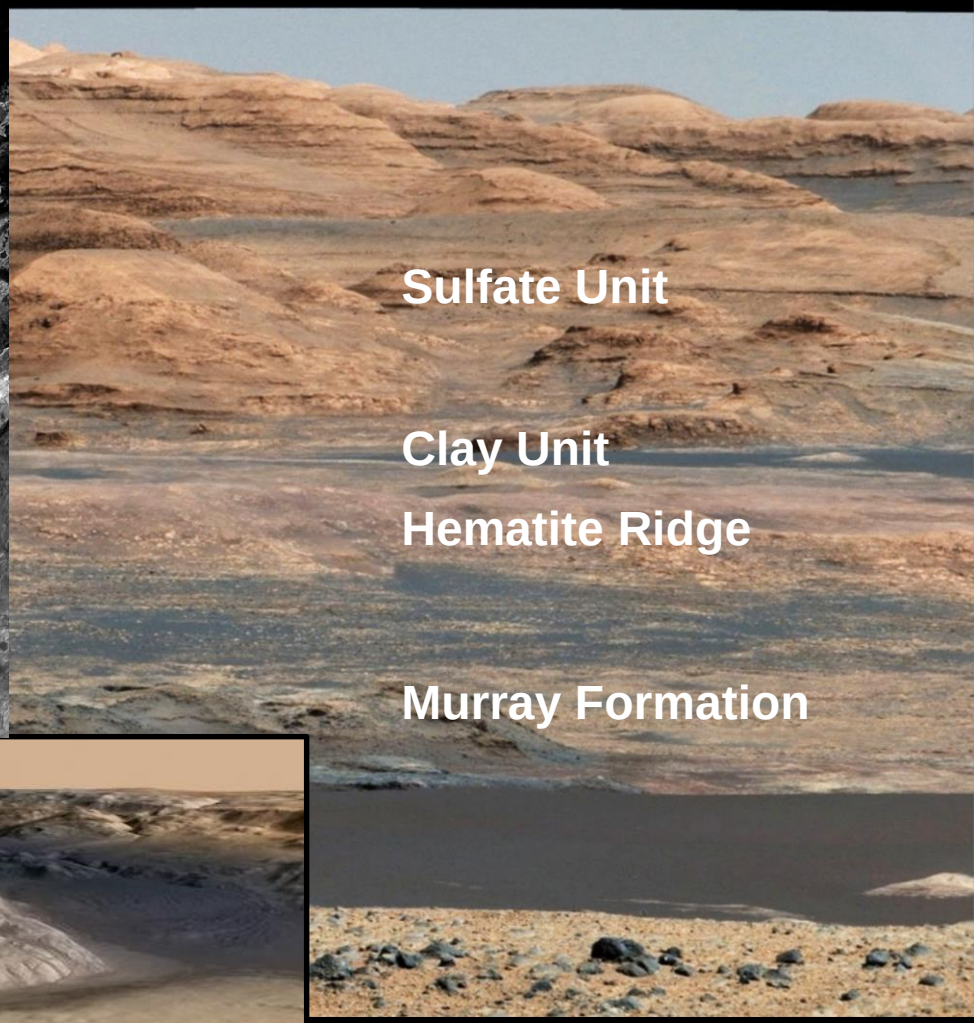
Curiosity is completing a 5-month campaign at Pahrump Hills, the first outcrop of bedrock that composes the base of Mount Sharp. A first pass through the 10-m section used imagers and ChemCam to survey the morphology and chemistry.

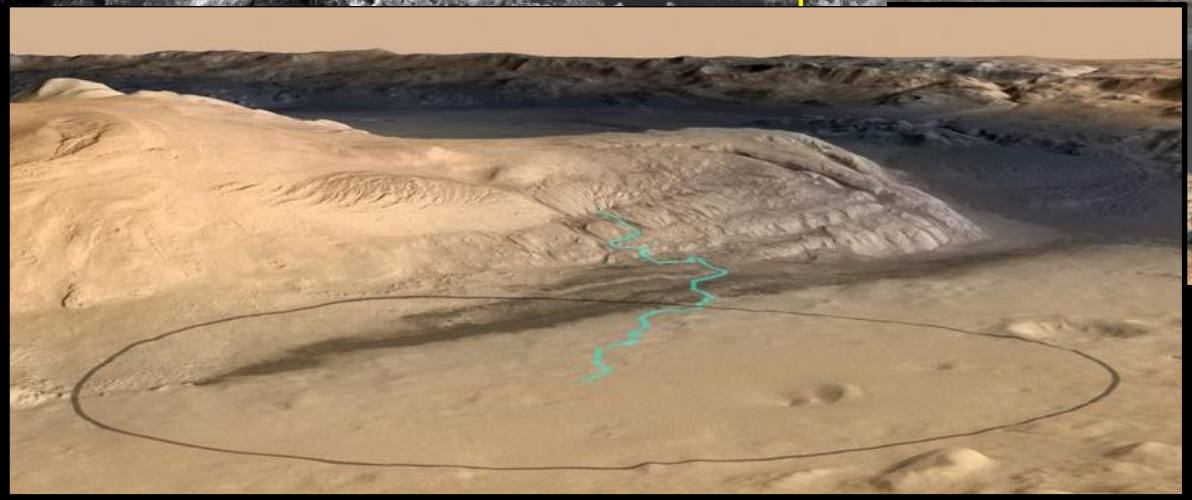




Curiosity is exploring a hypothesis that southward-tilted sandstone beds on Gale Crater's plains indicate fluvial transport of sediment toward Mount Sharp, building up lake deposits there.







NASA/JPL-Caltech/MSSS

Curiosity's Extended Mission will explore Mt. Sharp, with an emphasis on understanding the subset of habitable environments that preserve organic carbon

MARS
#JOURNEYTOMARS