National Aeronautics and Space Administration

Update from the Mars Science Laboratory

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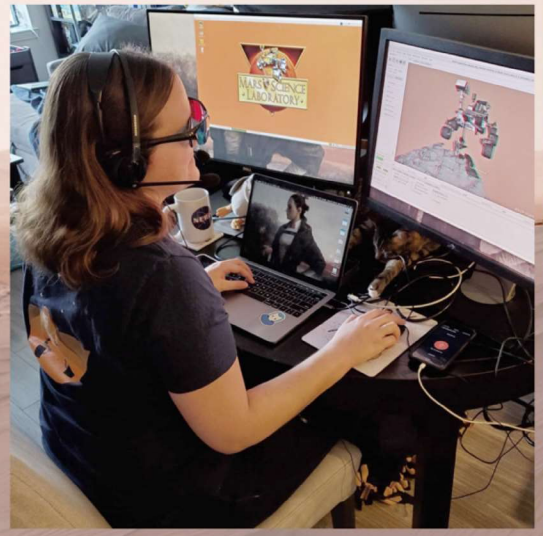
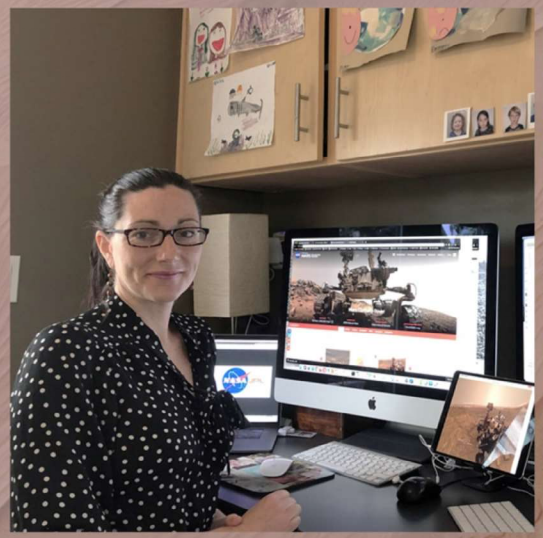
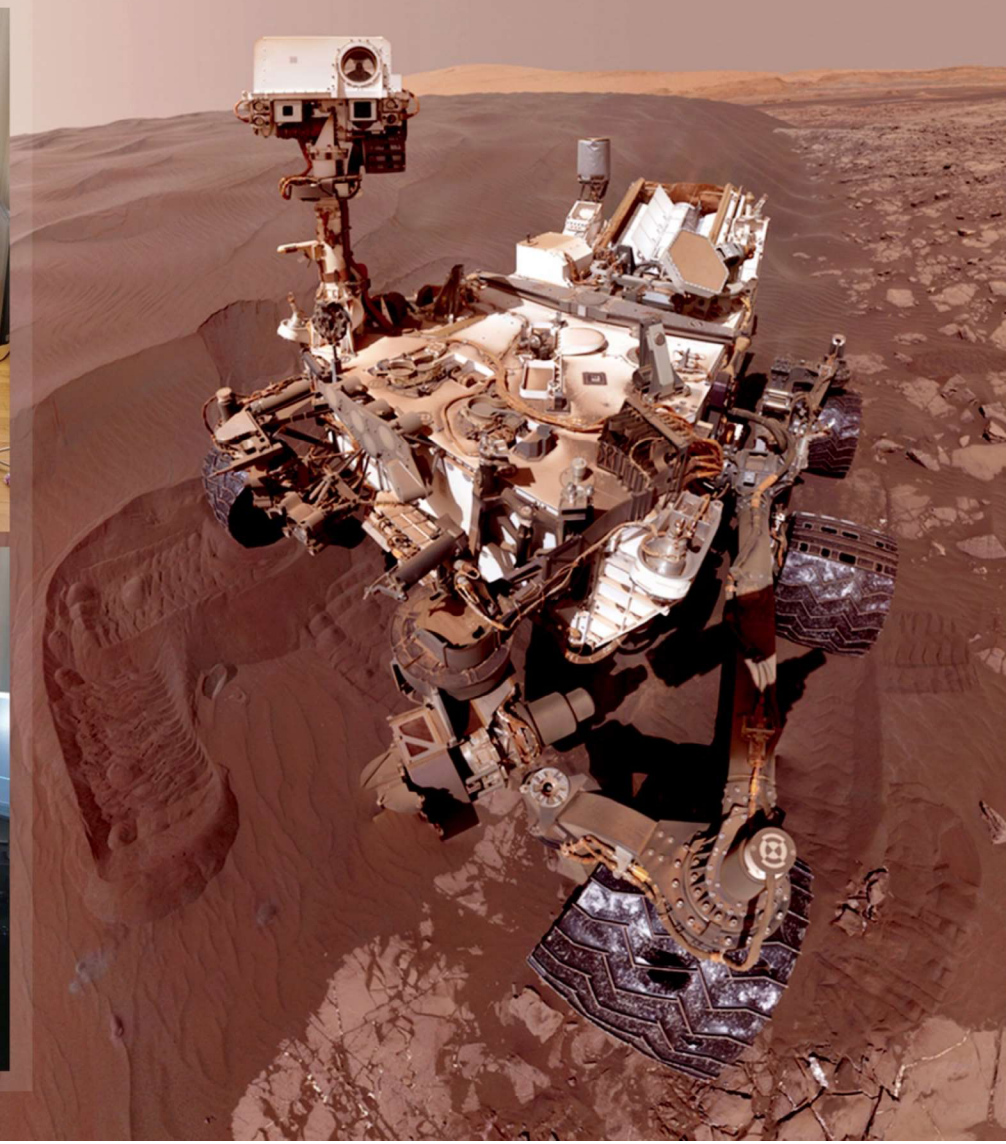
100% Working from Home





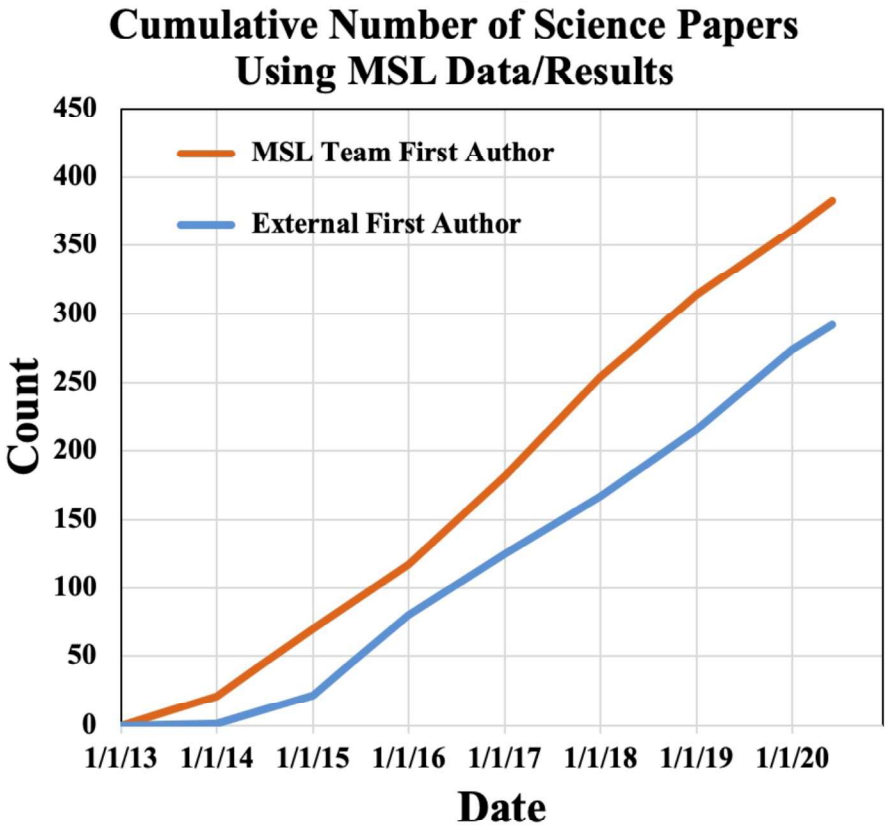


Rover and Instrument Status

- The Curiosity rover, payload, operations process, and team are capable of achieving the same quality and breadth of scientific analyses as at the end of the prime mission, with only a few exceptions. Ten out of ten instruments are working.

- In rare cases where degradation has been experienced, the team has developed and implemented effective mitigations:
  - Loss of the drill feed motor has been mitigated by feed-extended drilling and sample transfer.
  - Non-volatile memory on the A-side computer is no longer reliable. The B side is fully functional while the A side is being re-worked as an emergency backup.
  - Loss of minor instrument capabilities (REMS wind sensor, ChemCam focusing laser) have been mitigated by workarounds.
  - The wheels are estimated to support at least an additional 15 km. Traction control software is successfully reducing wheel loads.
  - The RTG power output is 60% of that at landing, but due to increased energy efficiency and better heater modeling, available energy is not expected to significantly limit operations until ~FY22.

Engagement of Science Community and Public



The publication rate of peer-reviewed papers has not fallen for either the MSL science team or the external community that uses MSL data.

Science return as strong as ever!

- Curiosity continues to excite the public
- In 2019-20, JPL issued 20 Curiosity releases resulting in **1,413** news stories and **4,571,037,709** media impressions
- 50+ posts on social media. Top 3:

1. 2 Billion Pixel Panorama (3/4/20)

- Facebook: 2,962,548 impressions; 2,945,697 reach
- Twitter: 1,565,650 impressions; 44,311,201 reach

2. Greenheugh climb (3/9/20)

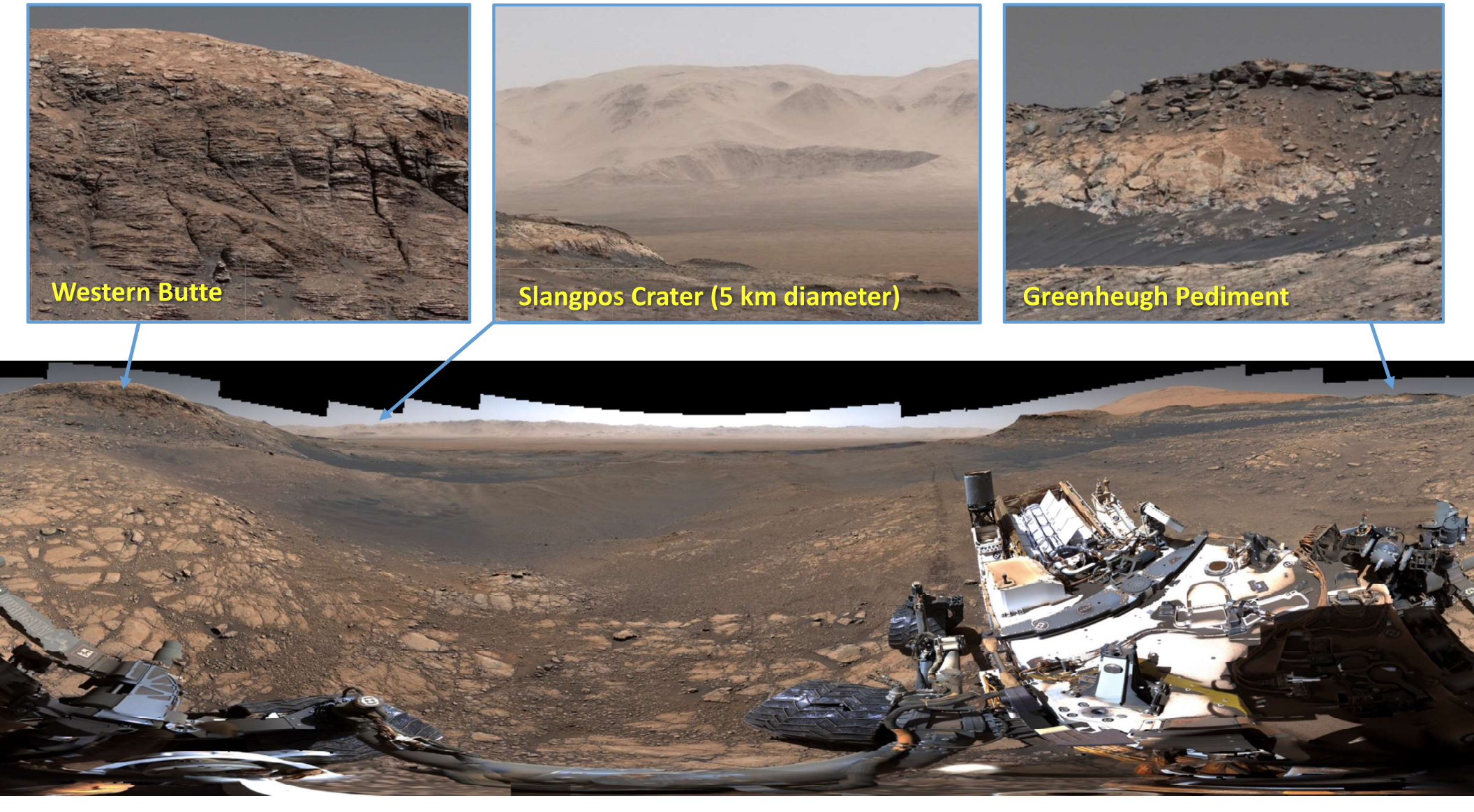
- Facebook: 987,012 impressions; 991,265 reach
- Twitter: 3,005,384 impressions; 45,824,596 reach

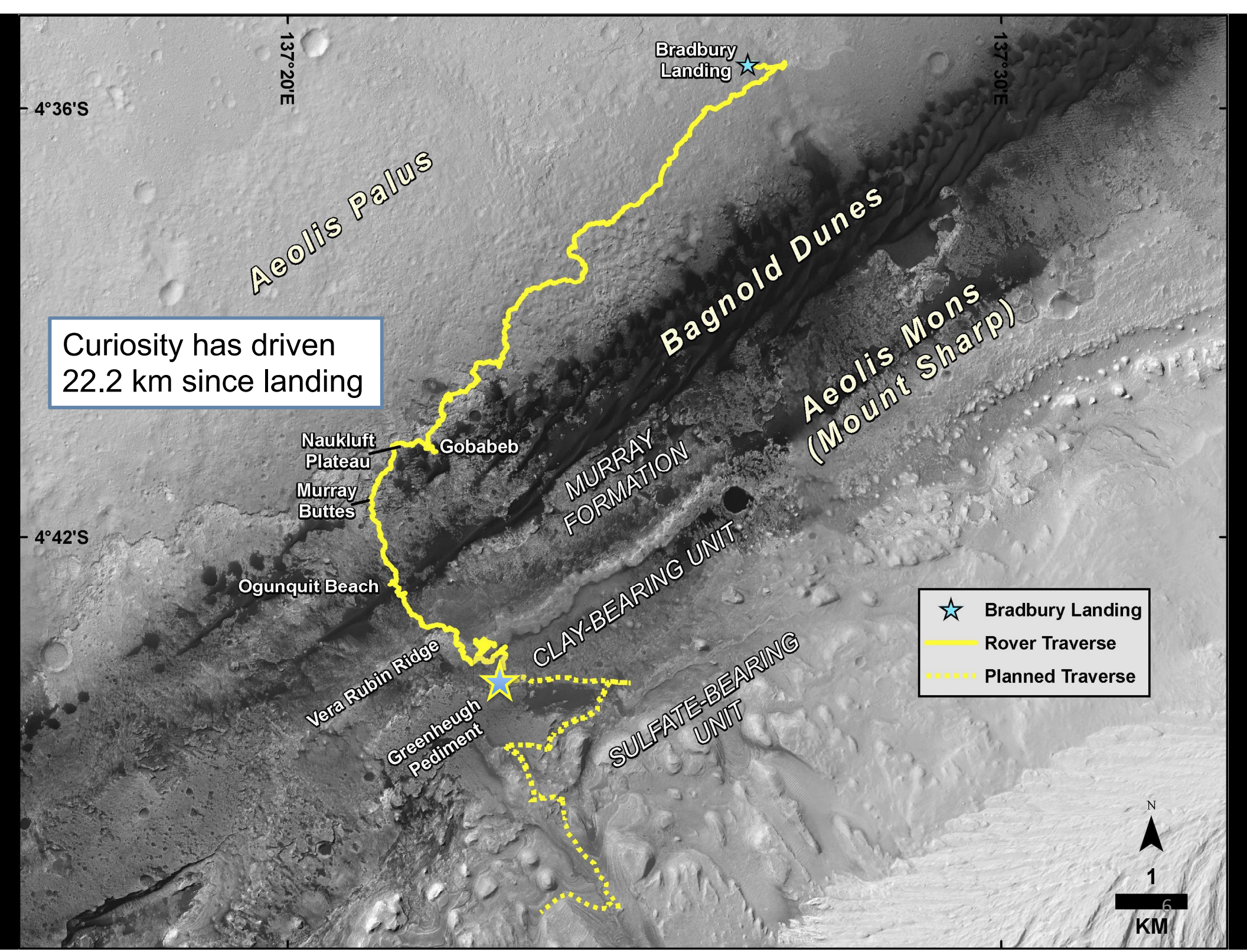
3. With Methane Mystery Unsolved, Curiosity Serves Scientists a New one: Oxygen (11/12/19)

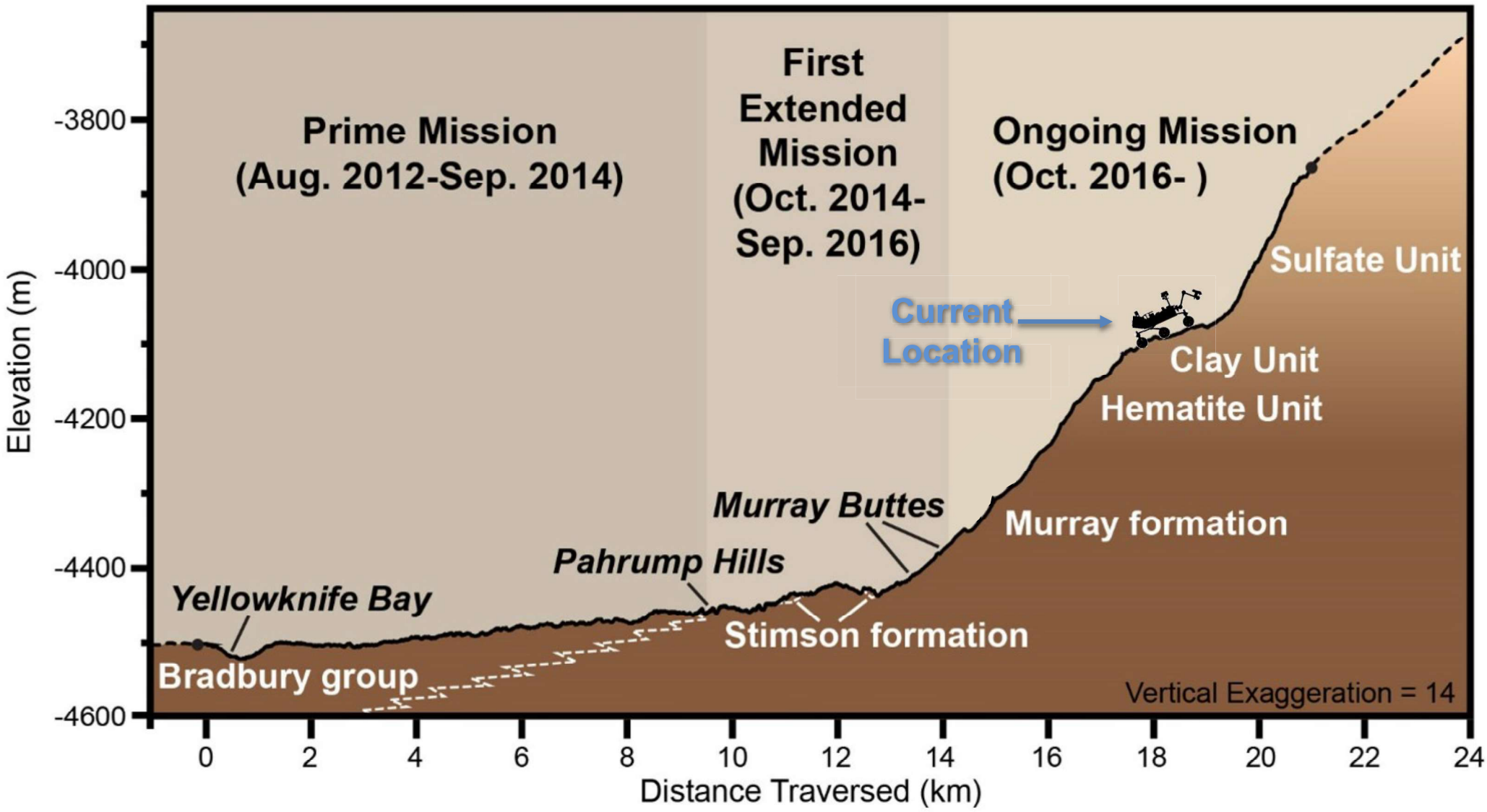
- Facebook: 290,075 impressions; 275,647 reach
- Twitter: 658,030 impressions; 7,792,444 reach

2-Billion Pixel Panorama

The 2019 Thanksgiving holiday gave the MSL team a rare chance to acquire a massive stereo panorama without interrupting ongoing science measurements. Curiosity acquired 2200 images over four days, comprising 2 billion pixels at the highest resolution.

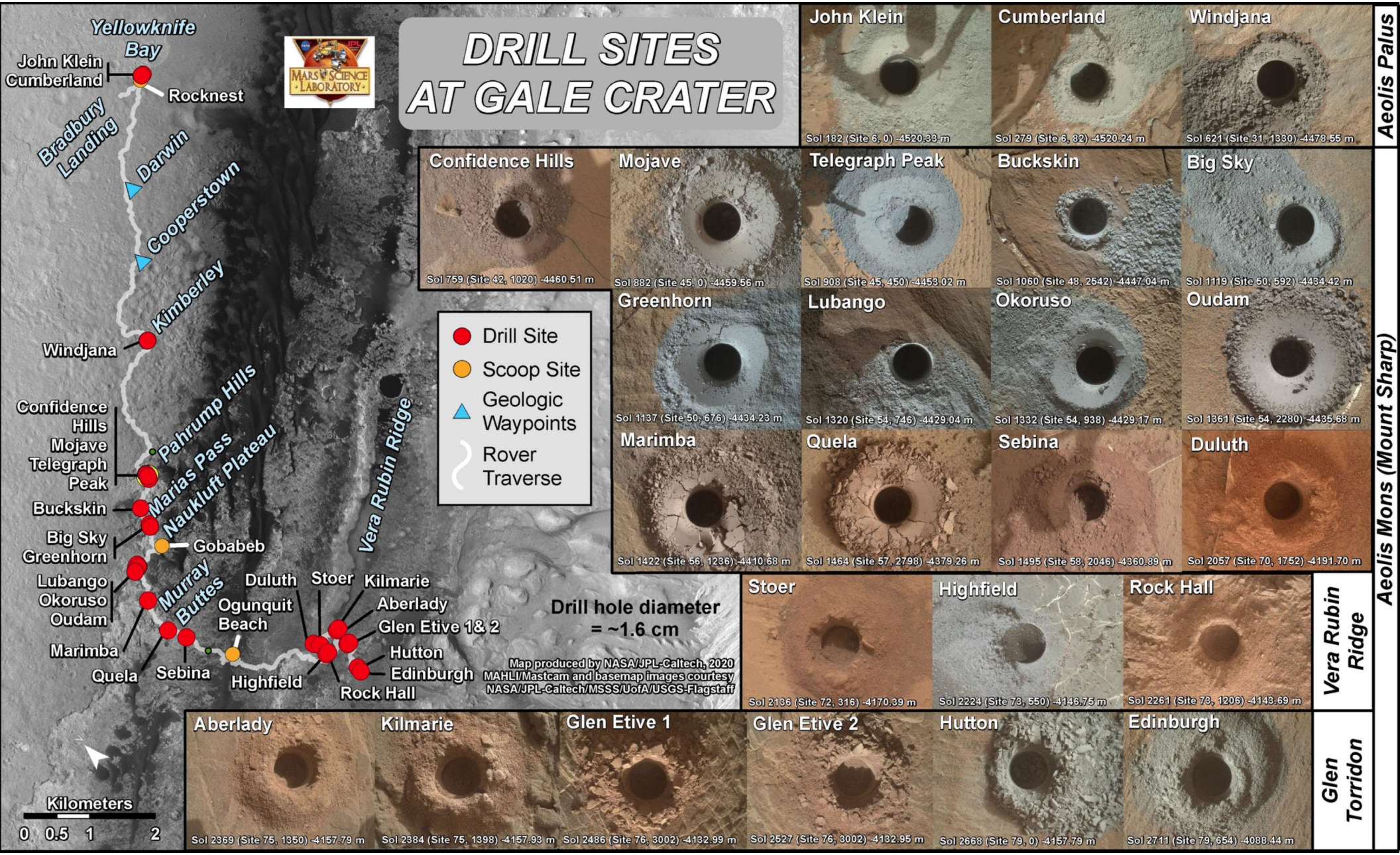



Curiosity has driven
22.2 km since landing
Bradbury Landing
137°20'E
137°30'E
4°36'S
4°42'S
Aeolis Palus
Bagnold Dunes
Aeolis Mons
(Mount Sharp)
Naukluft Plateau
Gobabeb
Murray Buttes
MURRAY FORMATION
CLAY-BEARING UNIT
SULFATE-BEARING UNIT
Ogunquit Beach
Vera Rubin Ridge
Greenheugh Pediment
Bradbury Landing
Rover Traverse
Planned Traverse
N
1
KM



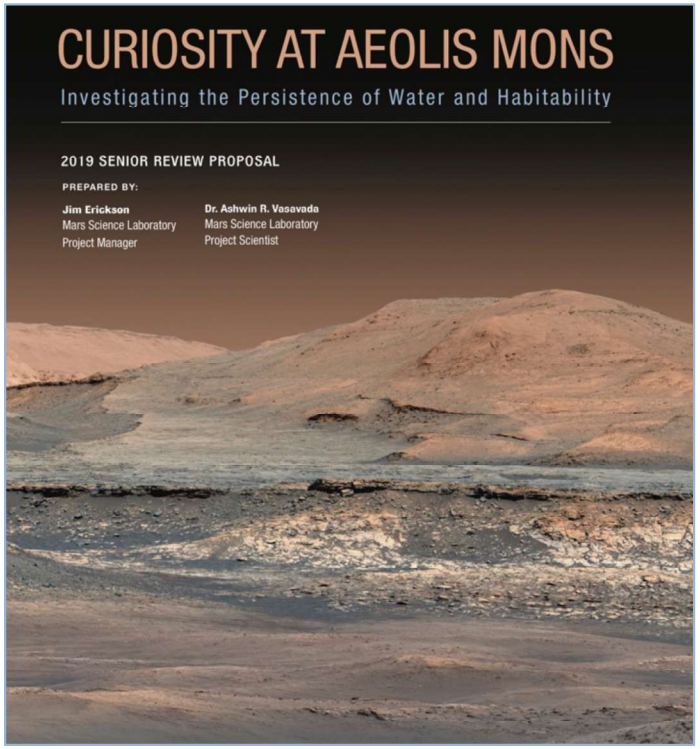
- Curiosity has gained ~ 410 m of elevation since landing.
- Over 340 m has been on Aeolis Mons. The depositional environment recorded in the strata over this interval has been primarily lacustrine.

25 Drilled Samples Analyzed

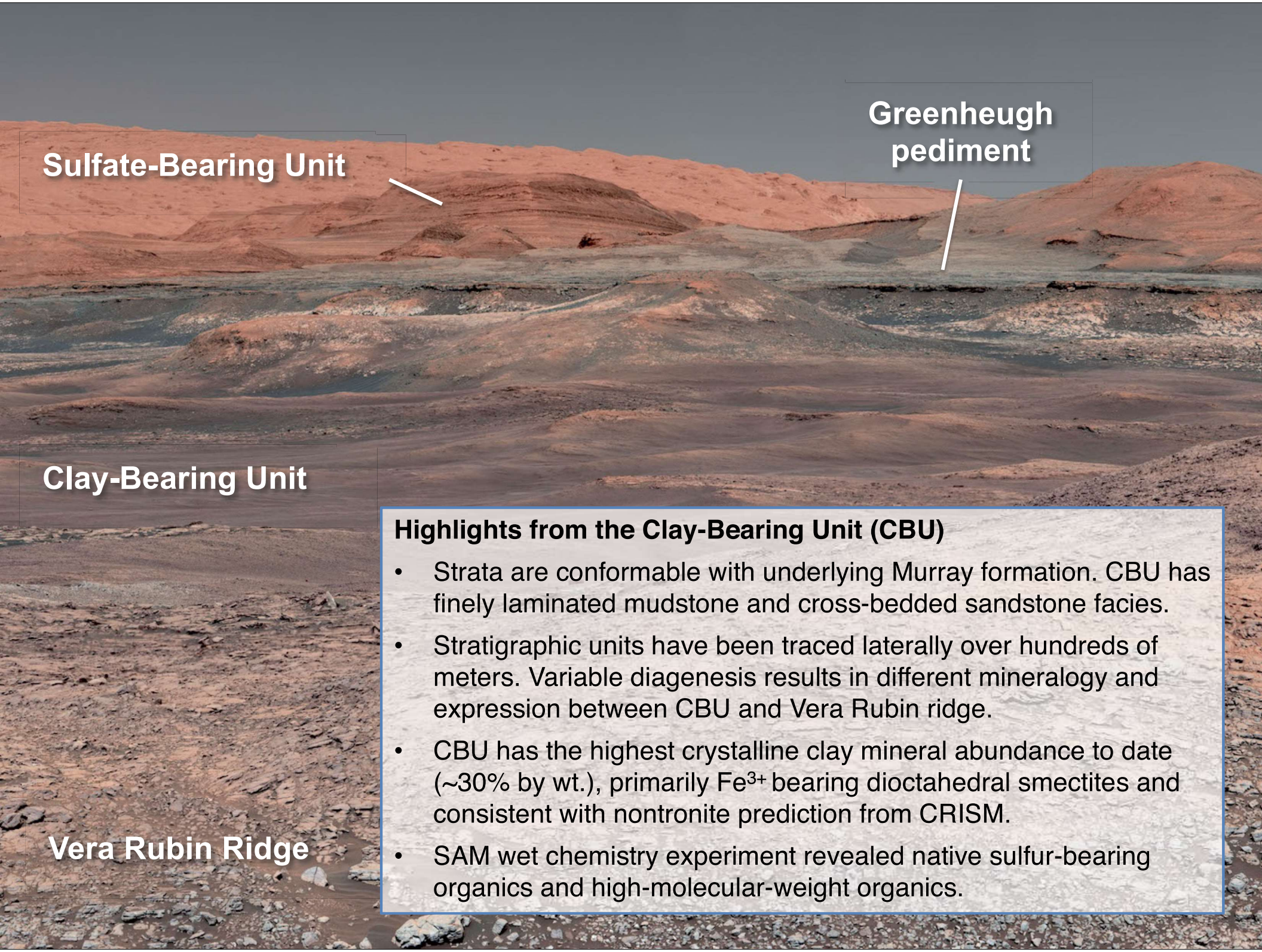


Curiosity's Proposed EM3

- Curiosity's third mission extension proposed to fundamentally advance our understanding of the persistence of water and habitable environments in the early Hesperian, a time of dramatic change in Gale crater and across Mars.



- EM3 brings the rover to three key regions on Mount Sharp for the first time:
  - A clay-bearing unit (in progress in FY20)
  - The clay-sulfate transition and sulfate-bearing unit
  - The Greenheugh pediment and Gediz Vallis ridge
- Each represents a distinct ancient environment, or change in environment, and each has the potential for groundbreaking advances in understanding Mars' ancient climate and the prospect of life, both of which are central goals of the Mars Exploration Program and Decadal Survey.

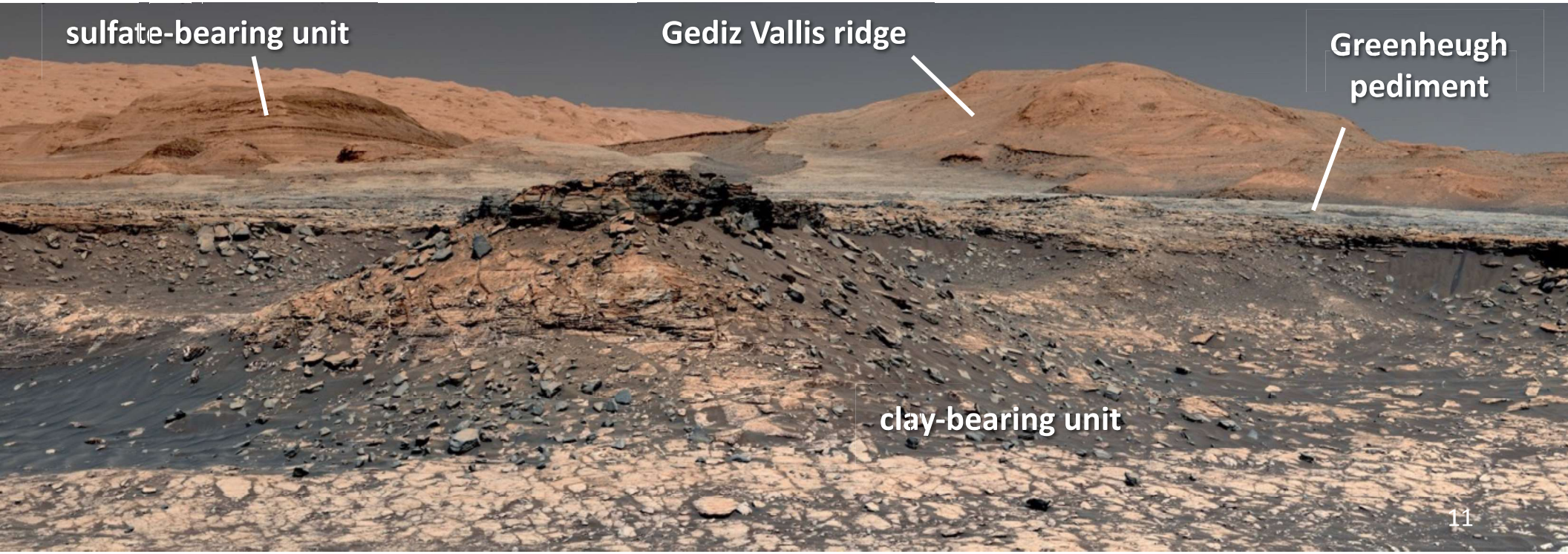


Highlights from the Clay-Bearing Unit (CBU)

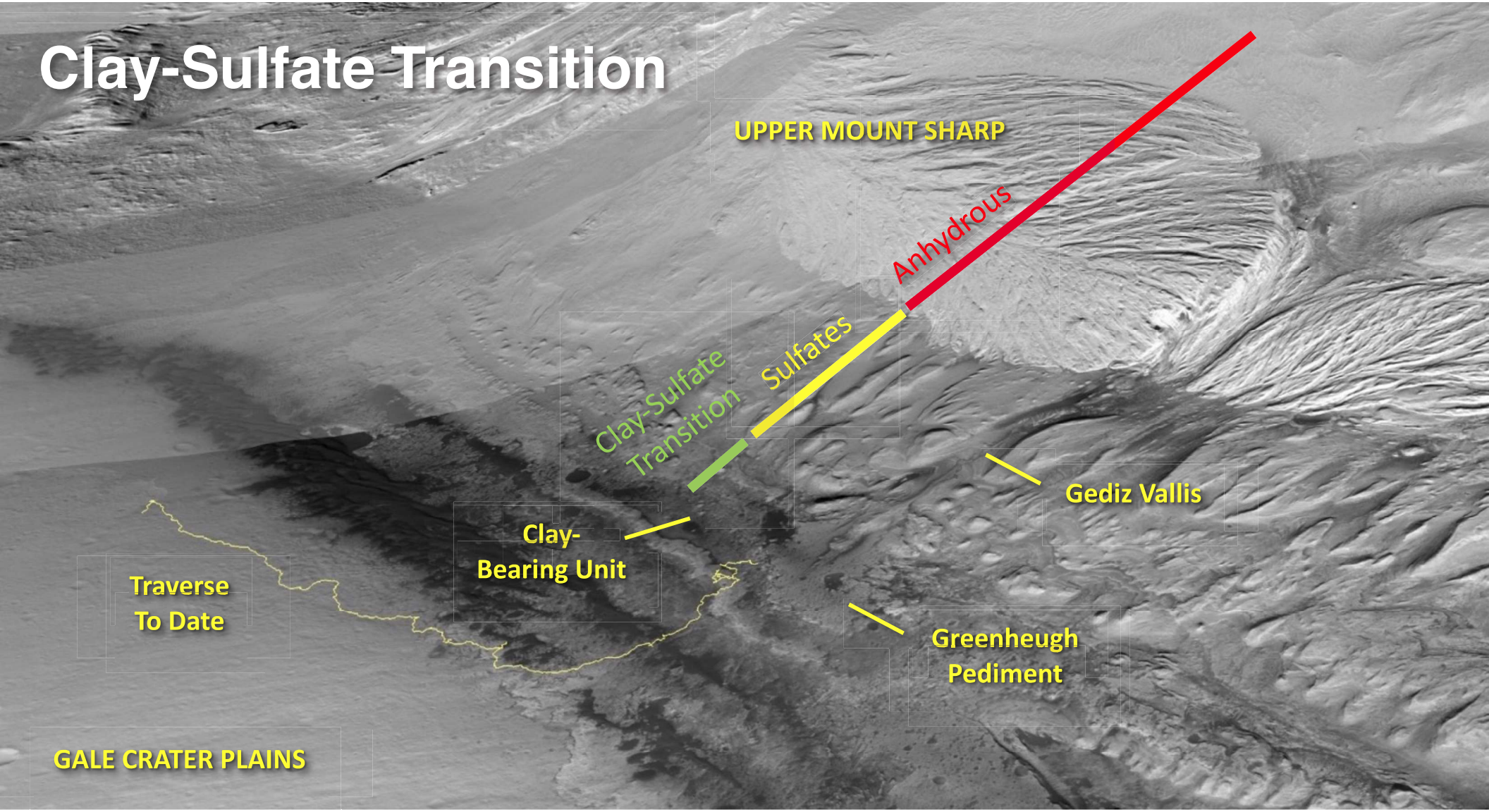
- Strata are conformable with underlying Murray formation. CBU has finely laminated mudstone and cross-bedded sandstone facies.
- Stratigraphic units have been traced laterally over hundreds of meters. Variable diagenesis results in different mineralogy and expression between CBU and Vera Rubin ridge.
- CBU has the highest crystalline clay mineral abundance to date (~30% by wt.), primarily Fe^{3+} bearing dioctahedral smectites and consistent with nontronite prediction from CRISM.
- SAM wet chemistry experiment revealed native sulfur-bearing organics and high-molecular-weight organics.

Greenheugh Pediment and Gediz Vallis Ridge

- The Greenheugh pediment is a gently sloping surface capped by a sandstone unit that retains pits and craters. The pediment truncates the underlying clay and sulfate units, indicating a major unconformity (time gap). The capping unit may once have extended over much of the area traversed on Mount Sharp.
- The pediment is adjacent to the outlet of Gediz Vallis, a major channel originating higher on Mount Sharp. The Gediz Vallis ridge that lies on top of the pediment may have been formed when water carried debris from higher on Mount Sharp, long after the lakes disappeared and Mount Sharp eroded to its present shape.
- How did they form, and what can we learn about more recent water in Gale?



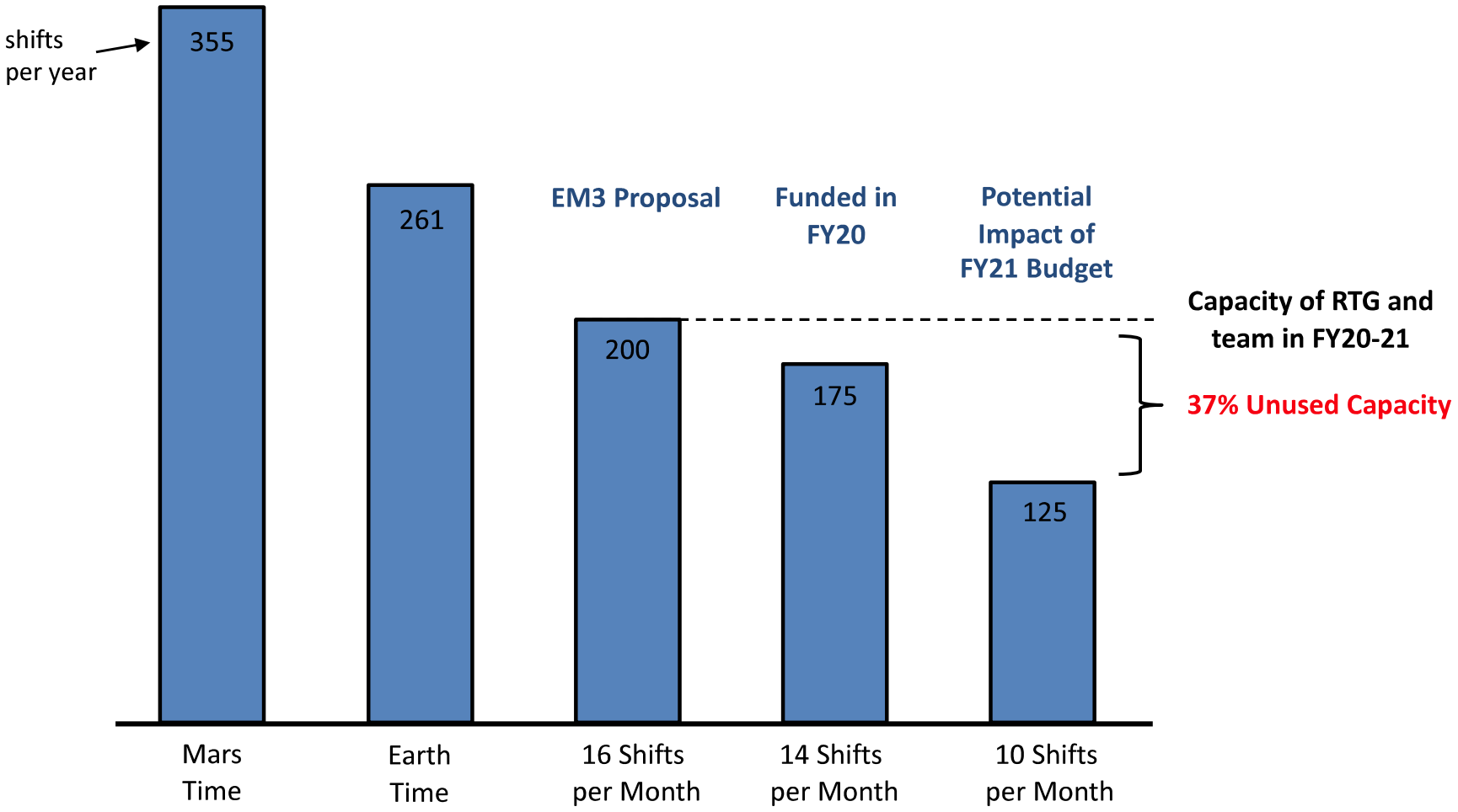
Clay-Sulfate Transition



Curiosity is nearing the transition from clay-bearing to sulfate-bearing strata on Mount Sharp, potentially marking a major environmental transition in Mars' history. The mineralogical and morphological transition identified from orbit was a key reason that Gale crater was selected for the mission's landing site.

What is the nature of this change, and what does it tell us about the persistence of water and habitability on ancient Mars?

Impact of FY21 Proposed Budget



Since FY20, funding limitations have resulted in unused rover and team capacity.

The mission is already behind on the proposed EM3 science after an unexpected 13% cut in FY20. The additional 20% cut proposed in the President's FY21 budget would severely reduce the number of planning cycles the mission can support.

Planning cycles translate directly into how much Curiosity can drive and sample.

Summary

From Senior Review Subcommittee (2019 Planetary Mission Senior Review):

- Scientific merit: rated 5 out of 5. No weaknesses.
- "Excellent scientific productivity in the past provides confidence in continued productivity during EM3. Significant discoveries were made during EM2."
- "EM3 might be the last opportunity to complete significant scientific investigations, given the progressive reduction in RTG power output and battery storage capacity."
- "The SRS recommends funding an Overguide to add command cycles as per the Overguide option."

In summary:

NASA and the Mars science community have the great fortune of having a flagship rover in remarkable shape, with an experienced operations team ready to further advance the understanding of Mars' ancient habitability.

The window to use this invaluable asset is rapidly closing as the rover's power system degrades. The proposed FY21 funding would force major EM3 objectives into EM4, when power and funding are likely even more limited.

Thank you for your support!