National Aeronautics and Space Administration

Update from the Mars Science Laboratory

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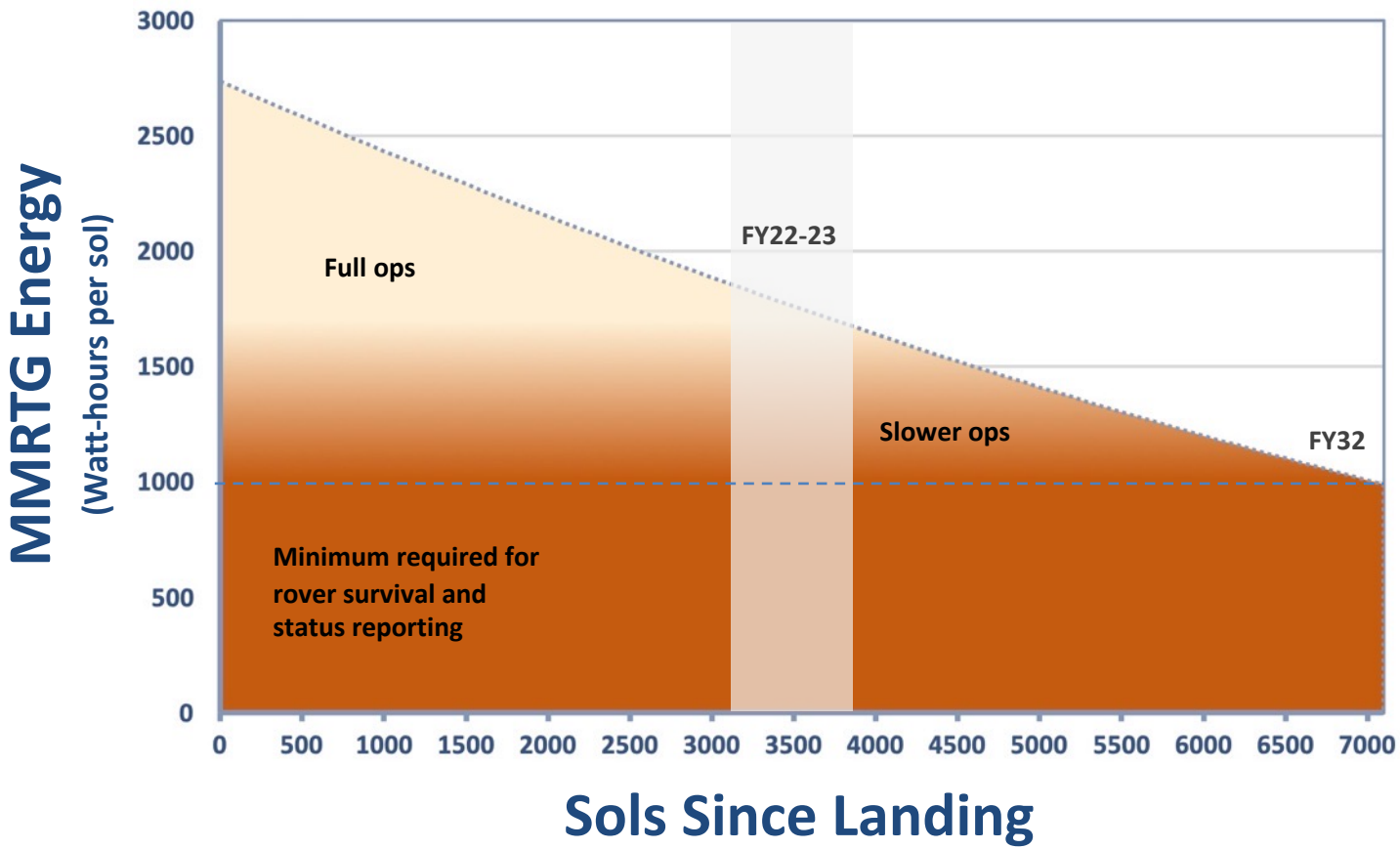
Overall Mission Status

- 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.
    - All ten payload instruments are producing high-quality measurements.
    - The wind sensor of REMS is no longer operational.
    - Non-volatile memory on the A-side computer is no longer reliable.
    - The wheels are estimated to support at least an additional 17 km.
    - The RTG will be discussed on the next slide.
- The full JPL operations team continues to operate remotely, with minor impact.
- The past year (number nine!) has been productive, with five drilled samples analyzed (31 total), 2.8 km traversed (25.7 km total), a major wet chemistry experiment, a cloud observation campaign, and a rapid-drive effort to the starting point of our current habitability campaign: searching for the clay-sulfate transition.

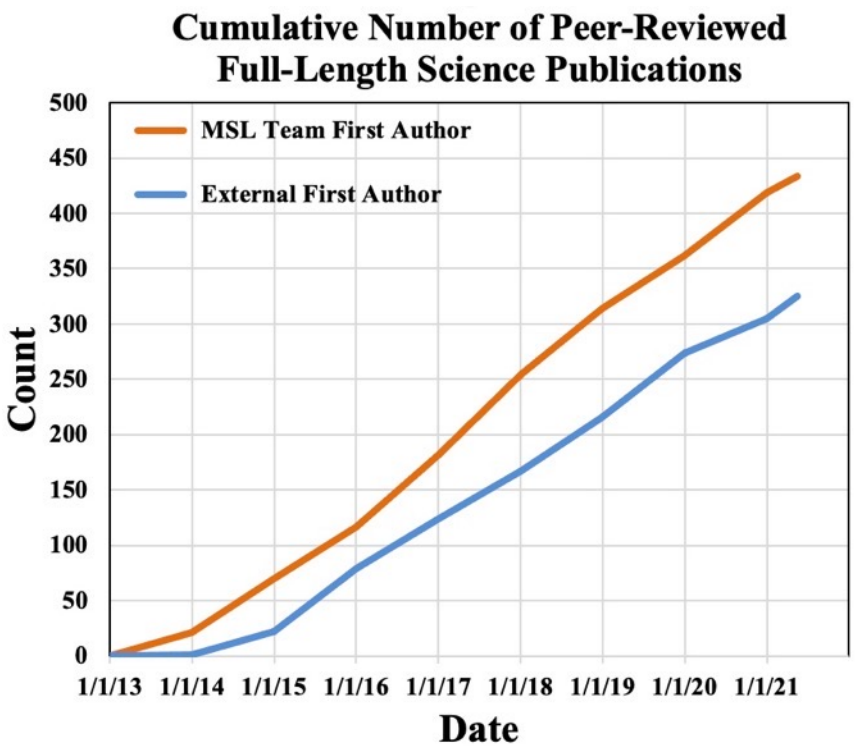
Curiosity's Radioisotope Power System



Power curve is approximate

Curiosity's RPS has decreased in output by 40% since landing, but more efficient energy use and better heater predictions have resulted in minimal impact to ongoing operations thus far. At the beginning of FY24 and beyond, operations may need to gradually slow to keep pace with the output.

Engagement of Science Community and Public



Over 760 peer-reviewed publications!

The publication rate of papers using MSL data/results has not fallen for either the MSL science team or the external community that uses MSL data.

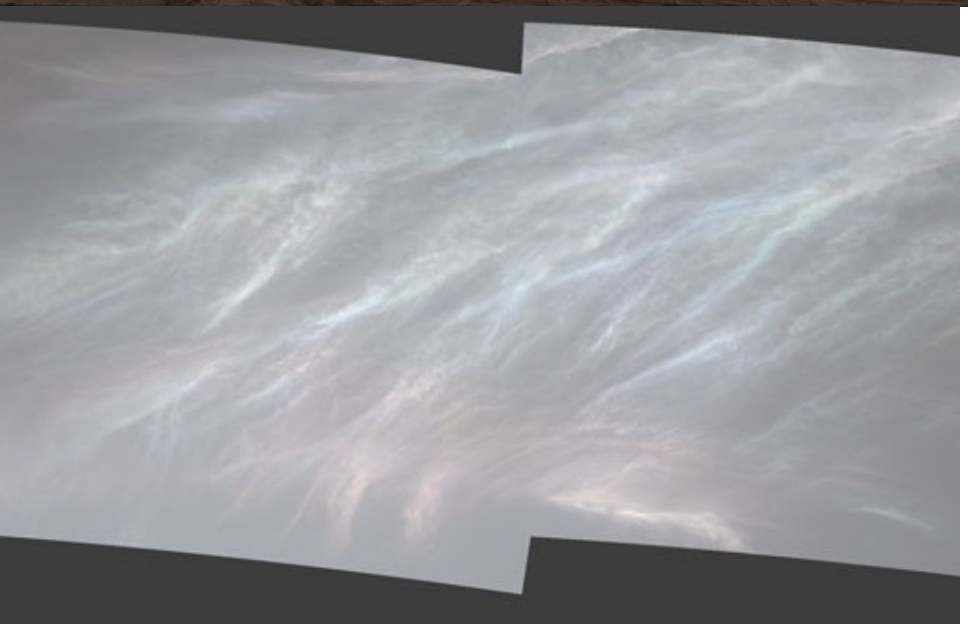
- Curiosity continues to excite the public!
- Recent news on twilight clouds was picked up by CNN, NPR, and many others. Images reached ~400,000 people on Facebook, ~270,000 on Twitter, and ~214,000 on Instagram.
- The cloud news story got ~150,000 views on the JPL web site, the highest in all of May by a factor of five.
- Highlights from 2020:

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)

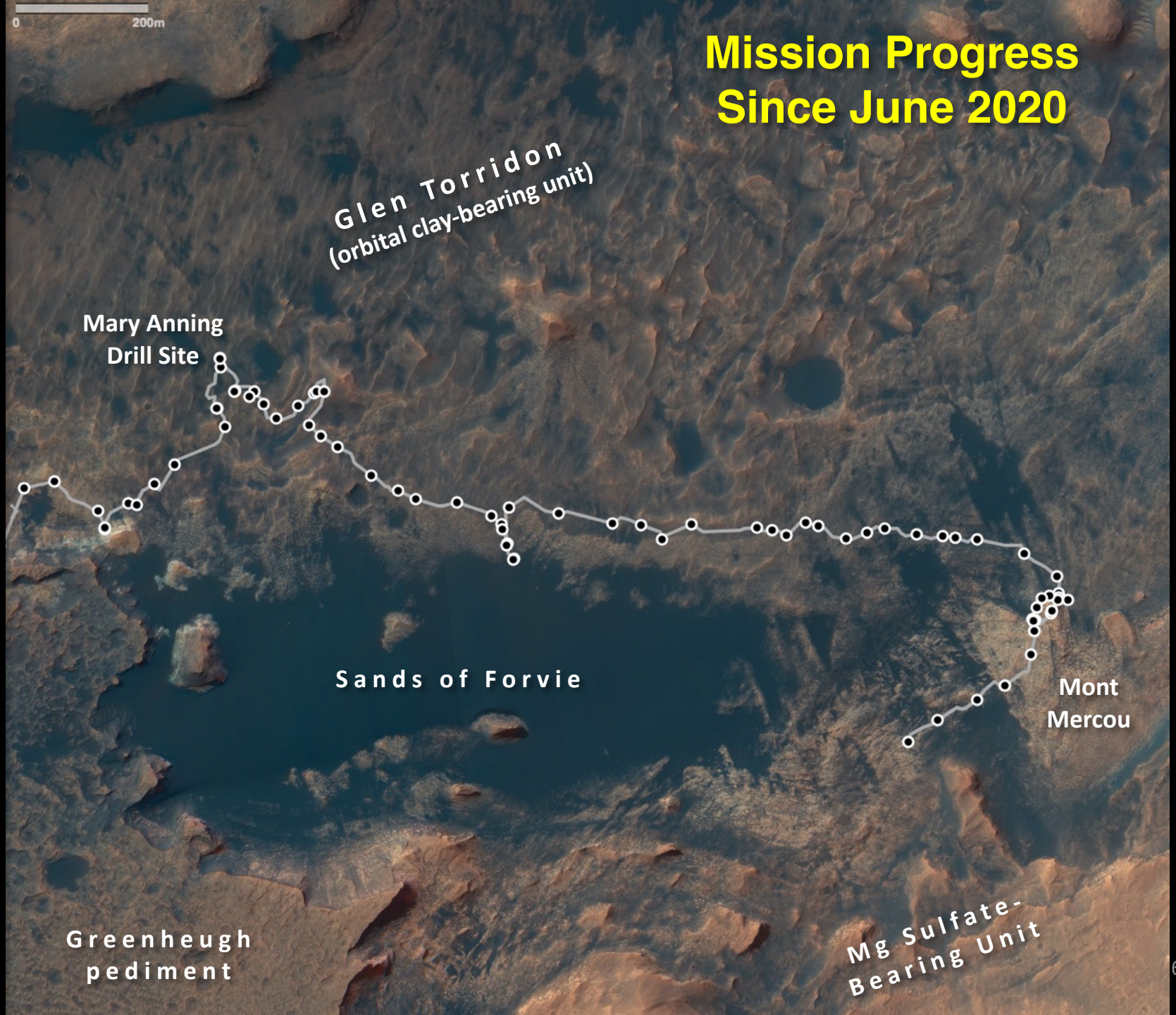
- Facebook: 987,012 impressions; 991,265 reach
- Twitter: 3,005,384 impressions; 45,824,596 reach



Twilight Clouds

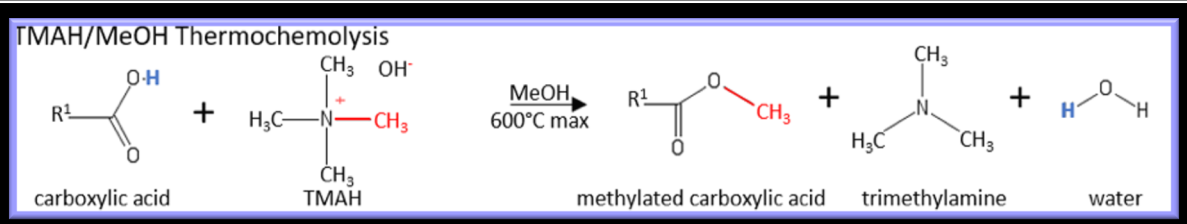
- The team conducted an observation campaign focused on high-altitude clouds illuminated from over the horizon by the setting sun.
- The clouds are either water or CO_2 ice.
- Very thin clouds and similarly-sized, small ice particles results in iridescence: the sunlight is diffracted into colors.

Mission Progress Since June 2020



Organic Molecules Detected with the First TMAH Wet Chemistry Experiment, Mary Anning, Gale Crater, Mars

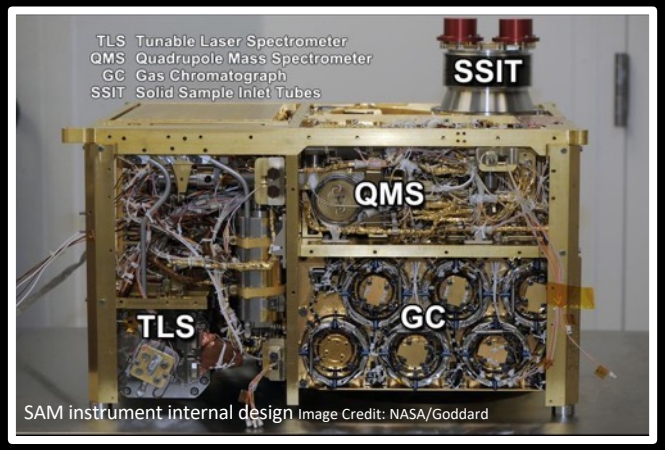
SAM can detect organic carbon with pyrolysis-GC-MS along with 'wet chemistry' reagents (either MTBSTFA derivatization or TMAH thermochemolysis) to make organics more volatile and amenable to GC-MS detection.



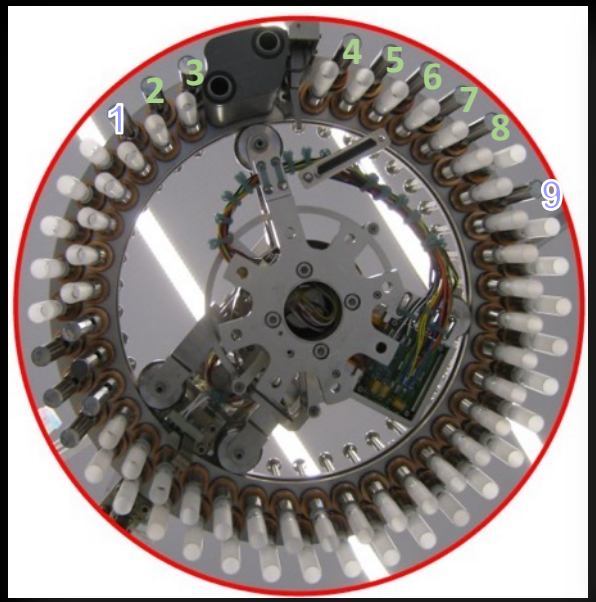
TMAH: Tetramethylammonium hydroxide

→ ***Adds a methyl group***

→ Releases polar molecules bound in macromolecules (e.g. fatty acids within cellular membranes or monomers from kerogen)



SAM instrument internal design Image Credit: NASA/Goddard



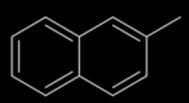
Foil cap designed for puncture using pin – Mars sample dropped into solvent filled cup through inlet tube

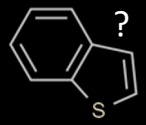
Preliminary Findings from the TMAH Experiment

1) The TMAH experiment on SAM was successful!

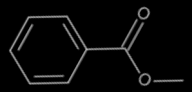
- TMAH was released and cup punctured, TMA byproduct masses detected.
- Presence of methylated compounds, new background, high molecular weight organic compounds, & a new pattern suggest the experiment worked.
- One recovery standard identified, haven't *yet* seen the internal standard.

2) A variety of organic molecules were detected.

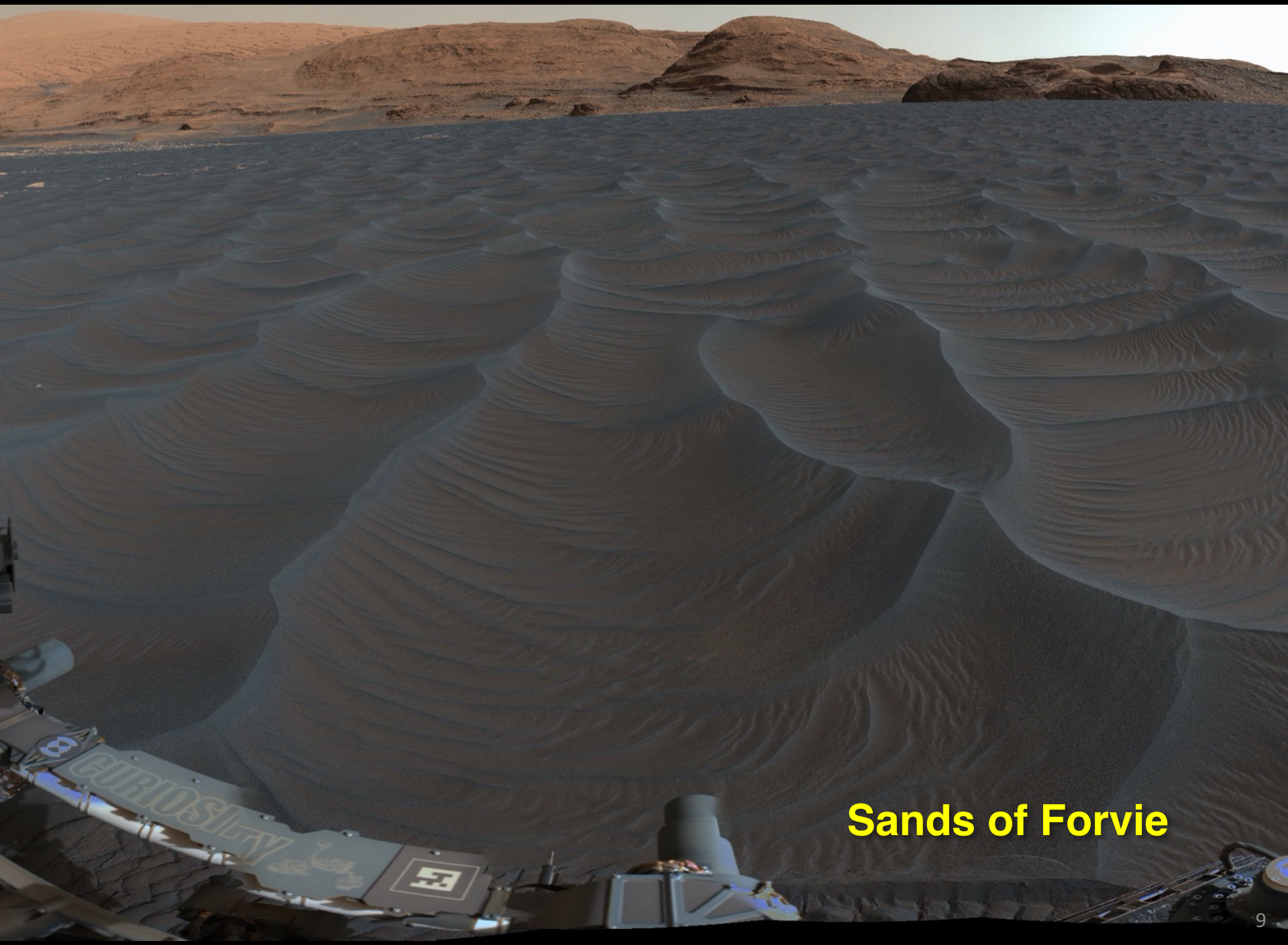




- Methylnaphthalene and benzothiophene may be indigenous.
- Benzoic acid methyl ester is present, source unresolved.

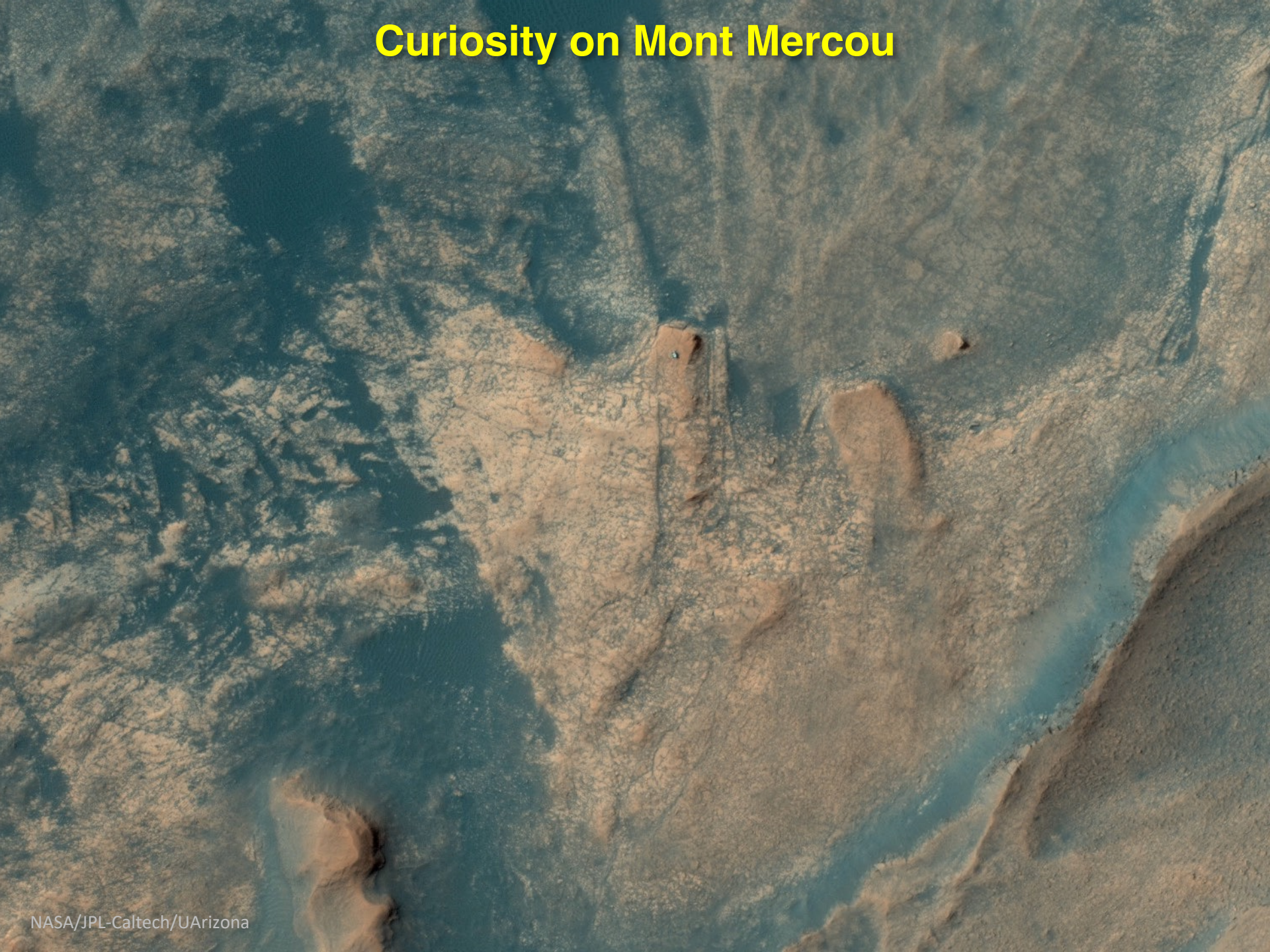


- Fatty acids are not yet detected - the search for other methyl esters is ongoing.
- Ongoing analyses and benchtop experiments will continue to deconvolve SAM-internal sources (e.g., reactions with the SAM hydrocarbon trap) from Mars indigenous sources.

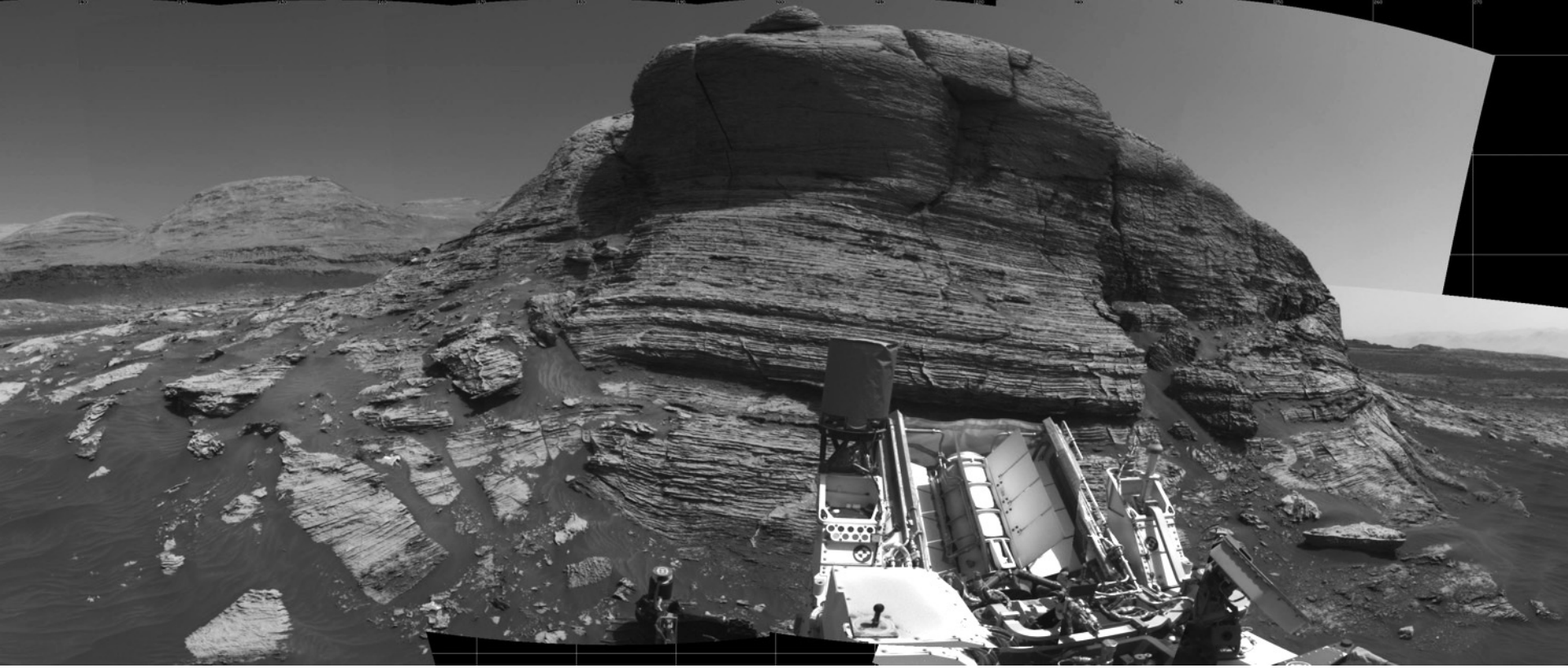


Sands of Forvie

Curiosity on Mont Mercou

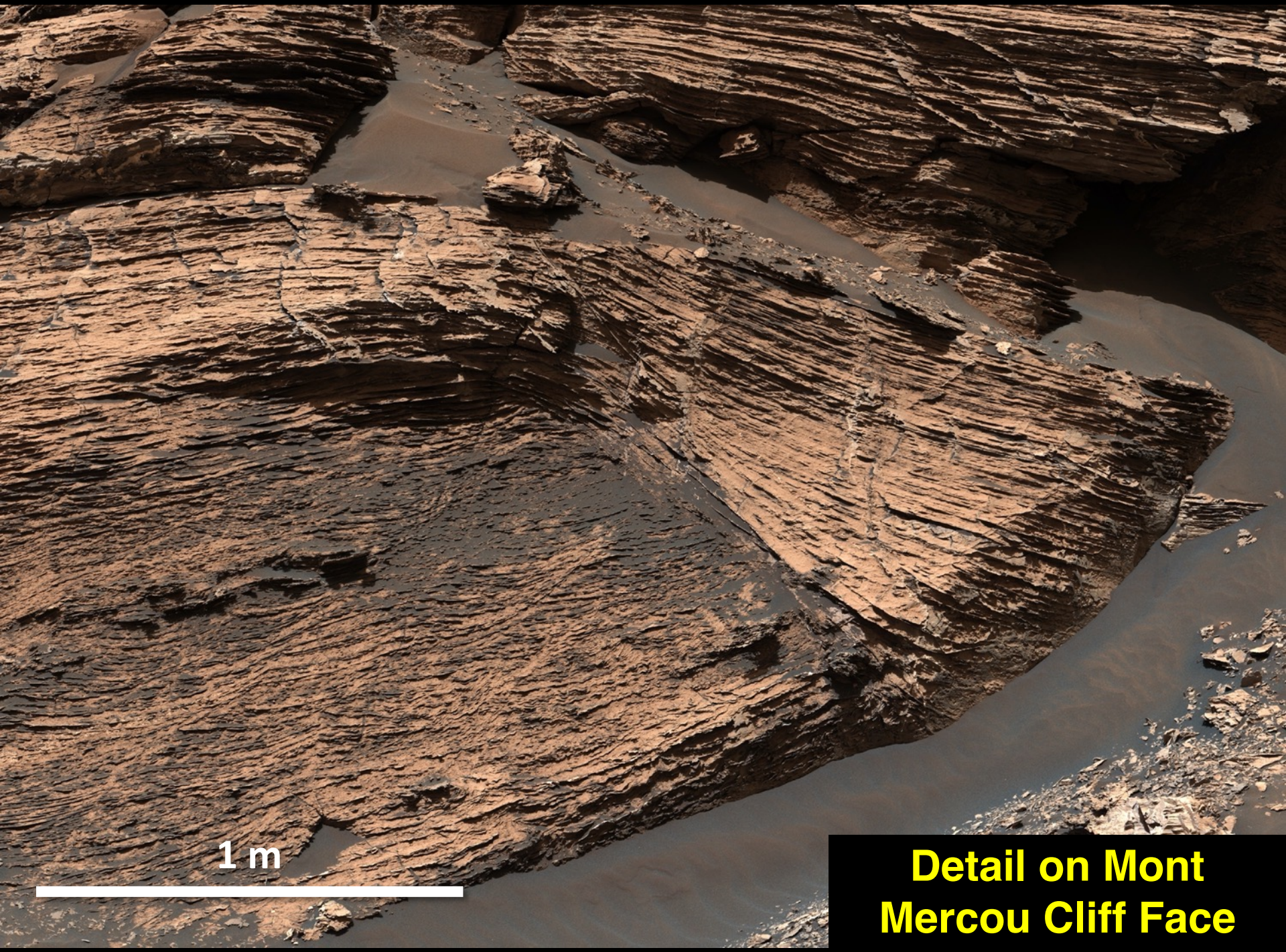


NASA/JPL-Caltech/UArizona



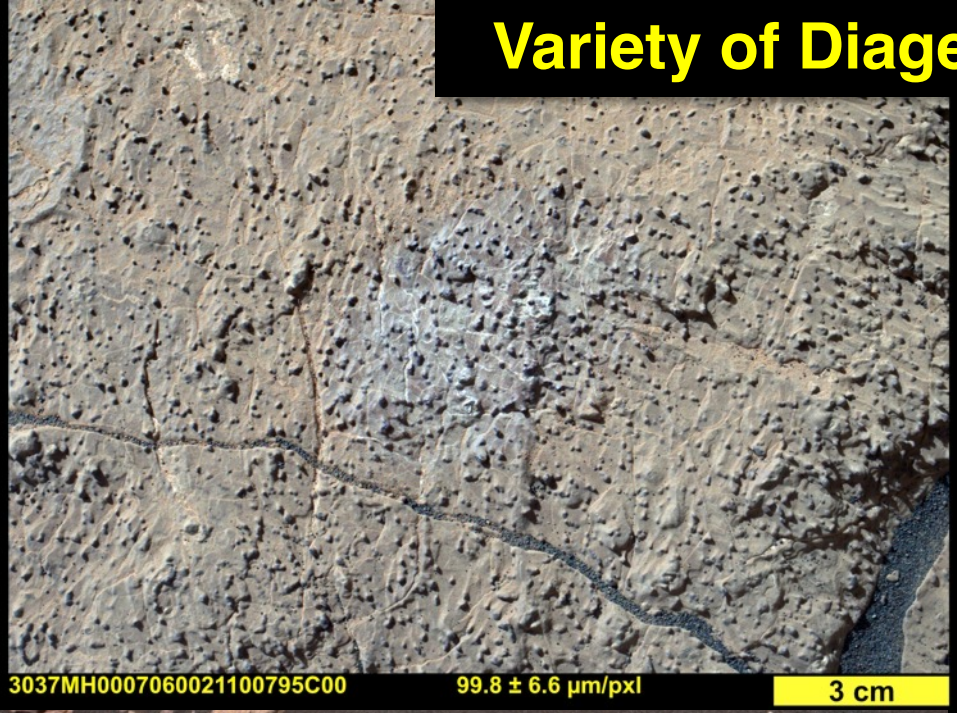
Shielding of High-Energy Radiation

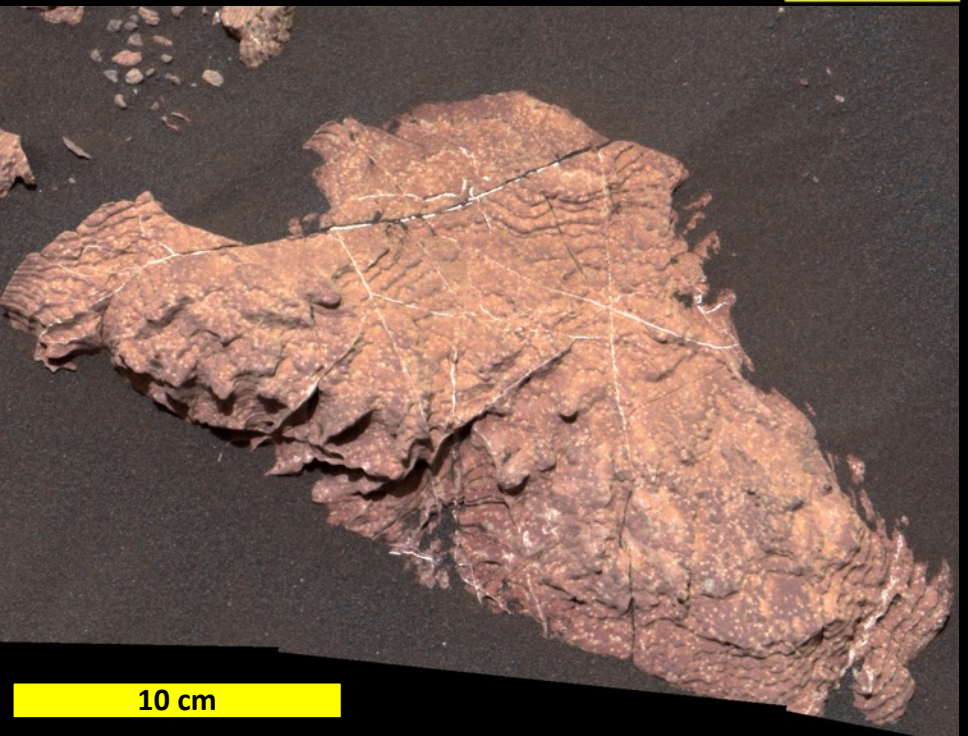
- The team intentionally parked the rover as close as possible to the 6-m high cliff face in order to characterize the shielding of isotropic high-energy radiation resulting from the cliff blocking a fraction of the sky.
- Understanding the effectiveness of topographic shielding is important for future human exploration of Mars, including the design of habitats. The RAD investigation is jointly funded by the Science (SMD) and Human Exploration and Operations (HEOMD) mission directorates of NASA.

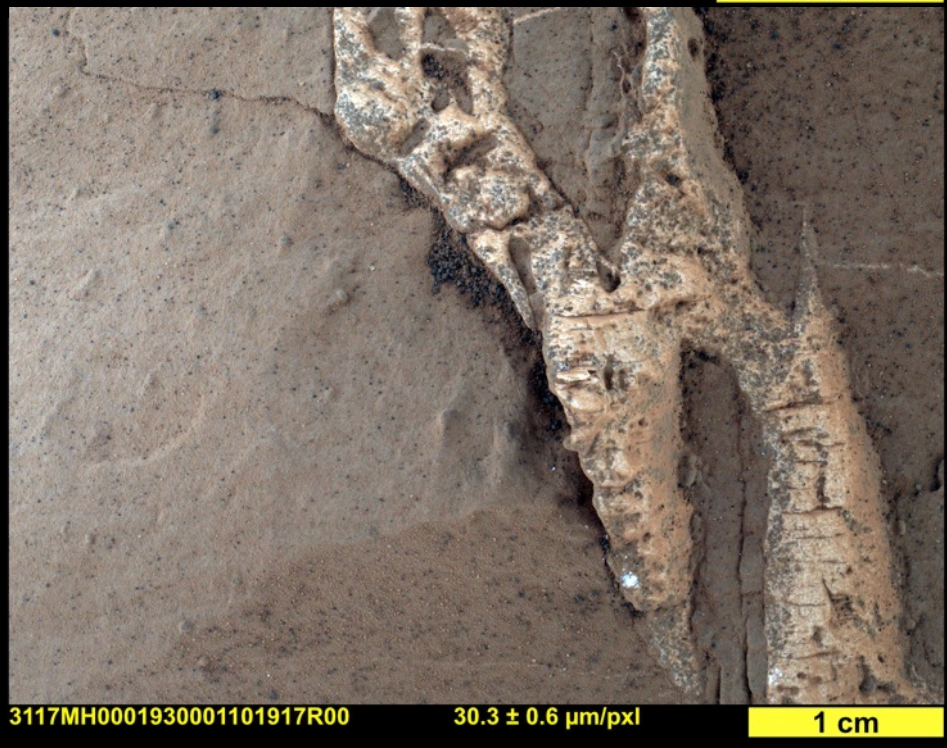


Detail on Mont Mercou Cliff Face

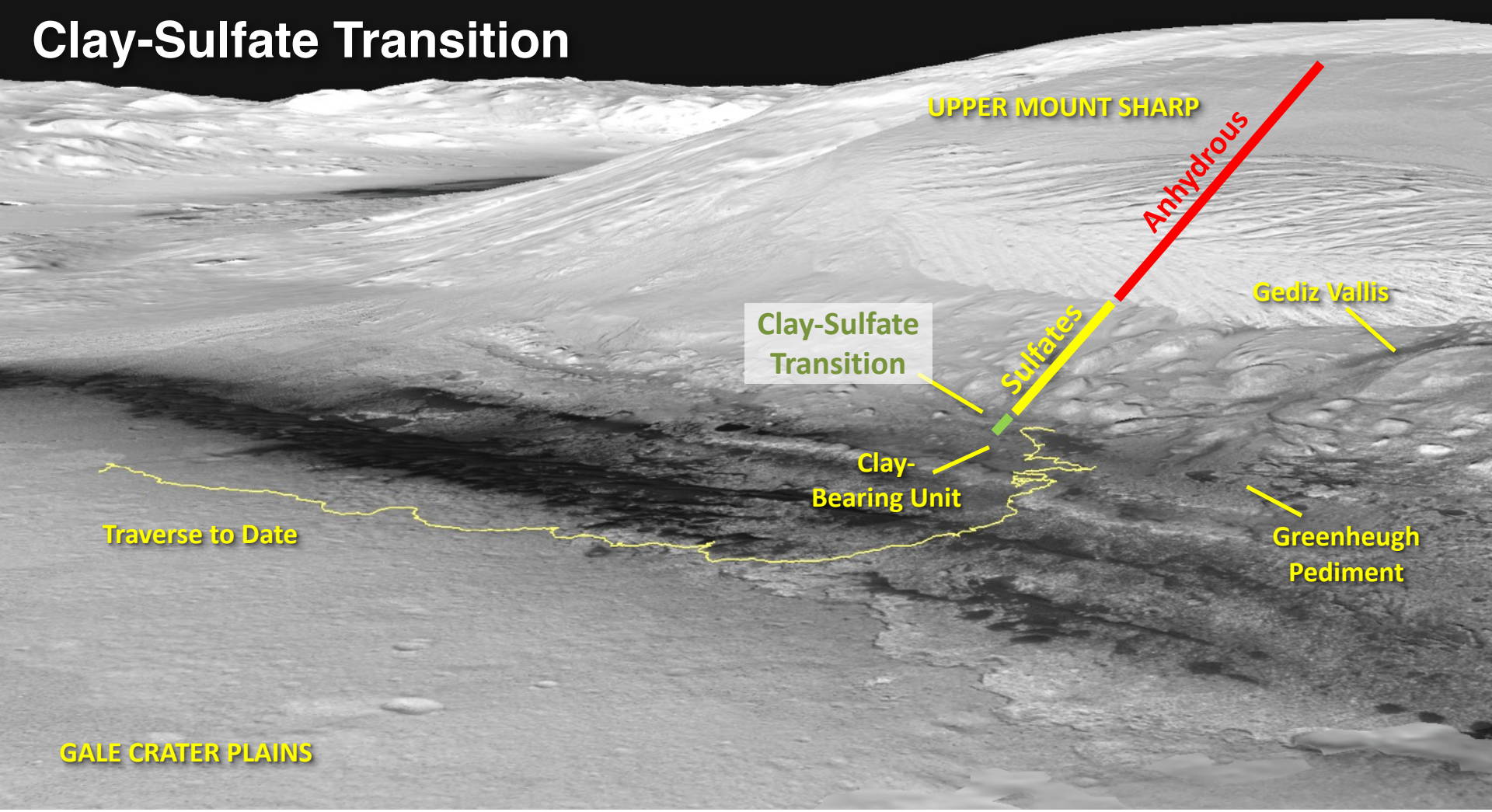
Variety of Diagenetic Features





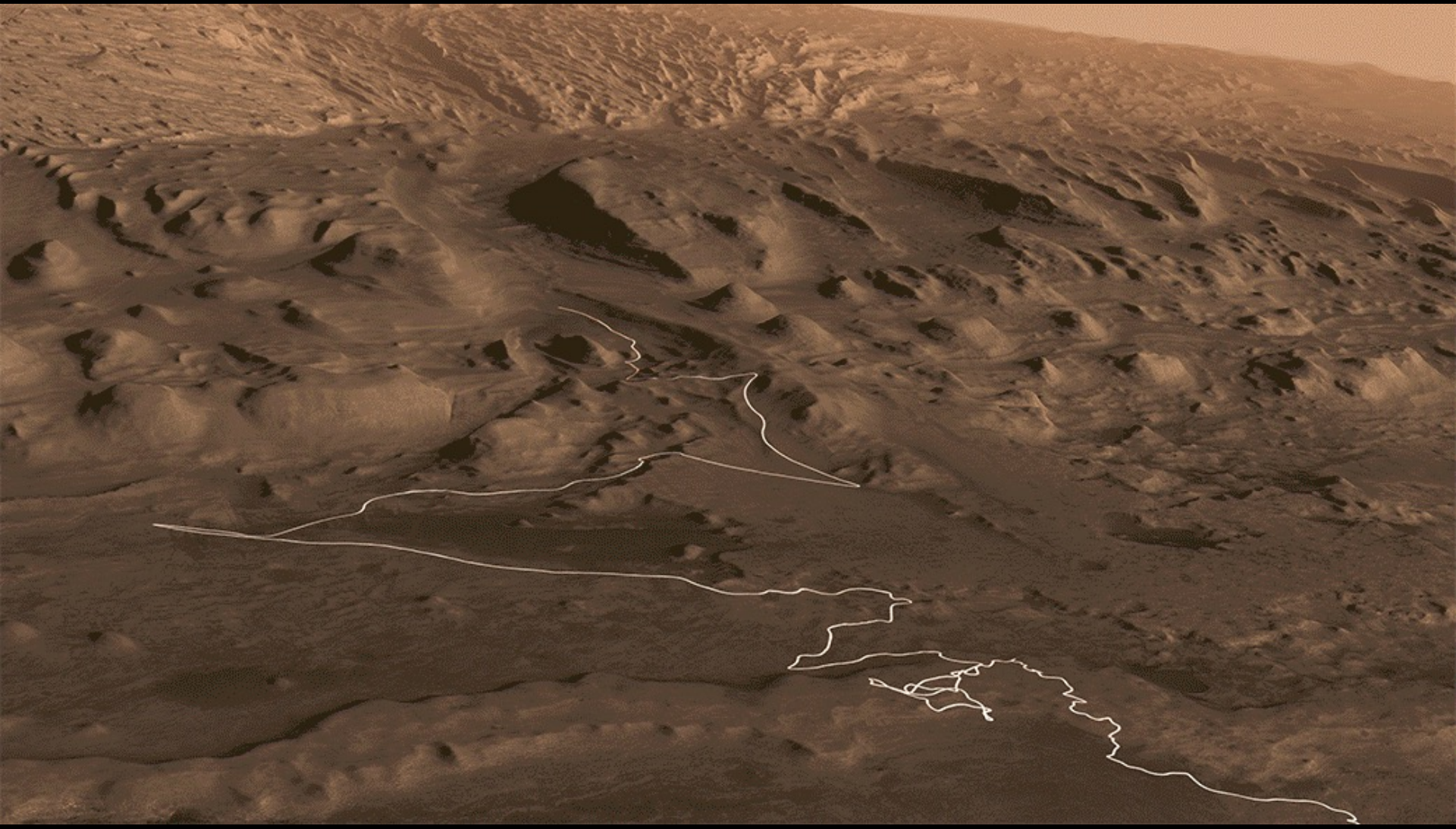


Clay-Sulfate Transition

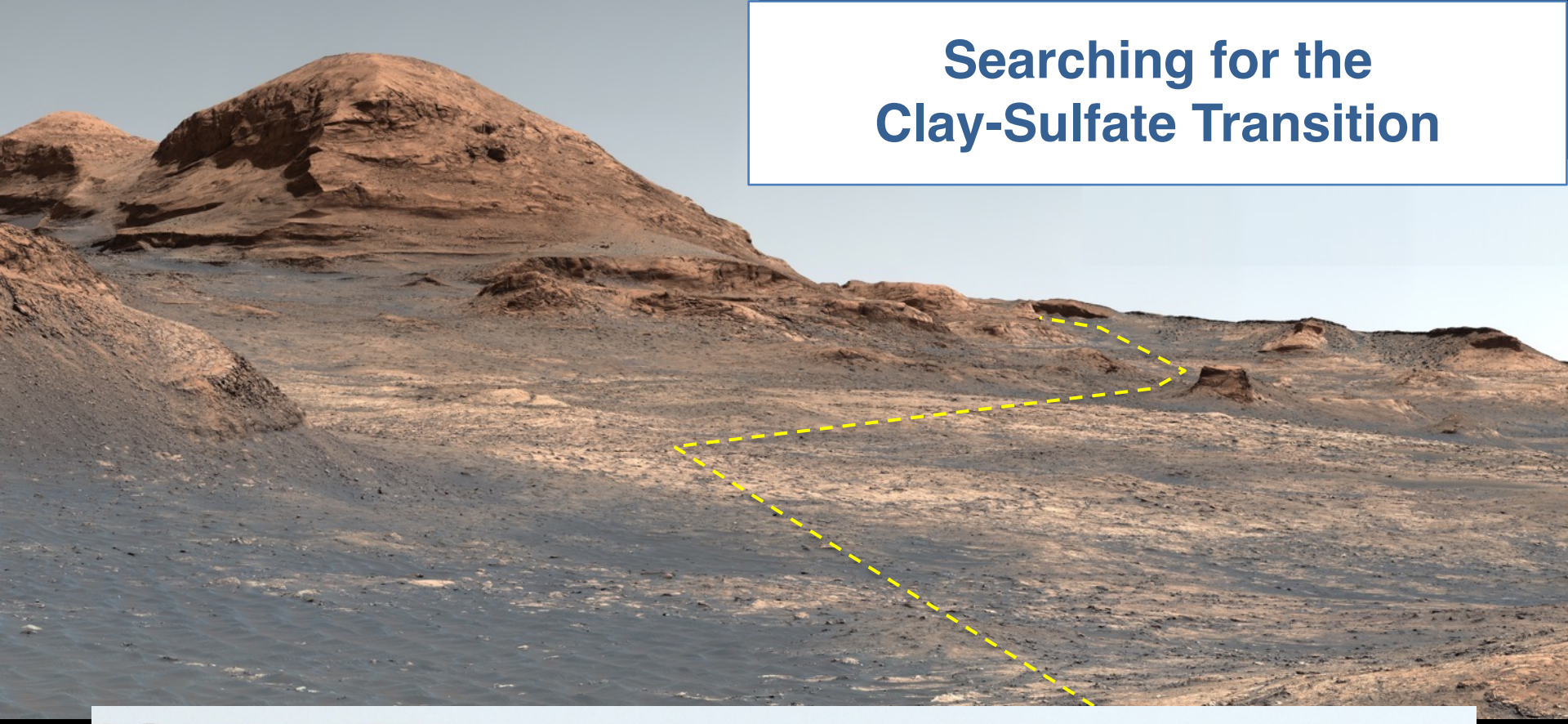


Curiosity is in a region where orbital data show Mount Sharp strata transition from clay-bearing to sulfate-bearing. This area likely records a major environmental transition and was a key reason that Gale crater was selected for the mission's landing site.

Curiosity is providing the first chance to explore this globally significant transition *in situ.* The team will search for evidence about the mechanisms driving this critical period of climate change in Mars' history, and its impact on the evolution of the planet's habitability.



Searching for the Clay-Sulfate Transition



Rafael Navarro Mountain

Summary

The Mars Science Laboratory continues to fulfill its mission of understanding the habitability of Mars. Mission extensions provide the opportunity to reach new stratigraphic levels on Mount Sharp and to investigate the depositional and post-depositional environmental conditions recorded within them.

The rover and instrument payload are healthy and continue to provide the full set of scientific capabilities needed to accomplish overall mission science objectives.

In the coming years, the mission will reach the clay-sulfate transition, explore the youngest landforms in Curiosity's field area that may have a fluvial origin, investigate the Mg hydrated sulfate-bearing unit, and extend the record of meteorology and high-energy radiation into future Mars years.