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Three years later, the search for life on Mars continues

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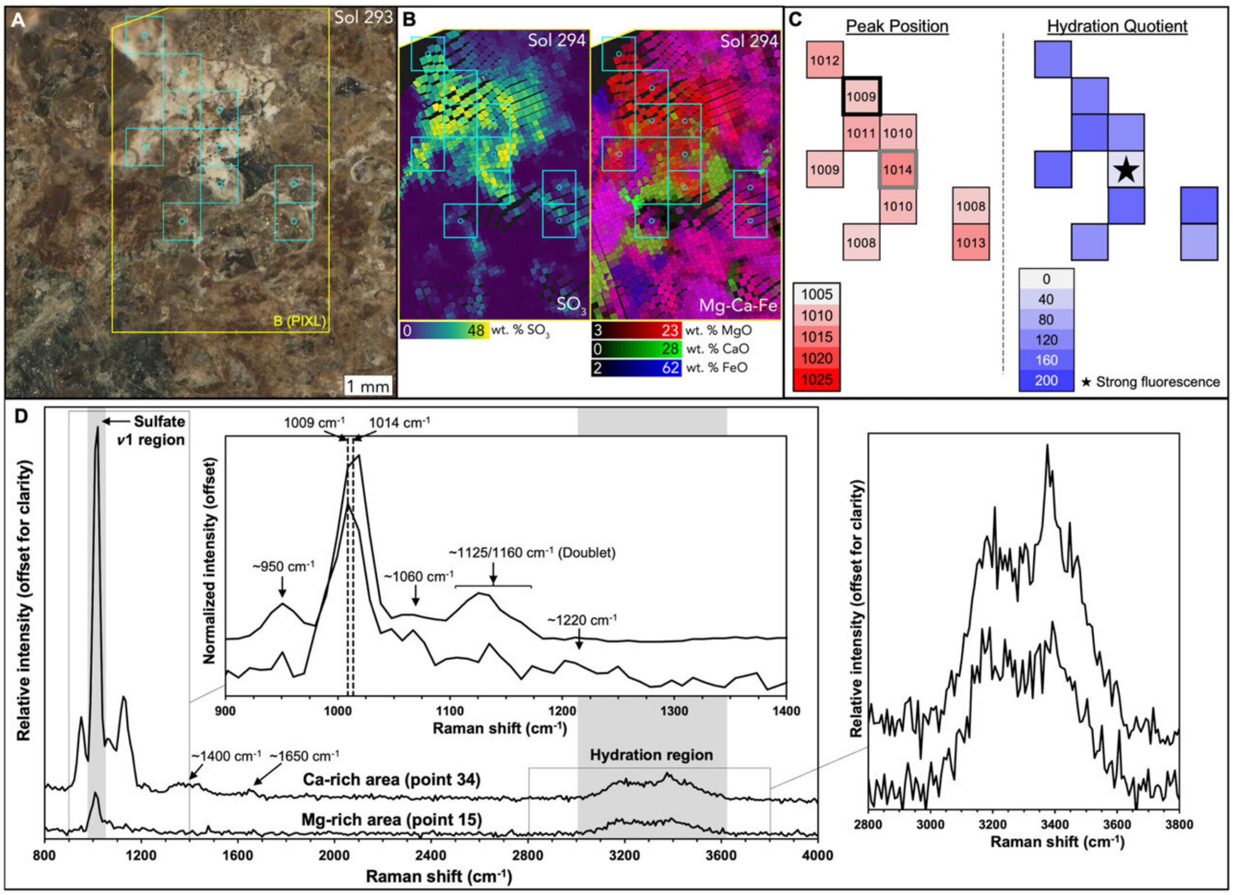

Scanning Habitable Environments with Raman and Luminescence for Organics and Chemistry (SHERLOC) and Planetary Instrument for X-ray Lithochemistry (PIXL) sulfate mineral compositions from the Quartier abrasion (SHERLOC sol 293). (a) Colorized ACI image of the analyzed region. The cyan boxes indicate the SHERLOC scan points where sulfate phases were detected at SNR ≥10. Cyan circles within each box indicate the position and size of the SHERLOC laser spot. The yellow polygon indicates the area of the PIXL scan on sol 294.

(b) PIXL maps of SO_3 abundance (left) and MgO, CaO, and FeO abundances (right). (c) Heat maps of sulfate ν1 peak positions and of hydration quotients (HQ, see text for how this was calculated). The heat maps for all abrasions have the same color scale (cf. Figures 3-6). The analysis spot with a fluorescence signal is indicated by a black star in the HQ map (the solid star indicates high fluorescence >5,000 counts). (d) Representative SHERLOC Raman spectra from Ca-, and Mg-rich areas in the PIXL elemental map. Points 15 and 34 are indicated by the bold black and gray outlines, respectively, in panel (c). The regions where sulfate ν1 and hydration features can be found are indicated by gray shading. Insets show details of the main sulfate peaks of each spectrum, which have here been normalized to the same sulfate ν1 peak height for ease of comparison, and of the hydration bands, which are not normalized. The vertical dashed lines indicate the fitted center for the ν1 peak of each spectrum. Other important peak centers are indicated. Credit: *Journal of Geophysical Research: Planets* (2024). DOI: 10.1029/2023JE007989

In the three years since NASA's Perseverance rover touched down on Mars, the NASA science team has made the daily task of investigating the red planet seem almost mundane.

The rover and its helicopter sidekick, Ingenuity, have captured stunning images of Mars and collected 23 unique rock core samples along 17 miles of an ancient river delta.

One science team member, University of Cincinnati Associate Professor Andy Czaja, said he sometimes has to remind himself that the project is anything but ordinary.

"This is so cool. I'm exploring another planet," he said. Czaja teaches in the Department of Geosciences in UC's College of Arts and Sciences. He is a paleobiologist and astrobiologist helping NASA look for evidence of ancient life on Mars using a rover outfitted with custom geoscience and imaging tools with three of his UC graduate students, Andrea Corpolongo, Brianna Orrill, and Sam Hall.

Three years into the mission, the rover has performed like a champ, he said.

"Perseverance has excelled. It's been fantastic. It has such capable instrumentation for doing geology work. It's able to explore distant objects with its zoom lens cameras and can focus on tiny objects at incredible resolution," Czaja said.

Along the way, the mission has recorded a number of firsts: the first powered flight, the first recorded sounds of Mars, the longest autonomous drive (nearly a half-mile), and new discoveries about the planet's geology, atmosphere, and climate.

Czaja was part of the NASA team that decided where on Mars to land the rover. And he remained on the science team that would pore over its daily data and discoveries to decide what the rover should do next.

Among the new discoveries was finding primary igneous rocks in Jezero Crater. These rocks are the hardened result of liquid magma. They offer scientists promising clues about refining the known age of the planet.

Scientists suspect Mars once had long-lived rivers, lakes, and streams. Today, water on Mars is found in ice at the poles and trapped below the Martian surface.

Czaja and his student Corpolongo were co-lead authors of a paper published in the *Journal of Geophysical Research, Planets* that revealed that Mars also may have had hydrothermal systems based on the hydrated magnesium sulfate the rover identified in the volcanic rocks.

"When those rocks cool off and fracture, they become a habitable environment for life," Czaja said.

Corpolongo also led a similar research paper in the same journal co-authored by Czaja detailing the results of the rover's analysis of samples using the SHERLOC deep ultraviolet Raman and fluorescence instrument. Both papers featured contributions from dozens of their fellow NASA researchers on the project.

Samples collected by the rover may finally answer the question of whether we are alone in the universe.

"We have not found any definitive evidence of life in these deposits yet. But if there were fossil microorganisms trapped in the rocks, they would be too small to see with the rover," Czaja said.

Czaja is hopeful funding will be approved for the anticipated Mars Sample Return mission to retrieve the hermetically sealed titanium tubes scientists have spent three years filling with interesting rock cores.

"These hydrated minerals trap water within themselves and record the history of how and when they formed," the study said. "Returning samples of these minerals to Earth would allow researchers to explore the history of Mars' water and climate and possibly evidence of ancient life with the most sensitive instruments possible."

But that was just the beginning. Perseverance began its deliberate exploration from the floor of the crater to the front of the delta, formed by an ancient river or drainage channel where it encountered sedimentary rocks that often contain trapped minerals and another avenue for evidence of ancient life.

And last year the rover made it to the crater's margin in what used to be an enormous lake where it is exploring deposits of magnesium carbonate, which can form geologically or biologically from bacteria.

Czaja said the decision to send Perseverance to Jezero Crater appears to be paying off.

"Absolutely. There were other places we could have gone that might have been just as good," he said. "You won't know until you explore them all. But Jezero was picked for good reason and it has been completely justified."

The helicopter Ingenuity's flying days appear to be over after it sustained rotor damage in January after landing on its 72nd flight. But Perseverance is still going strong. It still has 15 sample tubes at its disposal to capture additional interesting geologic specimens.

Next the rover will make its way out of Jezero Crater to explore the wider area. Czaja said they are likely to find rocks dating back 4 billion years or more. And Mars could harbor stromatolites or rocks that contain evidence of ancient layered mats of bacteria visible to the naked eye. On Earth, these rocks are sometimes found in extreme environments such as geyser basins.

The horizon of discovery continues to expand daily before the science team.

"I hope that Perseverance has just whetted our appetite for more Martian exploration," Czaja said. "And bringing back samples will allow us to study Mars and search for evidence of ancient life with instruments that haven't even been invented yet for years and years to come."

More information: Sandra Siljeström et al, Evidence of Sulfate-Rich Fluid Alteration in Jezero Crater Floor, Mars, *Journal of Geophysical*

Research: Planets (2024). DOI: 10.1029/2023JE007989

Andrea Corpolongo et al, SHERLOC Raman Mineral Class Detections of the Mars 2020 Crater Floor Campaign, *Journal of Geophysical Research: Planets* (2023). DOI: 10.1029/2022JE007455

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