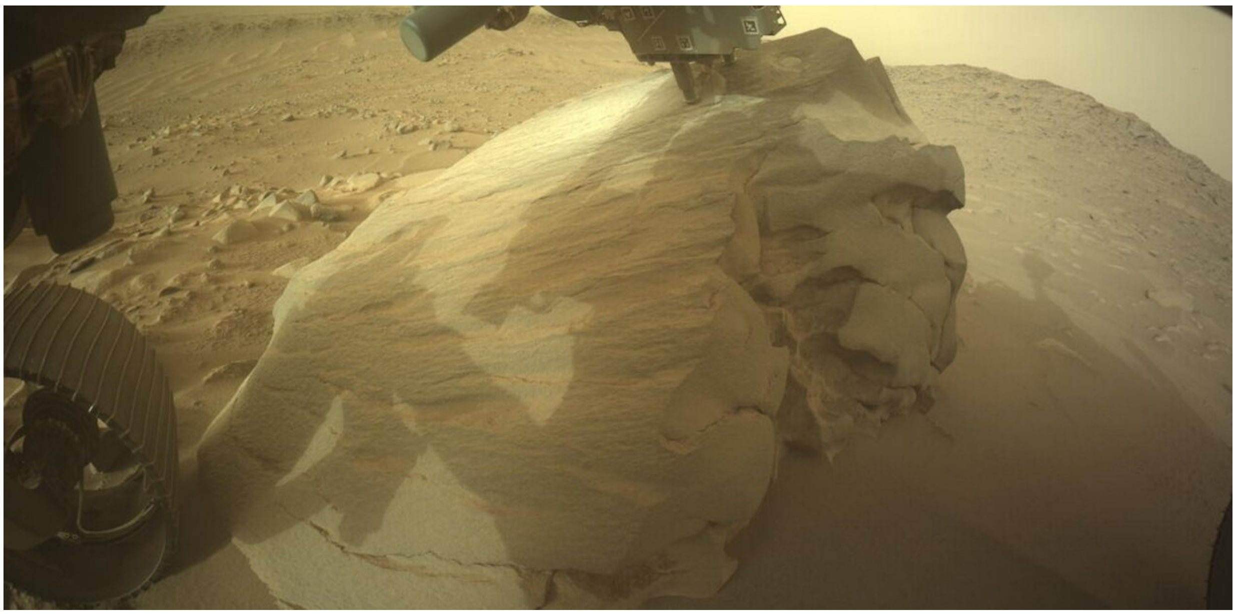
A NASA rover has reached a promising place to search for fossilized life on Mars

April 24 2024, by Sean McMahon



Credit: NASA/JPL-Caltech

While we go about our daily lives on Earth, a nuclear-powered robot the size of a small car is trundling around Mars looking for fossils. Unlike its predecessor Curiosity, NASA's Perseverance rover is explicitly intended to "search for potential evidence of past life", according to the official mission objectives.

Jezero Crater was chosen as the landing site largely because it contains the remnants of ancient muds and other sediments deposited where a river discharged into a lake more than 3 billion years ago. We don't know if there was life in that lake, but if there was, Perseverance might find evidence of it.

We can imagine Perseverance coming across large, well-preserved fossils of microbial colonies—perhaps resembling the cabbage-like "stromatolites" that solar-powered bacteria produced along ancient shorelines on Earth. Fossils like these would be big enough to see clearly with the rover's cameras, and might also contain chemical evidence for ancient life, which the rover's spectroscopic instruments could detect.

But even in such wildly optimistic scenarios, we wouldn't be completely sure we'd found fossils until we could see them under the microscope in laboratories on Earth. That's because it's possible for geological features produced by non-biological processes to resemble fossils. These are referred as pseudofossils. That's why Perseverance isn't just looking for fossils in situ: it's collecting samples. If all goes well, about 30 specimens will be returned to Earth by a follow-on mission, which is being planned in collaboration with the European Space Agency (ESA).

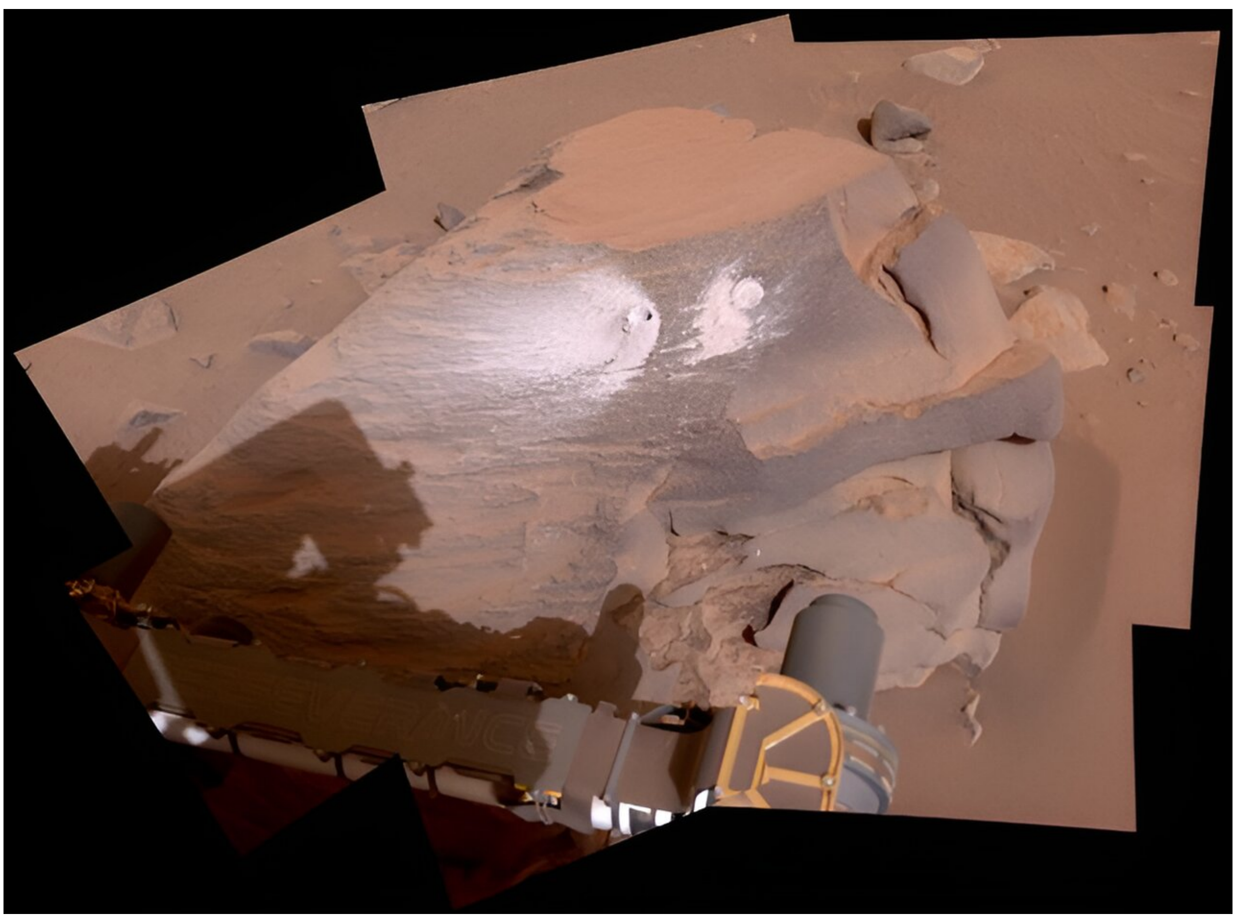
Earlier this month, NASA announced that a particularly intriguing sample, the 24th for Perseverance and informally named "Comet Geyser", had joined the rover's growing collection. This one comes from an outcrop called Bunsen Peak, part of a rocky deposit called the Margin Unit that's close to the crater's edge.

This rock unit may have formed along the shoreline of the ancient lake.

Rover instruments have shown that the Bunsen Peak sample is dominated by carbonate minerals (the main constituent of rocks like limestone, chalk and travertine on Earth).

The little carbonate grains are cemented together with pure silica (similar to opal or quartz). NASA's press release quotes Ken Farley, project scientist for Perseverance, saying: "This is the kind of rock we had hoped to find when we decided to investigate Jezero Crater."

But what's so special about carbonates? And what makes the Bunsen Peak sample particularly exciting from the point of view of astrobiology, the study of life in the universe? Well, first, this rock may have formed under conditions that we would recognize as habitable: able to support the metabolism of life as we know it.



Perseverance drilled into Bunsen Peak, revealing the white colouring inside the rock. Credit: NASA/JPL-Caltech/ASU/MSSS

One ingredient in habitability is the availability of water. Carbonate and silica minerals can both form by direct precipitation from liquid water. Sample 24 may have precipitated from the lake water under temperatures and chemical conditions compatible with life, although there may be other possibilities that need to be tested. In fact, carbonate minerals are puzzlingly rare on Mars, which has always had plenty of CO_2 available.

In the wet environments of early Mars, that CO_2 should have dissolved in water and reacted to form carbonate minerals. Analysis of Bunsen Peak and of Sample 24 when it is sent to Earth, may eventually help us solve this mystery. One face of the outcrop has some interesting rough and streaky textures which could clarify its origins, but they are hard to interpret without more data.

Second, we know from examples on Earth that ancient sedimentary carbonates can yield wonderful fossils. Such fossils include stromatolites composed of carbonate crystals precipitated directly by bacteria. Perseverance hasn't seen convincing examples of these.

There are some concentric circular patterns in the Margin Unit but they are almost certainly an effect of weathering. Even where stromatolites are absent, however, some ancient carbonates on Earth contain fossil colonies of microbial cells, which form ghostly sculptures where the original cellular structures have been replaced by minerals.

The small grain size of the "Comet Geyser" sample indicates a higher potential to preserve delicate fossils. Under some conditions, fine-grained carbonates can even retain organic matter —- the modified remains of the fats, pigments and other compounds that make up living things. The silica cement makes such preservation more likely: silica is generally harder, more inert, and less permeable than carbonate, and can protect fossil microbes and organic molecules inside rocks from chemical and physical alteration over billions of years.

When my colleagues and I wrote a scientific paper called A Field Guide to Finding Fossils on Mars in preparation for this mission, we explicitly recommended sampling fine-grained, silica-cemented rocks for these reasons. Of course, to crack open this sample and explore its secrets, we need to bring it back to Earth.

An independent review recently criticized NASA's plans for the return of samples from Mars as too risky, too slow, and too expensive. Modified mission architectures are now being evaluated to meet these challenges. In the meantime, hundreds of brilliant scientists and engineers at NASA's Jet Propulsion Laboratory in California lost their jobs because the US Congress effectively reduced funding for Mars sample return by failing to commit the necessary level of support.

Mars sample return remains NASA's highest planetary science priority and is strongly supported by the planetary science community around the world. The samples from Perseverance may revolutionize our view of life in the universe. Even if they don't contain fossils or biomolecules, they will fuel decades of research and give future generations a completely new view of Mars. Let's hope NASA and the US government can live up to the name of their rover, and persevere.

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