Rocks collected on Mars hold key to water and perhaps life on the planet: Researchers urge bringing them back to Earth

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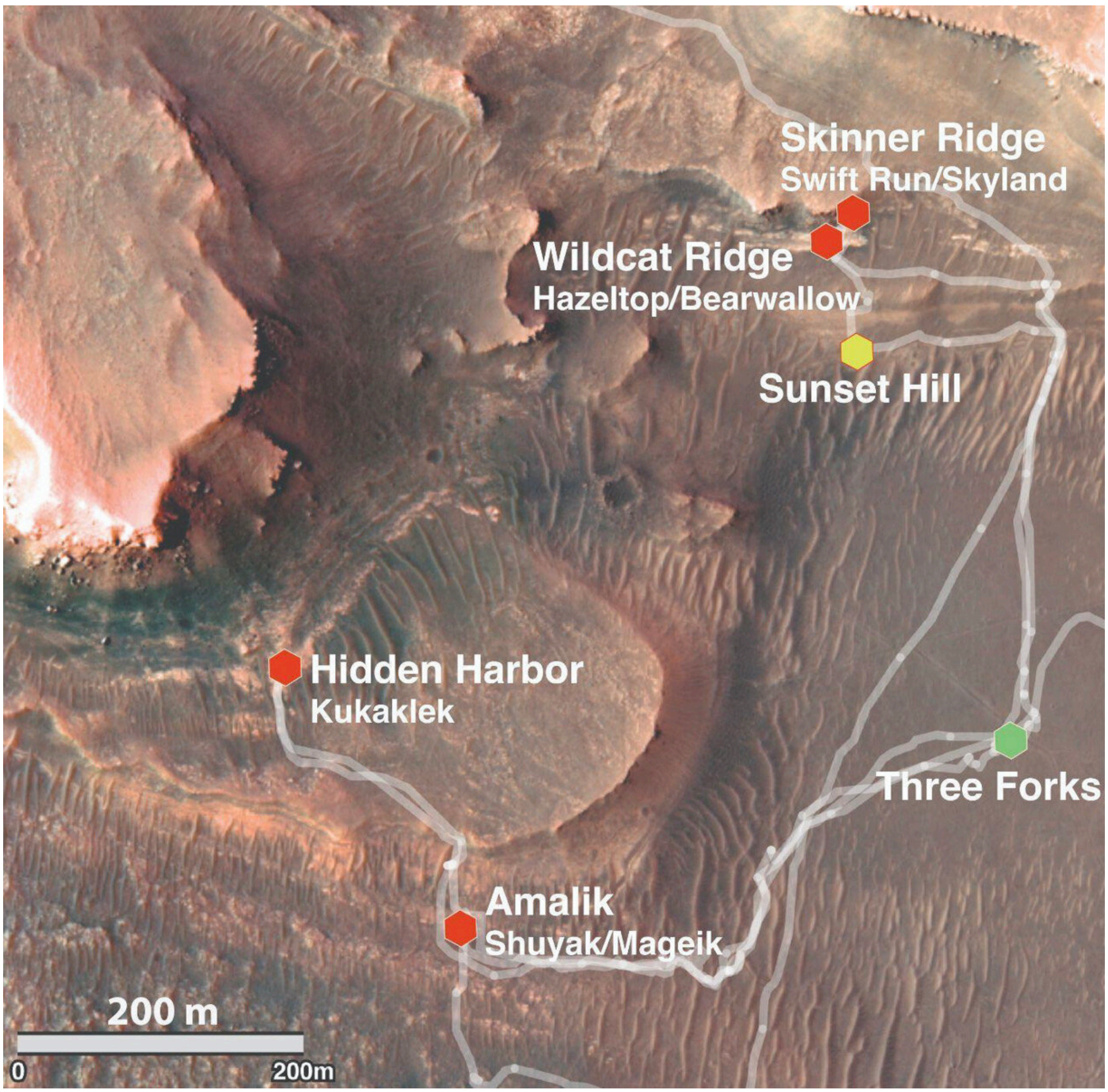

Red hexagons mark the four sites where the Perseverance rover collected rock samples around the sediment fan in Jezero crater in 2022. Credit: NASA

Over the course of nearly five months in 2022, NASA's Perseverance rover collected rock samples from Mars that could rewrite the history of water on the red planet and even contain evidence for past life on Mars.

But the information they contain can't be extracted without more detailed analysis on Earth, which requires a new mission to the planet to retrieve the samples and bring them back. Scientists hope to have the samples on Earth by 2033, though NASA's sample return mission may be delayed.

"These samples are the reason why our mission was flown," said paper co-author David Shuster, professor of Earth and planetary science at the University of California, Berkeley, and a member of NASA's science team for sample collection. "This is exactly what everyone was hoping to accomplish. And we've accomplished it. These are what we went looking for."

The critical importance of these rocks, sampled from river deposits in a dried-up lake that once filled a crater called Jezero, is detailed in a study to be published Aug. 14 in *AGU Advances*.

"These are the first and only sedimentary rocks that have been studied and collected from a planet other than Earth," said Shuster. "Sedimentary rocks are important because they were transported by water, deposited into a standing body of water and subsequently modified by chemistry that involved liquid water on the surface of Mars at some point in the past. The whole reason that we came to Jezero was to study this sort of rock type. These are absolutely fantastic samples for the overarching objectives of the mission."

Shuster is co-author of the paper with first author Tanja Bosak, a geobiologist at the Massachusetts Institute of Technology (MIT) in Cambridge.

"These rock cores are likely the oldest materials sampled from any known environment that may have supported life," Bosak said. "When we bring them back to Earth, they can tell us so much about when, why and for how long Mars contained liquid water, and whether some organic, prebiotic and potentially even biological evolution may have taken place on that planet."

Significantly, some of the samples contain very fine-grained sediments that are the most likely type of rock to retain evidence of past microbial life on Mars—if there ever was or is life on the planet.

"Liquid water is a key element in all of this because it is the key ingredient for biological activity, as far as we understand it," said Shuster, a geochemist. "Fine-grained sedimentary rocks on Earth are those that are most likely to preserve signatures of past biological activity, including organic molecules. That's why these samples are so important."

NASA announced on July 25 that Perseverance had collected new rock samples from an outcrop named Cheyava Falls that also might contain signs of past life on Mars. The rover's scientific instruments detected evidence of organic molecules, while "leopard spot" inclusions in the rocks are similar to features that on Earth are often associated with fossilized microbial life.

In a statement, Ken Farley, Perseverance project scientist at Caltech, said, "Scientifically, Perseverance has nothing more to give. To fully understand what really happened in that Martian river valley at Jezero crater billions of years ago, we'd want to bring the Cheyava Falls sample back to Earth, so it can be studied with the powerful instruments available in laboratories."

Sediments hold the answers

Shuster noted that Jezero and the fan of sediments left behind by the river that once flowed into it likely formed 3.5 billion years ago. That abundant water is now gone, either trapped underground or lost to space. But Mars was wet at a time when life on Earth—in the form of microbes—was already everywhere.

"Life was doing its thing on Earth at that point in time, 3.5 billion years ago," he said. "The basic question is: Was life also doing its thing on Mars at that point in time?

"Anywhere on Earth over the last 3.5 billion years, if you give me the scenario of a river flowing into a crater transporting materials to a standing body of water, biology would have taken hold there and left its mark, in one way or another," Shuster added. "And in the fine-grained sediment, specifically, we would have a very good chance of recording that biology in the laboratory observations that we can make on that material on Earth."

Shuster and Bosak acknowledge that the organic analysis equipment aboard the rover did not detect organic molecules in the four samples from the sedimentary fan. Organic molecules are used and produced by the type of life we're familiar with on Earth, though their presence is not unequivocal evidence of life.

"We did not clearly observe organic compounds in these key samples," Shuster said. "But just because that instrument did not detect organic compounds does not mean that they are not in these samples. It just means they weren't at a concentration detectable by the rover instrumentation in those particular rocks."

To date, Perseverance has collected a total of 25 samples, including duplicates and atmospheric samples, plus three "witness tubes" that capture possible contaminants around the rover. Eight duplicate rock samples plus an atmospheric sample and witness tube were deposited in the so-called Three Forks cache on the surface of Jezero as a backup in case the rover suffers problems and the onboard samples can't be retrieved. The other 15 samples—including the Cheyava Falls sample collected July 21—remain aboard the rover awaiting recovery.

Shuster was part of a team that analyzed the first eight rock samples collected, two from each site on the crater floor, all of which were igneous rocks likely created when a meteor impact smashed into the surface and excavated the crater. Those results were reported in a 2023 paper, based on analyses by the instruments aboard Perseverance.

The new paper is an analysis of seven more samples, three of them duplicates now cached on Mars' surface, collected between July 7 and November 29, 2022 from the front of the western sediment fan in Jezero. Bosak, Shuster and their colleagues found the rocks to be composed mostly of sandstone and mudstone, all created by fluvial processes.

"Perseverance encountered aqueously deposited sedimentary rocks at the front, top and margin of the western Jezero fan and collected a sample suite composed of eight carbonate-bearing sandstones, a sulfate-rich mudstone, a sulfate-rich sandstone, a sand-pebble conglomerate," Bosak said. "The rocks collected at the fan front are the oldest, whereas the rocks collected at the fan top are likely the youngest rocks produced during aqueous activity and sediment deposition in the western fan."

While Bosak is most interested in possible biosignatures in the fine-grained sediments, the coarse-grained sediments also contain key information about water on Mars, Shuster said. Though less likely to preserve organic matter or potential biological materials, they contain carbonate materials and detritus washed from upstream by the now-vanished river. They thus could help determine when water actually flowed on Mars, the main emphasis of Shuster's own research.

"With lab analysis of those detrital minerals, we could make quantitative statements about when the sediments were deposited and the chemistry of that water. What was the pH (acidity) of that water when those secondary phases precipitated? At what point in time was that chemical alteration taking place?" he said.

"We have this combination of samples now in the sample suite that are going to enable us to understand the environmental conditions when the liquid water was flowing into the crater. When was that liquid water flowing into the crater? Was it intermittent?"

Answers to these questions rely upon analyses of the returned materials in terrestrial laboratories to uncover the organic, isotopic, chemical, morphological, geochronological and paleomagnetic information they record, the researchers emphasized.

"One of the most important planetary science objectives is to bring these samples back," Shuster said.

More information: Astrobiological potential of rocks acquired by the Perseverance rover at a sedimentary fan front in Jezero crater, Mars, *AGU Advances* (2024).

Provided by University of California - Berkeley

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