Rock varnish may hold clues to life on Mars

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Two collection sites of rock varnish in New York. Image credit: David H. Krinsley, et al. ©2012 Elsevier

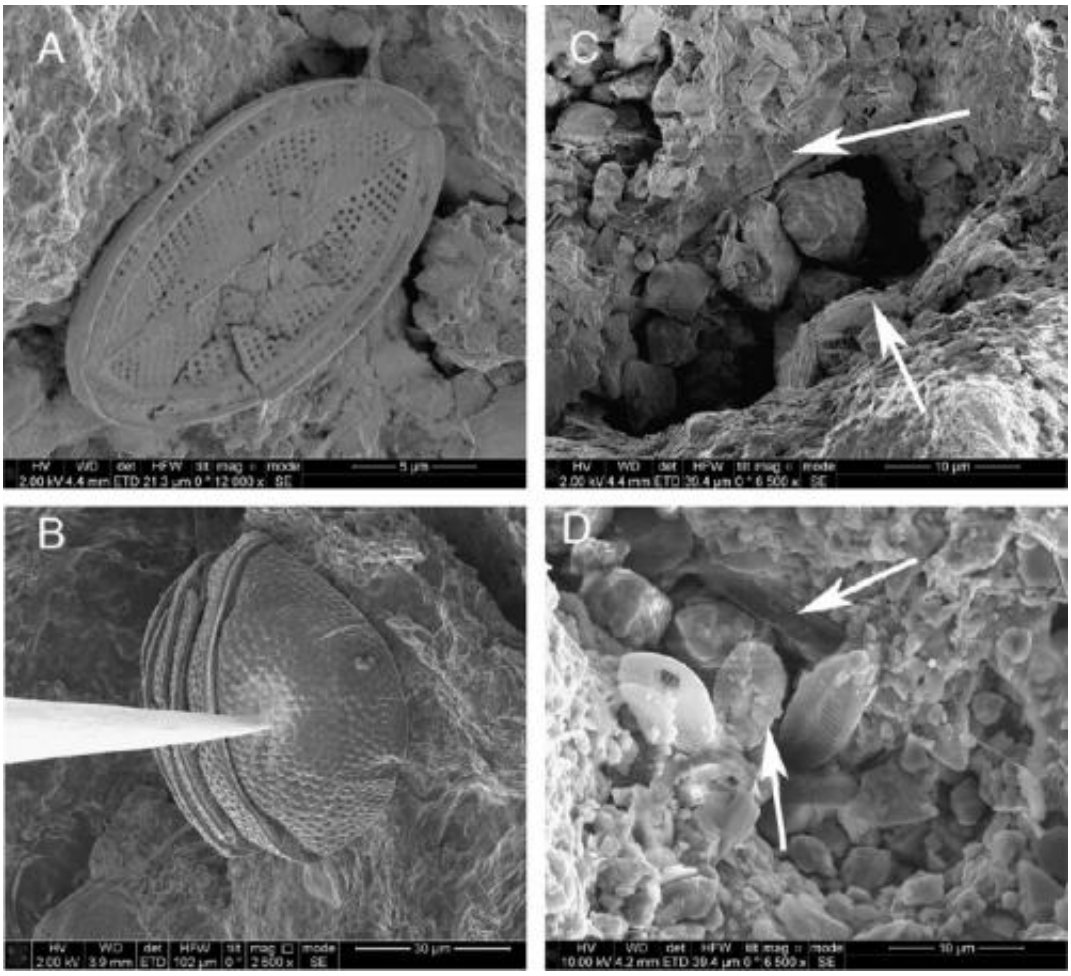
(Phys.org) -- As NASA's Curiosity rover prepares to search for signs that Mars may once have supported life, a team of researchers analyzing rocks in New York may have found a clue telling the rover where to look. By gazing through high-powered microscopes, the researchers discovered that the dark brownish/blackish coating on some rocks, called rock varnish, probably stems from large numbers of microorganisms that died on the rocks. Later, manganese in the microbes would have mixed with tiny clay minerals to adhere to the surface of the rocks and form the several-micrometers-thick layer of manganese-rich varnish.

"All life on Earth needs manganese to carry out biological functions," Barry E. DiGregorio at the University of Buckingham in the UK told *Phys.org*. "The microorganisms involved in forming manganese-rich

rock varnish in the samples we examined likely absorbed it from atmospheric dust, water vapor and other forms of precipitation - all available on Mars."

If Curiosity finds rocks with manganese-rich rock varnish, it could signify the remains of bacteria or fungi that once lived there. DiGregorio and his coauthors have recently published a paper in the journal *Geomorphology* in which they showed how microorganisms may have formed rock varnish under the humid conditions near New York stream beds.

Analyzing rock varnish has been a popular endeavor for researchers for more than 200 years, with Darwin himself investigating the manganese-rich rock coatings near tropical rivers. But it has never been clear as to whether rock varnish has biotic or abiotic origins.



Rock varnish coatings that are less than 100 years old show microorganisms in the process of creating the varnish: (A) a diatom from Higley Flow State Park, (B) a bioform sampled from a gneiss boulder along a fast-flowing section of the Raquette River, (C) pieces of microbe-looking forms on varnish from the Raquette River, and (D) more pieces from along the Erie Barge Canal. Image credit: David H. Krinsley, et al. ©2012 Elsevier

To answer this question, DiGregorio and his coauthors have peered inside rock varnish using the latest electron microscope technology at the CAMCOR University of Oregon, including a Dual-Beam Focused Ion Beam (DB-FIB) Scanning Electron Microscope. They also used a scanning transmission electron microscope, which provides a 500,000x

magnification and spatial resolution down to 1 nanometer. With these microscopes, the researchers observed forms in the varnish that were the right size (about a micrometer) and shape (spherical and ovoid) to be bacteria and fungi, and also observed diatoms (small algae). The scientists interpreted these forms as the desiccated remains of microbial sheaths, lending support to the argument that rock varnish has a biotic origin.

The finding may at first sound surprising since previous analyses of rock varnish in dry desert regions have not clearly identified the microbe-like forms. But it's also been well-documented that it takes thousands of years for rock varnish to form in dry regions, compared with mere decades in humid regions like New York stream beds. The researchers suspect that microorganisms can thrive better under wet conditions, accelerating the rates of varnish formation. More rapid varnishing then leads to a superior preservation of the microbial remains.

"Most of the rock varnish that has been examined by researchers and published in the scientific literature has focused on the varnish found in hot and cold desert areas where harsh environmental conditions such as extended desiccation time, untenuated solar UV and soil pH all limit the time it takes (calculated to be about one or two thousand years) to form a 1-200 micron layer," DiGregorio said. "It is because of this lengthy process of formation that the organic remains of any microorganisms eventually become obliterated over time with any remains of bacteria fused into the varnish layers. To complicate matters, all rocks exposed to the atmosphere, whether in the desert or in humid mountainous regions, have microorganisms living and dying on the surface of the rocks as they eke out their life cycle - these are known as adventitious microbes that have nothing to do with the formation of the varnish.

"On the other hand, humid region varnishes like the type we examined in New York State can form very quickly, allowing any microorganisms

involved in the process of concentrating the manganese to be observed. Our results conclusively show that microorganisms in humid environments like the samples we examined from New York State mediate and concentrate the manganese in rock varnish. There has been a small number of papers published linking microorganisms to the manganese content in rock varnish, but because the varnish examined was from extremely dry desert regions, the bacteria were in such a state of disintegration that it left room for doubts."

This image, taken by the Spirit rover in 2006, shows a potential rock varnish site on Mars. Image credit: NASA

The researchers acknowledge that their observations here have an

important limitation, which is that just because a form has the right size and shape to be a microorganism, it doesn't prove that the forms are microorganisms. Despite this uncertainty, they note that it would be difficult to explain the New York rock varnish formation through abiotic processes.

If the manganese-rich varnish were indeed formed by microorganisms, then the similar-looking rock varnish on Martian rocks certainly deserves a close look. As DiGregorio explains, Curiosity may land in the perfect place to look for rock varnish.

"Curiosity will land on an alluvial fan in Gale crater," he said. "Alluvial fans on Earth are known for their outstanding manganese-rich varnish coatings that can be viewed from aircraft and even satellites like LANDSAT. However, on Mars, the alluvial fans will be coated with a thin layer of dust so it will be necessary to remove the dust to expose any manganese-rich rock varnish. The Gale crater alluvial fan region is the perfect landing site to look for evidence of manganese-rich rock varnish. If Curiosity lands without incident I believe it is in the perfect landing zone to look for evidence of past or current life. If manganese-rich rock coatings are confirmed as I think they will be, then it would mean Mars likely has microbes still making this varnish today."

While successfully landing on Mars is a challenge in itself, analyzing the rock coatings will also require the use of cutting-edge rover technology.

"The ChemCam/LIBS experiment has the best capability of all the rover instruments to determine whether manganese-rich rock coatings exist on Mars," DiGregorio said. "Previous rovers and landers were not able to detect the manganese in any rock coatings. In the case of the Mars Pathfinder and MER rovers, the rock coatings were considered a nuisance because they prevented analyses of the underlying rock and are the reason the MER rovers were equipped with a rock abrasion tool - a

spinning brush designed to scrape rock coatings away. Once ChemCam/LIBS determines whether a rock coating is composed of manganese, the rover could then travel up to the rock, scrape a small sample and place it in the SAM organic analyses instrument to see what organic compounds exist. Unfortunately, none of the microscope instruments on Curiosity or sent to Mars previously had the ability to resolve bacteria. To do this would require sending a microscope that could 'see' something as small as 1 or 2 microns."

More information: More information: David H. Krinsley, et al. "Rock varnish in New York: An accelerated snapshot of accretionary processes." *Geomorphology* 138 (2012) 339-351. DOI: 10.1016/j.geomorph.2011.09.022