Water-rock reaction may provide enough hydrogen 'food' to sustain life in ocean's crust or on Mars

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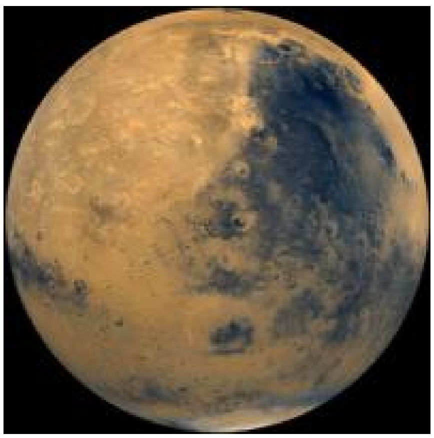

Mars. Image: NASA

A chemical reaction between iron-containing minerals and water may produce enough hydrogen "food" to sustain microbial communities living in pores and cracks within the enormous volume of rock below the ocean floor and parts of the continents, according to a new study led by the University of Colorado Boulder.

The findings, published in the journal *Nature Geoscience*, also hint at the possibility that hydrogen-dependent life could have existed where iron-rich igneous rocks on Mars were once in contact with water.

Scientists have thoroughly investigated how rock-water reactions can produce hydrogen in places where the temperatures are far too hot for living things to survive, such as in the rocks that underlie hydrothermal vent systems on the floor of the Atlantic Ocean. The hydrogen gases produced in those rocks do eventually feed microbial life, but the communities are located only in small, cooler oases where the vent fluids mix with seawater.

The new study, led by CU-Boulder Research Associate Lisa Mayhew, set out to investigate whether hydrogen-producing reactions also could take place in the much more abundant rocks that are infiltrated with water at temperatures cool enough for life to survive.

"Water-rock reactions that produce hydrogen gas are thought to have been one of the earliest sources of energy for life on Earth," said Mayhew, who worked on the study as a doctoral student in CU-Boulder Associate Professor Alexis Templeton's lab in the Department of Geological Sciences.

"However, we know very little about the possibility that hydrogen will be produced from these reactions when the temperatures are low enough that life can survive. If these reactions could make enough hydrogen at these low temperatures, then microorganisms might be able to live in the rocks where this reaction occurs, which could potentially be a huge subsurface microbial habitat for hydrogen-utilizing life."

When igneous rocks, which form when magma slowly cools deep within the Earth, are infiltrated by ocean water, some of the minerals release unstable atoms of iron into the water. At high temperatures—warmer than 392 degrees Fahrenheit—scientists know that the unstable atoms, known as reduced iron, can rapidly split water molecules and produce hydrogen gas, as well as new minerals containing iron in the more stable, oxidized form.

Mayhew and her co-authors, including Templeton, submerged rocks in water in the absence of oxygen to determine if a similar reaction would take place at much lower temperatures, between 122 and 212 degrees Fahrenheit. The researchers found that the rocks did create hydrogen—potentially enough hydrogen to support life.

To understand in more detail the chemical reactions that produced the hydrogen in the lab experiments, the researchers used "synchrotron radiation"—which is created by electrons orbiting in a manmade storage ring—to determine the type and location of iron in the rocks on a microscale.

The researchers expected to find that the reduced iron in minerals like olivine had converted to the more stable oxidized state, just as occurs at higher temperatures. But when they conducted their analyses at the Stanford Synchrotron Radiation Lightsource at Stanford University, they were surprised to find newly formed oxidized iron on "spinel" minerals found in the rocks. Spinels are minerals with a cubic structure that are highly conductive.

Finding oxidized iron on the spinels led the team to hypothesize that, at low temperatures, the conductive spinels were helping facilitate the exchange of electrons between reduced iron and water, a process that is necessary for the iron to split the water molecules and create the hydrogen gas.

"After observing the formation of oxidized iron on spinels, we realized there was a strong correlation between the amount of hydrogen produced and the volume percent of spinel phases in the reaction materials," Mayhew said. "Generally, the more spinels, the more hydrogen."

Not only is there a potentially large volume of rock on Earth that may undergo these low temperature reactions, but the same types of rocks also are prevalent on Mars, Mayhew said. Minerals that form as a result of the water-rock reactions on Earth have been detected on Mars as well, which means that the process described in the new study may have implications for potential Martian microbial habitats.

Provided by University of Colorado at Boulder

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