Discovery of unknown hydrogen in mid-ocean ridge points to hidden biosphere

May 18 2020

Credit: CC0 Public Domain

By providing the first estimate of how much hydrogen is available to fuel microbial life in the sunless sub-seafloor crust beneath the Mid-Ocean Ridge (MOR), a new Duke University-led study sheds light on one of Earth's least understood biospheres.

It may also help illuminate how similar conditions could support life in other extreme environments, from distant planets to early Earth itself.

Most microbes use sunlight-powered photosynthesis to create organic matter. But chemosynthetic microbial communities living deep within the volcanic rock of Earth's oceanic crust lack this energy source and use hydrogen, released as a free gas when water flows through the iron-rich rock, as their fuel to convert carbon dioxide into food.

Scientists have known that life can thrive in the abyss since shortly after the discovery of the first deep-sea hydrothermal vents in 1977. But it wasn't until 2013 that microbiologists discovered microbial communities living within volcanic rocks beneath the seafloor. That discovery sparked widespread scientific curiosity, not only due to the potential size of the newfound biosphere—the oceanic crust is several kilometers thick and covers 60% of Earth's surface—but also because the extreme, oxygen-poor conditions found there are similar to those when life first began on Earth, a time when chemical energy may have been the only energy source available to fuel microbes' metabolisms.

"Until now, however, we had no good constraints on the overall size of these microbial communities or how much hydrogen they consume. This new study provides a first estimate and gives us new insights into the scope of these microbes' impact on Earth's climate and paleoclimate," said Lincoln Pratson, Gendell Family Professor of Energy and Environment at Duke's Nicholas School of the Environment.

"It also gives us boundary conditions for what some of the earliest forms of life on Earth had to deal with, and for where you might look for life on other planets," he said.

The scientists published their peer-reviewed paper the week of May 11 in the *Proceedings of the National Academy of Sciences*.

To conduct their study, they constructed a box model that assessed the total production of hydrogen gas (H2) from nine different geological sources within a nearly 30 million-square-kilometer corridor of oceanic crust centered on the Mid-Ocean Ridge. The corridor snakes along the ridge through all the world's oceans and covers about 10% of the entire oceanic crust.

The team also estimated how much of this hydrogen gas likely was being released into the ocean through seafloor hydrothermal vents, based on more than 500 measurements of water samples collected by other researchers on previous expeditions along the Mid-Ocean Ridge.

"By subtracting the amount of gas being vented, which was roughly 20 million metric tons per year, from the amount being produced, which was roughly 30 million metric tons per year, we were left with around 10 million metric tons annually that are, presumably, being consumed by microbes within this strip of crust," said lead author Stacey L. Worman, a former student of Pratson's whose 2015 doctoral dissertation on hydrogen gas reserves beneath the Mid-Ocean Ridge provided the impetus for the new study.

These numbers suggest that microbial communities play a significant role in helping regulate Earth's global biogeochemistry, said Worman, who now works as a research analyst at Chevy Chase Trust in Bethesda, Md.

"Microbes beneath the seafloor and in the dark ocean consume significant quantities of this reduced gas. Without these microbes consuming this highly diffusive gas, this geologically produced H2 could conceivably escape into the atmosphere," she said.

Such an input would represent a sizable bump—about 10% - to the Earth's current atmospheric hydrogen budget. Since hydrogen gas can hasten the build-up of greenhouse gases in the lower atmosphere, that could have a significant impact on global warming.

On a global scale, the impact may be much larger, Pratson noted, since the remaining 90% of the ocean crust that was not included in this study may also have hydrogen production and consumption going on.

"While our analysis estimates how much H2 might be consumed by the deep biosphere in the vicinity of the MOR, it's unclear whether the size of the deep biosphere is limited by the availability of H2 or by other factors, such as temperature, nutrients, pressure, pH or even space," Worman said. "Combining this study and future work on the H2 budget with other key constraints on life is a promising avenue for advancing our understanding of its origin and evolution here on Earth and for targeting where to search for life elsewhere in the universe."

Worman and Pratson conducted the study with Jeffrey A. Karson, Jessie Page Heroy Professor of Geology at Syracuse University, and William H. Schlesinger, James B. Duke Professor Emeritus of Biogeochemistry, former dean of Duke's Nicholas School and president emeritus of the Cary Institute of Ecosystem Studies,

More information: Abiotic Hydrogen (H_2) Sources and Sinks Near the Mid-Ocean Ridge (MOR) with Implications for the Subseafloor Biosphere, *Proceedings of the National Academy of Sciences*. DOI: 10.1073/pnas.2002619117

Provided by Duke University