Life in the smoke of underwater volcanoes

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Enceladus black smoker at the Aurora Vent Field. Credit: HACON cruise 2021, REV Ocean

Deep down in the ocean at tectonic plate boundaries, hot fluids rise from hydrothermal vents. The fluids are devoid of oxygen and contain large amounts of metals such as iron, manganese or copper. Some may also

transport sulfides, methane and hydrogen. When the hot water mixes with the cold and oxygenated surrounding seawater, hydrothermal plumes develop containing smoke-like particles of metal sulfide.

These plumes rise hundreds of meters off the seafloor and disperse thousands of kilometers away from their source. Hydrothermal plumes might seem like a precarious place to make yourself at home. However, that does not stop certain bacteria from flourishing just there, a study now published in *Nature Microbiology* finds.

"We took a detailed look at bacteria of the genus Sulfurimonas," says first author Massimiliano Molari from the Max Planck Institute for Marine Microbiology in Bremen, Germany. These bacteria have so far only known to grow in low-oxygen environments, but gene sequences had occasionally also been detected in hydrothermal plumes. As their name suggests, they are known to use energy from sulfide. "It was assumed that they were flushed there from seafloor vent-associated environments. But we wondered whether the plumes might actually be a suitable environment for some members of the Sulfurimonas group."

Tough sampling conditions

Together with colleagues from the Alfred Wegener Institute, Helmholtz Center for Polar and Marine Research in Bremerhaven (AWI) and the MARUM Center for Marine Environmental Sciences of Bremen University, Molari thus took on a challenging sampling trip to hydrothermal plumes in the Central Arctic and South Atlantic Ocean.

"We sampled plumes in extremely remote areas of ultraslow spreading ridges that were never studied before. Collecting hydrothermal plume samples is very complicated, as they are not easy to locate. Sampling becomes even more difficult when the plume is located at depths of more than 2,500 meters and below Arctic sea ice, or within the stormy

zones of the Southern Ocean," explains Antje Boetius, group leader at the Max Planck Institute for Marine Microbiology and director of the AWI, who was the Chief scientist on the Arctic missions. Onboard of the research vessel Polarstern the scientists managed to collect samples and within this water studied the composition and metabolism of bacteria.

Research vessel Polarstern on expedition PS86 in the Greenland ice, approximately 4000 m above the Western Vulcanic Zone of Gakkel Ridge. Credit: Alfred Wegener Institute / Stefanie Arndt

The Polarstern team led by Prof. Dr. Antje Boetius. Back row, from left: Gunter Wegener, Massimiliano Molari, Mirja Meiners, Rafael Stiens, Antje Boetius, Fabian Schramm, Norbert Rieper. Front row: Andreas Türke, Yann Marcon. Credit: Alfred Wegener Institute / Stefanie Arndt

Well-equipped and widespread

Molari and his colleagues identified a new Sulfurimonas species called ^{U}Sulfurimonas pluma (the superscript "U" stands for "uncultivated") inhabiting the cold, oxygen-saturated hydrothermal plumes. Surprisingly, this microorganism used hydrogen from the plume as an energy source, rather than sulfide. The scientists also investigated the microbes' genome and found it to be strongly reduced, missing genes typical for their relatives, but being well-equipped with others to allow them to grow in

this dynamic environment.

"We think that the hydrothermal plume does not only disperse microorganisms from hydrothermal vents, but it might also ecologically connect the open ocean with seafloor habitats. Our phylogenetic analysis suggests that ^{U}Sulfurimonas pluma could have derived from a hydrothermal vent-associated ancestor, which acquired higher oxygen tolerance and then spread across the oceans. However, that remains to be further investigated," Molari says.

Aurora's hydrothermal vents at Gakkel Ridge (Central Arctic). A snapshot of a hydrothermal vent (upper left corner, indicated by the red arrow) and chimneys (yellow-orange structures on the right) captured by the underwater camera system OFOS, which made it possible to identify the location of the hydrothermal vents field during expedition PS86. Credit: Cruise report

A look at genome data from other plumes revealed that [U]Sulfurimonas pluma grows in these environments all over the world. "Obviously, they have found an ecological niche in cold, oxygen-saturated and hydrogen-rich hydrothermal plumes," says Molari. "That means we have to rethink our ideas on the ecological role of Sulfurimonas in the deep ocean—they might be much more important that we previously thought."

More information: Massimiliano Molari, A hydrogenotrophic Sulfurimonas is globally abundant in deep-sea oxygen-saturated hydrothermal plumes, *Nature Microbiology* (2023). DOI: 10.1038/s41564-023-01342-w. www.nature.com/articles/s41564-023-01342-w

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