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Determining the origin of thermogenic organic matter in high temperature hydrothermal vent fluids

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Hydrothermal vent systems are known to host organic-rich fluids; determining the origin (biogenic, thermogenic, or abiotic) of these organic compounds is important for understanding the role these systems play in fostering microbial communities and preserving or altering the sedimentary record of organic compounds. Hydrothermal vent systems were possibly an oasis for early life and thus developing methods to discern between abiotic and thermally altered biogenic (thermogenic) organic compounds in highly altered rocks is becoming increasingly important in the search for early life on both Earth and beyond.

Here we focus on constraining the extent of thermogenic alteration of organic matter in modern high temperature vents. We determined the composition and concentration of dissolved organic compounds in a variety of high temperature (>250° C) vent systems using ion chromatography and GC-MS. Vent fluid samples were taken from ~3670 m depth at Pescadero Basin, among the deepest known hydrothermal vent systems in the Pacific Ocean, collected by the ROV Hercules and the EV Nautilus in November 2017, and from 9° 50′ N on the East Pacific Rise (EPR), collected by the ROV Jason and the EV Roger Revelle in April 2021.

The fluids at Pescadero Basin interacted with an organic-rich sediment cover, providing opportunities to form both thermogenic, biogenic, and abiotic organic matter. A series of carboxylic acids including formate, acetate, and propionate were detected in the vent fluids. The carboxylic acids are likely the products of thermal alteration of n-alkanes within the sediments via n-alkane oxidation. Organic acids such as acetate can be produced abiotically, but their relative abundances suggest these are from thermally altered biogenic organic matter. The measured seafloor fluid temperatures at the Pescadero vents reach up to 290°C, and the great depth of these vents may allow circulating hydrothermal fluids to reach temperatures greater than those achieved in shallower systems, eliminating in-situ biogenic production in the fluids themselves. Pescadero basin hydrothermal vents thus represent a modern example of rapid thermal alteration of preserved organic matter. These organic acid byproducts could serve as important biomarkers for future studies of fluids and gases on ocean worlds such as Enceladus.