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TITLE: Hydrothermal Energy Transfer and Organic Carbon Production at the Deep Seafloor

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ABSTRACT:

In just four decades, hundreds of hydrothermal vent fields have been discovered, widely distributed along tectonic plate boundaries on the ocean floor. Vent invertebrate biomass reaching up to tens of kilograms per square meter has attracted attention as a potential contributor to the organic carbon pool available in the resource-limited deep sea. But the rate of chemosynthetic production of organic carbon at deep-sea hydrothermal vents is highly variable and still poorly constrained. Despite the advent of molecular techniques and in situ sensing technologies, the factors that control the capacity of vent communities to exploit the available chemical energy resources remain largely unknown. Here, we review key drivers of hydrothermal ecosystem productivity, including a) the diverse mechanisms governing energy transfer among biotic and abiotic processes; b) the tight linkages among these processes; and c) the nature and extent of spatial and temporal diversity within a variety of geological settings; and d) the influence of these and other factors on the turnover of microbial primary producers, including those associated with megafauna. This review proposes a revised consideration of the pathways leading to the biological conversion of inorganic energy sources into biomass in different hydrothermal habitats on the seafloor. We propose a conceptual model that departs from the canonical conservative mixing-continuum paradigm by distinguishing low-temperature diffuse flows (LT-diffuse flows) derived from seawater and high-temperature fluids (HT-diffuse flow) derived from end-member fluids. We further discuss the potential for sustained organic matter production at vent-field scale, accounting for the natural instability of hydrothermal ecosystems, from the climax vent communities of exceptional productivity to the long-term lower-activity assemblages. The parameterization of such a model crucially needs assessment of in situ rates and of the largely unrecognized natural variability on relevant temporal scales. Beyond the diversity of hydrothermal settings, the depth range and water mass distribution over oceanic ridge crests, volcanic arcs and back-arc systems is expected to significantly influence biomass production rates. A particular challenge is to develop observing strategies that will account for the full range of environmental variables while attempting to derive global or regional estimates.

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