

The chemical diversity of submarine vent fluids and its impact on global hydrothermal element fluxes and catabolic reactions

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Geologic processes shape the chemical characteristics of hydrothermal fluids, which serve as energy sources for microbial communities in chemosynthetic ecosystems. Key processes influencing hydrothermal vent fluid chemistry include water-rock interactions, phase separation, magmatic degassing, and mixing of upwelling hydrothermal fluids with entrained seawater. The relative extent to which these processes affect vent fluid chemistry is closely linked to the geodynamic framework of the venting site, resulting in systematic variations in vent fluid compositions, which, in turn, influence the energetics of catabolic metabolic reactions. The geodynamic framework likewise controls the water depth at which individual vent sites are located, which controls the temperature and processes of phase separation besides magmatic volatile influx and thereby also influences geochemical fluxes and energetic landscapes for microbial communities.

We present an evaluation of global hydrothermal vent fluid compositions and element fluxes across different geodynamic settings and provide a framework for exploring the relationship between hydrothermal fluids as "geofuels" and viable catabolic processes that sustain microbial communities across different domains of submarine venting.

The MARHYS database [1] allows for the fast and comprehensive comparison of vent fluids from different types of basement lithologies, subduction zone affinities, and water depth. We will present examples highlighting how specific mechanisms control vent fluid compositions in various settings. Ultramafic-hosted vent fluids, for instance, are typically found at greater water depths (>2000 m), are rich in H₂, CH₄, and Fe and support hydrogen or methane oxidation as main metabolic pathways. In contrast, arc hydrothermal fluids occur at shallower depths (<1500 m), are often influenced by magma degassing, and contain high concentrations of H₂S and CO₂ but low levels of H₂ and CH₄, favoring sulfide and iron oxidation as a primary catabolic pathway.

[1] Diehl & Bach (2024), MARHYS Database 4.0, PANGAEA, <https://doi.org/10.1594/PANGAEA.972999>