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Dissolved metal-mediated organic carbon transformations in oceanic hydrothermal systems

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Oceanic hydrothermal systems host unique habitable environments for the subsurface life, because they provide sources of essential elements, energy, and organic carbon for the deep ocean biosphere. The fate and cycling of organic carbon in deep-ocean hydrothermal systems are influenced by the surrounding minerals and rocks, which can play an important role in controlling the synthesis and degradation of organic compounds. Previous studies have reported many remarkable organic-mineral interactions in natural or laboratory-simulated hydrothermal systems, however, much less is known about the impact of dissolved metal salts on organic carbon transformations. In oceanic lithosphere, dissolved metal ions released from fluid-mineral interactions may form a complex array of metal salts to interact with sedimentary organic carbon. To improve our understanding of these hydrothermal organic-metal interactions, we performed both laboratory experiments and geochemical modeling to examine the effect of copper and iron salts on a variety of organic functional groups such as alkenes, alcohols, aldehydes, and carboxylic acids. Results show that organic compounds can be greatly influenced by the presence of metal salts, resulting in facilitated rates or even new reaction pathways. The consistency between experimental and theoretical data also implies that fluid chemistry (e.g., redox condition) is a driving force for these organic reactions. Our findings suggest that organic carbon transformations in hydrothermal fluids are not only controlled by minerals but also by dissolved metal salts. Future research on unraveling the roles of dissolved metal species may shed new light on organic geochemical processes in oceanic hydrothermal systems.