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Coupled cycling of Fe and organic carbon in submarine hydrothermal systems: Modelling approach

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It has been recently proposed that hydrothermal plumes may be a significant source of dissolved Fe to the oceans. In order to assess this proposal, we investigated the fate of dissolved Fe released from hydrothermal systems to the overlying ocean using an approach that combined modelling and field values. We based our work on a consensus conceptual model developed by members of SCOR-InterRidge Working Group 135. The model was both complex enough to capture the main processes of dissolved Fe released from hydrothermal systems and chemical transformation in the hydrothermal plume, and simple enough to be parameterized with existing field data. It included the following flows: Fe, water and heat in the high temperature vent fluids, in the fluids diffusing around the vent, and in the entrained seawater in the buoyant plume; Fe precipitation in polymetallic sulphides near the vent; transport of Fe in the non-buoyant plume, and both its precipitation in particles onto the sea bottom away from the vent and dissolution into deep-sea waters. In other words, there were three Fe input flows into the buoyant hydrothermal plume (vent-fluids; entrained diffuse flow; entrained seawater) and three Fe output flows (sedimentation from the buoyant plume as polymetallic sulfides; sedimentation from the non-buoyant plume in particulate form; export to the deep ocean in dissolved or nanoparticulate form). The output flows balanced the input flows.

We transformed the conceptual model into equations, and parameterized these with field data. To do so, we assumed that all hydrothermal systems, globally, can be represented by the circumstances that prevail at the EPR 9°50'N hydrothermal field, although we knew this assumption not to be accurate. We nevertheless achieved, by following this approach, two important goals, i.e. we could assemble into a coherent framework, for the first time, several discrete data sets acquired independently over decades of field work, and we could obtain model results that were consistent with recent field observations.

We used our model to explore scenarios of Fe emissions and transformations under various constraints. The modelling exercises indicated that the provision of significant amounts of dissolved Fe to the oceans by hydrothermal plumes was consistent with realistic model parameters. This supported the proposition that hydrothermal systems play significant roles in the global biogeochemical Fe cycle.