Links and feedbacks between oceanic hydrothermal fluxes and the environment

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Investigations of the evolution of ocean (and atmosphere) chemistry generally assume seafloor hydrothermal fluxes are either constant or scale simply with oceanic crustal production rate. In contrast, river fluxes are assumed to be related to environmental parameters (e.g. global climate, atmospheric composition) and to vary with biological evolution (e.g. the emergence of land plants) and hence play a central role in models of Earth system evolution. It is now clear that both on- and off-axis seafloor hydrothermal fluxes are also related to environmental parameters and can provide feedbacks on environmental (and biosphere) changes – incorporation of such links into models is needed.

Earth's thermostat, through the long-term C-cycle, provides one example. The extent of fluid-rock reaction in the upper oceanic crust in off-axis hydrothermal systems, that typcially operate at <30°C, are highly temperature sensitive. Because of the low-temperature of these systems, changes in bottom water temperature play a large role in controlling the average temperature of fluid-rock reaction directly linking global climate to seafloor basalt dissolution rate. Observations of greater CO_2 consumption by Cretaceous upper oceanic crust than late Cenozoic upper oceanic crust demonstrates that this feedback was important to the long-term C-cycle over the last 150 Myr. Seafloor sediment acts as a thermal blanket, with thicker sediment leading to higher fluid-rock reaction temperatures, meaning changes in sediment supply will also modify the chemical fluxes associated with off-axis hydrothermal systems. Times of changes in global average sediment cover over Earth history include the emergence and proliferation of marine plankton and times of supercontinent rifting (when ridges receive copious terrigeneous sediment).

Other examples of links and feedbacks between oceanic hydrothermal fluxes (axial and off-axis) and the environment abound and will be discussed (listed) to the extent time (space) allows: (i) changes in sea level (i.e. pressure), for example on glacial-interglacial timescales, changing the role of phase separation in axial hydrothermal systems; (ii) changes in bottom water composition changing the (bio)chemical behaviour of hydrothermal plumes and hydrothermal sediments; and (iii) changes in the magnitude of the off-axis P-sink with changing bottom water oxygenation.