Killed by geochemistry: Mass extinction in toxic oceans

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The boundaries between geological periods often mark major losses of biodiversity, i.e., mass extinctions. Geochemistry is used to investigate these events, both to determine the trigger for the event (asteroid/comet impact, volcanism) and the event's cause (abrupt warming, anoxia, trace metal poisoning, loss of habitat by sea-level fall, global wildfires, etc.). For the Cretaceous-Paleogene event, although the trigger is well established to be asteroid impact, the kill mechanism is less clear, and trace metal poisoning may have played a role. For the end-Permian, evidence for oceanic anoxia and the spread of sulfidic waters into the photic zone is widely associated with the extinction horizon in marine sedimentary rocks. Detailed studies of the spatio-temporal distribution of geochemical and isotopic proxies together with numerical simulations of these events is leading to a clearer picture of the cause and consequence of mass extinction in Earth history.

Super-high atmospheric oxygen levels during the Great Oxidation Event

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A combination of geological and isotopic evidence demonstrates that the atmosphere became oxygenated for the first time in Earth history roughly 2.5 billion years ago. The proxies for atmospheric oxygen in the rock record are quite sensitive, though; an atmosphere sufficiently oxygenated to support animal life may not have been established for hundreds of millions of years after this initial rise.

A new repository of geological information has recently become available, the result of scientific continental drilling in Fennoscandia (FAR-DEEP). Kilometers of drill core potentially record a detailed history of the path atmospheric oxygenation took through the critical interval from 2.5 to 2.0 billion years ago. Preliminary analysis of these cores has revealed an excursion in the carbon isotope composition of the ocean/atmosphere system that is best explained by a massive oxidation of the continental crust. The event terminates a well-known, equally anomalous but oppositely signed carbon isotope excursion that likely reflects a large accumulation of oxygen in the atmosphere from about 2.2 to 2.0 billion years ago. The hypothesis that arises from these observations is that atmospheric oxygen levels built up to levels that may have exceeded modern during the earlier interval, leading to pervasive oxidative weathering of the continental crust, the first in Earth history, and a large consumption of atmospheric oxygen during the termination event. The suggestion that oxygen levels may have exceeded modern levels during the early stages of planetary oxygenation is provocative, but is consistent with singular geologic events that happened at this time, including the generation of natural nuclear reactors resulting from concentration of uranium by oxygenated groundwaters, and the enrichment in the iron content of banded iron formations by oxidative weathering into ore-grade deposits.