Large Igneous Province volcanism, ocean anoxia and marine mass extinction

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Past global marine mass extinction events are often linked to terrestrial Large Igneous Province (LIP) volcanism, but exact mechanisms driving extinction are often not well constrained.

We studied two of Earth’s largest mass extinction events, at the Triassic-Jurassic (~201.4 Ma) and Permian-Triassic (~252 Ma) boundaries, which coincide with Central Atlantic Magmatic Province (CAMP) and Siberian Trap volcanism, respectively. The Triassic-Jurassic mass extinction is often suggested to be related to widespread ocean anoxia.

We compare Permian-Triassic and Triassic-Jurassic ocean redox change along continental margins in different geographic regions (Permian-Triassic: Greenland, Svalbard, Iran; Triassic-Jurassic: UK, Austria) and discuss its role in marine mass extinction.

Speciation of iron ([Fe^{III}/ Fe^{II}] and [Fe^{III}/ Fe^{II}]) and redox-sensitive trace element concentrations (e.g. Mo, V etc.) show that the Triassic-Jurassic marine mass extinction directly coincides with a rapid shift to anoxic and euxinic conditions at the onset of CAMP volcanism and increased atmospheric \( p_{CO_2} \). Biotic recovery after the extinction event only commences when redox-conditions return from a euxinic to a ferruginous state and stabilization of marine ecosystems only commences after decreasing atmospheric \( p_{CO_2} \) and a return to more oxic marine conditions.

Iron-speciation at both the Triassic-Jurassic and Permian-Triassic mass extinctions however shows 2 phases of euxinia along continental margins, with an initial short peak at the onset of volcanism followed by a shift to ferruginous conditions, possibly due to a strongly diminished ocean sulphate reservoir because of massive initial pyrite burial. \( D^{34}S_{pyrite} \) suggests that following prolonged (several 100 kyr) euxinic conditions only commence when the ocean sulphate reservoir is replenished by the release of sulphur from volcanism.