Ocean sulfate scarcity as a pre-condition for Large Igneous Province driven mass extinction

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Records of sulfur cycling during mass extinction events increasingly show that they are associated with rapid shifts in the sulfur isotope composition of seawater indicative of low concentrations of ocean sulfate [1-4]. These events are also often associated with the spread of anoxic conditions in the marine realm. We propose a feedback mechanism whereby the production of methane in marine sediments increases in proportion to decreasing sulfate and consumes bottom water oxygen, thus acting as a positive feedback on spread of anoxic waters. This can be further amplified via increased weathering or recycled fluxes of phosphate enhancing productivity [e.g. 5], the effects of increasing temperature on the rate of methanogenesis and the additional suppression of marine sulfate via increased pyrite burial.

We propose that sulfate drawdown occurs prior to climate forcing and other extinction drivers imposed by large igneous province (LIP) eruption. The likely mechanism for the drawdown of sulfate prior to these extinction is the removal of sulfate from the oceans as gypsum in evaporite deposits. Several large mid-Phanerozoic mass extinctions have clear evidence of increased evaporite deposition prior to, or approximately coincidental with LIP eruption and extinction.

If this idea is correct, the biological impact of a LIP will partly depend on the sulfate status of the ocean at the time of its eruption, and may at least partly explain the observation that whilst many mass extinctions are associated temporally with a LIP, not all LIPs seem to cause mass extinctions.