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Looking into sedimentary rocks for clues for a cause of the end-Triassic mass extinction event with the aid of geochemistry.

How can we resolve a 201 million years mass extinction case? With the aid of science, particularly geology and geochemistry, there is a way, but you need rocks! About 201 million years ago, towards the end of the Triassic period, one of the so called „big five“ mass extinction events of the Phanerozoic occurred. Creatures living on land and in the oceans started to disappear, as demonstrated by fossils, or rather lack of fossils in the rock record. Life in the oceans was especially affected amongst primary producers with high diversity losses amongst the phytoplankton as dinoflagellates and coccolithophorids. Amongst corals and calcareous algae that were badly hit, higher trophic level species as well, as for the megalodont bivalves and ammonites and the extinction of the renowned conodonts. But why and how were they affected?

All evidences lead to one culprit, a tremendous volcanic episode during deposition of the large igneous province of the Central Atlantic Magmatic Province (CAMP). Environmental conditions were abruptly affected by extensive prolonged volcanic episodes following the break-up of Pangea. This event is suggested to have brought large quantities of the greenhouse-gas CO_2 amongst other volatiles and unpleasant stuff into the atmosphere. Impacting on long term scales the temperatures in the atmosphere and in the oceans. The oceans are one of the most effective regulators of atmospheric CO_2, resulting mainly from photosynthesis of phytoplankton and general dissolution of CO_2 in the waters. The oceans eventually store the products of the phytoplankton and other organisms and what the oceans receive from erosion and weathering of the continents. If elements escape re-cycling in the oceans, they end up stored for the longer term in sedimentary rocks.

Figure 1. This sedimentary rock has a story to tell, here with bioturbation and bedding and from analytical results of trace elements and isotopes (Stenlille 4).

During the transition from the Triassic to Jurassic, the configurations of continents was different than today. An epicontinental ocean, a broad shallow sea, the Tethys was located within the interior of Pangea. This ocean is thought to have responded to the increased amounts of greenhouse gasses, by becoming anoxic. This is where the interactions of the crustal-ocean-atmosphere comes into play, they respond by adjusting to change within one system, either in a positive or a negative way, depending on how one implements it. It is often so that when one thing changes, it impacts another one. For the systems that operate on this globe, within rocks, waters or air, there is no exception. The struggle for the everlasting balance continues! The behaviour of elements can tell us significant stories of all kinds of processes that have operated in the past. Most of all the reasoning for how it operated in the past is based on observations made from today and new technology. A strong key component of it all comes from the discipline of geochemistry. Resulting in that reflecting on how the crustal-ocean-atmosphere interactions operated in the past is possible, even for events that happened long before our general recognition of time can even be comprehended and the most intriguing part is that these tell-tales can be stored in the rocks, as stories in books. What happens when oceans become reducing, is that the balance of the element’s changes. What makes up the final product of deposited sediments, goes through changes that demonstrate a pattern. This pattern is made in a familiar sequence when oxygen becomes unavailable during time of deposition, and additionally increased levels of reduction brings more availability of hydrogen ions to react with. While sediments are deposited, anoxic situations can occur in the water column or at the sediment-water interface. If there is a high availability of organic matter, bacteria consume all available oxygen (or other chemotrophic consumers with other oxidizing agents) and can create anoxic conditions on a small local scale via respiration. The elements that respond to changes following reduction, are trace elements. Observing their concentrations in sedimentary rocks can thus tell us about variations in redox conditions. Another way to get a glimpse to the past is to look into isotopes, as of the element carbon. Carbon has two naturally occurring isotopes, ^{12}C and a slight heavier ^{13}C. During photosynthesize, autotrophic organisms tend to be selective on the lighter carbon isotope, and when they get buried into sediments, the rate of productivity and burial rate of organic matter can be reflected on as a consequence of the fractionation process.

By unravelling the geological past through analysis of sedimentary rocks from the Triassic-Jurassic boundary from Denmark and north Germany, it was possible to draw conclusions about the state of the ocean, around the interval were the mass extinction event occurred. At the localities, it is demonstrated that lack of oxygen or anoxic conditions were not generally

met. Additionally, by looking into isotopes, they show indications of great perturbations in the carbon cycle towards the end of the Triassic period, in agreement with other studies of carbon isotopes from TJB interval successions.
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