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The shallow-water Permian-Triassic extinction record in western Tethys (Hungary and Turkey): evidence for ocean acidification or marine anoxia?

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The Permian-Triassic (PT) extinction was Earth's greatest ever biotic crisis. Despite controversy over the timing of losses, radio-isotopic dating indicates that extensive damage was done to both terrestrial and marine ecosystems in a very brief interval around the PT boundary. Diverse proposed kill mechanisms include marine anoxia, ocean acidification, volcanic winter, hypercapnia, global warming, increased sediment influx, ozone destruction, acid rain, extreme atmospheric oxygen depletion, poisoning by toxic trace metals, and bolide impact. Apart from the last cause, these mechanisms are related to Siberian Traps volcanism.

Here we examine evidence from shallow-water sections in western Tethys for two oft-cited volcanically-induced stresses: anoxia and ocean acidification. The development of anoxia has been linked to global warming of the oceans and recent studies point to a marked increase in sea surface temperatures between the Late Permian and Early Triassic. However, the timing and duration of anoxic events in boundary sections is complex and critics of this cause have noted that many shallow-water settings lack evidence for oxygen restriction. CO_2-driven ocean acidification also features in several PT extinction models with extinction selectivity, isotope proxies, and a carbonate dissolution surface reprted from China, Japan, and Turkey. However, the origin of such surfaces remains highly controversial because sea-level fall and karstification also generate the same features.

Our integrated facies, fossil, petrographic and geochemical (δ13Ccarb and trace metals) study of two PT boundary sections from western Tethys (Çürük Dag in Turkey [U+02D7] one of the "type sections" for the "acidification surface" [U+02D7] and Bálvány North in Hungary) indicates that the geological record through the extinction event is near-complete in each. Thus, δ13Ccarb curves from both sections show close correspondence with global records and feature a prominent negative excursion of 5-6 ‰The duration of any hiatus recorded by a prominent sequence boundary (the purported "acidification surface") at Çürük Dag was therefore likely very brief (no such surface is recorded at Bálvány, which probably records slightly deeper-water facies). An abrupt extinction of foraminifera occurs immediately above this sequence boundary at Çürük Dag, still within the negative carbon isotope shift, whereas at Bálvány the foraminifera disappear within a "Boundary Shale", but before the onset of the isotope shift. In both sections, evidence for a decline in benthic oxygen levels at the extinction level is supported by the appearance of pyrite framboids with a size distribution characteristic of dysoxic conditions (Bálvány), and trace metal concentrations (Çürük Dag, particularly an enrichment in U/Th, also characteristic of dysoxia).

We conclude that the "acidification surface" in our shallowest-water section, Çürük Dag, has its origins in karstification during a brief sea-level fall occurring prior to the main extinction of foraminifera. The PT extinction in both our western Tethyan locations coincides with a deterioration in benthic oxygen levels. Marine anoxia (or dysoxia) during an interval of rapid global warming is the most likely extinction driver in this region [U+02D7] evidence for ocean acidification is unsubstantiated.