ペルム紀末大量絶滅時の表層水溶存酸素と生物必須元素の枯渇と大量土壌流入

Oxygen and bioessential element-depleted surface waters with massive soil intrusion in the end-Permian mass extinction

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The largest mass extinction of biota in Earth’s history consisted of two extinctions; a main extinction followed by a second extinction, occurred at the Permian-Triassic transition. Siberian volcanism is the most likely cause of this extinction event. However, the direct causal mechanism for the biotic crisis has long remained a matter of some dispute. We reconstructed the ocean redox structure in the low latitudes before, during, and after the main extinction event, including the second extinction event, using sedimentary organic biomarker proxies, redox-sensitive elements, and pyrite morphology. The results indicated that anoxic-suboxic or euxinic conditions developed in all waters in the low-latitude Panthalassa and Paleotethys during the main extinction event. In particular, there was massive soil and mud intrusion and an abrupt decrease in oxygen in the surface waters in both the Paleotethys and Panthalassa. Exhaustion of bioessential elements (molybdenum [Mo] and vanadium [V]) in the ocean occurred during and just after the main extinction event. The main extinction horizon in the shallowest section is marked by a peak in oxygen depletion and a marine productivity proxy of biomarkers, indicating that maxima of marine productivity coincided with the peak of oxygen depletion and the main marine extinction event. The high flux of soil and rock-derived nutrients leading to algal blooms could have caused oxygen depletion in the shallow surface water. Expansion of the oxygen minimum zone could have induced deep-surface water anoxia. Massive soil and mud intrusion alone may have damaged sedentary organisms. The low oxygen surface water accompanied by the shortage of bioessential elements and massive soil, mud, and nutrient intrusion in the oceans contributed to the main extinction. Recovery of oxygen in the surface waters occurred just after the mass extinction, suggesting that global warming and ocean acidification may have caused the second extinction in the early Triassic.

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