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Multiproxy analysis across the Smithian-Spathian boundary: Evidence for persistent anoxia through the Early Triassic

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Following the largest known extinction, the end-Permian mass extinction, the Early Triassic Epoch is often considered an interval of slow biotic recovery. The mechanistic underpinning of this event has been hypothesized to be linked to elevated temperatures and widespread marine deoxygenation. During this disruptive interval, a minor extinction at the Smithian and Spathian substage boundary occurred, being only a couple of million years after the end-Permian. This has been linked to a specific interval of rapid change in global climate and expansion of anoxia, further compounding the slow biotic recovery post end-Permian mass extinction. However, there are still limitations and uncertainties to our understanding of the severity, extent, and persistence of anoxia across this time compared to the vast exploration of the end-Permian. Therefore, refining the local to global changes in reducing conditions will further improve our understanding of its effect on life in the wake of the largest mass extinction.

Here, we utilized iron speciation and trace metal concentrations for local redox conditions and a first time pairing of three metal isotope systems (thallium, molybdenum, and uranium isotopes) to track changes in global (de-)oxygenation. This geochemical data spans much of the Early Triassic at the Wallenbergfjellet section of Spitsbergen. Previous studies from different intervals of time have separately utilized these three isotope systems to ascertain global redox conditions, but none have incorporated all three. Importantly, these proxies have some overlap but also their own distinct mechanics that may allow for a more holistic global redox reconstruction. Local paleoredox proxies suggest relatively continuous anoxia with short-term euxinic intervals at Wallenbergfjellet. Notably, thallium isotopes suggest widespread persistent global anoxia during the Early Triassic, aligning with previous research, although less severe in the Smithian compared to the start of the Triassic. A sudden perturbation at the Smithian-Spathian boundary suggests an expansion of global anoxia. Additional work with molybdenum and uranium isotopes can confirm this expansion and provide evidence for degree of anoxia and/or euxinia. Both the generally more reducing global conditions and oscillating redox conditions, such as across the Smithian-Spathian boundary, likely contribute to the poor biotic recovery through the Early Triassic.