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The environmental backdrop leading to the end-Permian mass extinction: towards a multi-isotope tracer approach - *F.G. Houtermans Medal Lecture*

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The end-Permian mass extinction (EPME), which occurred ~252 Ma ago, was the most severe biotic crisis of the Phanerozoic, resulting in 89% of terrestrial and 81% of marine species mortality. There is growing evidence that the EPME was closely tied to the eruption of the Siberian Traps and subsequent CO_2 release, global warming, ocean acidification, and ocean anoxia. Although the basic architecture of events surrounding the EPME is growing clear, most prior studies focus on interpreting a single environmental factor, whereas the Earth's surface is actually perturbed as a system. Here, I combine several carbonate records from widely-space sections (Meishan and Dajiang sections from South China, Gartnerkofel-1 drillcore from Austria, and Abadeh section from Iran) to construct high-resolution δ^7Li, $\delta^{138}Ba$, and $\delta^{238}U$ profiles that provide new, quantitative constraints on changes in continental weathering, marine export productivity, and marine redox states during the EPME. These sections were temporally correlated using a combination of $\delta^{13}C$ records and conodont biostratigraphy.

The correlated sections show excellent agreement with an average δ^7Li value of 20‰ before the EPME, dropping to 10‰ during the EPME interval and staying around 15‰ into the earliest Triassic. The most plausible interpretation is a rapid enhancement of continental silicate weathering in response to CO_2 release from the Siberian Traps and volcanic activity on the margins of the South China block. Our new $\delta^{238}U$ records are consistent with published records showing a negative excursion immediately below the EPME horizon, documenting rapid expansion of marine anoxia. $\delta^{138}Ba$ values abruptly increased by ~0.2‰ prior to the EPME and the negative $\delta^{238}U$ excursion, and then decreased immediately following the EPME and remained relatively low during the earliest Triassic. Geochemical cycle modeling based on these isotopic records suggests that enhanced marine export productivity and climatic warming drove rapid expansion of marine anoxia, which was a primary cause of marine biodiversity loss. Our study provides a geological analog to modern global environmental and biotic changes, demonstrating the speed with which the Earth-surface environment responds to rapid CO_2 injections into the atmosphere-ocean system.