Ocean oxygenation during the Late Devonian Mass Extinction

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The Late Devonian Mass Extinction occurred at a time of significant biogeochemical changes in Earth's surface environments. The cause of this biotic crisis is controversial, and a range of environmental stresses related to climate, tectonics, terrestrialization and ocean anoxia have been suggested. Emphasis has been placed on European shale localities, defining two "Kellwasser events" which correlate extinction with fluctuating sea levels and ocean anoxia. In contrast, carbonate reef complexes of the Canning Basin, Western Australia, record Late Frasnian biotic crises without organic-rich shale units, and can provide a new perspective on Devonian ocean redox conditions.

The Lennard Shelf reef complexes record the Late Devonian Mass Extinction in a stratigraphically expanded section composed of fore-reef deposits that are cemented by large volumes of radiaxial calcite marine cements. We present trace metal and metal isotope geochemical data from well-preserved marine cements and other marine components from two stratigraphic sections straddling the Frasnian-Famennian boundary. Marine carbonates are considered to represent reliable records of marine chemical conditions when screened using petrographic and geochemical criteria. Rare earth element concentrations, including redox-sensitive cerium, provide new constraints on the redox state of this ocean basin. There is no Ce anomaly (suggesting large amounts of deep-water anoxia) through most of this Late Devonian stratigraphy. However, across the Frasnian-Famennian boundary, a negative Ce anomaly is developed in marine cements from both sections. This data suggests that shallow marine oxygenation, rather than ocean anoxia is associated with mass extinction in this basin. In a broader context, this extinction event occurs during the transition from widespread marine anoxia in early Paleozoic oceans into dominantly oxygenated oceans in the Late Devonian, co-incident with the rise of land plants. Therefore, unstable ocean redox conditions and widespread marine oxygenation in the Late Devonian may have been a major factor in this extinction event.