Ocean oxygenation during the Great Ordovician Biodiversification Event

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The most rapid and sustained period of biological diversification in Earth's history occurred between 485 and 455 million years ago in the Early and Middle Ordovician period. This event, known as the Great Ordovician Biodiversification Event (GOBE), took place as a series of discrete pulses of very rapid genera- and species-level originations. One of the largest of these pulses occurred during the Darriwilian stage of the Middle Ordovician, in close temporal proximity to the Mid-Darriwilian Carbon Isotope Excursion (MDICE). The MDICE, the focus of this study, is the first in a series of Middle and Late Ordovician carbon isotope excursions and serves as an important temporal indicator of biogeochemical cycles that were shifting away from steady state.

We have examined a Middle Ordovician carbonate sequence from western Nevada. A correlation of this sequence to several Estonian drill cores, previously documented to capture the MDICE, is made based on carbon isotope stratigraphy and supported by paleontological evidence. Paired carbon isotope data from carbonate and organic matter in our section are presented at high temporal resolution to assess any changes in the degree of biological fractionation of carbon ($\Delta^{13}C$) during the event. These paired results show a stepwise increase in $\Delta^{13}C$ of approximately 3‰ coincident with the onset of the $\delta^{13}C$ excursion in carbonate carbon.

The efficiency of carbon isotope fractionation in photosynthetic organisms has been shown to scale with the partial pressure of O_2. The observed increase in $\Delta^{13}C$ of 3‰ is consistent with an increase of 15% or more in atmospheric O_2 concentration (i.e., an increase from 10% O_2 to >25%). Furthermore, a rise in pO_2 as the mechanism for the observed $\Delta^{13}C$ increase is supported by the interpretation of the MDICE as an organic carbon burial event.

A high resolution carbonate associated sulfate (CAS) isotope stratigraphy is also presented for our section. The combination of variability in the $\delta^{13}C_{carbonate}$ and $\delta^{34}S_{CAS}$ records act as an independent proxy for the net addition of oxygen into the atmosphere via the burial of reduced carbon and sulfur species, specifically organic carbon and pyrite.