Are Devonian anoxic events astronomically paced? Cyclostratigraphy and numerical modeling as tools to assess potential relationships and causal mechanisms

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Abstract

The Devonian Period witnessed 29 regional-to-global anoxic events, some of which are linked to major extinction episodes. Evidence of these abiotic and biotic events can now be found in the geological record and, for the Kellwasser Event, suggests a link between the pacing of ocean anoxia and astronomical forcing (2.4 Myr eccentricity nodes). However, a consensus on the mechanisms behind the Devonian events has not yet been reached. Commonly, Devonian anoxic events are characterized by a perturbation of the global carbon cycle (i.e. δ13C excursions) and are expressed as organic-rich black shales interbedded in carbonate-dominated sediment. However, expression of anoxic events as an unconformity, facies change, or hiatus have been reported as well – i.e. the expression of anoxic events is variable and depends on the paleoenvironment and paleogeography. In addition, most reports on Devonian anoxic events suffer from significant sampling bias, focusing mainly on the pantropical belt or being restricted to only a few localities. In the 'WarmAnoxia' project, we will attempt to consolidate existing and new observations from geological records with scenarios provided by numerical modeling to assess existing hypotheses and underlying mechanisms. Preliminary simulations with the model cGENIE indicate that the extent of the oxygen minimum zone is inversely proportional to the atmospheric CO2 concentration and, that part of the upper ocean is close to hypoxic/anoxic conditions at an atmospheric oxygen level of 70% of the current value. We also provide preliminary simulations of soil dynamics, nutrient fluxes, atmospheric oxygen levels and oceanic chemistry response by combining a complex atmosphere model with a module for soil dynamics and an ocean box model. A hierarchy of models will be used to assess a range of physical and biogeochemical hypotheses linking astronomical forcing to anoxia. On the other hand, application of cyclostratigraphy and carbon isotope stratigraphy will be used to constrain the temporal (phase) relationship between astronomical forcing and anoxic events recorded in the sedimentary record. Using a combination of numerical modeling and an integrated stratigraphic approach, it will be investigated whether complex multicausal factors and the 2.4 Myr eccentricity nodes can be associated with other Devonian anoxic events, either as a window of opportunity or rather the decisive trigger.

Keywords: Devonian, Anoxic Events, Astronomical Forcing, Cyclostratigraphy, Modeling

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