Geophysical Research Abstracts
Vol. 18, EGU2016-8193-1, 2016
EGU General Assembly 2016

A global cyclostratigraphic framework constrains the timing and pacing of environmental changes over the Late Devonian (Frasnian – Famennian) mass extinction

David De Vleeschouwer (1), Anne-Christine Da Silva (2), James E. Day (3), Michael Whalen (4), and Philippe Claeys (5)

(1) Universität Bremen, MARUM, MARUM, Bremen, Germany (ddevleeschouwer@marum.de), (2) Utrecht University, Utrecht, The Netherlands, (3) Illinois State University, Normal, Illinois, USA, (4) University of Alaska Fairbanks, Fairbanks, Alaska, USA, (5) Vrije Universiteit Brussel, Brussels, Belgium

Milankovitch cycles (obliquity, eccentricity and precession) result in changes in the distribution of solar energy over seasons, as well as over latitudes, on time scales of ten thousands of years to millions of years. These changing patterns in insolation have induced significant variations in Earth's past climate over the last 4.5 billion years. Cyclostratigraphy and astrochronology utilize the geologic imprint of such quasi-cyclic climatic variations to measure geologic time. In recent years, major improvements of the Geologic Time Scale have been proposed through the application of cyclostratigraphy, mostly for the Mesozoic and Cenozoic (Gradstein et al., 2012). However, the field of Paleozoic cyclostratigraphy and astrochronology is still in its infancy and the application of cyclostratigraphic techniques in the Paleozoic allows for a whole new range of research questions. For example, unraveling the timing and pacing of environmental changes over the Late Devonian mass extinction on a 10^5-year time-scale concerns such a novel research question.

Here, we present a global cyclostratigraphic framework for late Frasnian to early Famennian climatic and environmental change, through the integration of globally distributed sections. The backbone of this relative time scale consists of previously published cyclostratigraphies for western Canada and Poland (De Vleeschouwer et al., 2012; De Vleeschouwer et al., 2013). We elaborate this Euramerican base by integrating new proxy data –interpreted in terms of astronomical climate forcing- from the Iowa basin (USA, magnetic susceptibility and carbon isotope data) and Belgium (XRF and carbon isotope data). Next, we expand this well-established cyclostratigraphic framework towards the Paleo-Tethys Ocean, using magnetic susceptibility and carbon isotope records from the Fuhe section in South China (Whalen et al., 2015). The resulting global cyclostratigraphic framework implies an important refinement of the late Frasnian to early Famennian stratigraphy, but also allows for an evaluation of the role of astronomical forcing in perturbing the global carbon cycle and pacing anoxic conditions throughout the Late Devonian mass extinction event. The late Frasnian anoxic Kellwasser events, for example, each represent only a portion of a 405-kyr eccentricity cycle, with the onset of both events separated by 500-600 kyr.

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