Cyclostratigraphic calibration of the Late Devonian time scale

Damien Pas*[1,2], Linda Hinnov[1], James E. (jed) Day[3], Kenneth Kodama[4], Matthias Sinnesael[5], and Wei Liu[1,6]

[1]Department of Atmospheric, Oceanic, and Earth Sciences, George Mason University – Fairfax, VA 22030, United States

[2]Pétrologie sédimentaire, B20, Géologie, Université de Liège – Sart Tilman, 4000 Liège, Belgium

[3]Department of Geography-Geology, Illinois State University – Normal, IL 61790, United States

[4]Department of Earth and Environmental Sciences, Lehigh University – Bethlehem, PA 18015, United States

[5]AMGC, Vrije Universiteit Brussel – Pleinlaan 2, 1050 Brussels, Belgium

[6]School of Ocean Sciences, China University of Geosciences, Beijing, 100083, – Beijing, 100083, China

Abstract

The Late Devonian was affected by major, irreversible changes including two of the most severe biodiversity crises in Earth's history, the so-called Kellwasser and Hangenberg Events (respectively near the Frasnian – Famennian and the Famennian – Carboniferous boundaries). Currently, hypotheses for the Late Devonian extinctions include sea-level fluctuations and regression, climate cooling, ocean anoxia, massive volcanism and/or bolide impact. Unfortunately, testing these hypotheses is impaired by a lack of sufficient temporal resolution in paleobiological, tectonic and proxy climate records. Recent advances in astronomical calibration have improved the accuracy of the Frasnian time scale and part of the Famennian. However, the time duration of the Famennian stage remains poorly constrained even though this is the key to understanding cause-and-effect relationships of the Late Devonian greenhouse–icehouse transition marked by the onset of the end Famennian glaciation that ultimately led to the Hangenberg Event just prior the Devonian–Carboniferous boundary.
During the Late Devonian, an epieric sea in North-America mid-continent occupied the Illinois Basin where a complete Late Frasnian – Early Carboniferous succession of deep-shelf deposits was deposited. A record of this sequence, composed of calcareous shales, organic-rich shale, silty-shales and subtidal platform carbonates, is captured in three overlapping cores stored in the Iowa Geological Survey (H-30, Sullivan Slough and H-32). The H-30 core section spans the Frasnian-Famennian boundary; the Sullivan Slough section spans almost all of the Famennian (from *Palmatolepis delicatula platys* to lower part of the *Bithspadodus ultimus* zones of Spalletta et al., (2017) and the H-32 section sampled spans the upper part of the *Bispathodus costatus* through the *Protognathodus kockeli* Zone. The Devonian-Carboniferous Boundary, as revised by Spalletta et al. (2017) is at the base of the *P. kockeli* Zone.

To have the best chance of capturing Milankovitch cycles (long- and short-eccentricity cycles as well as obliquity and precession), 2200 rock samples were collected at 5-cm-interval across

*Speaker

the entire sequence. Magnetic susceptibility (*MS*) was measured on each sample and the preservation of paleoenvironmental/climatic information into the signal was verified through geochemical analyses (Ti, Al, Zr by XRF) and magnetic measurements (low temperature magnetic susceptibility and IRM acquisitions). Correlation and overlap between each core was made using available conodont biostratigraphy and then refined by comparing the trends in the *MS* and δ13C signals for critical intervals. To estimate the duration of the Famennian stage, we applied multiple techniques on the *MS* signal (multitaper method, evolutive harmonic analysis and adaptive-weighted harmonic F-test). By combining these techniques, we identified highly stable 405-kyr cycles across the Sullivan Slough and the H-32 cores. 405-kyr cycles were not observed in H-30, but 100-kyr cycles were identified. A preliminary estimate of the duration for the Famennian stage using the 405-kyr cycle as chronometer constrains the duration of the Famennian stage to 12.8 $\pm$ 0.4 Myr with an average sedimentation rate of 0.5 cm/kyr across the sequence.

Spalletta, C., Perri, M.C., Over, D.J. and Corradini, C. (2017) Famennian (Upper Devonian) conodont zonation: revised global standard. *Bulletin of Geosciences*, 92, 31-57.