Subcommission on Devonian Stratigraphy
and
IGCP 652 Reading geologic time in Paleozoic sedimentary rocks

Geneseo, New York, 27 July – 06 August 2023

Program and Abstracts

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New York State has been the focus of Devonian studies for over 200 years. 2023 marks the 200th anniversary of several publications by Amos Eaton (and Eaton and Beck) that described the geology of Albany County as well as the lands between the Susquehanna and Hudson rivers. It is fitting that the SDS recognize and celebrate this with a return to New York and the type Devonian of North America.

Compiled and edited by D. Jeffrey Over and the organizing committee.
Printed at SUNY-Geneseo, Geneseo, New York 14454 July 2023.

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Organizers

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Gordon Baird, Dept. of Geology and Environmental Sciences, SUNY-Fredonia, Fredonia, New York

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Carlton Brett, Dept. of Geosciences, Univ. of Cincinnati, Cincinnati, Ohio

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Charles Ver Straeten, Geological Survey/New York State Museum, Albany, New York

Jay Zambito, Dept. of Geology, Beloit College, Beloit, Wisconsin

Welcome!
Welcome to Geneseo, New York, in the verdant western Finger Lakes and Genesee River Valley and the 2023 meeting of the Subcommission on Devonian Stratigraphy (SDS) and IGCP 652 Reading geologic time in Paleozoic sedimentary rocks. Conference web site: www.geneseo.edu/SDS_2023

Welcoming Party
29 July, 7:00 PM, Livingston Lanes & Pub, 4260 Lakeville Road (US 20A), just uphill (east) from the Quality Inn, Geneseo. (The pre-meeting field trip will arrive a bit late, but we will be there.)

Conference Site
The poster and technical sessions will be held in the Integrated Science Center (ISC), Building 4, and Newton Hall, Building 3 on the Campus Map, 1 College Circle, Geneseo, New York. The posters will be displayed in ISC 142/144. The technical sessions will be in Newton Hall 204.

Lodging
There are numerous places in the village and neighboring communities to find lodging; rooms have been blocked at the Quality Inn - Geneseo, 4242 Lakeville Road (US 20A), +1 585 243-0500. The closest area with numerous hotels outside Geneseo is Henrietta, a suburb of Rochester. **https://geneseony.com/#** - Geneseo village web site with links to lodging.

Dining
The campus dormitories and dining areas will be closed for the summer, with the exception of the coffee shop in the campus union. There are numerous eateries on Main Street adjacent to the Integrated Science Building. There are also several restaurants further east of the campus along US 20A, but these are at least a kilometer away: **https://geneseony.com/#** - Geneseo village web site with links to eateries.

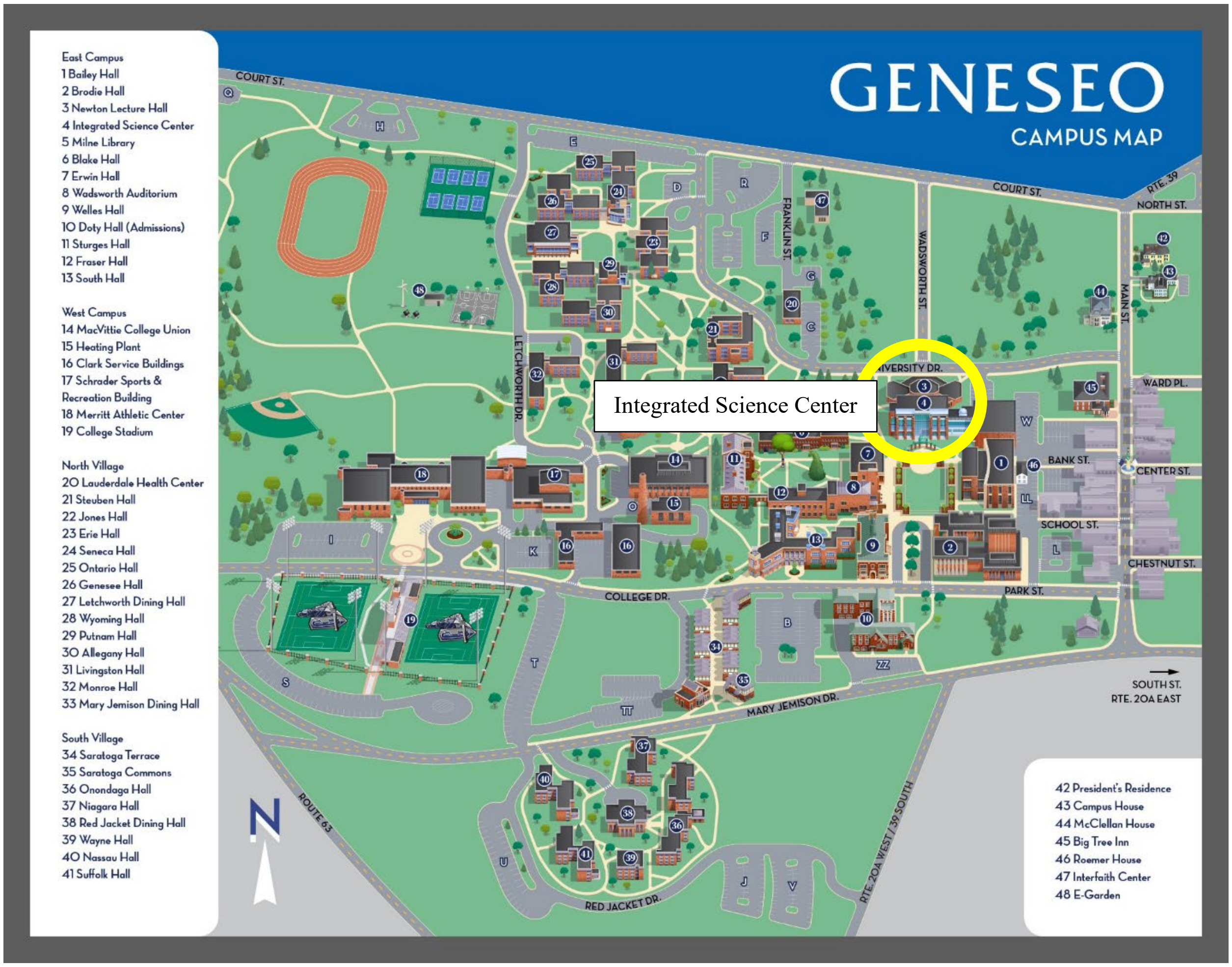
Transportation
Parking will be available on campus in Lot A and Lot C adjacent to the ISC Building, as well as Lot H and Lot U, which are on the periphery of the campus - **Geneseo Campus Map.doc**. A shuttle will run from the Quality Inn-Geneseo to the ISC on 30 July and 01 August in the morning prior to the start of sessions and in the evening after the end of sessions, as well as intermittently through the day. Arrivals to Rochester on 29 July will be picked up by arrangement.

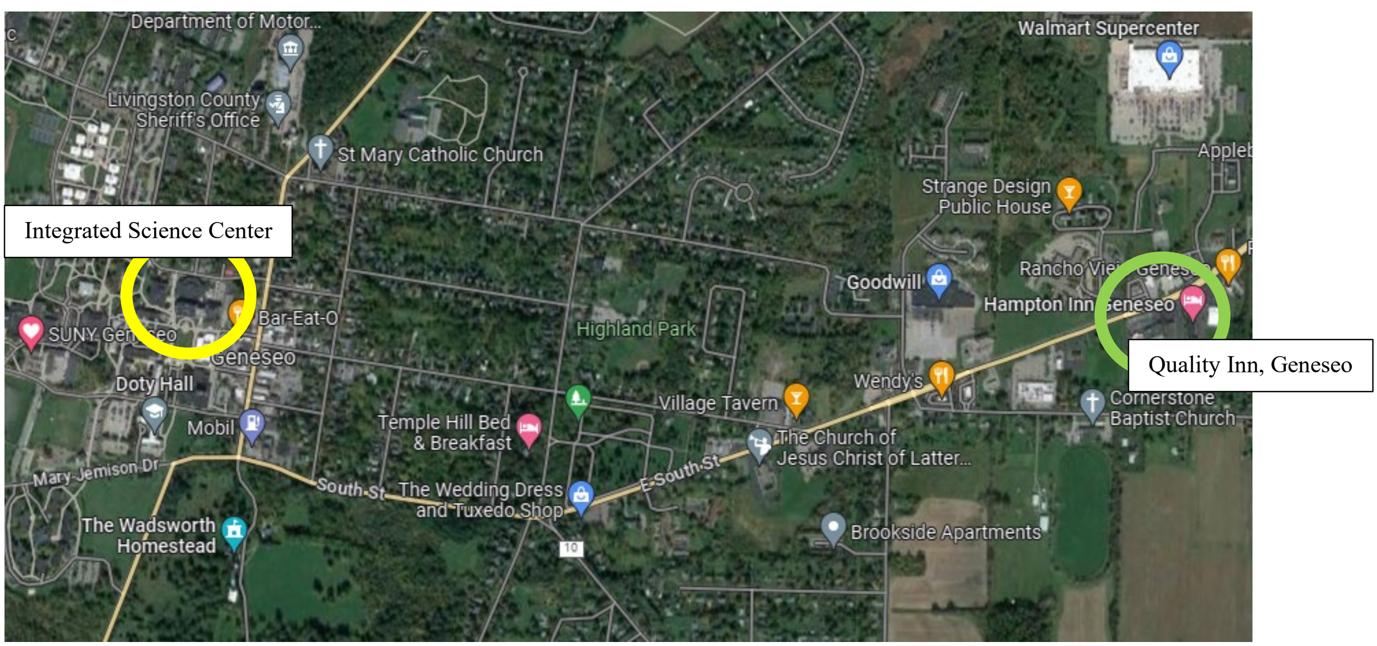
Emergencies/After Hours Health Care
Campus Police – +1 585 245-5222
Livingston County Sheriff – 911
U of R - Noyes Urgent Care – 50 South Street (US 20A), Geneseo, +1 585 243-9595

Post Office
13 South Street (US 20A), Geneseo, NY

Pharmacy and Grocery
Wegman's, 4287 Lakeville Road – Genesee Valley Plaza

Department of Geological Sciences, SUNY Geneseo
ISC 235, +1 585 245-5291


GENESEO
CAMPUS MAP
Integrated Science Center
East Campus
1 Bailey Hall
2 Brodie Hall
3 Newton Lecture Hall
4 Integrated Science Center
5 Milne Library
6 Blake Hall
7 Erwin Hall
8 Wadsworth Auditorium
9 Welles Hall
10 Doty Hall (Admissions)
11 Sturges Hall
12 Fraser Hall
13 South Hall
West Campus
14 MacVittie College Union
15 Heating Plant
16 Clark Service Buildings
17 Schrader Sports &
Recreation Building
18 Merritt Athletic Center
19 College Stadium
North Village
20 Lauderdale Health Center
21 Steuben Hall
22 Jones Hall
23 Erie Hall
24 Seneca Hall
25 Ontario Hall
26 Genesee Hall
27 Letchworth Dining Hall
28 Wyoming Hall
29 Putnam Hall
30 Allegany Hall
31 Livingston Hall
32 Monroe Hall
33 Mary Jemison Dining Hall
South Village
34 Saratoga Terrace
35 Saratoga Commons
36 Onondaga Hall
37 Niagara Hall
38 Red Jacket Dining Hall
39 Wayne Hall
40 Nassau Hall
41 Suffolk Hall
42 President's Residence
43 Campus House
44 McClellan House
45 Big Tree Inn
46 Roemer House
47 Interfaith Center
48 E-Garden
COURT ST.
NORTH ST.
RTE. 39
FRANKLIN ST.
WADSWORTH ST.
MAIN ST.
LETCHWORTH DR.
WARD PL.
BANK ST.
CENTER ST.
SCHOOL ST.
CHESTNUT ST.
PARK ST.
COLLEGE DR.
MARY JEMISON DR.
RED JACKET DR.
ROUTE 63
RTE. 20A WEST / 39 SOUTH
SOUTH ST.
RTE. 20A EAST
N


Integrated Science Center
Quality Inn, Geneseo
Department of Motor...
Livingston County Sheriff's Office
St Mary Catholic Church
Walmart Supercenter
Strange Design Public House
Goodwill
Hampton Inn
SUNY Geneseo
Bar-Eat-O
Geneseo
Doty Hall
Mobil
Highland Park
Temple Hill Bed & Breakfast
Village Tavern
Wendy's
The Church of Jesus Christ of Latter...
Cornerstone Baptist Church
Mary Jemison Dr
South St
E South St
The Wedding Dress and Tuxedo Shop
The Wadsworth Homestead
Brookside Apartments
10

General schedule:
26 July – Arrive Cleveland, Ohio for pre-meeting field trip – departure from Geneseo and Rochester at 1:00 pm
27 July – field trip departs, Upper Devonian strata - spend night in Erie, PA
28 July – field trip, Upper Devonian strata - spend night in Fredonia, NY
29 July – field trip, Upper Devonian strata - spend night in Geneseo, NY
non-field trip conference participants arrive in Geneseo, NY – welcome gathering @ Livingston Lanes 4260 Lakeville Road
30 July – conference begins, stay in Geneseo
31 July – intra-conference field trip – Upper Devonian strata **or** Niagara Falls, stay in Geneseo
01 Aug – conference, stay in Geneseo
02 Aug – field trip to Lower and Middle Devonian strata and PRI-MOTE in Ithaca, banquet, spend night in Ithaca, NY
03 Aug – field trip, Middle Devonian strata - spend night in Tully, NY
04 Aug – field trip, Middle Devonian strata - spend night in Schoharie, NY
05 Aug - field trip, Lower and Middle Devonian strata - spend night in Saugerties, NY
06 Aug – field trip, Lower and Middle Devonian strata – spend night in Saugerties, NY – end of field trip
07 Aug – return to Geneseo/Rochester, transport to travel hubs

Subcommission on Devonian Stratigraphy
The International Union of Geosciences (IUGS), amongst other tasks, features the International Commission on Stratigraphy (ICS), which is composed of subcommissions on individual systems and the Precambrian that build the formal, officially and internationally defined time units (chronostratigraphic units) of Earth History. The Subcommision on Devonian Stratigraphy has been one of the most active subcommissions of the ICS since it formed in 1973, which is mostly based on a highly successful integration of all leading specialists of Devonian stratigraphy, regardless of their specialization or their origin. SDS currently comprises three **officers** (chairman, vice-chairman, secretary/second vice chairman), 18 **Titular Members**, and ca. 80 **Corresponding Members**, covering all continents and all stratigraphic methods. http://devonian.stratigraphy.org/ - *Official website of the Subcommission on Devonian Stratigraphy.*

IGCP 652 Reading Geological Time in Sedimentary Rocks
The IGCP is a cooperative enterprise of United Nations Educational, Scientific and Cultural Organization (UNESCO) and the International Union of Geological Sciences (IUGS) and has been stimulating comparative studies in the Earth Sciences since 1972. After three decades of successful work, the "International Geological Correlation Programme" continued, as "International Geoscience Programme". Up to this day, IGCP has made research results available to a huge number of scientists around the world with about 400 projects.
The thesis of IGCP 652 is that major events punctuated the Paleozoic, such as ecological crises and diversifications, shifts in ocean chemistry, and climatic changes. One of the key-obstacles in understanding these events is the difficulty of providing precise estimates of the duration represented by a sequence of Paleozoic sedimentary rocks. This lack of temporal precision severely hampers the evaluation of forcing mechanisms and rates of climatic, ecological or biogeochemical changes. It is therefore essential to first improve the Paleozoic timescale to then unravel the history of the Paleozoic Earth system. Cyclostratigraphy is a powerful chronometer, based on the detection of the Milankovitch cycles in the sedimentary record. Those cycles result from periodic variations in the Earth-Sun system, affecting the distribution of solar energy over the Planet influencing Earth's climate on time scales between 10^4 and 10^6 years. Through the

integration of this astronomical time scale with biostratigraphy and radio-isotopic dating, this project intends to document the environmental evolution during the Paleozoic with a focus on the Ordovician to Devonian (485 – 359 million years). It gathers participants (> 200) from all over the world (36 countries) and promotes the participation of young scientists and scientists from developing countries. http://www.geolsed.ulg.ac.be/IGCP_652/index.html - *website of IGCP Project 652.*

***Business Meeting SDS and IGCP 652*: 30 July 2023**

Geneseo, New York

Geneseo – sandy bank - was founded in 1832 in the historic lands of the Seneca Nation in the rural western Finger Lakes of New York State. It is the seat of Livingston County and home of the State University of New York College at Geneseo. The National Historic Landmark village, population of 9,000, is in the heart of rich farm land sitting above the broad Genesee River Valley adjacent to Letchworth State Park that features a deep gorge cut into Upper Devonian strata. Toronto, Canada (3 hours), Buffalo, NY (1.2 hours), and Rochester, NY (40 minutes) are nearby metropolitan areas. In July the average high temperature is 80 F (27 C) degrees and the low temperature is 60 F (16 C) degrees. It rains one in four days through the month.

Instructions to Presenters

Oral presentations

All presentations will be in PowerPoint 10 (pptx) or compatible. Standard 4:3 is best. Be sure to give your presentation on thumb drive or e-mail to the projectionist to load onto the hard drive of the computer the session before the presentation. All speakers are requested to keep within the designated time slot which includes time for questions.

Poster presentations

Posters are to be 110 cm x 90 cm maximum dimensions. Posters will be displayed for the duration of the conference in ISC 144. Wall adhesive, push pins, or Velcro tabs will be provided.

Publication of proceedings: *Bulletins of American Paleontology,* a publication of the Paleontological Research Institute in Ithaca, New York, will publish papers presented at the meeting, as well as other contributions on Devonian topics. Manuscripts are due to D.J. Over before 15 December 2023. The target publication date is 1 July 2024. Instructions for authors are at https://www.priweb.org/blog-post/bap-information

Program

30 July 2023 (Sunday) – Newton Hall 204 on the Campus of SUNY Geneseo

8:30 WELCOME AND INTRODUCTION
President Denise Battles and D. Jeffrey Over

Devonian Stratigraphy and Structure   Linda Ivany and Nicholas Hogancamp presiding

8:45 THE DEVONIAN IN NEW YORK AND NORTH AMERICA/LAURENTIA
Ver Straeten, C. A.

9:15 BASAL EMSIAN GSSP – POSSIBILITIES IN THE PRAGUE SYNFROM
Slavík, L., Weinerová, H., Weiner, T. and Hladil, J.

9:35 MARINE STRATA OF THE MIDDLE AND UPPER HAMILTON GROUP (MIDDLE DEVONIAN, LOWER GIVETIAN), EASTERN OUTCROP BELT IN NEW YORK STATE
Bartholomew, A. J. and Ver Straeten, C. A.

9:55 DEVONIAN CONODONT STRATIGRAPHY AND FACIES DEVELOPMENT OF THE AZROU REGION (EASTERN PART OF WESTERN MOROCCAN MESETA)
Aboussalam, Z. S., Becker, R. T., Hartenfels, S. and El Hassani, E.

10:15-10:40 Coffee and Posters

10:40 STRUCTURAL INFLUENCE ON DEVONIAN BLACK SHALE DEPOSITION IN SOUTHWESTERN NEW YORK STATE: BASIN ARCHITECTURE DRIVEN BY CRUSTAL SCALE THRUST LOADING TO THE EAST AND TO THE SOUTH/SOUTHEAST
Jacobi, R. D., and Smith, G. J.

11:00 SUMMARIZING A DECADE OF DEVONIAN SUBSURFACE MAPPING IN OHIO BY THE OHIO GEOLOGICAL SURVEY
Waid, C. B. T.

11:20 NORTHWEST THINNING OF FAMENNIAN BEDS IN WESTERN NEW YORK STATE
Vaughan, R. C.

11:40 NEW OBSERVATIONS IN END-DEVONIAN TO BASAL TOURNAISIAN SUCCESSION IN OHIO RELEVANT TO THE NEED FOR RENEWED, DETAILED CHRONOSTRATIGRAPHIC STUDY OF CONTINUOUS OUTCROP SECTIONS.
Baird, G. C., Over, D. J., Hannibal, J. T., McKenzie, S. C., Harper, J. A., and Tesmer, I. H.

12:00 FAMENNIAN TO EARLY TOURNAISIAN DEPOSITIONAL SEQUENCES FROM THE WILLISTON BASIN AND SURROUNDING AREAS, NORTHWESTERN UNITED STATES.
Hogancamp, N. J., Hohman, J. C., Guthrie, J. M, and Rodriguez, A. P.

12:20-1:20 Lunch

<u>Ecological and evolutionary studies   Elizabeth Dowding and James Zambito presiding</u>

1:20 ENVIRONMENTAL STASIS AND VOLATILITY: DRIVERS OF ECOLOGICAL-EVOLUTIONARY PATTERN AND MACROEVOLUTIONARY PROCESS IN THE DEVONIAN APPALACHIAN BASIN
Brett, C. E., Baird, G. C., Bartholomew A., Ivany, L. C., and Zambito, J.

1:40 THE CENTRAL ASIAN OROGENIC BELT (WESTERN CHINA AND MONGOLIA) WAS A BIODIVERSITY HOTSPOT IN THE LATE DEVONIAN
Waters, J. A., Waters, J. W., Carmichael, S. K., Königshof, P., Munkhjargal, A. and Gonchigdorj, S.

2:00 REVISION OF LATEST SILURIAN – MID-DEVONIAN BRACHIOPOD FAUNAS FROM THE RHENISH MASSIF (GERMANY): STATE OF THE ART AND PERSPECTIVES
Jansen, U.

2:20 LATE DEVONIAN CRINOID AND BLASTOID GHOST LINEAGES
McIntosh, G. C.

2:40-3:00 Coffee and posters

<u>Devonian Magnetic Field and Terrestrial Strata   Annique van der Boon and Charles Ver Straeten presiding</u>

3:00 DEVONIAN TERRESTRIAL SYSTEM IN NEW YORK STATE
Ver Straeten C. A.

3:20 MAPPING THE MIDDLE AND UPPER DEVONIAN MARINE-NONMARINE TRANSITION IN THE APPALACHIAN BASIN FROM WEST VIRGINIA TO NEW YORK
Doctor, D. H., and Pitts, A. D.

3:40 THE QUEST FOR THE DEVONIAN MAGNETIC FIELD: AN UPDATE
van der Boon, A.

4:00 Posters

4:30 SDS Business Meeting followed by IGCP 652 Business Meeting

31 July 2023 (Monday)

Excursion to Niagara Falls – leader Carlton Brett – meet in Quality Inn Parking Lot at 8:00

Excursion to Tioga, Pennsylvania, and Frasnian-Famennian strata – leader Andrew Bush – meet in Quality Inn Parking Lot at 8:15

01 August 2023 (Tuesday) Newton Hall 204 on the Campus of SUNY Geneseo

Devonian Extinctions and geochemistry   Diana Boyer and Nina Wichern presiding

8:20 UPPER DEVONIAN LOWER AND UPPER KELLWASSER EXTINCTION RECORD IN THE SWEETLAND AND GRASSY CREEK SHALES IN THE IOWA BASIN OF CENTRAL NORTH AMERICA
Day, J., and Long, G.

8:40 TIMING OF THE LATE DEVONIAN KELLWASSER CRISIS: CYCLOSTRATIGRAPHIC ANALYSIS OF THE JAVA GROUP AT THE WALNUT CREEK SECTION, NEW YORK, USA
Klisiewicz, J. , Wichern N. , Over, D. J., Tuskes, K., Hinnov, L. A., De Vleeschouwer D.

9:00 GEOCHEMICAL AND SEDIMENTOLOGICAL ANALYSIS OF THE UPPERMOST DEPOSITS OF THE UPPER DEVONIAN HANOVER SHALE IN WESTERN NEW YORK STATE
Blood, D. R., McCallum, S. D., and Douds, A. S. B.

9:20 DECIPHERING THE ROLE OF TERRESTRIAL/ATMOSPHERIC INTERACTIONS IN LATE DEVONIAN KELLWASSER BLACK SHALE DEPOSITION: A HIGH-RESOLUTION CYCLOSTRATIGRAPHIC STUDY OF THE WINSENBERG SECTION (RHENISH MASSIF, GERMANY)
Wichern, N. M. A., Bialik, O. M., Nohl, T. , Percival, L. M. E., Kaskes, P., Becker, R. T., and De Vleeschouwer, D.

9:40 PYRITE FRAMBOID DISTRIBUTIONS AS INDICATORS OF ANOXIA: CAN WE USE THEM IN SHALLOW WATER ENVIRONMENTS?
Carmichael, S. K., Waters, J. A., and Boyer, D. L.

10:00-10:30 Coffee and Posters

10:30 LATE DEVONIAN TO EARLY CARBONIFEROUS INTERVALS (D/C TRANSITIONS) FROM MONGOLIA: INSIGHTS FROM TWO DIFFERENT TERRANES.
Munkhjargal, A., Königshof, P., Waters, J. A., Carmichael, S. K., Gonchigdorj, S., Nazik, A., Crônier, C., Udchachon, M. , Thassanapak, H. , Roelofs, B. , Duckett, K., and Foronda, J.

10:50 THE HANGENBERG CRISIS (DEVONIAN-CARBONIFEROUS BOUNDARY) TIMING AND CLIMATIC FORCING (CHANXHE AND ANSEREMME SECTIONS, BELGIUM).
da Silva, A.C., Arts, M., Crucifix, M., Franck, L., Huygh, J., Omar, H., and Denayer, J.

11:10 HYDROGRAPHIC AND GEOCHEMICAL EVOLUTION OF THE LATE DEVONIAN EPEIRIC SEAS OF NORTH AMERICA: LINKAGES BETWEEN REDOX, SALINITY, AND BIOTIC CRISES
Gilleaudeau, G. J., Remírez, M. N., Wei, W., Song, Y., Sahoo, S. K., Kaufman, A. J., and Algeo, T. J.

11:30 USING $\delta^{13}C_{TOC}$ CHEMOSTRATIGRAPHY TO RECOGNIZE DEVONIAN GLOBAL EVENTS IN THE NEW ALBANY SHALE (ILLINOIS BASIN, U.S.A.)
Zambito, J. J., Weldon, A. C., Farbarik, O. B., Bolin, D. L., and McLaughlin, P. I.

11:50-1:30 Lunch

Devonian Events, Cyclic Stratigraphy, and Astrochronology Faye Higgins and David De Vleeschouwer presiding

1:30 THE KINGSTON RECORD, NEW YORK STATE, U.S.A – A WINDOW TO THE DEVONIAN PALEOCLIMATE AND TO THE DURATION OF PART OF THE EMSIAN.
da Silva, A.C., Brett, C., Bartholomew, A., Ver Straeten, C., Hilgen, F., Dekkers, M.J.

1:50 EXPRESSION OF THE MIDDLE DEVONIAN KAČÁK EPISODE IN THE MACKENZIE MOUNTAINS, NORTHWEST TERRITORIES, CANADA.
Gouwy, S.A.

2:10 IMPACT OF GLOBAL EVENTS ON THE DROWNING AND EXTINCTION OF GIVETIAN/FRASNIAN REEFS IN THE NORTHERN RHENISH MASSIF (GERMANY)
Becker, R. T., and Aboussalam, Z. S.

2:30 INVESTIGATING THE LINK BETWEEN DEVONIAN ANOXIC EVENTS AND ASTRONOMICAL FORCING
Huygh, J. , Gérard, J., Sablon, S., Crucifix, M., and da Silva, A.-C.

2:50-3:20 Coffee and Posters

3:20 ASTROCHRONOLOGY OF THE HANOVER FORMATION, LATE DEVONIAN, WESTERN NEW YORK
Higgins, F., Tuskes, K., Over, D. J., Giorgis, S., and Slater, B.

3:40 BASIN-WIDE CORRELATION OF ASTRONOMICALLY FORCED CYCLES IN THE FAMENNIAN OHIO SHALE, APPALACHIAN BASIN, OHIO, USA
Hinnov, L. A., Algeo, T. J., and Lisiecki, L. E.

4:00 NUMERICAL SIMULATIONS OF THE EFFECTS OF ASTRONOMICAL FORCING ON NUTRIENT SUPPLY AND OXYGEN LEVELS DURING THE DEVONIAN
Crucifix, M., Sablon, L., Gerard, J., Godderis, Y., and da Silva, A.

02 August 2023 (Wednesday)

Depart from Quality Inn at 8:00
Stop 1 – Neid Road Quarry – Silurian Devonian unconformity, Silurian, Lower Devonian, Middle Devonian strata
Stop 2 – Fall Brook Glen – Middle-Upper Devonian boundary
Lunch in Geneseo
Stop 3 - Taughannock Falls – Middle Devonian

Banquet "under the whale" at Paleontological Research Institution – Museum of the Earth, 1259 Trumansburg Road, Ithaca, New York - Dinner at 7:30. Lodging at Quality Inn-Ithaca, 356 Elmira Road, Ithaca, NY.

POSTERS – ISC 144

[1] REASSESSING HYDROCARBON VOLUMES OF THE DEVONIAN SHALES IN EASTERN OHIO AT MEMBER-LEVEL SCALE
Danielsen, E. M., Blood, D. R., and Waid, C. B. T.

[2] A REVISED PALAEOGEOGRAPHY FOR THE FRASNIAN-TOURNAISIAN OF ANGARIDA (SIBERIA).
Dowding, E. M., Akulov, N., Torsvik, T. H., and Markussen Marcilly, C.

[3] THE LATEST EIFELIAN-FRASNIAN HORN RIVER GROUP IN THE NORTHERN MACKENZIE MOUNTAINS AND MACKENZIE VALLEY (NW TERRITORIES, CANADA): INTEGRATED STRATIGRAPHY AND SECTION CORRELATION.
S.A. Gouwy, P. Kabanov, W. Chan, T. Hadlari and T.T. Uyeno

[4] VARIABILITY, RELIABILITY, AND SIGNIFICANCE OF BRACHIOPOD $\delta^{18}O$ VALUES FROM THE MIDDLE DEVONIAN HAMILTON GROUP.
Ivany, L. C., Welych-Flanagan, M., and Owens, J. C.

[5] TIMING OF THE LATE DEVONIAN KELLWASSER CRISIS: CYCLOSTRATIGRAPHIC ANALYSIS OF THE JAVA GROUP AT THE WALNUT CREEK SECTION, NEW YORK, USA
Klisiewicz, J. , Wichern N. , Over, D. J., Tuskes, K., Hinnov, L. A., De Vleeschouwer D.

[6] UNTANGLING THE LATE DEVONIAN CARBON CYCLE USING COMPOUND SPECIFIC ISOTOPES
Logie, T., Bhattacharya, T., Uveges, B., and Junium, C.

[7] INTEGRATED CONODONT, CARBON ISOTOPE, TRACE ELEMENT, AND SEQUENCE STRATIGRAPHIC DATA FROM THE GIVETIAN-FRASNIAN 'FRASNES EVENT' AND *FALSIOVALIS* EXCURSION IN IOWA AND NEVADA, USA.
McAdams, N. E. B., Day, J. E., Morgan, D., and Fiorito, A.

[8] LATE DEVONIAN TO EARLY CARBONIFEROUS INTERVALS (D/C TRANSITIONS) FROM MONGOLIA: INSIGHTS FROM TWO DIFFERENT TERRANNES.
Munkhjargal, A., Königshof, P., Waters, J. A., Carmichael, S. K., Gonchigdorj, S., Nazik, A., Crônier, C., Udchachon, M., Thassanapak, H., Roelofs, B., Duckett, K., and Foronda, J.

[9] DIVERSITY AND BODY SIZE TRENDS OF DACRYOCONARIDS ACROSS THE LATE DEVONIAN *PUNCTATA* EXCURSION, APPALACHIAN BASIN
Prow, A. N., Yang, Z., Lu, Z., Meehan, K.C., and Payne, J. L.

[10] KEY STRATIGRAPHIC MARKERS IN THE LATE DEVONIAN NORTH AMERICAN SEAWAY: TOWARDS A CHEMOSTRATIGRAPHIC FRAMEWORK FOR CORRELATION IN MUD-DOMINATED BASINS
Remirez, M. N., Gilleaudeau, G. J., Elrick, M., Algeo, T. J.

[11] A UNIQUE OCCURRENCE OF *SCHIZOPHORIA* (KING, 1850) IN LOWER GIVETIAN STRATA OF EASTERN NY
Sabatino, F., Grippo, A., Bartholomew, A. B.

[12] GEOLOGIC CROSS SECTION A-A' FROM GENESEE COUNTY, WESTERN NEW YORK, TO LYCOMING COUNTY, NORTH-CENTRAL PENNSYLVANIA, SHOWING THE REGIONAL STRUCTURAL AND STRATIGRAPHIC FRAMEWORK OF THE ALLEGHENY PLATEAU AND VALLEY AND RIDGE PROVINCES IN THE NORTHERN APPALACHIAN BASIN
Trippi, M. H.

[13] INTEGRATED STRATIGRAPHY OF MIDDLE DEVONIAN STRATA IN THE CARGILL TEST #17 CORE (LANSING CORE) OF NEW YORK STATE
Zambito, J. J., Brett, C. E. , Da Silva, A.-C., Farbarik, O. B., and Willison M. J.

[14] INTEGRATED STRATIGRAPHIC AND PALEOENVIRONMENTAL STUDY OF THE MIDDLE-LATE DEVONIAN CARBONATE TO BLACK SHALE TRANSITION IN THE MICHIGAN BASIN
Zambito, J. J., Voice, P. J., Barker-Edwards, T., Giehler, M., Gugino, J., Johnson, I., O'Bryan, H., Quiroz, C., Truong, L., Wiesner, A., and Winget, M.

ABSTRACTS

DEVONIAN CONODONT STRATIGRAPHY AND FACIES DEVELOPMENT OF THE AZROU REGION (EASTERN PART OF WESTERN MOROCCAN MESETA)

Aboussalam, Z. S.,[1] Becker, R. T.[1], Hartenfels, S.[2] and El Hassani, E.[3]. [1]Institute for Geology and Palaeontology, WWU, Correnssstr. 24, D-48149 Münster, Germany, taghanic@uni-muenster.de and rbecker@uni-muenster.de; [2]Institute for Geology and Mineralogy, Universität zu Köln, Zülpicher Str. 49a, D-50674 Cologne, Germany, s.hartenf@uni-koeln.de; [3]Académie Hasan II des Sciences et Techniques, Km 4 Avenue Mohammed VI, 10000 Rabat, Morocco, a.elhassani@academiesciences.ma.

ORAL

Introduction: The Moroccan Meseta represents the northwestern margin of Gondwana that was strongly tectonized in the Carboniferous during the main Variscan orogeny, in continuation of the southern European Variscides. In the Devonian, the region was a subtropical archipelago with reefs, subdivided by synsedimentary, Eovariscan block faulting into a complex mosaic of basins and rises. Investigation of their individual facies histories, stratigraphy and faunas was the topic of a joint DFG-CNRST Maroc project. Results on various regions have been published in two recent monographs [1, 2] and this contribution is part of a third volume that has a focus in the eastern part of the Western Meseta.

The Azrou region belongs to a Variscan nappe which was transported westwards in the Viséan. This resulted in a strong tectonization which affected the preservation of fossils. For example, a fair amount of conodonts shows weak to strong plastic deformation, and macrofauna is difficult to extract from folded, partly cleaved, and strongly diagenetically overprinted limestones. However, a high-resolution reconstruction of facies developments is possible by combined conodont and microfacies investigations. This commenced with a pioneer study by G. Bohrmann and G. Fischer [3] and is refined by our new data.

Three different Devonian successions exposed in various erosional windows below a cover of Mesozoic sediments and Quarternary volcanics have been recognized in the Azrou region. Measured and sampled outcrops represent individual nappes and tectonic slices overthrusted onto Ordovician and thin Silurian siliciclastics. In the whole region, the Lochkovian/main Pragian is represented by silty shales to fine sandstones with dacryoconarids, trilobite debris, and rare *Pleurodictyum*.

NW Succession. It is represented ca. 4 km NNW of downtown Azrou by a thick section exposed on the slope just north of a convenient new auberge with swimming pool. The lower part are up to 150 m thick, light-grey calcareous shales assigned to the Bab-al-Ari Formation. Thin, dark-grey, fine-grained crinoidal limestones ca. 7 m below the top yielded a *Belodella* fauna with a single, poorly preserved *Icriodus ?ultimus,* which indicates an Emsian age. Previous records from the unit [3] include typical lower Emsian icriodids. The subsequent, massive, light-grey flaser limestones of the Azrou Formation include a strange jump from the *bilatericrescens/excavatus* Zones at the base to Eifelian faunas still in the lower part. The upper Emsian seems missing due to non-deposition. In the upper part, there are basal middle Givetian conodonts with *I. difficilis*. The Azrou Formation is capped by a lenticular to massive flat pebble breccia with tabulate, solitary and colonial rugose corals (*Phillipsastrea*). It forms the base of the Bou Ighial Formation. The reworking of a near-by biostrome occurred in the upper part of FZ 3 (*Ancyrodella africana* Zone). Laterally, reef debris limestones have been dated as *ansatus* Zone [3] suggesting that the biostrome had a middle Givetian age.

Ca. 2.5 km to the north thick-bedded limestones grade into a succession of breccia beds that still fall in the middle Givetian, showing an early onset of synsedimentary uplift and re-deposition.

Bou Ighial. There is a marked, high ridge in the middle of Azrou, which lower part is occupied first by silty greenish shales, then by calcareous grey shales of the Bab-al-Ari Formation. In the western part, the first limestones of the Azrou Formation yielded among a flood of *Belodella* an unknown *Polygnathus* resembling Eifelian forms. Flaser limestones grade into and alternate with brecciated limestones with lower/middle Givetian conodonts. At short distance, this brecciated Bou Ighial Formation truncates into the Lower Devonian shales. Near the base, *Linguipolygnathus lingui*formis is mixed with top-Givetian taxa, such as *Po. paradecorosus* and *Po. dengleri dengleri*. Several meters higher, weakly tectonized, platy limestones yielded a lower Frasnian fauna with *Ad. africana* (upper FZ 3). Following a thick shale interval, there is a thick upper conglomerate/breccia succession alternating with laminated dark-grey shales. The succession yielded *Scaphignathus velifer leptus, Sc. velifer velifer, Palmatolepis marginifera duplicata, Pa. perlobata schindewolfi, Po. fallax*, and others. This proves a second prolonged interval of Eovariscan uplift and erosion of parts of a deep neritic/shallow pelagicc platform in the middle Famennian. There are numerous Givetian and Frasnian reworked conodonts, including possibly new forms that could be from any of the three stages. A distinctive feature is the rarity of middle/upper Frasnian and lower Famennian palmatolepids. We assume that there was non-deposition or extreme condensation at that time.

Bab-el-Ari. A different succession ranging from the Lochkovian/Pragian to the uppermost Famennian is exposed at the isolated Bab-el-Ari hill ca. 3 km northeast of the Bou Ighial. Above ca. 50 m silty and sandy shales, grey calcareous shales of the lower Bab-al-Ari Formation are interrupted by a ca. 10 m thick unit (local Member 2) of coarse crinoidal limestones. It yielded near the base a rich fauna with dominant *Belodella* and common *Caudicriodus claudiae*, a typical Pragian species. Member 3, the ca. 75 m thick upper calcareous shales are not dated but thin lenticular limestones at the base of the Azrou Formation yielded a lower Emsian fauna with *Latericriodus multicostatus* and *Lat. gracilis*. As previously advocated [3], we suspect that the upper Emsian is missing again. Ca. 15 m higher, micritic flaser limestones yielded only *Belodella*, but 23-25 m higher, there are middle Givetian faunas that reach to the formation top.

The Bou Ighial Formation characterized by recurrent Eovariscan reworking consists in the main section of alternating shales and thin conglomerate layers, first with conodonts of the *marginifera* Zone. Ca. 30 m higher, a thick conglomerate contains reworked Givetian reef fauna, which is restricted to this marker unit. The next hill to the north differs in a lower conglomerate with reworked sandstone blocks and a middle Frasnian conodont fauna (FZ 6 with *Ad. lobata*). It is overlain by ca. 20 m of thin sandstones and siltstone, a unit that was obviously cut out laterally by erosion before the basal middle Famennian transgression. In the northern section, lateral section, the main Bou Ighial Formation falls in the *marginifera* to *velifer* Zones, occasionally with reworked Givetian and Frasnian taxa). Near the top, where limestones become sparse and thin, there is a record [3] of *Bispathodus ultimus*. suggesting long phases of non-deposition and condensation.

References: [1] Becker, R. T., El Hassani, A., and Aboussalam, Z. S. (Eds., 2020) *Front. Sci. Engineer. 10(1)*, 1-194. [2] Becker, R. T., El Hassani, A., and Aboussalam, Z. S. (Eds., 2020) *Front. Sci. Engineer. 10(2)*, 1-333. [3] Bohrmann, G., and Fischer, G. (1985) *Geol. Palaeont. 19, 15-37*. [4] .

NEW OBSERVATIONS IN END-DEVONIAN TO BASAL TOURNAISIAN SUCCESSION IN OHIO RELEVANT TO THE NEED FOR RENEWED, DETAILED CHRONOSTRATIGRAPHIC STUDY OF CONTINUOUS OUTCROP SECTIONS.

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ORAL – type of presentation

Much of what we have learned about the nature and timing of key end-Devonian events (Dasberg transgression, Hangenberg biocrises) has come from very detailed zonal studies of "old world" outcrops in Europe and North Africa, which are largely developed in condensed sections recording offshore pelagic conditions. In contrast, Ohio and northwest Pennsylvania offer numerous accessible sections, which are developed in thicker, variably neritic and sometimes enigmatic facies. Physical mapping by the present authors has led to the discovery of many new sections. Moreover, additional work by others has revealed direct and indirect evidence of end-Devonian glacial events in the northern Appalachian Basin region. However, the relative paucity of detailed biostratigraphic work on these strata leaves a great many unanswered questions concerning the timing of these and other events.

Reexamination of the upper Famennian succession in Ohio has confirmed earlier work suggesting that sections in central and southern Ohio record relatively offshore, marine to marginally marine conditions. In particular, these sections suggest that deposition was largely continuous during much of the end-Devonian biocrisis interval. West of Cleveland, Ohio, the basal contact of the black, basinal Cleveland Shale with the underlying grey Chagrin Shale grades basinward from a prominent drowning surface disconformity to depositional conformity. More significantly, the base-Bedford Formation disconformity capping the Cleveland Shale across the Cleveland metropolitan area and across northeastern Ohio, similarly becomes gradational westward. This contact is distinctly conformable from the vicinity of Amherst in northwest-central Ohio southwestward to Columbus in central Ohio. This deposition continuity provides an opportunity to secure an unbroken record of the conodont, palynomorph, and ammonoid successions from the basinal upper Chagrin and Cleveland Shale successions, upward to, and possibly through, the enigmatic middle (red) Bedford succession, into the minimally studied marine, uppermost grey Bedford interval at Columbus. Such work should eventually lead to confident recognition of the key global Hangenberg markers, *Hangenberg black shale*, *Hangenberg grey shale,* and *Hangenberg sandstone* expressed locally in basinal to nearshore facies.

The presence of unusual lithofacies ("barren" red Bedford and succeeding Berea Sandstone) in the Ohio late Famennian section as well as evidence of glacial and/or peri-glacial deposits in eastern Pennsylvania, Maryland, and Kentucky, suggest that these distinctive deposits should allow a connection between successive lithologic events and likely causal factors. Hence, detailed future biostratigraphic and chemostratigraphic studies, particularly in the upper Cleveland Shale to basal Berea Sandstone interval, in multiple long sections, offers great promise inraveling the succession of end-Devonian events.

MARINE STRATA OF THE MIDDLE AND UPPER HAMILTON GROUP (MIDDLE DEVONIAN, LOWER GIVETIAN), EASTERN OUTCROP BELT IN NEW YORK STATE

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Background: The -74.75° West meridian marks roughly the eastern limit, in both the northern and southern outcrop belts, of fully marine facies of the Hamilton Group (Fig. 1), with the transition to terrestrial facies occurring progressively lower in the section as one moves eastward. Lower Givetian strata east of this line present a challenging puzzle compared to equivalent strata to the west in New York State. As opposed to the more-well understood strata to the west, strata in this region: 1) have overall less abundant and complete exposure; 2) preserve relatively varied facies that in places change laterally over short geographic distances; 3) are generally thicker (in some cases over two orders of magnitude thicker compared to correlative intervals in western New York State) with less vertical heterogeneity and more gradational facies changes within the vertical succession; 4) further complicating matters are in which in shallow-water, shoreface sandstone packages it can be difficult to correlate between sections due to a lack of intermingled contrasting lithologies (i.e., dark shales) and finally; 5) some levels contain anomalous faunal elements when compared to the standard list of taxa for the Hamilton interval.

A significant problem related to the homogeneity of nearshore facies is the paucity of recognition of distinct, correlatable marker units. This has resulted in a lack of identity of the key position of strata correlative with the base of the Skaneateles and Ludlowville formations, the Mottville and Centerfield members, in Schoharie, Albany, Greene and Ulster counties, in the eastern outcrop belt. All of this is also complicated by the greater overall thickness and greater degree of cover of the strata, as well as a lack clear biostratigraphic data. Furthermore, very few workers have attempted to carry out stratigraphic and paleontologic studies within this region over the last 150 years, as opposed to the myriad of studies carried out in western and central New York State on age-equivalent strata.

Results: Our own fieldwork, combined with the interpreted findings of previous workers, has allowed us to: 1) correlate basal Skaneateles Formation strata of the Mottville interval in central New York further eastward into the Schoharie Valley region (Fig. 2); 2) establish tentative correlations between coral-rich strata in eastern Schoharie County and western Albany County and the Mottville Member interval to the west (Fig. 2); 3) redefine the boundary of the Mount Marion and Panther Mountain formations proximal to the base of the Mottville correlative interval, narrowing this down stratigraphically in eastern sections (Fig. 2); 4) identify two distinct intervals rich in the anomalous brachiopod *Schizophoria* (King, 1850) in southwestern Albany County, northwestern Greene County, and northern to central Ulster County (Fig. 2); 5) gain a better understanding of the stratigraphic distribution of conglomerate intervals in the interval of the upper Mount Marion Formation and to some degree the lower Panther Mountain Formation; and 6) identified the lowest level of marginal marine/terrestrial facies within the Hamilton Group as occurring within the upper Marcellus interval in Greene County.

In the process of our work, we have also come to a more resolved view of the stratigraphic and geographic location of the lowest (oldest) position of the transition between marine and terrestrial environments within the Middle Devonian strata across this region. In the area between the Schoharie Valley and Otsego County (region 2 in Fig. 1) this transition takes place within the upper Panther Mountain interval. In the area of eastern Schoharie County and southwestern Albany County (region 3 in Fig. 1) this transition takes place within the lower Panther Mountain interval. In central Greene County southward into Ulster County (region 4 in Fig. 1) this transition takes place within the upper portion of the Mount Marion Formation. Finally, in the region through southwestern Ulster through western Orange County in the southern outcrop belt (region 5 in

Fig. 1) this transition again rises up through the formations getting back to totally marine strata extending through the entire Hamilton Group interval around Port Jervis in western Orange County near the -74.75° West meridian.

Additionally, we have been able to further resolve the stratigraphic position of tongues of marine strata that extend eastward into areas dominated by terrestrial facies. Thus far we have identified intervals interpreted by us to be at the base of both the Panther Mountain and Cooperstown formations that preserve thin tongues of marine facies characterized by stenotypic marine fauna including brachiopods, bivalves, and echinoderms sandwiched between thicker packages of strata preserving transitional to fully terrestrial facies.

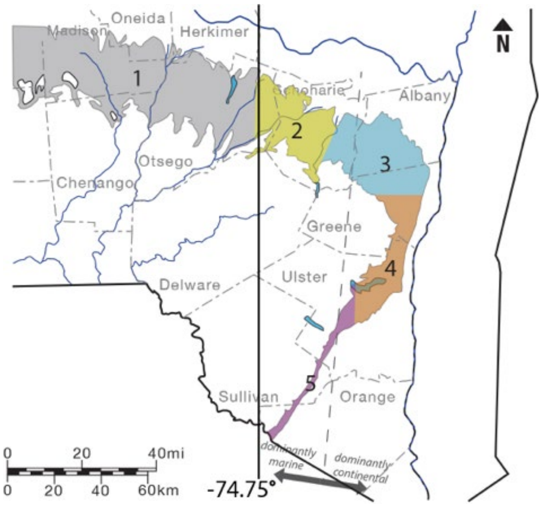

Figure 1: Location map for eastern New York State showing major regions of study showing -74.75° West meridian.

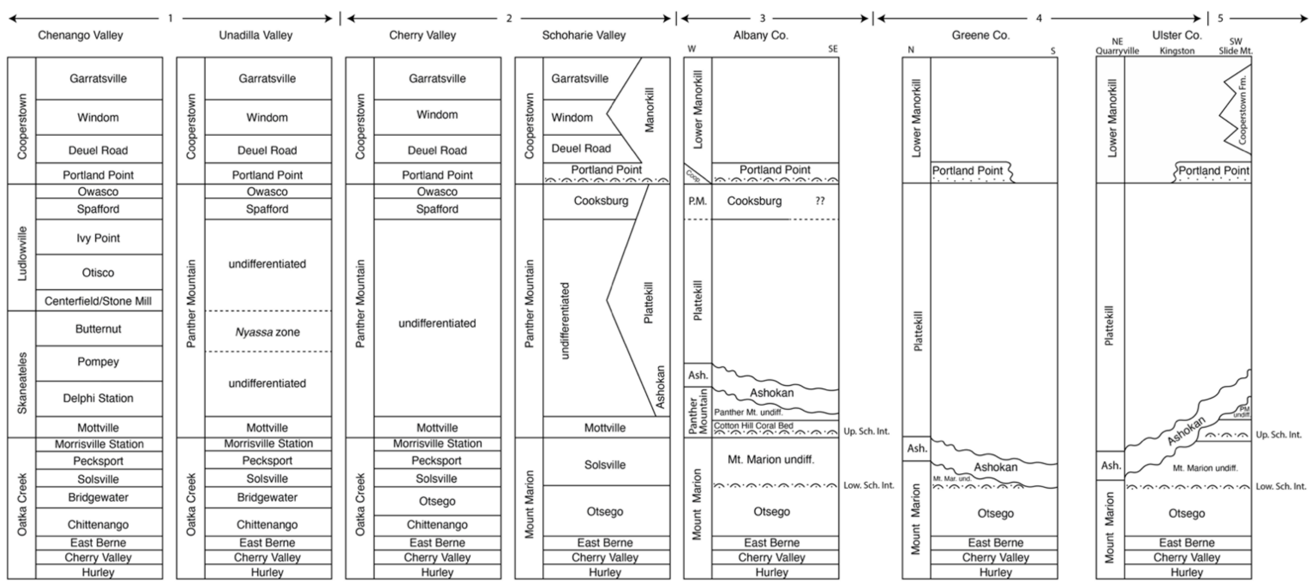

Figure 2: Stratigraphic Columns for the various regions of study. PM = Panther Mountain, Sch. Int. = *Schizophoria* interval, undiff. = undifferentiated, Mt. Mar. = Mount Marion, Coop. = Cooperstown, Ash. = Ashokan

IMPACT OF GLOBAL EVENTS ON THE DROWNING AND EXTINCTION OF GIVETIAN/FRASNIAN REEFS IN THE NORTHERN RHENISH MASSIF (GERMANY)

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Introduction: There are numerous Givetian and Frasnian reefs in the Rhenish Massif, which have been quarried in partly huge quarries or which have been explored by fully cored bore holes in conjunction with the mining operations or during the search for metalliferous deposits. In the northern Rhenish Massif, from the Aachen region in the southwest to the Brilon and Messinghausen reefs in the northeast, there are ten larger and some small-sized biostromes and bioherms that grew on the southern shelf of the Old Red Continent in times of reduced siliciclastic delivery from the eroding Caledonian orogen.

After a first period during the initial geological mapping in the early 20th century, and a second period in the 60ies/70ties, research slowed down and modern microfacies and high-resolution biostratigraphic data were published only in a few cases. In the last 20 years, the Devonian Münster Group, in close cooperation with the Geological Survey/Service at Münster (M. Piecha, D. Juch, J. Drozdzewski, S. Hartenfels, S. Stichling, S. Becker), investigated numerous outcrops of nine reefs but research is continuing. Our studies, which included numerous B.Sc. and M.Sc. theses, benefitted much from the good cooperation and partial financial support by the Lhoist Germany Rheinkalk GmbH. They provided access to active quarries and core material. Our work had a wide range of goals, from geological mapping, to reef microfacies types, palaeoecology, microbial carbonates, and initial phases and their microfaunas [1] to diagenesis in the context of their geothermal potential, reefal detritus, sedimentary geochemistry, and post-reefal facies history. The identification of reef builders by A. May (Unna) was crucial. We had a strong focus on conodont or ammonoid dating of the locally very different drowning and final extinction phases and their potential correlation with the well-known global events as a possible trigger.

The Walheim Reef Complex lies in the Inde Syncline of the Aachen region. A deepening interval marked by dark-grey marls with the last dechenellid trilobites and just below the extinction of *Stringocephalus* has been roughly correlated with the Taghanic Transgression. The reef survived into the lower Frasnian, where it was drowned a second time in the course of the Timan Event (high in FZ 3). It recovered once more and a final coral garden biostrome fell victim to the *semichatovae* Transgression.

The similar but older (uppermost Givetian) biostrome of Hofermühle South (northern Velbert Anticline) was sharply interrupted by a black shale that represent probably the main pulse of the Frasnes Event. In the northern reef, thin detrital limestones at the base of a un-named siliciclastic unit yielded middle Frasnian conodonts. Since coarse conglomerates are already intercalated in the lower Frasnian, the Hofermühle Reef is regionally exceptional since it seems to have been suffocated by the spread of clastic wedges from a small island (now in the subsurface) to the north.

In the upper Frasnian, a crinoidal-microbial (stromatolithic) carbonate platform with subordinate corals and stromatopores was re-established. It ranges right to a unique angular unconformity at the Frasnian-Famennian boundary that was temporarily exposed at Hülsbeck.

Just a few km to the east, the very different and thick Wülfrath Reef Complex started to grow with the same basal Frasnian transgression that almost killed the adjacent Hofermühle Reef. The Rohdenhaus bioherm was drowned by the *semichatovae* Transgression and turned into a extensive deeper-water microbial platform with rare corals, the youngest Devonian reef body of all the Rhenish Massif. The Upper Kellwasser Event led to a sharp termination of the last *Stromatactis* layers, followed by a marked unconformity that reflects the major F-F boundary tectonic event of the region [2]. The Upper Kellwasser platform flooding and F-F tectonism are expressed at the southern end of the Wülfrath Reef, at Schlupkothen, by a thin black homoctenite overlying thick microbialites and a basal Famennian reworking unit with cross-bedding and megaripples.

At the southern limb of the Velbert Anticline, the Neanderthal Reef, famous for its ancient cave man, has hardly been studied. A black shale overlying back-reef *Amphipora* limestones yielded an *Acanthoclymenia* fauna that proves a lower Frasnian age. It suggests terminal reef drowning by the Frasnes Event, similar as at Hofermühle. New data from the Wuppertal region (Hahnenfurt railway station) show that this is also true for the Dornap Reef but huge allochthonous reef blocks re-occur much higher in the Voßbeck Quarry.

The Hagen-Balve Reef Complex extends for more than 20 km in west-east direction along the northern margin of the Remscheid-Altena Anticline. The lower/middle Givetian reaches a thickness of up to one km at its eastern end. In the western Hagen-Hohenlimburg region, the bioherm drowned during the Taghanic Events [3] and was abruptly covered by hypoxic shales and turbidites (Flinz facies). But the retro- and then prograding reef margin shed coarse reefal debris northwards until the basal Frasnian. In the eastern Hönne Valley, the Frasnes Events caused a major transformation from a thick, fast growing bioherm into a condensed open coral garden. The platform remained in the lower photic Zone; there is no basinal Flinz facies. A last, short coral biostrome recovery occurred before the Middlesex Transgression [4].

From the Hagen-Balve Reef to the east, some work has started on the poorly known, lower Givetian, biostromal *Sparganophyllum* Limestone, which is sandwiched between pelagic shales. Further eastwards, the large Brilon Reef has been subject of a voluminous monograph by J. Brinkmann and D. Stoppel which is in print since several years.

In the eastern Sauerland, we focused on the Messinghausen Atoll, which clear separation from the Brilon Reef has partly been overlooked in previous studies. The atoll talus at Beringhauser Tunnel is famous for its conodont-dated colonial Rugosa [5]. We analyzed the carbon isotope stratigraphy in search for the positive excursions of the Timan and Middlesex Events. The latter is developed in distal reefal debris facies at Padberg [6].

In summary, almost all regional reef drowning and extinction phases can be aligned with global transgressive or anoxic events

References: [1] Löw, M., Söte, T., Becker, R. T., Stichling, S., May, A., Aboussalam, Z. S. and Zoppe, S. F. (2022) *Palaeodiv. Palaeoenv., 102,* 573-612. [2] Becker, R. T., Aboussalam, Z. S., Hartenfels, S., Nowak, H., Juch, D. and Drozdzewski, G. (2016) *Münst. Forsch. Geol. Paläont. 108,* 76-101. [3] May, A. and Becker, R. T. (1996) *Berl. Geowiss. Abh, E18,* 209-241. [4] Stichling, S., Becker, R. T., Hartenfels, S., Aboussalam, Z. S. and May, A. (2022) *Palaeodiv. Palaeoenv. 102,* 629-696. [5] Errenst, C. (1993) *Geol. Paläont. Westf. 26,* 7-45. [6] Pisarzowska, A., Becker, R. T., Aboussalam, Z. S., Szczerba, M., Sobień, K., Kremer, B., Owocki, K. and Racki, G. (2020) *Glob. Planet. Change, 191*, 103211.

GEOCHEMICAL AND SEDIMENTOLOGICAL ANALYSIS OF THE UPPERMOST DEPOSITS OF THE UPPER DEVONIAN HANOVER SHALE IN WESTERN NEW YORK STATE

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ORAL

Introduction: The Upper Devonian shale succession of western New York State is notable for thick accumulations of interbedded black and gray shale. Many of the gray shale units contain numerous packages of thin black shale beds (TBSs). Such beds depict sharp basal contacts with underlying gray shale, upper contacts are sharp, often undulatory, and in some cases, bioturbated with planolites-type burrows. In effort to understand the depositional and diagenetic story behind these TBSs, we conducted a detailed analysis of the uppermost beds of the Upper Devonian Hanover Shale in a series of lakeshore and creek exposures in Chautauqua, Erie, and Wyoming counties.

Stratigraphic Setting: The Hanover Shale in western New York comprises gray, bioturbated mudstone, with numerous packages of TBSs, occasional carbonate concretion horizons and siltstone beds. Near the top of the unit a conspicuous black shale, the Point Gratiot Bed marks the culmination of the Upper Devonian Mass Extinction event. Overlying the Point Gratiot Bed is an eastward thickening wedge of gray to silty gray shale, occasional nodular carbonate, and an eastward increasing occurrence of TBSs. This wedge of shale, here termed the Beaver Meadow Beds thickens from 15 cm at its western most exposure at Pt. Gratiot, NY, to over 8 meters along Beaver Meadow Creek in Java Village, NY, a distance of approx. 75 kms. The Dunkirk Shale unconformably overlies the Beaver Meadow Beds, and the basal contact is often marked by the presence of a detrital pyrite lag.

Methods: A 41 mm diameter continuous core of outcrop sections was collected using Shaw Backpack drill. Cores were collected from approx. 1 meter above the contact with the overlying Dunkirk Shale to approx. 1 meter below the base of the Point Gratiot Bed. Cores were cleaned and cut into 1 cm "pucks" using a Dewalt 10" high-capacity wet tile saw. Pucks were disaggregated and powdered using an Across International PQ-NO4 100ml x 4 Planetary Ball Mill. The Powders were compressed into 32 mm diameter sample cups and analyzed by a Niton XL3t GOLDD+ X-Ray Fluorescence analyzer.

Results: Zirconium/Aluminum (Zr/Al) profiles through the Beaver Meadow Beds reveal distinct trends through TBSs. Thin black shale beds in the bottom of the Beaver Meadow sections, referred to as Type 1 black shales, show asymmetric to symmetric Zr/Al profiles where Zr/Al sharply increase at the base of the black shale from underlying gray shale values, achieve a maximum within the black shale, and gradually return to baseline gray shale values. It is noteworthy that the Zr/Al profiles often remain elevated, and do not return to background gray shale values for some distance above the top of the black shale. Thin black shale beds higher in the Beaver Meadow Beds, Type 2 black shales, display markedly different Zr/Al profiles. Gray shales underlying these beds demonstrate a largely uniform Zr/Al profile which is interrupted by an increase in Zr/Al associated with the thin black shale. The Zr/Al values generally return to a consistent baseline in the gray shale overlying the TBS, however, the Zr/Al values are often greater or less than those of the gray shale underlying the TBS. It is noteworthy that unlike the Type 1 black shale beds lower in the section, the Type 2 black shale beds are often accompanied by a detrital pyrite lag. In all sections examined, Type 2 thin black shale beds always occur above Type 1 black shale beds.

Gray shale underlying both types of thin black shale beds contain abundant pyrite in the form of pyritized worm burrows, nodules, and concretions. The size and occurrence of pyrite generally decreases down section from the contact between the base of the black shale and the underlying gray shale. Iron/Al (Fe/Al) profiles through these intervals show a similar pattern where Fe/Al values achieve a maximum within the black shale, or at its base. The Fe/Al values remain elevated decreasing to background gray shale values some distance below the TBS. Indeed, Fe/Al ratios are highest in the gray shale where macroscopic pyrite is present.

Discussion: The Zr/Al profiles through Type 1 TBSs are consistent with their deposition as hyperpycnites. The increasing Zr/Al reflects increased energy during the flood stages of river systems transporting sediment to the sea, while the decreasing Zr/Al profile reflects the waning stage of the flood. Moreover, pyrite masses found within these deposits may represent fossilized fecal pellets of organic matter which accumulated in a nearshore estuary or lagoon. We interpret Type 2 TBSs as transgressive black shales. As sea level rose, the pycnocline impinged on the seafloor, eroding underlying gray muds and leaving behind placer-like lags of detrital pyrite. Continued sea-level rise led to the deposition of organic-rich black muds over pyrite lag. Subsequent sea level drop resulted in the renewed deposition of gray muds, often under different depositional conditions as evinced by the different Zr/Al baselines.

The Fe/Al profiles are interpreted to reflect fossilized hydrogen sulfide fronts diffusing into underlying gray muds. Bacterial sulfate reduction of organic matter within the black muds consumed the local supply of reactive iron long before the production of hydrogen sulfide ended. While much of the hydrogen sulfide likely diffused into the overlying water column, some portion of it diffused into underlying sediment. Here, the hydrogen sulfide scavenged reactive iron to form nodular and concretionary pyrite. Decreasing Fe/Al values down section from the base of thin black shales, and the notable decrease in the size and occurrence of visible pyrite point to the slowing and eventual arrestment of downward diffusing hydrogen sulfide.

Finally, the sharp upper contacts of these thin black shales warrant explanation. Elevated Zr/Al profiles some distance above the tops of the hyperpycnites suggests that the present-day thickness of a TBS may not represent original depositional thickness. Oxygen, aided by bioturbation, may have diffused downward into the TBS, oxidizing organic matter, and remobilizing redox sensitive trace elements in a process known as "burn-down".

Summary: In sum, The Beaver Meadow Beds represent deposition during transgression. Rising sea-level flooded nearshore river mouths creating estuaries and lagoons where organic matter accumulated. Occasional storms flushed this material out to the deeper basin where it was deposited as hyperpycnites. Continued sea level rise led to the deposition of transgressive black shale. Minor changes in sea-level led to numerous transgressive black shale/gray shale cycles before transgression culminated in deposition of the overlying Dunkirk Shale. After deposition, excess hydrogen sulfide diffused out of organic-rich muds into underlying gray shale forming abundant pyrite. The return of (dys?)oxic water and deposition of gray muds over black shales led to burndown likely aided by bioturbation.

ECOLOGICAL-EVOLUTIONARY PATTERNS AND PROCESSES IN THE DEVONIAN OF THE APPALACHIAN BASIN

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Introduction: The well-preserved Devonian record of the Appalachian Basin in eastern North America has proven a natural laboratory for the study of evolutionary paleoecology. Edredge and Gould's seminal hypothesis of punctuated equilibrium within species lineages [1] was based in large measure on Devonian phacopid trilobites from New York. At nearly the same time, two papers on faunal associations in the Middle-Upper Devonian in New York [2,3] provided exemplars of the community paleoecology approach. Brett and Baird [4] attempted to bridge evolutionary and ecological approaches in mid-Paleozoic faunas with a special focus on the rich fossil assemblages of New York State.

Coordinated Stasis: The pattern of Coordinated Stasis [4] describes morphological and ecological stability in basin-wide faunas over extended intervals of geologic time (10^5 to 10^6 yrs) with original examples from the Silurian-Devonian marine faunas of eastern North America. These "ecological-evolutionary subunits" (EESUs) are separated by episodes of rapid faunal change. For example, the most studied of these units, the Middle Devonian Hamilton fauna of New York, shows a high degree of persistence of both species (~80%) and biofacies through the majority of the Givetian Stage [5]. The absence of significant morphological change in a majority of lineages over long time intervals and across their biogeographic ranges indicates that phyletic change is negligible during most of geologic time and <u>morphological stasis</u> prevails. A combination of stabilizing selection, habitat tracking, and incumbency likely maintains morphological stasis during these times, despite significant oscillations in sea level and environmental shift.

EE subunits also display a strong degree of <u>ecological stasis</u> [5, 6]. Biofacies and gradients of faunal distribution are relatively stable in terms of overall species composition, richness, and guild structure, although there are frequent short term fluctuations in relative abundance and some short-lived proliferations or incursions of a few species (epiboles). Despite geographic shifts in faunal associations over 100s of km during 4th order (~10^5 yr) cycles of relative sea level change, faunal associations/gradients appear to track shifts in environment with considerable fidelity. In addition, there are predictable changes in the areal extent of particular communities or biofacies during transgressive-regressive cycles. For example, during times of regression and sediment progradation, high diversity, coral-rich biofacies adapted to shallow shelf, clean water environments, may contract along depositional strike to a small fraction (<1/4th) of their most expansive distribution during times of transgression and associated offshore siliciclastic starvation. Yet, again, despite these strong changes in geographic distribution there appears to be minimal change in the ecological properties of the biofacies. These patterns do not necessarily require ecological locking [7], but minimally they indicate that species tend to maintain the same fundamental niche; i.e., there is little niche modification or evolution during EE subunits [8].

A further important aspect of the pattern is <u>coordinated faunal turnovers</u> that include extinction, migration and speciation, as well as ecological reorganization. In many cases, these changes can be constrained to portions of small scale cycles, typically late transgressions to early highstands, representing intevals of time on the order of 10^3 to 10^4 yrs. They appear to record times of climatic instability and may be characterized by rapid fluctuation of biogeographic boundaries, akin to Vrba's Turnover Pulse model [9]. It should be noted that these times of rapid fluctuation bound relatively stable intervals (EESUs) that may span from <100,000 to several million years. For example, the Givetian in the

Appalachian Basin shows high volatility at the stage level. However, it contains the remarkably stable Hamilton fauna, which persisted for more than 3 million years, even though it is bracketed by the short-lived Stony Hollow (below) and Lower Tully (above) EESUs [10].

Volatility and Faunal Turnover: Newly developing high-resolution chronostratigraphy for the Devonian reveals the environmental framework within which long-term stasis and rapid evolutionary and ecological change occurs. EESUs persist longest during intervals, such as the Emsian Stage, of comparatively low-amplitude variation in climate, sea level, and the carbon cycle, as reflected in stable isotope records [11]. In contrast, intervals, such as the late Eifelian to Frasnian, show a much higher degree of environmental volatility. Such intervals of comparatively abrupt, clustered fluctuations in climate, often associated with hypoxia and sea-level rise, may drive regional or global benthic assemblage turnovers, migrations, and speciation. Associated conodont and ammonoid biozonal durations are short during volatile intervals, suggesting similar evolutionary and biogeographic responses in the nekton as well. These patterns indicate that volatility in the global ocean-climate system is a primary driver of macroevolution, at least during the Devonian Period, although the ultimate causes of alternating intervals of environmental volatility and prolonged stable times remain unclear.

Fertile areas for future inquiry include both a) further tests of the association of patterns of faunal stasis and turnover, with more detailed records of environmental change, and b) tests of the generality of the patterns of stability and change observed in other time intervals and environmental settings. It will be important, going forward, to document the relative stability as well as the timing and severity of faunal turnovers in post-Paleozoic assemblages to determine whether or not coordinated stasis signals persist into the age of higher diversity, metabolically enabled, benthic associations.

References: [1] Eldredge, N. and Gould, S. J. (1972) *Models in Paleobiology*, 82-115. [2] Bowen Z. P. et al. (1974) *Lethaia, 7,* 93-120. [3] Thayer C. W. (1974) *Lethaia, 7,* 121-155. [4] Brett, C. E. and Baird G. C. (1995) *New Approaches to Speciation in the Fossil Record*, 285-315. [5] Brett, C.E., et al. (2007) *Palaios, 22*, 306-324. [6] Ivany, L. et al. (2009) *Paleobiology,* 35, 499-524. [7] Morris, P.M. et al. (1995) *Proceedings of the National Academy of Sciences*, *92*, 11269-11273. [8] Brett, C.E. et al. (2016) *Evolutionary Theory: A Hierarchical Perspective.* University of Chicago Press, 282-306. [9] Vrba, E. (1985) *South African J. of Sci. 81*, 229-236. [10] Brett, C.E. et al. (2009) *Geological Society of London, Special Publications, 314*, 7-36.[11] Brett, C.E. et al. (2020) *Palaeogeography, Palaeoclimatology, Palaeoecology, 549,* 1-10.

PYRITE FRAMBOID DISTRIBUTIONS AS INDICATORS OF ANOXIA: CAN WE USE THEM IN SHALLOW WATER ENVIRONMENTS?

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Depending on the environment of deposition, stratigraphic intervals that are associated with marine anoxic events may be exhibited as a black shale sequence, an organic-rich carbonate sequence, an organic-poor carbonate sequence, a turbidite sequence, or a shallow-water nearshore sediment sequence. In the sediments that do not display obvious visual evidence of anoxia in the field (i.e. black shale layers), multiple ichnological, geochemical, mineralogical, and isotopic proxies can be used to infer the presence or absence of anoxia. Most of these proxies provide a binary "presence vs. absence" indicator of anoxia; however, pyrite framboid distributions and the amount of bioturbation are both ways that the relative severity of oxygen stress can be assessed in the rock record.

In the absence of obvious trace fossil evidence, pyrite framboid distributions become the primary way to measure the degree of anoxia. Pyrite framboids are aggregated microcrystalline pyrite spheres that appear similar to raspberries under scanning electron microscopy (Fig 1). The size and shape of these individual framboids are functions of the degree of anoxia in the marine water column. To assess the severity of anoxia, pyrite framboids are counted and their diameters are measured using scanning electron microscopy, and the diameters are plotted in a histogram (Fig. 2). Based on studies in modern reduced oxygen settings, a histogram with framboids clustered in the 3-5 µm range indicates a euxinic water column (where anoxia is so severe that free H_2S is present), anoxia is represented by pyrite framboids primarily ~ 5 µm or less, but with a wider size distribution. Dysoxic/suboxic conditions result in pyrite framboid distributions where the size range is far greater (from 5-10 µm, with some framboids up to 20+ µm in diameter) [1]. If there are no framboids present, the water column is likely oxygenated.

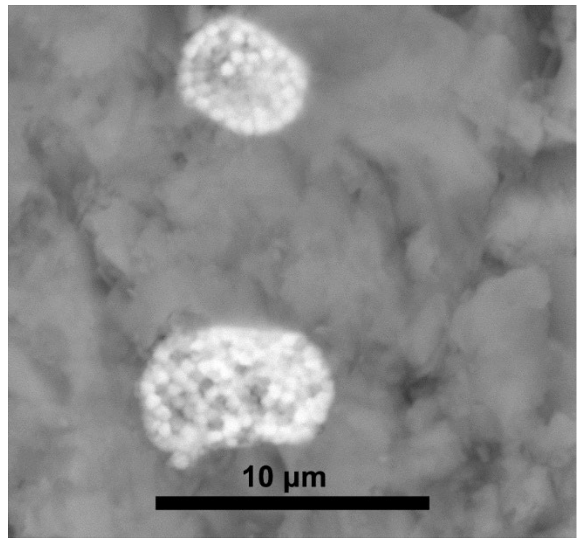

Fig.1. Pyrite framboids in a clay, quartz, and albite-rich sediment (modified from [2]).

In our research, pyrite framboid distributions have proven useful in detecting and assessing the severity of anoxia in both the Kellwasser and Hangenerg Events in sections around the globe that lack black shales. Their utility can be complicated by the presence of framboid-filled burrows that are invisble at the hand sample scale (Fig. 3). Framboid-filled burrows reflect anoxic conditions within the burrow itself due to microbial sulfate reduction of organic waste material trapped in the burrow, and do not reflect the overall level of oxygenation in the water column.

In cases where the only framboids that are present are within burrows, the water column is likely fully oxygenated. In cases where framboids are not in burrows but are scattered individually throughout the sample, the pyrite size distribution histograms can be used to assess the severity of oxygen loss. In cases where there are both individual framboids throughout the sample, as well as framboids within burrows, care must be taken to eliminate the framboids within the burrows from the size distribution analysis. As demonstrated by the bioturbation index, burrows may be present even in sediments with reduced oxygen levels, so samples with framboid-filled burrows cannot be discounted when assessing sediment packages for signatures of anoxia.

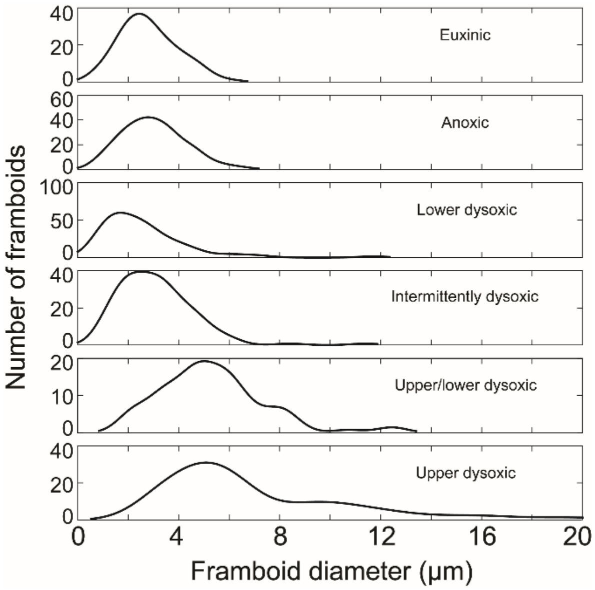

Fig 2. Pyrite framboid distributions showing the degrees of oxygen stress severity, based on histogram shape [3].

Most studies of ocean anoxia using pyrite framboid distributions have been focused on deeper water environments and the assessment using these distributions was relatively straightforward, where the severity of anoxia corresponded to known ocean anoxia events. Our research on the Kellwasser and Hangenberg Events spans both deep and shallow water sections in a variety of paleoenvironments, from shallow to deep water carbonates, mudstones in tectonic and foreland basins, and open ocean volcanic island arc settings at a variety of depths. Like previous studies, our assessment of anoxia using pyrite framboid distributions in deeper water sections was relatively straightforward and corresponded to both the expected stratigraphic interval of anoxia as well as other geochemical and isotopic proxies. In contrast, our ongoing assessment of anoxia in shallower water environments shows a far more complex picture and may reflect local conditions rather than global conditions.

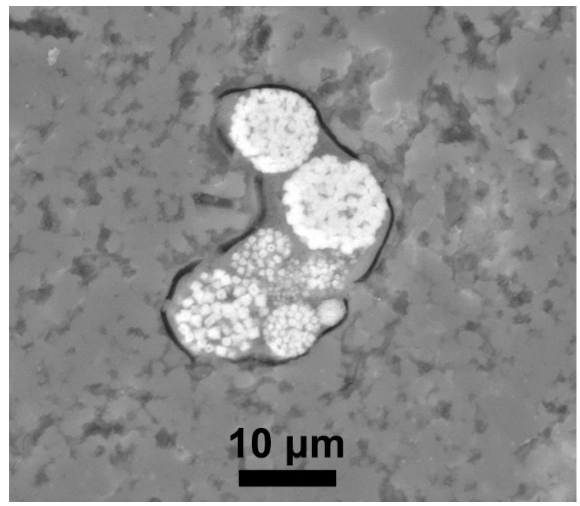

Fig 3. Framboids in burrows (modified from [2])

References:

[1] Wignall and Newton (1998) *Am. J. Sci.*, 298(7), 537-552.

[2] Carmichael et al. (2016) *Gondwana Res.*, 32: 213-231.

[3] Paschall et al. (2019) *Global Planet. Change*, 175, 64-81.

NUMERICAL SIMULATIONS OF THE EFFECTS OF ASTRONOMICAL FORCING ON NUTRIENT SUPPLY AND OXYGEN LEVELS DURING THE DEVONIAN

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Declining oxygen levels in the ocean since the middle of the 20th century have been linked to increasing temperatures, CO_2 concentrations, and nutrient inputs. In the geological past, numerous oceanic anoxic events have occurred under similar conditions. These events, during which dissolved oxygen in the ocean drop to potentially harmful levels, can have serious consequences for marine life and can also alter the geochemistry of the ocean.

The sixty million years Devonian stage was the theatre of at least 29 identified anoxic events [1], marked most of the time by the deposition of black shales, associated with carbon isotopic excursion. It is understood that concurrent trends in CO_2 and silicate weathering during the Devonian period have generated a context prone to ocean anoxia. On the other hand, there is growing evidence that their periodic recurrences in sedimentary records may have been influenced by astronomical forcing, such as changes in Earth's axis rotation and orbit geometry [2,3].

In the umbrella project WarmAnoxia, we combine climate models and geological observations to explore and test proposals linking astronomical forcing to Devonian anoxia. Through this presentation, we focus specifically on the hypothesis that astronomical forcing influenced precipitation and temperature patterns in a way that significantly modified soil weathering dynamics, with enough effects on nutrient fluxes toward the ocean to promote oceanic anoxia.

To test this proposal, we performed 81 experiments with the global atmosphere-slab model HadSM3. Experiments have been designed to span the range of astronomical forcing and CO2 concentrations experienced during the Devonian. The output was used to calibrate an emulator. With the latter, we estimate the transient evolutions of temperature and precipitation over 5 million-year periods, for which we assumed both simplified and realistic astronomical forcing scenarios. In turn, these transient evolutions force the GEOCLIM model [4], which simulates soil dynamics, estimates nutrient fluxes from the continents to the oceans, and the response on the oceanic chemistry and atmospheric oxygen levels.

The presentation also highlights progress in the simulation of deep ocean dynamics during the Devonian, using the model of intermediate complexity cGENIE.

References:

[1] Becker R.T. et al. (2020), The Geological Time scale, 10.1016/B978-0-12-824360-2.00022-X

[2] Da Silva A. et al., (2020), Scientific Reports, 10 (12940) doi:10.1038/s41598-020-69097-6

[3] De Vleeschouwer D., A. Da Silva, M. Sinnesael, et al. (2017),Nature Communications, (8) art. 2268, None doi:10.1038/s41467-017-02407-1

[4] Maffre P. et al., (2022) American Journal of Science, (322) 461–492,

REASSESSING HYDROCARBON VOLUMES OF THE DEVONIAN SHALES IN EASTERN OHIO AT MEMBER-LEVEL SCALE

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POSTER

Background: Middle and Upper Devonian siliciclastic rocks exposed in a north-to-south trending outcrop belt through central Ohio and along Lake Erie were deposited on the western edge of the Appalachian Basin during the Acadian Orogeny. These units are composed of mostly shales and mudstones with minor carbonates, siltstones, and sandstones that range from the top of the Middle Devonian limestones (e.g., Columbus and Onondaga limestones) through the upper Famennian Bedford Shale and Berea Sandstone (Fig. 1). From the westernmost part of the outcrop, where the Middle to Upper Devonian succession can be as thin as 500 feet (~150 meters), these rocks dip eastward into the subsurface and expand to almost 4,000 feet thick (>1,200 meters) at the eastern border of the state.

Many parts of the shale units in this succession are organic-rich and hydrocarbon baring. In Ohio, these include the Marcellus Shale, Rhinestreet Member of the West Falls Formation, lower part of the Huron Member of the Ohio Shale, and Cleveland Member of the Ohio Shale. Several studies were conducted between the 1970s and the 1990s to assess the hydrocarbon resource potential of these organic-rich shale units across the Appalachian Basin. The advent of unconventional drilling technology and the potential for CO_2 sequestration in organic-rich rocks spurred further research on these units over the past decade. This has resulted in a large quantity of data being produced for these shale units in Ohio, though few studies have been done at the formation or member-level scale. The goals of this project are to compile the disparate data from several past projects into a curated dataset, and to use the dataset to produce a general estimate of hydrocarbon resource volumes for the Devonian shale units within Ohio.

Assessment Methods: The Rhinestreet Member and lower Huron Member are the initial focus of this study as they are the most extensive and organic rich of the Devonian shale units in Ohio [1], [2]. Waid [3] developed a stratigraphic

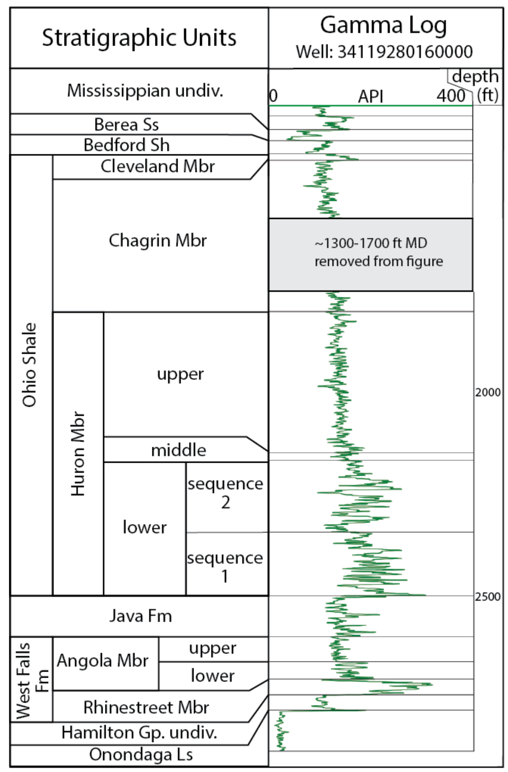

Figure 1. Typical gamma-ray log from Muskingum County showing stratigraphic nomenclature for the Middle and Upper Devonian interval in eastern Ohio.

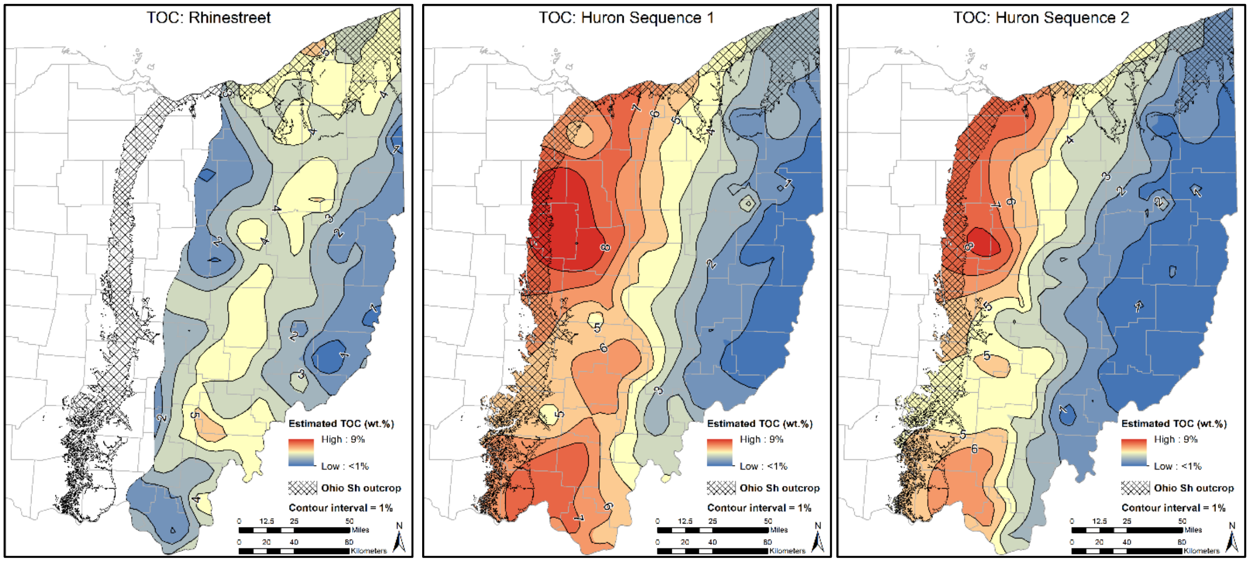

Figure 2. Average estimated total organic carbon (TOC) content in weight percent for the Rhinestreet Member of the West Falls Formation and for sequences one and two of the lower Huron Member of the Ohio Shale (see fig.1 for sequence definition). The relationship between measured TOC from five cores and their associated gamma-ray and density logs defined the equation used to estimate TOC from geophysical logs in 175 wells across the eastern half of Ohio.

framework for these units in the subsurface using over 800 geophysical well logs across the eastern half of Ohio. Two sequences in the lower Huron were identified and correlated across the study area, which helped us assess the lower Huron at a finer stratigraphic resolution as it reaches thicknesses over 1,000 feet (~300 meters) in the easternmost part of the state. Thickness was mapped for each sequence in the lower Huron and for the Rhinestreet.

To initially assess the Rhinestreet and lower Huron for hydrocarbons, total organic carbon (TOC) content and thermal maturity of each unit were mapped across eastern Ohio. TOC measurements from Devonian cores in Ohio have a limited spatial resolution, so to achieve a more even data distribution across the study area we used digital geophysical logs to estimate TOC. Measured TOC data from cores sampled in previous studies (e.g., [4], [5]) were used to determine the relationship between measured TOC and gamma-ray and density log responses. The resulting equation ($R^2 = 0.65$) was applied to 175 wells across the study area. The average TOC values estimated for each unit were mapped for the Rhinestreet and both lower Huron sequences (Fig. 2).

Thermal maturity was assessed using vitrinite reflectance and Tmax data from programed pyrolysis. Data collected from both cores and cuttings were compiled from previous studies (e.g., [4], [6]). Approximately 2,000 samples of either measured vitrinite reflectance or Tmax were found to have been collected through most of the Devonian shale units in 72 wells. This sample size provides adequate coverage across eastern Ohio. The resulting thermal maturity map was used to determine the extent of the oil window in Ohio. Within the oil window, density logs were used to estimate the porosity of the units. Potential oil volumes were calculated using the estimated porosity and unit thickness maps.

References: [1] Gray J. D. et al. (1982) *U.S. DOE Report No. DOE/ET/12131-1399*. [2] Roen J. B. and Kepferle R. C. (1993) *USGS Bulletin 1909*. [3] Waid C. B. T. (2018) *Ohio Geo. Survey GN 13*. [4] Zielinski R. E. and McIver R. D. (1981) *U.S. DOE Report No. DOE/DP/0053-1125*. [5] Repetski J. E. et al. (2008) *USGS Scientific Investigations Map 3006*. [6] Exlog/Brown & Ruth Lab. Inc. (1988) *Gas Research Institute, GRI 88/0223, Contract No. 5085-213-1181*.

THE HANGENBERG CRISIS (DEVONIAN-CARBONIFEROUS BOUNDARY) TIMING AND CLIMATIC FORCING (CHANXHE AND ANSEREMME SECTIONS, BELGIUM).

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The Hangenberg Crisis, at the Devonian-Carboniferous Boundary, severely affected the marine realm. The crisis is characterised by several events associated with change in the sedimentation and biotic extinctions and turnovers. The Hangenberg Black Shale event that recorded the extinction peak in the pelagic realm corresponds to a widespread development of oceanic anoxia and/or dysoxia. The Hangenberg Sandstone event is associated with an extinction of neritic fauna in shallow-water settings, including the final demise of several classical Devonian faunas (stromatoporoids, quasiendothyrid foraminifers, placoderms, etc.). The succession of these events is nowadays explained by a combination of sea level fluctuations (third order transgressive sequence, out-of-sequence regression) and global climatic changes. Through the identification of Milankovitch cycles in the Chanxhe and Anseremme records, we aim at getting a better understanding of the timing and orbital forcing of the different events of the Hangenberg Crisis in shallow-water settings.

The sedimentary record of the interval of interest at Chanxhe is composed of 16 m of alternating decimetre-thick carbonate beds with shaly siltstones, which displays a clear cyclicity. The carbonate-siliciclastic alternations (~0.8 m) are bundled into larger cycles (~5 m) which are separated by intervals dominated by the shaly facies. This is followed by 11 m of carbonate dominated lithology with thin shale layers displaying a less clear cyclicity with ~3 m thick cycles. Then the equivalent of the Hangenberg dark shales is recorded as two dark shaly intervals separated by a carbonate bed. After the Hangenberg dark shales, the section displays carbonates, with the Devonian Carboniferous boundary in massive carbonates 7 m above the top of the black shales. The Record at Anseremme, is characterized carbonate-siliciclastic alternations (~0.8 m) bundled into larger cycles (~5 m) and the lithology remains much more stable. Samples have been collected along these records every 10 cm which were measured by the portable X-Ray Fluorescence device (Tracer 5, Bruker) and magnetic susceptibility with a selection of samples for carbon isotopes. Spectral analysis is applied on Ca and Al, to identify the main cyclicity in the record. The 0.8 meter-thick limestone/shale alternations is clearly recorded in the Ca and Al records and are associated with precession cycles (18 kyr), while the 5 m-cycles are associated with short eccentricity (100 kyr). Prior to the Hangenberg anoxic events, the 100-kyr cycles became less clear and shorter (~ 3 m) which is interpreted as a long-term (equivalent to 2.4 Myr) minimum eccentricity. During and after the Hangenberg, the cyclicity returns. Severe anoxic events such as the Oceanic Anoxic Event II in the Cretaceous, as well as the upper Kellwasser Devonian anoxic event have been associated with long term eccentricity minima. It is essential to better understand the mechanism behind the astronomical forcing and anoxia expansion, and the identification of the long-term minima through the geologic time scale is key to better understand the climate forcing.

THE KINGSTON RECORD, NEW YORK STATE, U.S.A – A WINDOW TO THE DEVONIAN PALEOCLIMATE AND TO THE DURATION OF PART OF THE EMSIAN.

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ORAL –

The Emsian is among the Devonian stages with the least U-Pb constraints, together with the Givetian. These two Stages are classically used as an adjustment variable for the Devonian time scale and they are stretched or squeezed depending on the new age constraints obtained for other Stages. Indeed, the duration of the Emsian swung between ~4 Myr (Harland et al., 1990) and ~17 Myr (Kaufmann, 2006). So, any new constraints on its duration is essential. We introduce the Kingston record in New York State (U.S.A.), which goes through part of the Schoharie Formation. It is characterized by exceptional Milankovitch forcing color patterns visible at the outcrop. It is a window through the paleoclimate of the Devonian, as well as a precise chronometer part of the Emsian. We propose high resolution portable XRF measurements, magnetic susceptibility, spectrophotometry and carbon isotope for the Kingston record. At the outcrop scale, 3 main type of cyclicities can be identified with the smallest cycle corresponding to dark-light beige alternations. Five to seven of those alternations occur between distinctive light white to orange beds. Four of these medial-scale cycles then bundle into larger scale cycles. So, there is a ratio of ~24:4:1 between these cycles, which fits well with the ratio between precession, short eccentricity and long eccentricity for the Devonian (23.6:4:1). These cycles are clearly recorded also in the PXRF records, as well as magnetic susceptibility, but they are less clear into the spectrophotometry record and carbon isotopes. This allows to transform the record from the distance domain into the time domain. It also includes a maxima long term eccentricity (today 2.4 Myr) in the middle of the record, marked by the best development of cyclicity. We also propose to use these data as constrains for the duration of the precession cycle in the Devonian.

UPPER DEVONIAN LOWER AND UPPER KELLWASSER EXTINCTION RECORD IN THE SWEETLAND AND GRASSY CREEK SHALES IN THE IOWA BASIN OF CENTRAL NORTH AMERICA

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ORAL

Introduction: The Sweetland Creek and lower Grassy Creek shales in Muscatine County in eastern Iowa comprise a condensed deep ramp succession of hemipelagic shales and mudstones that accumulated seaward of the Lime Creek Formation carbonate platform that transitions into the western Illinois Basin (Fig. 1) [1, 2]. These facies are equivalents to the Selmier Shale Member of the New Albany Shale in the adjacent Illinois Basin, although they differ in that they are thermally pristine as indicated by conodont CAI values of 1 [1,2,3]. Continuous sampling in 2016-2020 of the type section of the Sweetland Creek Shale and overlying Grassy Creek Shale (Fig. 2) yield conodont faunas of spanning Frasnian Zones 11 and 12, Subzones 13a to 13c, and the Lower Famennian *Palmatolepis subperlobata* to *Pa. triangularis* Zones. Species LADs and FADs clearly identify the Lower and Upper Kellwasser extinction (LKE and UKE) intervals.

Frasnian Zone 11: A diverse fauna, first reported from two samples in 1992 [4] from the basal 50 cm shale, complemented by three new samples collected in 2020, includes: *Palmatolepis semichatovae, Pa. proversa, Pa. kireevae, Ancryodella hamata*, *Ancryognathus iowensis*, *Icriodus symmetricus*, *Pa. ljaschenkoae*, *Pa. plana*, *Pa. playfordi, Pa*. aff. *Pa. rhenana, A. gigas* form 3, *A. curvata* early form, and *A. curvata* late form. The lower 20 cm of the "siltstone" is marked by additional FADS of *Pa. amplificata*, *Pa. hassi* s .l., *Polygnathus unicornis*, *P. webbi, P. decorosus,* and *Ag. triangularis*. Additional *s*tepped FADs of *Ancryognathus? deformis, P. politus, P. brevis, P. sublatus,* and *Mehlina gradata* occur in the overlying 30 cm of the "siltstone*"* (Fig. 2).

Frasnian Zone 12: The lowest occurrence of *Pa. foliacea* with *Pa. rehnana* identifies the base of Zone 12 in the upper 5 cm of the "siltstone" above a prominent prytitic hardground. Above the "siltstone"-capping hardground, *Pa. winchelli* and *Ag. asymmetricus* have their FADS in the lower Zone 12 interval.

Frasnian Subzone 13a: The base of Frasnian subzone 13a is 185 cm above the base of the Sweetland Creek Shale, identified by the FAD of *Pa. bogartensis*, with FADs of *Pa. hassi* s .s., *Ag. calvini, Ag.* sp. aff *Ag. altus, P. alatus, P. brevicarina, and Ozarkodina dissimilis* low in Subzone13a. In Iowa, *Ag calvini* is restricted to a 35 cm interval low in Subzone 13a. Its LAD high in Frasnian Subzone 13b to lower 13c in southern New Mexico.

Lower Kellwasser Extinction and Crisis Interval: The LKE is marked by the LADs of *Pa. kireevae, Pa. amplificata, Pa. foliacea* and *Pa. muelleri*. The LKE interval is 45 cm thick spanning the upper part of Frasnian Zone 12 and extending into the lower part of Frasnian Subzone 13a in the Sweetland Creek Shale with the onset denoted by the occurrences of pathogenic (teratological) *Ag. asymmetricus*, with pathogenic specimens of *Ag.* aff. *Ag. altus*, *P. decorosus*, and *Palmatolepis winchelli*? And *Pa. n.sp*. defining the LKE crisis interval in the lower 30 cm of Subzone 13a.

Frasnian Subzones 13b-c and the Upper Kellwasser Extinction Interval: The FAD of *Pa. linguiformis* defines the base of Subzone 13b. The onset of the UKE is marked by LADs of *Pa. boogardi* 5 cm below, and *P.alatus* immediately below the first K-bentonite bed in the lower Grassy Creek Shale. Extinctions of most typical Frasnian conodont taxa characterize the 15 cm thick UKE crisis interval (Frasnian Subzone 13c) with species LADs of surviving typical Frasnian conodont taxa immediately below the second K-bentonite bed in the Grassy Creek.

Earliest Famennian: Frasnian survivors (*P. decorosus*) and FADS of *Pa subperlobata* and *Ancyrognathus cryptus* early form denote the position the lowermost Famennian and F-F boundary at the base of the second K-bentonite bed in the Grassy Creek Shale at this location.

Famennian conodont zonal boundaries and Lower and Upper Kellwasser Extinction interval (LKE and UKE) positions based species FADs and LADs. Numbered Zones 3-4, 11, 12, 13a, 13b and 13c are Frasnian Zones or Subzones of [8]. Early Famennian zones: sup = *Palmatolepis subperlobata*, follow the current usage [9].

[1] Day, J., and Witzke, B.J. (2017) *Strat & Time-scales 2* 243-332. [2] Day, J. (2022) *ICOS P&A*. [3] Johnson, J.G., and Klapper, G. (1992) *OGSB 145* 127–135. [4] Day, J., Witzke, B.J., and B. Bunker (2008). *ISSGB 28* 15-39. [5] Day, J., Witzke, B.J., and B.J. Bunker (2013) *IGSGB 29* 1-40. [6] Johnson, J.G., Klapper, G., and Sandberg, C.A. (1985). *GSAB 96* 567–587. [7] Day, J. (1998) *APP 43* 205-240. [8] Klapper, G. and Kirchgasser, W.T. (2016) *JP 90* 525-554. [9] Spalletta, C., Perri, M.C., Over, D.J., and Corradini, C. (2017). *BG 92(1)* 31–57. [10] De Vleeschouwer, D, M.T. Whalen, J. Day, and P. Claeys (2012) *GSAB 124* 928-942. [11] De Vleeschouwer D., Da Silva A.-C., Sinnesael, M., Chen, D., Day, J., Whalen, M.T., Guo, Z., and P. Claeys (2017) *NatCom 8:2268* 11 pp. [12] Pas, D., Hinnov, L., Day, J.E., Kodama, K., Sinnesael, M., Liu, W. (2018) *EPSL 488* 102–114. [13] Over, D.J.(2002) *PPP 181* 153-170. [14] Over, D.J. (2006) *IGSGB 26* 74–79.

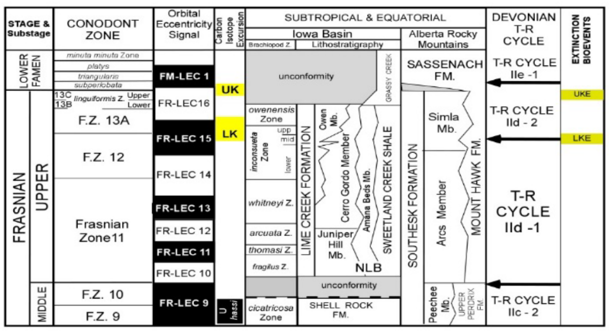

Figure 1.—Chronostratigraphy of the Late Devonian (Middle Frasnian to Early Famennian) strata of the Iowa Basin. See Devonian lithostratigraphy in [4,5,1]. Qualitative Euramerica Devonian eustatic T-R cycles in [6,3]; Late Frasnian subdivisions proposed in [7]. Upper Devonian (Frasnian) conodont biostratigraphy follows [8], and the Famennian global standard zonation [9]. Devonian brachiopod biostratigraphy from Day in [1]. Magnetic Susceptibility Cyclostratigraphy for the Late Frasnian and Early Famennian from [10, 11, 12]. Abbreviations: NLB = North Liberty Beds; Fm. = Formation, Mb. = Member; LKE = Upper Kellwasser Event, UKE = Upper Kellwasser Event; FR-LEC = Frasnian Long Eccentricity Cycle, FM-LEC = Famennian Long Eccentricity Cycle. Modified from fig. 3 in [1].

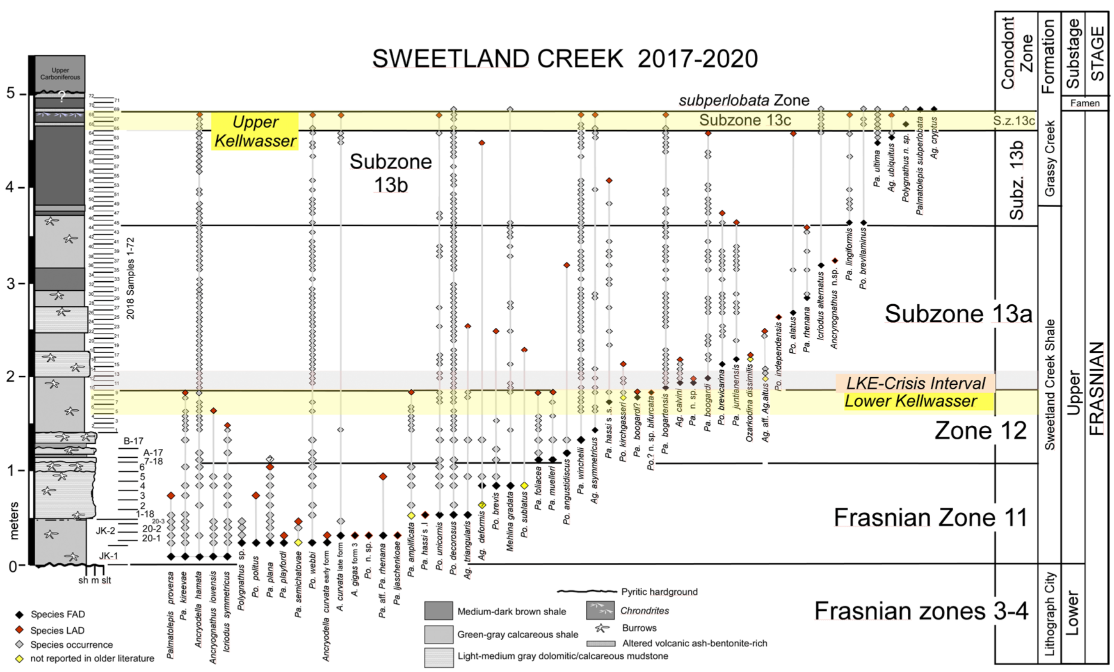

Figure 2.—Type section of the Sweetland Creek Shale exposed on Sweetland Creek, Muscatine County, Iowa in June of 2016- 2021 (see location in [1,13,14]; appendix 1 of [8], p. 28). Composite of lower two samples reported by Klapper in [3], p. 132, fig. 2), new samples collected by Day in 2017 (A-17 & B-17), 2018 (1-18 to 7-18, SC-1 to SC-80) and 2020 (20-1 to 20-3). Frasnian and Famennian conodont zonal boundaries and Lower and Upper Kellwasser Extinction interval (LKE and UKE) positions based species FADs and LADs. Numbered Zones 3-4, 11, 12, 13a, 13b and 13c are Frasnian Zones or Subzones of [8]. Early Famennian zones: sup = *Palmatolepis subperlobata*, follow the current usage [9].

MAPPING THE MIDDLE AND UPPER DEVONIAN MARINE-NONMARINE TRANSITION IN THE APPALACHIAN BASIN FROM WEST VIRGINIA TO NEW YORK

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ORAL

Introduction: Middle and Upper Devonian strata representing the transition from the marine to nonmarine environment in the Appalachian Basin have proven to be problematic for consistent geologic mapping and stratigraphic correlation for decades. The units that represent this environment include the Foreknobs Formation in West Virginia, Virginia and Maryland, and the Irish Valley Member of the Catskill Formation in central and northeastern Pennsylvania; strata representative of this transition have yet to be consistently mapped within north-central Pennsylvania and south-central New York. In central and north-eastern Pennsylvania, these strata are generally included within the lower part of the Catskill Formation. In south-central New York near Binghamton these strata have been placed within the West Falls Group, but formation-level units have yet to be formally defined. Further to the east near Wurtsboro, New York, these strata have been placed either within the Oneonta Formation of the Genesee Group or in the upper part of the Hamilton Group [1].

Approach: In order to achieve better consistency in the identification and mapping of these transitional units, we recommend revising existing stratigraphy to formally define the intercalated marine, marginal marine, nonmarine strata into a separate formational lithostratigraphic unit. Over the course of a decade, the authors have traced this interval of transitional strata from southeastern West Virginia to north-central New York and have established criteria that may be used for consistently identifying a basal formational contact; namely, the first mappable occurrence of either a quartz-rich sandstone package containing rounded quartz pebbles or a series of conglomeratic beds that transition up section from interbedded, fossiliferous sandstone, siltstone, and shale. The quartz-rich sandstone package may be fossiliferous, but can be differentiated from sands lower in the stratigraphy by the greater abundance of quartz in the sand fraction. The presence of rounded quartz pebbles in high-angle cross-bedded sands, mud rip-up clasts, fossil hash beds within sandstones, and other indicators of nearshore storm and wave action all aid in identification of this unit. The first appearance of pebble-sized quartz clasts likely indicates the the arrival of deltaic and shoreline-derived detrital sediments into the basin [2]. The ultimateabsence of marine fossils intercalated with terrestrial sediments indicates the gradational upper contact with fully terrestrial strata.

This approach has been proven successful for reconciling numerous offsets within previously published geologic maps in the stratigraphic interval formerly represented by the Greenland Gap Group (Foreknobs and Scherr Formations) in the states of West Virginia and Virginia. Recent revisions to the Greenland Gap Group resulted in abandonment of the Scherr Formation and Mallow Member of the Foreknobs Formation. These strata are proposed to be placed within an informal upper member of the underlying Brallier Formation, and the base of the Foreknobs Formation is revised as being coincident with the base of the Briery Gap Sandstone Member of the formation [3].

Challenges: A primary challenge to implementing these stratigraphic changes northward is that the thickness of this interval greatly increases in central Pennsylvania and southern New York, making the heterolithic nature of the marine-nonmarine transitional interval more pronounced and more difficult to map with consistency. However, recent mapping in central Pennsylvania and southern New York has revealed that the first occurrence of quartz pebbles into marine strata can be used to identify the base of the marine-nonmarine transition. A second challenge for correlation is the time-trangressive nature of this transitional interval as it becomes younger from east to west, and from northeast to southwest [2, 4].

Sequence Stratigraphic Framework: The diachroneity of the marine-nonmarine transition means that the strata comprising these lithostratigraphic units will necessarily change in both time and space. However, the sensitivity of the transitional unit to base level changes provides variably resistent topographic expressions that, when combined with advancements in lidar-derived, high resolution topography, has allowed for the regional mapping of major surfaces and the construction of a basin-wide sequence stratigraphic framework for the interval. In this manner, we have traced two major third order cycles within the Foreknobs and Irish Valley from West Virginia into central Pennsylvania. In the Foreknobs Formation, two major base level low stands are represented by the Briery Gap and Pound Sandstone Members in West Virginia, Virginia, Maryland and into south-central Pennsylvania. Near Raystown Lake, Pennsylvania, the Briery Gap and Pound Sandstone Members have been shown to be equivalent to the informal Allegrippis sandstone and Saxton conglomerate members [4], respectively. Within the Irish Valley Member of the Catskill Formation at Selinsgrove, Pennsylvania, two sea level lowstands are separated by a distinct sea level highstand; however, intermeditate proposed fourth- and fifth-order parasequences [5] are not definitively traceable across the extent of the basin. Work is ongoing to trace the third-order cycles through northeastern Pennsylvania into southeastern New York.

References

[1] Rickard, L.V., Isachsen, Y.W., and Fisher, D.W. (1970) Geologic Map of New York—Lower Hudson sheet, New York State Museum Map and Chart Series 15, scale 1:250,000.

[2] Harper, J.A. (1999) Devonian, in Schulz, C.H., ed., The Geology of Pennsylvania, Chapter 7: Harrisburg, Pennsylvania Geological Survey, 109-127

[3] Doctor, D.H. (2020) How Scherr is it? Stratigraphic revision of the Upper Devonian Greenland Gap Group in West Virginia and Virginia based on mapping with lidar-derived elevation imagery, *Geological Society of America Abstracts with Programs*, 52(2), doi: 10.1130/abs/2020SE-344037

[4] Oliver Jr, W.A., de Witt Jr, W., Dennison, J.M., Hoskins, D.M., and Huddle, J.W. (1967) Devonian of the Appalachian Basin, United States, in *International Symposium of the Devonian System, vol. 1*. Calgary: Canadian Society of Petroleum Geologists, 1001-1041.

[5] Butts, C. (1945) Hollidaysburg-Huntingdon folio, Pennsylvania: U.S. Geological Survey Geologic Atlas of the United States Folio, GF-227, 20 p., scale 1:62,500

[6] Cotter, E., and Driese, S.G. (1998) Incised-valley fills and other evidence of sea-level fluctuations affecting deposition of the Catskill Formation (Upper Devonian), Appalachian foreland basin, Pennsylvania. *Journal of Sedimentary Research*, 68(2), 347-361.

A REVISED PALAEOGEOGRAPHY FOR THE FRASNIAN-TOURNAISIAN OF ANGARIDA (SIBERIA).

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POSTER

Introduction: During the Devonian, Angarida was a large and semi-isolated continent within the warm, arid zones of the northern hemisphere. In the Late Devonian, the Viluy-Yakutsk Large Igneous Province (V-Y LIP) had two active phases and dramatically altered the physical and chemical environment of both the terrestrial and the marine systems. Using fossils and facies, a revised palaeography of Frasnian to Tournaisian Angarida was reconstructed using GPlates [1] to map the changing terrain of the continent. Plate polygons were sourced from Torsvik and Cocks (2017, [2]). Both GEOCAB-SULFvolv [3] COPSE [4] with methods outlined in Marcilly et al (2021 [5]) were used to model changes in weathering, carbon, and climate based upon the revised palaeogeography.

Results indicate an increased availability of terrestrial environments between the Frasnain and Tournasian. The new palaeogeography also records the changing deposition of evaporites, and highlights alterations in terrestrial weathing. The alteration of terrestrial habitat availability has importance for the colonisation of Angarida by land plants, for changing weathering regimes, and their follow on effects on climate[6]. This revised palaeography is also the stage for the activity of the V-Y LIP, allowing local and regional study of its biotic impact with a view towards the global Late Devonian Biocrises.

The presented revision of the Frasnian-Tournasian palaeogeography of Angarida is part of an ongoing project aimed at studying the impact of Large Igneous Proviences on local to regional scales and over short time intervals.

References: [1] Müller, R. T. et al. (2018) GGG, 2243-2261. [2] Torsvik, T. H. and Cocks, L. R. M. (2017),CUPress. [3] Lenton, T. M. et al (2018), Geology, 627-630. [4]Royer, D. I. et al (2014) AM.J.Sci. 1259-1283. [5] Marcilly, C. M. et al (2021). GondRes, 97,176–203 [6]Dowding, E. M., et al. (2023) ProcRSocB, 20221079.

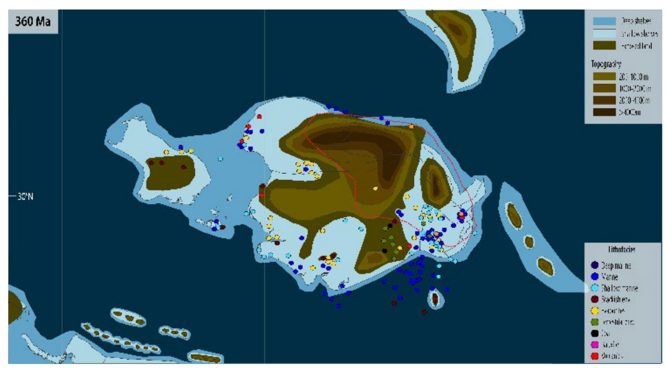

Figure 1. An example of the revised palaeogeography for Angarida highlighting added data for a 360Ma time slice.

HYDROGRAPHIC AND GEOCHEMICAL EVOLUTION OF THE LATE DEVONIAN EPEIRIC SEAS OF NORTH AMERICA: LINKAGES BETWEEN REDOX, SALINITY, AND BIOTIC CRISES

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ORAL – type of presentation

Introduction: The Late Devonian marks a major transition in Earth history when the expansion of rooted land plants led to a cascade of effects, including enhanced terrestrial weathering and oceanic nutrient delivery, expanded anoxia in epeiric seas, organic carbon burial that drove a decline in $p\mathrm{CO_2}$ and a rise in $p\mathrm{O_2}$, and the transition to the Late Paleozoic Ice Age. The Late Devonian was also characterized by a series of major extinction events, the two largest of which were the Kellwasser Events near the Frasnian-Famennian boundary and the Hangenberg Event just prior to the Devonian-Carboiferous boundary. In this study, we present new information on the hydrographic and geochemical conditions that accompanied these important events in the widespread epeiric seas of North America. Specifically, we present new proxy data for redox and salinity through the Famennian in six cores from the Appalachian Basin (Ohio and Kentucky), three cores from the Illinois Basin (Indiana, Illinois, and Tennessee), and two cores from the Williston Basin (North Dakota). These data elucidate the environmental conditions that fostered dynamic biotic changes through the Famennian.

Redox and hydrographic conditions: In the lower Cleveland Shale of the Appalachian Basin, iron speciation indicates a gradient from intermittently oxic conditions at the most proximal site, to persistently anoxic and periodically ferruginous conditions in the deep basin center, to persistently euxinic conditions approaching the Cumberland Sill. Mo/TOC (units of ppm/wt.%) is consistently between ~13 and 18, indicating a moderate degree of basin restriction. In the upper Cleveland Shale, however, iron speciation, trace metal abundances, and pyrite sulfur isotopes indicate expansion of euxinia to all six cores, accompanied by a pronounced pattern of Mo and U drawdown from north to south. Mo/TOC averages ~19 in the most proximal core but progressively decreases to ~3 in the southernmost cores, indicating highly restricted conditions. These data suggest that the lower and upper Cleveland Shale represent distinct intervals in the hydrographic evolution of the Appalachian Basin. The Upper Cleveland Shale, which records maximum euxinic expansion across the basin and potentially in the photic zone, may record the Hangenberg (or Dasberg) Event, suggesting that euxinic expansion in shallow water was an important kill mechanism during the Late Devonian mass extinction.

In the New Albany Shale of the Illinois Basin, a major transgression at the base of the Famennian was accompanied by an expansion of basinal anoxia, which biostratigraphy relates to the Upper Kellwasser Event. The mid-Famennian is also characterized by broad transgression and anoxic expansion, which may be related to the Enkeberg Event. Mo/TOC is between ~10 and 13 in the Illinois Basin throughout the Famennian, indicating a moderate degree of basin restriction.

In the Lower Bakken Shale of the Williston Basin, three progressive pulses of marine transgression and euxinic expansion can be directly related to the Annulata, Dasberg, and Hangenberg events, with maximum onlapping of euxinia onto the shallow basin margins ocurring during the Hangenberg Event. In addition to the two cores we investigated for a full suite of geochemical proxies, this interpretation is aided by a compilation of XRF trace metal data from 90 cores (~11,000 data points) across the entire Williston Basin. This dataset allows for a four-dimensional reconstruction of basin redox, which clearly shows euxinic waters shoaling and onlapping the basin margins during the Hangenberg Event. Strong trace metal enrichments during the Hangenberg Event and Mo/TOC ratios consistently greater than 20 indicate strong connection of the Williston Basin with the open ocean.

Paleosalinity conditions: We also used the B/Ga ratio to investigate paleosalinity in these ancient epeiric seas, with B/Ga shown to effectively delineate freshwater, brackish, and marine conditions in modern sediments. In the Appalachian Basin, these data record a pronounced gradient from brackish conditions proximal to the Catskill Delta to fully marine conditions in the basin interior. This trend is interrupted by a shift back to brackish salinity in the southernmost core, which was deposited in shallow waters atop the Cumberland Sill. In addition, there are strong relationships between paleosalinity, detrital sediment input, and redox indicators such as TOC, Mo, and U in the cores proximal to the Catskill Delta, indicating that freshwater input promoted bottom-water oxygenation.

In the Illinois Basin, the Famennian was characterized by brackish conditions in shallow water near the Cumberland Sill and fully marine conditions in the basin interior. Interestingly, salinity was uniformly higher in the Illinois Basin during the preceding Frasnian interval when the basin was more restricted, followed by a reduction in salinity across the Frasnian-Famennian boundary.

In the Williston Basin, however, the Lower Bakken Shale records exceptionally high B/Ga ratios consistent with deposition under hypersaline conditions. Hypersalinity is also evidenced by abundant evaporites in the Frasnian, and may have been promoted by arid climatic conditions and high evaporation rates in this paleo-subtropical setting.

Conclusions: Ultimately, our data reveal that the Upper Devonian black shales of North America were deposited under a remarkable variety of hydrographic, redox, and salinity conditions across time and space. Pulses of anoxia and/or euxinia in all three basins can be confidently linked to biotic crises that witnessed widespread devastation of marine ecosystems, including the Hangenberg Event. Our future work will aim to identify synchronous changes in sea level, watermass chemistry, and extinction across all the major Upper Devonian black shale units of North America using refined bio- and chemostratigraphy, as well as Re-Os geochronology. We also seek to tie events in the marine realm with synchronous changes in terrestrial environments through investigation of coeval terrestrial sections in the Appalachian hinterland.

THE LATEST EIFELIAN-FRASNIAN HORN RIVER GROUP IN THE NORTHERN MACKENZIE MOUNTAINS AND MACKENZIE VALLEY (NW TERRITORIES, CANADA): INTEGRATED STRATIGRAPHY AND SECTION CORRELATION.

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POSTER

Introduction: the latest Eifelian to early Late Frasnian in the Mackenzie Mountains and Mackenzie Valley is represented by the Horn River Group, a deposit of mainly dark grey and black shales (Hare Indian and Canol formations) and localized platform and reefal limestones (Ramparts Formation). The Group overlies the Eifelian Hume Formation and is overlain by the Frasnian-Famennian Imperial Formation. Lateral variations in facies and thickness of the Horn River Group are described in terms of Givetian-Frasnian paleogeographic zones recognized from SW to NW within the study area (Figure): the southern off-bank zone (SOB), the bank-and-trough zone (BAT), and the western off-bank zone (WOB).

The sharp onlap of the Hare Indian black shales (Bluefish Mb.) upon the Hume limestone records the spread of anoxic/dysoxic waters over the shallow-water carbonate shelf in the latest Eifelian-earliest Givetian. The gradational shift to the grey shales of the Bell Creek Mb. in the BAT area and to the grey and dark grey shales of the Francis Creek and Prohibition Cr. members respectively in the SOB area occurred in the Early Givetian, representing a shift from anoxic to more oxic conditions in a marginal basin setting. Deposition of these grey calcisiltites of the Hare Indian Formation is interpreted as progradation of a clastic wedge that filled into the basin. Reflecting attenuation of siliciclastic influx, the Hare Indian clastics grade upward and partly laterally into an alternation of calcareous shales and limestones before the establishment of small carbonate platforms or banks (Ramparts Fm.) on top of the clastic wedge. On these carbonate banks, a reefal facies (Kee scarp Mb.) developed locally. Reef debris accumulated locally on reef flanks and toes (referred to as the *Allochthonous limestone beds*). The Hare Indian and Ramparts deposits are blanketed by the dark siliceous Canol shale that again represents deeper anoxic/dysoxic conditions [1]

Biostratigraphy (Figure): Conodont research in the study area began in the early 1970's by T. Uyeno [2] and was continued over the years by several other researchers. The state-of-the-art conodont biostratigraphy in the Mackenzie Mountains was published in 2022[3] based on new field samples combined with archival collection material. Conodont faunas indicate a late Eifelian age (*ensensis* Zone) for the base of the Horn River Group. The Bluefish Mb. straddles the Eifelian-Givetian boundary and changes into the Bell Creek Mb. during the Early Givetian (*timorensis* Zone). In the Middle Givetian (*ansatus* Zone), carbonate banks of the Ramparts Fm. start to develop on the Bell Creek Mb. These banks persist till the latest Givetian (*norrisi* Zone) and are locally topped by carbonate reefs that drowned in the late Early Frasnian (Zone 4). The Canol Fm. covers the entire area from the Late Givetian until the early Late Frasnian (Zones 11-12) when it grades into the Imperial Fm.

Correlations: Several outcrop sections and cores, measured and sampled along the northern Mackenzie Mountain front and in the Mackenzie Plain, are correlated using a combination of gamma-ray measurements, lithostratigraphy and chemostratigraphy for the lithostratigraphic correlation and biostratigraphy combined with anoxic event stratigraphy for the chronostratigraphic correlation creating a WNW-ESE profile along the northern Mackenzie Mountain front and a NE-SW profile through the Mackenzie Valley. The sections represent the BAT, WOB and SOB paleogeographic areas [4]. The resulting correlations show a synchronous drowning of the Hume platform in the entire area, with no significant hiatus between the Hume and Hare Indian formations. The Ramparts carbonate banks seem to develop simultaneous while there is a suggestion of different timing for the drowning of the Kee Scarp reefs [5]. The lower part of the Canol Formation is locally time-equivalent of the upper part of the Ramparts Platform Mb. The Canol Fm. continued to be deposited during reef growth and after drowning of the reefs. There is no evidence of a pre-Canol unconformity or hiatus.

References:

[1] Kabanov, P. (2019). *JGS*, *176*, 29–45. [2] Uyeno, T.T. (1978). *In* C. R. Stelck and B. D. E. Chatterton (eds.), Western and Arctic Canadian Biostratigraphy. GAC, Special Paper, 18, 233–257. [3] Gouwy, S.A. (2022). *In* D. Lavoie, and K. Dewing (ed.), 2022. Sedimentary basins of northern Canada: contributions to a 1000 Ma geological journey and insight on resource potential; GSC, Bull. 609, 159-184. [4] Kabanov, P. and Gouwy, S.A. (2017). *CJES*, *54*, 409–429. [5] Muir, I. et al. (1985). *In* M.W. Longman, K.W. Shanley, R.F. Lindsay and D.E. Eby (eds.), Rocky Mountain Carbonate reservoirs: a core workshop. SEPM core workshop no. 7, Golden, Colorado, 311–341.

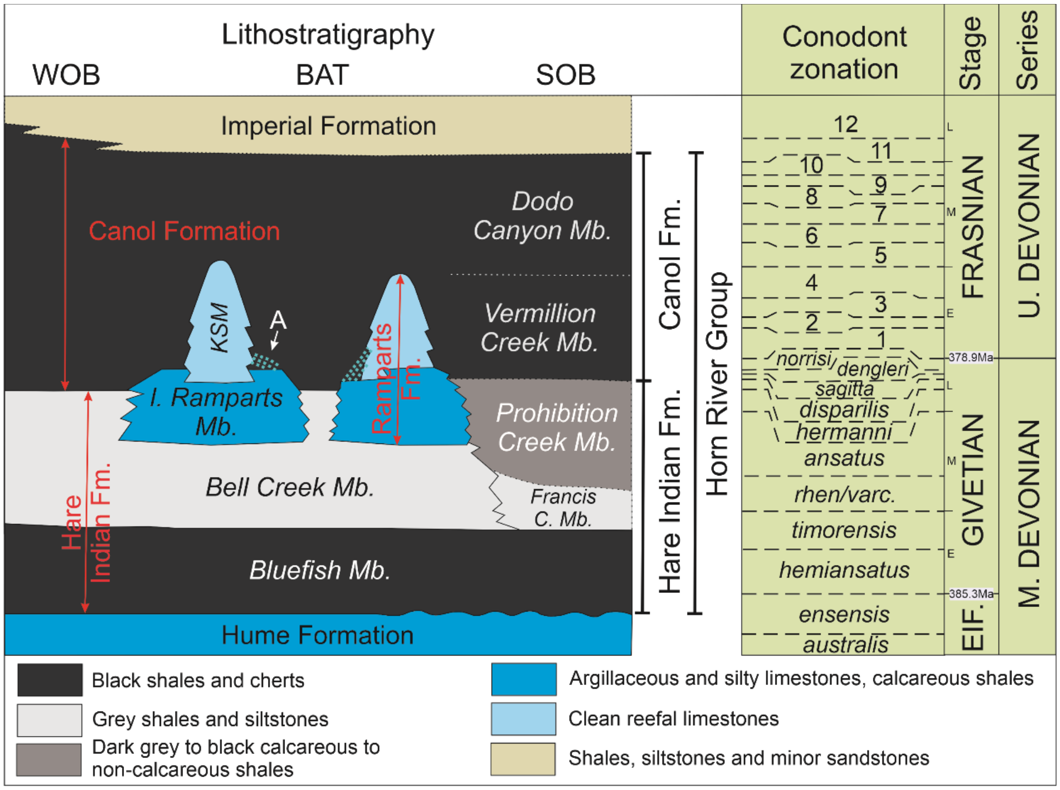

Figure. Chronostratigraphic diagram of the Horn River Group in the Mackenzie Mountains and Mackenzie Valley. Paleogeographic areas: WOB: western off-bank area, BAT: bank and trough area, SOB: southern off-bank area. KSM: Kee scarp Member, A: Allochthonous limestone beds, Francis C.: Francis Creek, Mb: Member, Fm.: Formation, E.: Early, M.: Middle, L.: Late. Figure is modified from earlier publications [1] and [4].

EXPRESSION OF THE MIDDLE DEVONIAN KAČÁK EPISODE IN THE MACKENZIE MOUNTAINS, NORTHWEST TERRITORIES, CANADA.

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ORAL

In the Mackenzie Mountains (NW Territories, Canada), the Kačák Episode interval situated close to the Late Eifelian-Early Givetian boundary is characterized by a sharp facies change due to a hypoxic perturbation. The open-shelf limestone of the Hume Formation is overlain by the fine black calcareous shales of the Bluefish Member (Hare Indian Formation). This interval was studied in 6 sections along the northern Mackenzie Mountain front.

Conodont faunas from the Hume Formation place its main part in the Eifelian *kockelianus* Zone. The initial onset of the black shales took place in the Eifelian *ensensis* Zone, suggested by the appearance of the brachiopod *Eliorhynchus castanea* in the uppermost 3 meters of the Hume Formation. The first Givetian conodont fauna was identified at 7.5m above the base of the Bluefish Member.

The global Kačák Episode represents a polyphased biotic crisis, usually associated with a transgression, with a first phase indicated by a sharp turnover in conodont fauna and facies: a sudden onset of dark *otomari* shales in the hemipelagic to pelagic realms (*otomari* event), and a second phase (Kačák event s.s.) coinciding with the Eifelian-Givetian boundary.

The Hume-Hare Indian formations transition is generally interpreted as a deepening event and the sharp contact between the two formations as a drowning surface. *Nowakia* sp. cf. *otomari* appears in the uppermost meter of the Hume Formation. This *otomari* event coincides here with an innovation in conodont fauna: new taxa and new morphotypes appear in the top of the Hume Formation, right below the onset of the black shales. The Eifelian-Givetian boundary (and the Kačák event s.s.) cannot be accurately situated in the sections, due to the lack of the index taxon *Polygnathus hemiansatus*.

Based on stable oxygen isotope analysis on conodont apatite of monogeneric assemblages, this innovation coincides with a significant decrease of $\delta^{18}O$ values from 18.1 -18.2‰ in the Hume Formation to 16-17.2‰ in the uppermost meter of the Hume Formation and lowermost few meters of the Bluefish Member. If no change in salinity were assumed, this shift would suggest a warming of the paleo-ocean surface waters that might have promoted the innovation and could have induced a reduction in oxygenation of the lower part of the water column in combination with a sea-level rise.

ASTROCHRONOLOGY OF THE HANOVER FORMATION, LATE DEVONIAN, WESTERN NEW YORK

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ORAL

The Hanover Formation in western New York State is predominantly composed of interbedded bioturbated light-gray silty shales and dark-gray organic-rich silty shales. These shales were deposited in a pro-deltaic deep shelf-to-basin setting on the northeastern margin of the Appalachian Basin. Within this area, the Hanover Formation is framed by the distinct biostratigraphically constrained Pipe Creek Formation, which is equivalent to the Lower Kellwasser interval, and the Pt. Gratiot Bed, which is equivalent to the Upper Kellwasser interval, below the thick and distint black shales of the Dunkirk Formation. Radiometric dates indicate that the 32 m thick strata of the Pipe Creek and Hanover Formation represent ~800,000 years, where the eccentricity, obliquity, and precession oscillations are visible as packages in decimeter to meter-thick couplets of black and light-gray shales. Two 4.69 m and 2.15 m intervals of the Hanover Formation obtained from the West Valley NX-1 core (API#31-009-06740-00-00) were sampled continuously at 1 cm intervals for magnetic susceptibility (MS). An astrochronologic timescale reconstruction with any statistical significance was not feasible on either of the West Valley core segments because neither were long enough to preserve an eccentricity cycle that could be used as a geochronometer. Using a third MS series encompassing the entire Hanover Formation along Walnut Creek near the Village of Silver Creek, New York, there was the opportunity to create a significant astrochronology for the Hanover Formation to which the West Valley core intervals could be tuned. Using the MATLAB package *Acycle*, the Walnut Creek dataset was analyzed with sedimentation rate estimators, multiple methods of spectral analysis, filtering, and age scale tuning (Figure 1). From this, a timescale of 822,922 ± 250 years was produced for the entire Hanover Formation which is comparable to the age date derived from radiometric dating. The tuning of the core segments produced age scales of 143,101 ± 250 years for core segment #1 and an age scale of 71,456 ± 250 years for core segment #2. Due to the high-resolution sampling interval of the core segments, the 2π multi-taper method spectral analysis plots from both segments showed the presence of fine-scale climatic cycles with a statistical confidence above 95%. A 7-8 ky cycle was interpreted to be the result of combination tones of Milankovitch cycles, a 2.6 ky cycle was interpreted to be the Hallstatt cycle, a 1.5 ky cycle was interpreted to be Dansgaard-Oeschger variations, and a 900-year cycle is interpreted to be the Eddy cycle (Figure 2). This astrochronology of the Hanover Formation creates a high-precision timescale that could be used to help pinpoint the timing of environmental/evolutional events, and the identification of known cycles within the West Valley Core intervals aids in demonstrating the origin and persistence of millennial and centennial-scale cycles during the Late Devonian

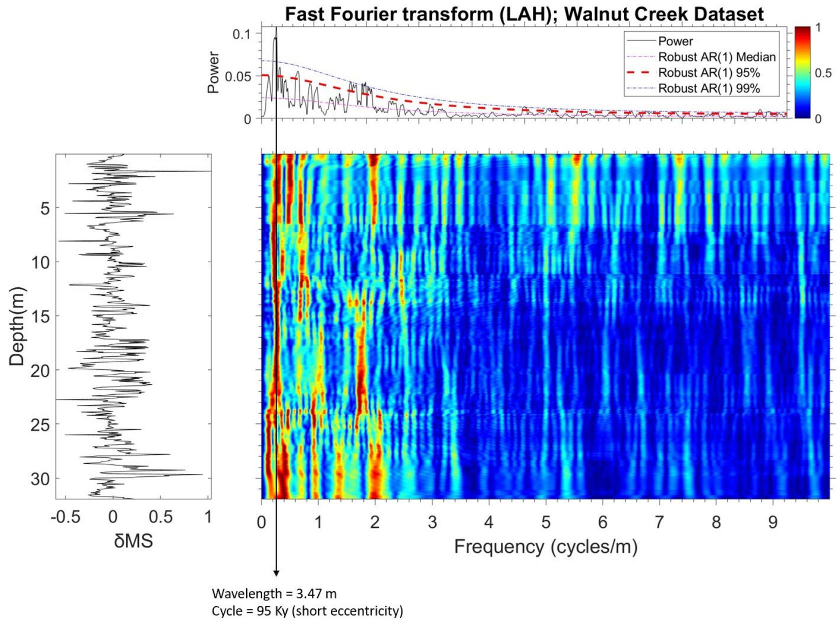

Figure 1. Evolutionary fast Fourier transform (FFT) of the linearly detrended δMS series from the Hanover Formation section on Walnut Creek with a sliding window at 11.18 m with a step of 0.05 m. The 2π MTM plot is shown above the evolutionary plot and is correlated to the plot by frequency (cycles/m) along the x-axis. The linearly detrended δMS plot on the left side of the figure is correlated to the evolutionary plot by depth(m) along the y-axis. This plot shows how the spectral power of the Walnut Creek δMS series varies through depth and time due to changes in sedimentation rate. The gradient color bar correlates to spectral power, with dark blue showing no power, and dark red showing high power. The black arrow going through power spectrum at a frequency of 0.2795 cycle/m corresponds to the short eccentricity cycle which is presenting high spectral power and shows little variance throughout the section.

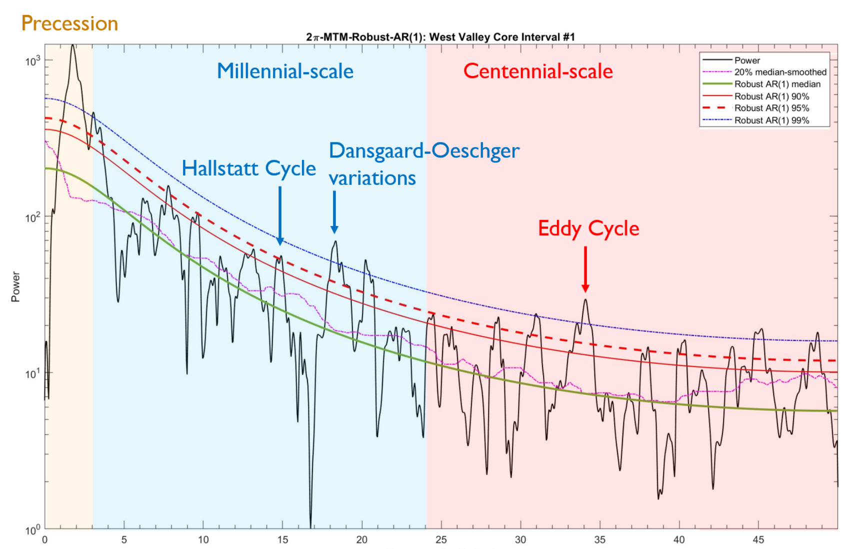

Figure 2. Annotated 2π MTM spectral analysis of West Valley core interval #1 δMS series showing the length of the cycles detected and known cycles that are interpreted to be present. Cycles present within the yellow panel are precession, cycles present within blue are millennial-scale, and cycles present within red are centennial-scale. The Hallstatt cycle occurs within the millennial scale cycles panel at a wavelength of 0.104 m and a confidence level of 95%. Dansgaard-Oeschger variations occur within the millennial-scale panel at a wavelength of 0.055 m and a confidence level above 99%. The Eddy cycle occurs within the centennial-scale panel with a wavelength of 0.035 m and a confidence level above 99%.

BASIN-WIDE CORRELATION OF ASTRONOMICALLY FORCED CYCLES IN THE FAMENNIAN OHIO SHALE, APPALACHIAN BASIN, OHIO, USA

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ORAL

Introduction: The Upper Devonian Ohio Shale of the Appalachian Basin, USA exhibits pervasive decimeter (dm)-scale cyclicity, with organic-rich layers linked to reduced siliciclastic influx and organic-poor layers to increased siliciclastic influx, and a time scale that is on the order of the climatic precession cycle (~20-kyr). The formation consists of 5 members: Lower Huron, Middle Huron, Upper Huron, Three Lick Bed and Cleveland. In the state of Ohio, toward the north, the Chagrin Shale replaces the Middle and Upper Huron members; here, starting at the base of the Middle Huron Member (Chagrin Shale), an extended interval of relatively uniform sedimentary cyclicity provides strong evidence for astronomical forcing frequencies [1]. This raises the prospect for addressing multiple geological problems at once: (1) the paleoclimate-sediment response of late Devonian black shales to astronomical forcing; (2) late Devonian precession rate and rotation rate of the Earth, and Earth-Moon distance; (3) correlation of Ohio Shale members across the Appalachian Basin; and (4) development of an astrochronological framework for the Ohio Shale.

Data: Ultra-high-resolution spectral gamma ray (UHR-SGR) logging with <1 mm measurement spacing [1] was used to measure U (organic matter and phosphate), Th (clay minerals), and K (potassium feldspar) through the Ohio Shale in three drillcores, from north to south: OHLO-2 (Lorraine Co.), OHDW-2 (Delaware Co.) and OHRS-5 (Ross Co.). Starting from the base of the Middle Huron Member, a succession of 13 meter-scale "bundles" of dm-scale cycles characterizes the total GR log for the Middle Huron Member in OHRS-5 and OHDW-2, and the lower Chagrin Shale in OHLO-2 (**Fig. 1**).

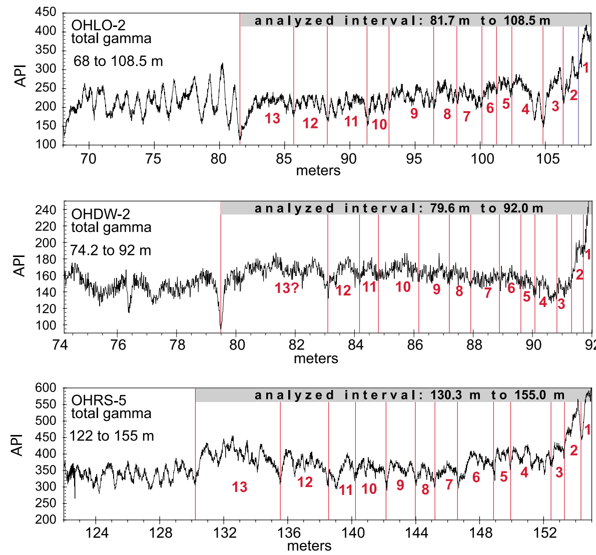

Figure 1. UHR-SGR logs of total gamma ray for three drillcores (OHLO-2, OHDW-2 and OHRS-5) through the Middle Huron Member (lower Chagrin Shale) of the Ohio Shale, Appalachian Basin, Ohio, USA. Measurement spacing is <1 mm; stratigraphic up is toward the left. The base of the illustrated interval is imprecisely assigned to the base of the (new) *gracilis* conodont Zone [2, 3]. The shaded "analyzed interval" for each of the three logs exhibits 13 bundles of dm-scale cycles; the top of Bundle 13 is marked by a GR minimum, and followed by a distinct change in cycling wavelength and pattern.

Methods:

Statistical correlation. The "analyzed interval" of each UHR-SGR log was correlated to those of the other two logs using a hidden Markov model correlation technique with error estimation (borrowed from DNA sequencing methods), HMM-Match [4]. The goal was to determine how well the dm-scale cycles in the 13 bundles correlate among the three logs.

Astrochronology. OHLO-2 provides the thickest (26.8 m; thus potentially highest-resolution) record of the analyzed interval, and so it was analyzed for the presence of astronomical frequencies using spectral analysis, method of ratios, time optimization, and minimal tuning [5, 6]. The reconstructed astrochronology for OHLO-2 was then propagated into the other two correlated logs (OHDW-2 and OHRS-5).

Results:

Statistical correlation. HMM-Match was performed on the UHR-SGR logs: (1) OHLO-2 vs. OHDW-2, (2) OHLO-2 vs. OHRS-5, and (3) OHDW-2 vs. OHRS-5. All three logs show excellent matches with one another, with errors (95% uncertainty) on the order of a few cm except in a few isolated m-long intervals where they expand up to ~45 cm, indicating uncertainty over a single dm-scale cycle.

Astrochronology. The stratigraphic spectrum of OHLO-2 shows primary power in a band centered at a 3-m wavelength, and secondary power at peaks centered on a ~0.6-m wavelength; the ratio, 3 m/0.6 m = 5:1 is suggestive of the orbital eccentricity:climatic precession ratio, i.e., 100 kyr:20 kyr. Time optimization is applied to support this interpretation. Spectrograms indicate a 5-m-long interval in which frequencies shift to significantly higher values; minimal tuning is applied to estimate the sediment accumulation rates responsible for this shift. The reconstructed astrochronology from these estimated sediment accumulation rates was transferred to the other two logs via the correlations established above.

Summary: This study presents evidence for astronomical forcing of the Famennian Ohio Shale, Appalachian Basin, USA with a shift in the climatic precession frequency band to a value that is higher than present-day (although lower than expected for ~370 Ma), corresponding to a shorter precession period and indicative of faster Earth rotation. Hidden Markov model matching reveals a high degree of correlation of the depositional cyclicity throughout the Middle Huron Member (lower Chagrin Shale) across a 250-km north-south transect of ultra-high resolution gamma ray logs from three drillcores (OHLO-2, OHDW-2 and OHRS-5). The results provide a detailed (~20-kyr resolution) ~0.9-Myr-long numerical time grid across the Appalachian Basin for the Middle Huron Member. This includes the (new) *gracilis* and *marginifera* conodont zones, which can be used to project the time grid globally.

References: [1] Algeo, T.J., et al. (2006), *GSA Ann. Meet.,* Paper 113078, 38(7), 268. [2] Liu, J., et al. (in review), *GSA Bull.* [3] Spalletta, C., et al. (2017), *Bull. Geosci.,* 92(1), 31-57. [4] Lin, L., et al. (2014), *Paleoceanog*., 29, 976–989. [5] Li, M., et al., *Comput. Geosci.,* 127, 12-22. [6] Meyers, S.R. (2014), https://cran.r-project.org/package=astrochron.

FAMENNIAN TO EARLY TOURNAISIAN DEPOSITIONAL SEQUENCES FROM THE WILLISTON BASIN AND SURROUNDING AREAS, NORTHWESTERN UNITED STATES.

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ORAL

Introduction: The Famennian to Early Tournaisian comprises the Bakken and Three Forks formations in the subsurface Williston Basin of northwestern North Dakota[1,2]. The Bakken-Three Forks interval comprises mixed siliciclastic, carbonate, evaporite, and organic black shale lithologies that represent a diverse array of depositional environments[1,2]. This interval lies between two thick, marine, carbonate units, the underlying Devonian Jefferson Group and the overlying Mississippian Madison Group. The Bakken-Three Forks interval is subdivided into ten depositional sequences with four Three Forks sequences characterized by carbonates and evaporites overlain by six Bakken sequences characterized by three silitstone-dominated sequences and three shale-dominated sequences[3]. Each sequence is bound by regionally extensive unconformities and contains distinctive lithological characteristics indicative of different depositional settings [3,4].

Lithological Sequences: The four Three Forks sequences contains dolomitic tidal flat, coastal plain, and evaporite deposits [3,4,5]. the basal part of the Bakken includes the lower Pronghorn sequence that is composed of open marine shoreface siltstones, shales, and offshore fossiliferous limestone deposits [3,4,6]. The upper Pronghorn sequence is a restricted marine, bioturbated siltstone to low organic-bearing shale [3,4,6]. The Lower Bakken sequence is rich in pyritic, marine, organic-bearing shale [3,4,7]. The Middle Bakken is composed of two sequences that both comprises a mixed siliciclastic to carbonate marine shoreface setting[3,4,8]. The Upper Bakken sequence includes pyritic to calcareous organic-bearing shale [3,4,9,10]. Thinning of the sequences is related to onlap at the base during sedimentation, or truncation at the top during subaerial exposure and erosion between sequences [3,4] (Figure 1).

Biostratigraphy: Biostratigraphic data comes from a mixture of literature and private sampling collections collected from the Williston Basin of North Dakota [4] and South Dakota [11], the Sappington Basin in Montana and Wyoming [12,13,14], and the South Alberta Basin [15,16]. Data from all these study areas are used to determine the age of each sequence and justify the correlation of lithological units between these depocenters (Figure 2).

Summary: Each sequence contains its own unique facies successions, sequence stratigraphic architecture, and depositional environments. The varying depositional environments between the sequences shows that the region was under different environmental and climate conditions at different times throughout the Famennian and Early Tournaisian. Correlation of lithological units across the major bounding sequence boundaries is not supported by the regional stratigraphic mapping or biostratigraphy and depositional models invoking these correlations should be abandoned. Future detailed biostratigraphic sampling will refine the upper and lower age boundaries for each sequence and further aid in interbasinal correlations.

References:

[1] Sonnenberg, S. A. (2020) *AAPG Bulletin, 104,* 2557-2601. [2] Hart, B. and Hoffman, M. (2020) *The Sedimentary Record, March,* 4-9. [3] Hohman, J. C. et al. (2017) *AAPG Rocky Mountain Section*, Article# 90301. [4] Hogancamp, N. J. and Pocknall, D. T. (2018) *Stratigraphy, 15,* 197-224. [5] Hogancamp, N. J. et al. (2019) *Stratigraphy, 16,* 145-164. [6] LeFever, J. A. et al. (2011) in Robinson et al. (Eds.) *Rocky Mountain Association of Geologists,* 11-26. [7] Hogancamp, N. J. et al. (2018) *AAPG National Section,* Article# 90323. [8] Egenhoff, S. O. et al. (2011) in Robinson et al (Eds.) *Rocky Mountain Association of Geologists*, 27-47. [9] Egenhoff, S. O. and Fishman, N. S. (2013) *JSR, 83,* 803-824. [10] Hohman, J. C. et al. (2019) *AAPG National Section,* Article# 90350. [11] Hogancamp, N. J. and Rodriguez, A. P. (2020) *Stratigraphy 17,* 65-

119. [12] Klapper, G. (1966) *The University of Kansas Paleontological Contributions, 3,* 43 p. [13] di Pasquo, M. et al. (2017) *Palynology, 41,* 189-220 [14] Rice, B. J. (2021) *Ph.D. dissertation, University of Idaho,* 202 p. [15] Drees, N. C. M. and Johnston, D. I. (1994) *BCPG, 42,* 55-62. [16] Johnston, D. I. et al.

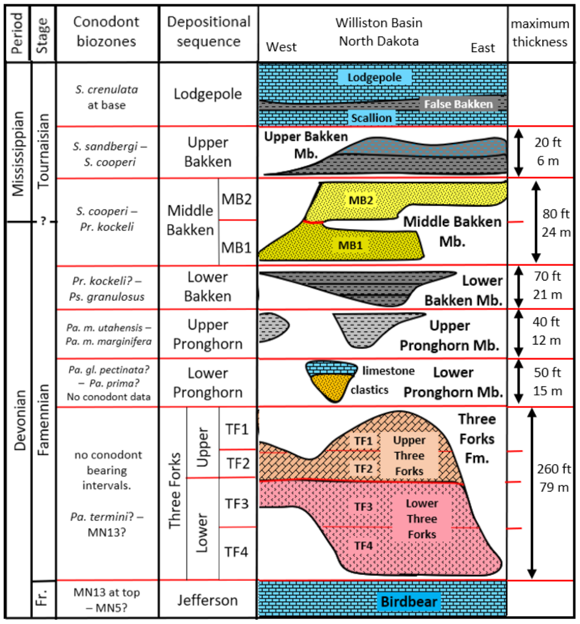

Figure 1 Composite stratigraphy of the Williston Basin showing the changes in thickness from west to east for each depositional sequence.

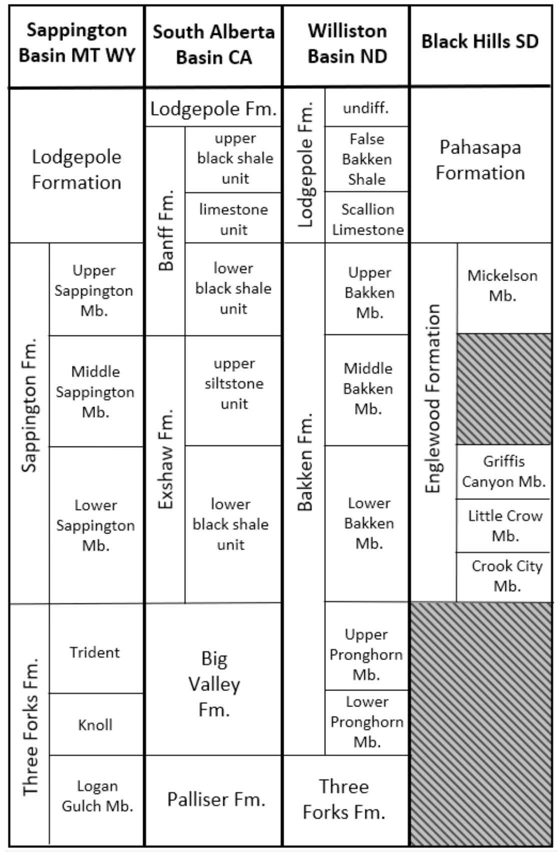

Figure 2 Stratigraphic correlation table of lithological units from the Williston Basin and the surrounding areas. CA = Canada, Fm. = Formation, ND = North Dakota, Mb. = Member, MT = Montana, SD = South Dakota, WY = Wyoming.

INVESTIGATING THE LINK BETWEEN DEVONIAN ANOXIC EVENTS AND ASTRONOMICAL FORCING

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ORAL

The Devonian geological record bears evidence of numerous regional-to-global anoxic events. Even though some of these events are believed to have had a limited impact on the biosphere (e.g. shifts in biodiversity, decimation of specific ecosystems), the Kellwasser Event (Frasnian – Famennian boundary) and the Hangenberg Event (Devonian – Carboniferous boundary) are linked to major extinction episodes. Commonly, these anoxic events are characterized by a positive carbon isotope excursion (CIE) and are often expressed as organic-rich black shales interbedded in carbonate-rich sediment. Yet, absence of a positive CIE and 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.

Even though a consensus on the mechanisms behind these events has not yet been reached, clues have been uncovered that suggest a link between the pacing of ocean anoxia and astronomical forcing (2.4 Myr eccentricity nodes) for the Kellwasser Event. It is the main goal of the 'WarmAnoxia' project to investigate the potential link between ocean anoxia and astronomical forcing and – if identified – what their phase relationship is and which mechanisms are driving the development of ocean anoxia.

In the scope of the 'WarmAnoxia' project, existing geological records covering nearly the entire Devonian (except the Frasnian stage) will be re-evaluated and complemented by new observations of the Lansing Core, NY (USA) and the Oued Ferkla section (Morocco). The stratigraphic position of the anoxic events will be constrained by evaluating the existing biostratigraphic framework and geochemical composition of the sedimentary record (elemental composition, carbon isotope record). Using cyclostratigraphy, these anoxic events will then be located in a well-constrained temporal framework and their duration and position relative to astronomical forcing nodes (i.e. 2.4 Myr eccentricity minima or maxima) will be investigated. Only then will it be possible to attempt consolidating formulated hypotheses with scenarios provided by numerical modeling. This way, it will be investigated which complex multicausal factors can be associated with Devonian anoxic events, which role astronomical forcing plays in their pacing and whether the 2.4 Myr eccentricity nodes act as a window of opportunity or rather the decisive trigger.

VARIABILITY, RELIABILITY, AND SIGNIFICANCE OF BRACHIOPOD δ^{18}O VALUES FROM THE MIDDLE DEVONIAN HAMILTON GROUP.

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POSTER

Introduction: Paleotemperatures, glacial regime, and salinity are among the factors that remain mysterious in the Middle Devonian. Stable oxygen isotope values of brachiopod shell calcite hold the promise to resolve some of these uncertainties and reveal benthic paleo-environmental conditions if their own integrity can be established. Simpler collection and larger specimen sizes offer advantages over conodonts, but their mineralogy and microtextures make them more susceptible to diagen-etic alteration. Assessing variation in shell δ^{18}O values across a range of spatio-temporal scales may help shed light on the sources of that variation and their potential to retain original compositions.

Methodological Approach: Shells of the impunctate brachiopods *Mucrospirifer* and *Spinocyrtia* with visually well-preserved calcite were collected from multiple localities in the Marcellus, Ludlowville, and Moscow Fms, spanning the Middle Devonian Hamilton Group in Central New York. Fresh surfaces of all shells were revealed via crushing or abrasion, and subsamples of clean shell calcite were collected using tweezers or a hand-held dental drill. The interior of the heavily calcified hinge region was targeted for sampling whenever possible. Preservation of shell microtextures was assessed with scanning electron microscopy on the JEOL Neoscope II at SU and the potential for secondary/diagenetic calcite was evaluated with Fe and Mn concentrations of shell subsamples done on the ICP-MS at SUNY-ESF. Stable oxygen and carbon isotope analyses of shell subsamples were performed at the University of Michigan Stable Isotope Lab and the Northern Illinois University Stable Isotope Laboratory. Fossil shell textures are compared to those from modern brachiopods collected off the coast of Argentina, and elemental data are compared to published data on modern brachiopod shells from Brand et al [1].

We explore variation in δ^{18}O and δ^{13}C values, Mn and Fe concentrations, and shell microtextures within and among shells, within and among localities, and within and among formations. The Cascade outcrop of the Ludlowville Formation was intensely sampled with decimeter-scale stratigraphic resolution to test for variation across putative fifth-order (20-100 ky) depositional cycles. Individual shells were subsampled along the growth axis to reveal variability within a single shell over an individual's lifespan. This multi-scale approach has the potential to disentangle issues of preservation from real ontogenetic and paleoenvironmental variation on subannual to mega-annual scales.

Initial Results: SEM imagery reveals frequent retention of shell microtextures with very high fideltity. Individual crystal edges are generally sharp and clean, comparable to the micro- and macro-scale textural features seen in modern brachiopod shell. Evidence for minor dissolution is occasionally seen on the surfaces of fibers. A very few images reveal what might be secondary calcite precipitating on fiber surfaces. Shell Mn and Fe concentrations nearly all fall within the range of values documented from living brachiopods [1], if on the higher end of that range.

As found by prior workers [2], δ^{18}O values of Hamilton Group brachiopods overall are disconcertingly low, ranging from approximately -4.0 to -11.0 per mil. δ^{13}C values generally fall between +1 and +3 per mil and do not correlate with δ^{18}O. Localities within the Moscow are distinct, as are data from the three formations. Samples with low δ^{18}O values do not exhibit Fe or Mn concentrations outside the range of modern shells, and the several fossil samples with significantly elevated Fe or Mn span the full range of δ^{18}O values. Diagenetic cement from the Moscow Fm. at Geer Road, the Marcellus Fm. at Swamp Road, and published whole-rock values from the Marcellus Fm. [3] are 2 per mil or more lower in δ^{18}O than all brachiopod analyses from the Marcellus and Moscow Fms. Geer Road cement additionally plots well above and outside the range of modern brachiopod shells for both Mn and Fe.

Samples collected from the Ludlowville at Cascade generally yield lower $\delta^{18}O$ and $\delta^{13}C$ values than those from the Marcellus and Moscow Fms. Samples from within an individual horizon often span the full range of values seen aross the whole section. Consistently low $\delta^{18}O$ (~ -5.5 to -11.0 per mil) and low and more variable $\delta^{13}C$ (~ +3 to -6 per mil) suggest a greater potential for alteration, with low values converging on the diagenetic end member. These samples were picked from crushed shell fragments or drilled from freshly abraded shell exteriors rather than drilled from shell cross sections. The data from Cascade suggest that either this site was cryptically altered in ways not observed by SEM, or that these methods, especially the exterior drilling method, are susceptible to incorporation of secondary calcite.

Oxygen isotope values from ontogenetic profiles collected from Marcellus Shale *Spinocyrtia* span the full range of values exhibited by bulk shell values from multiple individuals. $\delta^{13}C$ values suggest the presence of at least 4 'cycles' across 43 mm of shell growth, but these are not mirrored in $\delta^{18}O$ and so their significance has yet to be established. Transects across polished shell cross sections using laser-ablation ICP-MS are pending and could shed more light on the significance of ontogenetic variation. If Fe and Mn are low and do not covary with $\delta^{18}O$, then we might conclude that stable isotope variation along the growth profile is more likely to reflect original sub- and interannual environmental variation.

Preliminary Assessment: These initial data suggest that, minimally, Hamilton Group brachiopod calcite is geochemically distinct from clearly diagenetic precipitates when collected from within heavily calcified shell cross sections. Shell textures and Mn and Fe concentrations are comparable to those seen in modern shell. *En toto*, samples with more typically 'marine' $\delta^{13}C$ values (+2 to +3 per mil) span a range of $\delta^{18}O$ values (-4 to -9 per mil), samples with $\delta^{13}C$ values < 2 have lower $\delta^{18}O$ values (-7 to -10 per mil), and at $\delta^{13}C$ values < -2 per mil, $\delta^{18}O$ variability decreases and centers around -8.5 per mil. This suggests mixing reflecting the increasing incorporation of diagenetic carbonate, derived from interaction with meteoric water, in brachiopod shell, with $\delta^{18}O$ affected first and $\delta^{13}C$ only beginning to shift with higher water:rock ratios [4]. Nevertheless, even presumably altered brachiopod shell retains primary microtextures. Whether this mixing line begins at original shell compositions or even the most positive $\delta^{18}O$ values are already depleted relative to original values remains to be seen.

References: [1] Brand, U., Logan, A., Hiller, N., and Richardson, J. (2003) *Chem. Geol. 198*, 305-334. [2] Selleck, B., and Koff, D. (2008) *NE Geol. & Env. Sci. 30*, 330-343. [3] Frappier, A. B., Lindemann, R. H., & Frappier, B. R. (2015) *Rapid Comm. in Mass Spectrometry 29*, 764-774. [4] Lohmann, K. C. (1988) *in* James, N. P., and Choquette, P. W., eds., Paleokarst: Berlin, Springer-Verlag, p. 50-80.

STRUCTURAL INFLUENCE ON DEVONIAN BLACK SHALE DEPOSITION IN SOUTHWESTERN NEW YORK STATE: BASIN ARCHITECTURE DRIVEN BY CRUSTAL SCALE THRUST LOADING TO THE EAST AND TO THE SOUTH/SOUTHEAST

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ORAL

Isochore maps of Devonian black shales and a limestone in southwestern New York State and northwestern Pennsylvania that were constructed in 2009 [1] show a startling spatial coincidence between sharp gradients in isochore thickness and trends of structural features (faults and folds) that were proposed in 2002 [2]. The isochore thicknesses of the Marcellus, Geneseo, Middlesex, Rhinestreet and Tully formations are based on between 1572 and 4680 well logs.

Two sets of structural systems apparently influenced the deposition of these units and the basin architecture: 1) northerly-striking fault systems and 2) an arcuate (in map-view) structural system that includes northeasterly-striking faults and folds with less dominant orthogonal faults. The arcuate trends overprint the northerly-striking trends, and dominate in the southern part of the area of interest, whereas the northerly-striking trends are dominant in the north.

The northerly-striking syndepositional faults are reactivated Grenvillian fault systems. Although some of the northerly trending thickness gradients are gradual, sharp breaks in thickness across known fault locations suggest that at least some of the syndepositional faults extended to the surface or near surface at the time of deposition (e.g., the abrupt changes in Tully thickness across the Clarendon Linden Fault System).

Reactivation of the northerly-striking faults reflect a thrust load to the east of the Catskill Delta Complex. There, (neo) Acadian metamorphic infrastructure developed during growth of an altiplano that was associated with crustal-scale thrusts with westward transport [3], e.g., the Green Mountain and Berkshire massifs. Recent Ar/Ar dates on these thrusts [4] show they were generally active during the time of the black shale and limestone deposition. Only one isochore black shale map--the Middlesex--does not display northerly-striking trends, and significantly, the altiplano thrusts do not appear to have been active at the time of Middlesex black shale deposition.

For the arcuate structural system, 2D and 3D seismic reflection data display growth faults at the Precambrian/Cambrian (pC/C) contact that indicate the faults were active in Iapetan opening and Rome Trough time. Structurally disturbed zones of the arcuate set are aligned upsection from the pC/C contact to even above the Silurian salt section. Seismic reflection data and well log analyses suggest that the arcuate fault systems were reactivated during Taconic, Salinic and Neoacadian orogenies (and probably more recently).

Well log and seismic data show that black shales onlap and thin against salt-cored anticlines and infill local structural lows (e.g., Marcellus infilling Onondaga structural lows).

Thrust loads to the south and southeast, such as reactivation of the Blue Ridge thrust, probably account for the general subsidence to the southeast with the ensuant arcuate structural system development.

Thrust loads both to the east and southeast with consequent basin subsidence led to a complicated basin architecture of intersecting northerly-striking faults and arcuate faults and folds. The subsidence accompanied by fault and fold growth were important drivers that strongly influenced the extent and thickness of the Devonian black shale deposition, in addition to the usual suspects, including eustatic sea level and sediment supply.

[1] Smith, G.J., Jacobi, R.D., Seever, J.L. and Loewenstein, S. (2009) *AAPG Annual Meeting Official Program, 18*, 198. [2] Jacobi, R. D. (2002) *Tectonophysics, 353*, 75-113. [3] Hillenbrand, I. W., Williams, M. L., Li, C. and Gao, H. (2021) *Earth and Planetary Science Letters, 560*, 116797. [4] Webb, L. and Karabinos, P. M. (2023) *Geological Society of America Abstracts with Programs, 55, n. 2,* ppr 385867.

REVISION OF LATEST SILURIAN – MID-DEVONIAN BRACHIOPOD FAUNAS FROM THE RHENISH MASSIF (GERMANY): STATE OF THE ART AND PERSPECTIVES

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ORAL

Introduction: The long-term taxonomic revision of latest Silurian (Prídolí) to early Mid-Devonian (Eifelian) brachiopods from the Rhenish Massif has resulted in numerous new implications on their phylogeny, biostratigraphy, palaeoecology, and palaeobiogeography [1, 2, 3, work in progr.]. At least 220 species are presently known from the area, and many of these are currently still under revision. In addition, a number of new genera and species have already been or will be introduced. One of the future aims is the reconstruction of the changing brachiopod biotopes in space and time.

Taxonomy: There are important taxonomic novelties concerning some Rhenish strophomenides, orthides and spiriferides; several taxa will even be accommodated in other families. Lingulides and craniides are now included as well.

Biostratigraphy: As an indispensable prerequisite, a predominantly brachiopod-based biostratigraphic framework is established, enabling the reconstruction of spatio-temporal developments of faunas, palaeoenvironments and palaeobiogeographic relations. The twofold brachiopod biozonation consists of 25 spiriferide taxon range zones (plus subzones) and 20 brachiopod assemblage zones ('faunal zones') allowing well-constricted regional and supraregional correlations – including regions in Western Europe and North Africa formerly belonging to North Gondwana. With respect to the future re-definition of a basal Emsian GSSP, the international correlation of the traditional basal Emsian boundary in the Rhenish type region is one subject presently focused on. Although it is very difficult to pinpoint the boundary in any of the very thick Rhenish sequences, approximate levels can be indicated. The boundary in the Rhenish Massif is distinctly older than the boundary commonly indicated in the Ardennes.

Facies and palaeoenvironment: The prevailing siliciclastic-neritic 'rhenotypic' facies reflects a broad spectrum of shallow-marine, tropical shelf palaeoenvironments with diverse brachiopod faunas. The 'eurhenotypic facies' is characterized by rich turbidicolous (turbid water tolerating) faunas of the open shelf; proximal, medial and distal variations of this facies show faunal change and increasing diversity along a depth gradient from lower intertidal to middle subtidal settings – estimated water-depths range from 5 to 60 metres. The 'pararhenotypic facies' shows low-diversity lingulide-terebratulide brachiopod faunas of marginal-marine palaeoenvironments with changeable conditions in the intertidal. The 'allorhenotypic facies' is marked by rich claricolous (± clear water requiring) brachiopod faunas that inhabited shallow to moderately deep subtidal settings with mixed calcareous-siliciclastic sedimentation. The spatial distribution of brachiopod assemblages is dependent on various factors such as substrate conditions, turbidity, hydrodynamic energy and salinity. Currently the rhenotypic facies concept is compared with Boucot's concept of Benthic Assemblages [5]. A depth-depending succession of assemblages is reconstructed, including estimated absolute water depths. It is also attempted to analyse/quantify the composition of selected Rhenish faunas and the ecospace utilization. The distal eurhenotypic fauna at Daleiden (upper Emsian, Eifel region), for example, is dominated by brachiopods ('brachiopodetum'). It includes a high quantity of surficially living, non-motile suspension-feeders showing calm, nutrient-rich biotopes and little disturbance by burrowing animals ('bull-dozing').

Stratigraphic succession of brachiopod faunas: The Rhenish brachiopod 'faunas' (in an ecological-evolutionary sense) occur in stratigraphically successive intervals with more or less consistent taxonomic composition, but they are also represented by different 'communities' *within* these intervals. The faunas are named by key spiriferide species, including (in stratigraphic order) *Quadrifarius dumontianus*, *Howellella mercurii*, *Acrospirifer primaevus*, *Arduspirifer antecedens*, *Euryspirifer paradoxus* and *Paraspirifer cultrijugatus*. Each of these faunas is separated from the under- and overlying one by events characterized by marked faunal turnover. Rapid eustatic sea-level fluctuations and regional changes in crustal subsidence and sedimentation rates caused shelf-wide or more regional changes in the palaeoenvironment which led to emigration or extinction of substantial parts of a brachiopod fauna. Thereafter, with onset of more suitable conditions, a largely new fauna could immigrate. A longer perturbation is the 'Rhenish Gap', representing a 6–8 myr lasting interval of a facies largely unsuitable for brachiopods, ranging from the late Lochkovian to early Pragian; it has largely been neglected or underestimated in biostratigraphic correlation and palaeobiogeographic studies.

Palaeobiogeography: The project includes side-by-side comparisons of brachiopods on a world-wide scale, with a focus on Western European and North African faunas. Brachiopod-based palaeobiogeographic patterns are largely consistent with currently accepted geodynamic reconstructions for the Silurian–early Middle Devonian that distinguish Laurussia in the north and North Gondwana in the south separated by the Rheic Ocean; a 'Rhenish Province' is distinguished from a 'North Gondwanan Province', together representing a 'Maghrebo-European Realm' [3, 4]. Differences between northern ('Avalonian') and southern ('North Gonwanan') faunas are distinct in the Prídolí–early Emsian, but often caused or augmented by different facies developments; differences generally diminished in the Middle Devonian, corresponding to narrowing of the Rheic Ocean.

Concluding remarks and perspectives: It is concluded that brachiopod-based stratigraphic correlations, palaeoecological studies and palaeobiogeographic reconstructions must consider a complex set of problems referred to the palaeoecology of these facies-sensitive fossils, taxonomic bias, questions of origination, extinction and migration, and variable rates of evolution in different brachiopod stocks. Brachiopod-based biostratigraphy, palaeoecology and palaeobiogeography still suffer from a lack of taxonomic standardisation. In addition, it is problematic to use genera as proxies for species – a widespread practice lacking a theoretical basis. Age differences between allegedly coeval faunas have often been underestimated. There is still much to do as regards species-level taxonomy and side-by-side comparison of faunas on the world-wide scale.

References: [1] Jansen U. (2016) *Geol. Soc. London Spec Publ. 423,* 45–122. [2] Jansen U. (2019) *Riv. Ital. Pal. Strat. 125, 735–759.* [3] Jansen U. et al. (in press) in U. Linnemann (ed.): *Geology of the Central European Variscides, Springer Book.* [4] Jansen U. (2018) *Permophiles 66, suppl. 1,* 59–60. [5] Boucot A.J. (1975) *Dev. Pal. and Strat.,* 1–427.

TIMING OF THE LATE DEVONIAN KELLWASSER CRISIS: CYCLOSTRATIGRAPHIC ANALYSIS OF THE JAVA GROUP AT THE WALNUT CREEK SECTION, NEW YORK, USA

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POSTER and ORAL

Introduction: The Kellwasser Crisis represents one of the big five mass extinction events in Earth's history. In many places in Europe and North America it is character- ized by successions of black shales in the li- thologies of the late Frasnian and early Famennian, punctuated by two thick black shales known as the Lower and Upper Kellwasser events. These black shales indi- cate rapid changes from oxic to anoxic ma- rine conditions. The driving mechanisms and the timing of the Kellwasser Crisis re- main a matter of debate.

Previous Devonian astrochronology: U-Pb dating of zircon crystals from a bentonite layer in uppermost-Frasnian sediments from Steinbruch Schmidt, Germany yielded an age of 372.36 ± 0.053 Ma for the Frasnian Famennian boundary [1]. Astrochronologi- cal studies offered a new perspective on the exact timing and pacing of the Frasnian- Famennian extinctions [2, 3]. By correlating magnetic susceptibility data to astronomical cycles, the duration of the interval between the Lower and Upper Kellwasser events was estimated to be 600 kyr. The inferred astro- chronology suggests that there was an orbital eccentricity minimum at the onset of the Up- per Kellwasser event, which reduced sea- sonal extremes. A few tens of thousands of years later, this orbital eccentricity minimum was succeeded by a fast change to an orbital eccentricity maximum and increased climate variability. The hypothesis that an orbital eccentricity minimum led to a stable climate with low action from orbital precession forc- ing will be tested with a cyclostratigraphic analysis of the Java Group strata at the Wal- nut Creek section (New York, USA) which spans the Lower-Upper Kellwasser events.

Lithology and Methods: Samples were taken from a 32 m thick cyclic sedimentary section from basin to prodeltaic sediments at Walnut Creek, New York, USA which spans a series of key Frasnian extinction pulses, in the Pipe Creek Shale and Hanover Shale of the Java Group [4]. The strata consist of gray shales, with interbedded mudstones, car- bonates, and black shales. The section was sampled at 5 cm-scale resolution (N = 639) and a magnetic susceptibility stratigraphic- series has been established. This series will be compared with XRF geochemistry re- sults. Cyclostratigraphic analysis of this multi-proxy dataset will be used to construct a floating astrochronology, that can be linked to other investigation sites in North America [5]. Principal component analysis will be used to identify environmental prox- ies based on their fluctuation patterns and rates. These paleoenvironmental proxies will be used to determine and quantify changes in detrital input, redox conditions, and organic productivity at a high-resolution precession- timescale to characterize depositional dy- namics.

Through this investigation of the pacing and timing of paleoenvironmental proxy concentrations, this study contributes signif- icantly to understanding the origins of the Kellwasser Crisis.

References:

[1] Percival L. M. E. et al. (2018) *Sci Rep 8,* 9578. [2] De Vleeschouwer D. et al. (2017) *Nat Commun, 8,* 2268. [3] Harrigan C. O. et al. (2021) *GSA Bulletin, 134,* 1931-1948. [4] Tuskes, K. (2017) *Unpub. Master's Thesis,* George Mason University. [5] Whalen M. T. (2015) *Geol Soc Spec Publ, 414,* 37-72.

UNTANGLING THE LATE DEVONIAN CARBON CYCLE USING COMPOUND SPECIFIC ISOTOPES

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POSTER

Introduction: The Late Devonian Kellwasser Events were periods of global anoxia and enhanced carbon burial in marine basins and are associated with a major perturbation to the carbon cycle. The burial of massive quantities of isotopically light carbon in marine settings caused a significant CO_2 drawdown, which is recorded by a positive carbon isotope excursion [1]. However, in the Appalachian Basin, a regional initial negative isotope excursion is superimposed over the global signal [2]. There are multiple potential environmental and ecological reasons for this mismatch. These include, but are not limited to, mixing of terrestrial and organic matter, environmental pressures affecting the marine primary producer community, ecological overturn, or secondary carbon sources. Because each of these factors can create identical bulk organic carbon $\delta^{13}C$ records, additional tools must be used to understand the cause of the regional carbon cycle variability.

Compound specific isotopes are used to analyze the isotopic change within certain molecular fossils, or biomarkers, with known precursors. This can provide information on the type of organism that produced the biomarkers. For example, pristane and phytane record the average isotopic values of most marine primary producers (algae, cyanobacteria, etc.), but is not directly affected by terrestrial matter or methanotrophic bacteria. Long chain n-alkanes provide information about terrestrial plants, but not marine organisms [3]. Comparing the specific behavior of these groups to the overall organic carbon average can be used to identify the biological groups responsible for the difference between regional and global carbon isotope trends. Once this is established, it can be used to determine the environmental and ecological mechanisms that caused the observed behavior.

Initial data through the Lower Kellwasser Event and overlying shales show that the unique regional signal observed in the total organic carbon record was not caused by the marine primary producer community. In fact, at each transition from grey to black shale, there are opposite trends observed between the phytane isotope data and bulk organic isotope data. Furthermore, the concentration of terrestrial organic matter does not change significantly throughout the measured samples, so the transport of organic matter from land is not likely to explain to the observed carbon isotope trend. The cause of the regional excursion may instead be an expansion of methanogenic consumers or sulfur reducing bacteria in the microbial ecosystem, or environmental mechanisms relating to the recycling of carbon within the basin. These other hypotheses are further tested using the isotopes of medium and long chain n-alkanes.

References: **[1]** Joachimski, M.M., Ostertag-Henning, C., Pancost, R.D., Strauss, H., Freeman, K.H., Littke, R., Sinninghe Damsté, J.S., and Racki, G. (2001) Chemical Geology, 175, p. 109–131. **[2]** Uveges, B.T., Junium, C.K., Boyer, D.L., Cohen, P.A., and Day, J.E. (2019) Palaeogeography, Palaeoclimatology, Palaeoecology, 531, p. 108787,. **[3]** Close, H.G. (2019) Annual Review of Marine Science, 11, p. 27–56.

INTEGRATED CONODONT, CARBON ISOTOPE, TRACE ELEMENT, AND SEQUENCE STRATIGRAPHIC DATA FROM THE GIVETIAN-FRASNIAN 'FRASNES EVENT' AND *FALSIOVALIS* EXCURSION IN IOWA AND NEVADA, USA.

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POSTER

Introduction: The Devonian is characterized by a series of global events and crises which variably combine extinctions, positive carbon isotope excursions, and intervals of black shale deposition [1, 2]. These events are often considered to represent rapid eustatic deepening and hypoxia or anoxia, although geochemical data for redox conditions is not available for the majority of events. The Givetian-Frasnian 'Frasnes' Event (or Crisis), a second-order mass extinction, is stratigraphically proximal to the *falsiovalis* positive carbon isotope excursion and up to three black shale intervals [3]. Like other Devonian biogeochemical events with all three components, it may represent a Paleozoic Oceanic Anoxic Event (OAE), but the order and timing of the signals is not well constrained due to the lack of high resolution integrated datasets.

Integrated data from Nevada, USA, is the first to combine conodont biostratigraphy, carbon isotope chemostratigraphy, major and trace element chemostratigraphy via portable X-ray fluorescence analysis, and sequence stratigraphy to characterize the Givetian-Frasnian boundary and the Frasnes and *falsiovalis* biogeochemical event in a carbonate dominated section. Additional data from Iowa are correlated using bio- and sequence stratigraphy.

The Givetian-Frasnian boundary in both areas occurs in shallow water biofacies dominated by species of *Polygnathus*, *Icriodus*, and *Pandorinella insita*, which do not allow for precise placement of the boundary due to the inability to identify *Ancyrodella*-based Frasnian biozones. Correlation is improved by sequence stratigraphy in both locations and the identification of global Devonian transgressive-regressive (T-R) cycle boundaries.

In Nevada and Iowa, the onset of the carbon isotope excursion closely follows the base of T-R Cycle IIb-1. It occurs very low in the *P. insita* faunal zone in Iowa, but cannot be further constrained to a conodont biozone in Nevada. In Nevada, the excursion is preceded by a thin anoxic black shale facies which may represent a late Givetian black shale horizon of the Frasnes Crisis. The excursion is also followed by anoxic black shales which likely represent a Frasnian phase of the crisis. In both areas, the presence of Frasnian Montagne Noir zones 2-4 conodont species constrains the age of the top of the crisis and excursion interval.

Correlation of the Iowa data with the Waterways Fm. of Alberta, Canada, suggests that the excursion likely begins in the latest Givetian *Skeletognathus norrisi* Zone and reaches peak values in MN Zone 1. The combined datasets suggest that deepening pulses and expansions of anoxic shale facies both preceded and succeeded the *falsiovalis* excursion, but that normal marine conditions occurred during the excursion. Additional data are needed to test whether the same sequence of events is present in other localities.

References: [1] Becker, R.T. et al. (2016) *Geol. Soc. London, 423,*1–10. [3] Becker, R.T. et al. (2020) *GTS*, 733–810. [3] Brett, C.E. et al. (2018) *P*^{3}*, 549*, 108843.

LATE DEVONIAN CRINOID AND BLASTOID GHOST LINEAGES

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ORAL

Introduction: A brief review of Late Devonian crinoids and blastoids, based on more recent research, is somewhat in order given this year marks the centenary anniversary of Winifred Goldring's (1923) *Devonian Crinoids of New York* [1]. A good deal of research on Devonian crinoids and blastoids has taken place since that time and review of the broad outlines of their diversity and taxonomic change through the interval is timely.

The origins of many Mississippian crinoid and blastoid clades can be traced back to the Early Devonian (Emsian) of Germany [2] and Spain [3] as well as the Middle Devonian (Eifelian and Givetian) of eastern and central North America. After reaching a peak in diversity during the Middle Devonian (e.g. 38 species in the Dock Street Clay of Michigan (*P. rhenanus / P. varcus* zones); 46 species in the Kashong fauna (*P. ansatus* zone) of New York) there is a marked reduction in crinoid and blastoid diversity beginning in the late Givetian (S. *hermanni* and *K. disparilis* zones) of Iowa, Wisconsin, New Mexico, and Michigan following the Taghanic event. A majority of Middle Devonian crinoid and blastoid clades are to date absent during the Frasnian and Famennian.

Crinoids are often at times abundant during the Frasnian although crinoid faunas are generally lacking in diversity. The camerate crinoid genera *Melocrinites* and *"Hexacrinites"* are cosmopolitan and may be abundant in the Frasnian of North America, Western Europe, and Australia and strongly dominate most assemblages. Both of these genera are characterized by complex arm patterns evolved to maximize the capture fine zoo- and phytoplankton. *Arthroacantha*, possessing a more conventional camerate arm structure, is also cosmopolitan, ranging over the same regions. The moveable spines, that characterize this genus, show a marked increase in size over time during the Frasnian. All three of these common Frasnian camerate genera go extinct at the end Frasnian Upper Kellwasser event.

The glossocrinid cladids [4] are widespread in North America during the Frasnian but are extinct by the end of the stage. While sustaining losses in the late Givetian, the cladid scytalocrinid and decadocrinid crinoid clades are cosmopolitan, increasingly morphologically diverse, and often common throughout the Frasnian and Famennian.

In contrast to the disparid anamesocrinids, the synbathocrinids and calceocrinids, though obviously extant, are absent in all known crinoid faunas during the Frasnian. Flexible crinoid clades appear to have been largely unaffected during the Frasnian although this subclass is need of more detailed review.

Frasnian blastoids are exceptionally rare. The author is only aware of 13 blastoid specimens; two individuals from the Sly Gap of New Mexico and eleven specimens from the Virgin Hills Formation of Australia [5].

Rare and low diversity of crinoid faunas are known from the Famennian of Montana (Sappington Formation that also preserves the only reported North American Famennian blastoid genus), Nevada (Pilot Formation), New Mexico (Box Member of the Percha Formation), New York (Alfred Shale, Gowanda, and Chadakoin formations) and Colorado (Broken Rib Member of the Dyer Formation). Crinoids and blastoids increased in abundance and diversity in the Famennian of Western Europe, Mongolia [6] and western China before becoming greatly reduced by the Hangenberg event. Relatively scarce in the earliest Tournaisian, diverse and abundant crinoid and blastoid faunas only reappear in the Late Tournaisian (upper *S. crenulata* to *P. communis carina* zones) of North America and Western Europe, ushering in the "Age of Crinoids."[7] It is particularly notable that many of the crinoid and blastoid genera that appear in the Tournaisian are representatives of clades that have no record for much or all of the Frasnian to Famennian interval.

Chronologically, many of the missing clades are absent for over 25 million years. A regional example is the Late Tournaisian (*S. quadruplicata – S. crenulata* zone) Meadville Shale crinoid fauna from northern Ohio[8], located less than 400 km from western New York, that contains 11 species of camerate, cladid, and disparid crinoids derived from Middle Devonian clades.

Examples of these "missing crinoid clades" include: the cladid atelestrocrinids, goniocrinids, pellecrinids, and botryocrinids; the camerate gilbertsocrinids, megistocrinids, platycrinitids, and eretmocrinids; and the disparid synbathocrinids and calceocrinids.

The underlying cause of Late Devonian ghost crinoid clades is presently unknown. Environmental conditions at presently reported Late Devonian localities were clearly not favorable to the majority of Middle Devonian derived clades. The cosmopolitan Frasnian camerate taxa discovered to date were extinguished by the Hangenberg extinction event, only to be eventually replaced by the descendants of Middle Devonian taxa millions of years later. It is possible that the crinoids survive only elsewhere in unpreserved depositional settings, possibly including deep-sea environments. The lack of taphonomic preservational conditions, critical for identifying most crinoids, may offer a possible explanation. Additionally, the challenge of discovering crinoids in the massive Frasnian sandstone and siltstone beds of New York and similar Upper Devonian facies elsewhere may provide a partial explanation. Finally, it is also possible that "stealth" Middle Devonian taxa were present in very low numbers at known localities and simply were either not preserved or are as yet to be discovered.

References: [1] Goldring, W. (1923) The Devonian crinoids of the state of New York. New York State Memoir 16, 1-1670. [2] Schmidt, W. E. (1934) Die Crinoideen des rheinischen Devons, Teil I, Die Crinoideen des Hunsruckschiefers. Abhandlungen der Preussischen Geologischen Landesanstalt (neue folge) 163, 1-149. [3] Breimer, A. (1962) A monograph on Spanish Palaeozoic Crinoidea. Leidse Geologische Mededelingen 27, 1-189. [4] McIntosh, G. C. (2001) Devonian cladid crinoids: Families Glosscrinidae Goldring, 1923, and Rutkowskicrinidae new family. Journal of Paleontology 75, 783-807. [5] Jell, P. A. and Jell, J. S. (1999) Crinoids, a blastoid and a cyclocystoid from the Upper Devonian reef complex of the Canning Basin, Western Australia: Memoirs of the Queenland Museum, vol.43 (1), 201-236. [6] Waters, J.A., Waters, J.W., Königshof, P. *et al.* (2021) Famennian crinoids and blastoids (Echinodermata) from Mongolia. *Palaeobio Palaeoenv* 101, 725–740.
[7] Kammer, T. W. and Ausich, W. I. (2006) The "Age of Crinoids": a Mississippian biodiversity spike coincident with widespread carbonate ramps. Palaois, 21, 238–248. [8] Kammer, T. W. and Roeser, E. W. (2012) Cladid crinoids from the Late Kinderhookian Meadville Shale, Cuyahoga Formation of Ohio. Journal of Paleontology 86, 470-487.

LATE DEVONIAN TO EARLY CARBONIFEROUS INTERVALS (D/C TRANSITIONS) FROM MONGOLIA: INSIGHTS FROM TWO DIFFERENT TERRANES.

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ORAL

The Central Asian Orogenic Belt (CAOB) is the world's largest Paleozoic accretionary orogenic belt, which has evolved over 800 million years, from Neoproterozoic time until the Cenozoic. Mongolia lies in the center of the CAOB, which is composed of a large number of different terranes. Mongolia is divided into a northern and southern domain by a Main Mongolian Lineament. Mid-Paleozoic deposits cover a huge area south of this lineament. In the frame of a several years-lasting collaboration undertaken by a working group of IGCP 580 and IGCP 596, three different Devonian/Carboniferous intervals have been studied in western and southern Mongolia.

The Hushoot Shiveetiin Gol site is located in Baruunhuurai Terrane of the Central Asian Orogenic Belt (CAOB), which ranges from the Famennian to the Lower Mississippian and is composed of primarily siliciclastic rocks including thin layers of calcareous rocks and volcaniclastics. Conodont biostratigraphy of the section ranges from the *Palmatolepis minuta minuta* conodont Zone to at least the *Palmatolepis rugosa trachytera* Zone. Due to the facies setting, hiatuses of several conodont zones occur. Nevertheless, due to lithological comparisons with other sections in the vicinity it seems likely that thick sandstones in the uppermost part of the section represent the Lower Mississippian rocks. Eight facies types were recognized in the Hushoot Shiveetiin Gol site, which ranges from shallow intertidal to open marine palaeoenvironments. The facies setting was characterized by coeval subaerial volcanism resulting in numerous pyroclastic deposits. The depositional environments and intense volcanic activity at the section limited the stratigraphic distribution, abundance, and diversity of many faunal elements, such as brachiopods and microvertebrates. The latter ones show low diversity, yet are abundant in distinct layers of the section, whereas ostracods are very abundant and diverse through many parts of the section. The diverse ostracode assemblage of this section is remarkable.

Deposits of the Devonian/Carboniferous transition of the Bayankhoshuu Ruins section in southern Mongolia likely occurred on either the Mandalovoo-or Gurvansayhan Terrane. In contrast to the western section, this section exposes mainly deep-water (hemipelagic and pelagic) deposits composed of limestones, siltstones, and chert. The marine sedimentary succession is interjected by volcanic rocks, basaltic lava, and volcaniclastic bentonite and tuff of remarkable thickness. Shallow-water sediments are less frequent. It is interesting to note that the intense volcanic activities were observed starting in the Givetian, through the entire Frasnian and Famennian. Evidence of both subaerial and submarine volcanism occurs by several meters of thickness pyroclastic ash and pillow basalt, and the section has experienced greenschist-facies metamorphism and hydrothermal alteration (Duckett 2021) which is consistent with the tectonic setting of an island arc with intensive volcanic activity during Middle-Late Devonian. The overall facies suggest an island arc setting with intensive volcanic activity during Middle-Late Devonian. Prolonged volcanic activity particularly in the Late Devonian is reported from many places around the world and has been suggested to be a driver of ecological collapse at the D/C boundary (e.g., Moreno et al. 1996; Paschall et al. 2019; Racki et al. 2018; Racki 2019). The stratigraphy of the Baynkhoshuu Ruins section was improved based on a few findings of radiolarians and conodonts, but more data is necessary for a better biostratigraphic record.

In the summer of 2022, the working group measured the Mid-Paleozoic two sections in detail in the Shinejinst region of southern Mongolia. We have found a number of new things such as coral/stromatoporoid biostroms, and bivalve biostroms in Early Devonian, and mapped approximately 50 volcaniclastic layers in Middle-Late Devonian. The talk aims to contribute to a better understanding of Paleozoic rocks within the critical period of Earth's History around the D/C boundary in different facies settings. Furthermore, we present new sedimentological and biostratigraphical data within the Paleozoic Terrane scheme for Mongolia, an area little details are known so far in terms of biostartigraphy and sedimentology.

References:

[1] Moreno C., Sierra S., and Saez R. (1996) *Evidence for catastrophism at the Famennian-Dinantian boundary in the Iberian Pyrite Belt, Geological Society London Special Publications 107*(1), 153–162. https://doi.org/10.1144/GSL.SP.1996.107.01.12.

[2] Paschall O. C. et al. (2019) *The Hangenberg event in Vietnam: Sustained ocean anoxia with a volcanic trigger? Global and Planetary Change, 175,* 64–81. https://doi.org/10.1016/j.gloplacha.2019.01.021.

[3] Racki G. (2019) *Volcanism as a prime cause of mass extinctions: Retrospectives and perspectives, Mass extinctions, volcanism, and impacts: New developments,* Geological Society of America Special Paper, 544. https://doi.org/10.1130/2019.2544(01.

[4] Racki G. (2018) *Anomalous Upper Devonian mercury enrichments: Comparison of inductively cou-pled plasma–mass spectrometry (ICPMS) and AAS analytical data, Geology Quarterly, 62*(3), 487–495. https://doi.org/10.7306/gq.1419.https://doi.org/10.1144/GSL.SP.1996.107.01.12.

[5] Duckett K. (2021) *Late Devonian rocks from a new site: The Bayankhoshuu Ruins od Southwestern Mongolia*, Thesis work.

DIVERSITY AND BODY SIZE TRENDS OF DACRYOCONARIDS ACROSS THE LATE DEVONIAN PUNCTATA EXCURSION, APPALACHIAN BASIN

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POSTER

Introduction: Dacryoconarids are an extinct group of marine microfossils that were abundant and globally distributed during the Devonian period. Climate instability during the Late Devonian caused a sharp decline in their diversity and eventual extinction in the early Frasnian stage (~383-375 Ma)[1, 2]. Dacryoconarids exhibited concomitant body size reductions [3], however, it is not certain if this was due to abiotic factors related to environmental degradation driving a true reduction in size (Lilliput effect) or biological reorganization favoring smaller species. This study examines the diversity and size dynamics of dacryoconarids in the Northern Appalachian basin across the globally recognized *punctata* positive carbon isotope excursion during the Frasnian [4]. The adult conch and embryonic chamber volumes of dacryoconarids were measured from consecutive shale-bearing units representing the upper Moscow through West Falls groups at Eighteen Mile Creek in New York.

Results: The family Nowakiidae exhibited slowly declining relative abundance through the late Givetian becoming very rare in the Frasnian. The family becomes locally extirpated prior to the *punctata* event and makes a brief reappearance after the termination of the excursion. The families Striatostyliolina and Styliolina co-occur throughout. Dacryoconarids altogether disappear at the Rhinestreet-Angola contact and exhibit a brief last occurrence several meters up in a narrow window of the Angola shale. Some of the stratigraphic size variations in bulb volume can be explained by diversity, however, a statistically significant reduction in both growth stages coincident with the onset of a negative carbon isotope excursion superimposed on the *punctata* event suggests a causal mechanism. Microtektites in this interval indicate a volcanic origin of depleted carbon and a possible environmental driver. The gradual decline in the assemblage scale adult body size through the early Frasnian is consistent with warming trends at similar paleolatitudes inferred from oxygen isotope trends derived from conodont apatite [5]. This suggests a potential thermally driven mechanism, such as the Temperature Size Rule [6], behind declining body sizes. Other geochemical proxy evidence for productivity and anoxia in the Appalachian basin [4, 7] are being explored as additional drivers of the observed changes.

References: [1] Bond, D.P.G. (2006) *Geobiology*, 4(3), 167-177. [2] Wittmer, J.M. and Miller, A. I. (2011), *Paelaeogeogr Palaeocl* 312(1), 54-65. [3] Wei, F. (2019), *Lethaia,* 52(4), 454-463. [4] Lash, G.G. (2019), *Global Planet Change*, 177, 239-254. [5] Joachimski M.M et al. (2009), *Earth Planet Sc Lett,* 284 (3), 599-609. [6] Atkinson et al. (2019) *Palaeontology*, 62(4), 561-582. [7] Sageman et al. (2003), *Chem Geo.* 195, 229-273.

KEY STRATIGRAPHIC MARKERS IN THE LATE DEVONIAN NORTH AMERICAN SEAWAY: TOWARDS A CHEMOSTRATIGRAPHIC FRAMEWORK FOR CORRELATION IN MUD-DOMINATED BASINS

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POSTER

Introduction: Throughout many ancient intervals of greenhouse climates and resulting high sea levels, stable cratons were flooded, leading to the formation of large shallow epeiric seas. Although modern analogues of these settings are rare, they constitute a significant proportion of the preserved sedimentary record, providing valuable insight into Earth's history prior to the Jurassic Period. Therefore, the reconstruction of fundamental characteristics of ancient epeiric seas, including depth, bathymetry, hydrography, restriction, water circulation, watermass chemistry, redox, and salinity, is crucial to understand the environmental context of many ancient sedimentary deposits. Such reconstructions are critical for enhancing our knowledge of Earth's environmental history and advancing the field of sedimentary geology, but also is crucial for a broad and deep understanding of life's evolution. Epeiric seas often comprise large areas dominated by mudrocks with limited facies diversity, rendering traditional techniques like conventional litho-sequence stratigraphy challenging to apply. The lack of proper sequence stratigraphic context as well as limited biostratigraphic control hinder our ability to correlate mud-dominated epeiric sea deposits. In the present contribution, we provide a detailed geochemical (Zr, Zr/Rb, Mo, and U) and sedimentological characterization of six cores from the Illinois Basin that allowed us to establish a sequence stratigraphic and basin evolution model that we correlated to 50 wells across the basin using gamma ray logs. From this model, we extrapolated the key stratigraphic markers to 10 cores and outcrops from the Upper Devonian Appalachian, Iowa, Anadarko, and Permian basins, which allowed us to define evolutionary patterns for each basin. This craton-wide integration creates identifiable and correlatable stratigraphic markers that allows for the correlation of epeiric sea deposits that can be used for climatic and paleoenvironmenal reconstructions.

Illinois Basin model and extrapolation: Our results suggest that during the Late Devonian, Illinois Basin mudrocks were deposited in three onlapping stages (one aggradational-progradational, one progradational, and one retrogradational sequence). Upon initial flooding of the basin at the base of the Stage I, the Frasnian interval was characterized by highstand deposits in a restricted basin with a relatively steep bathymetric gradient. A second transgression (Stage II) was then recorded immediately following the Frasnian-Famennian boundary (FFB), followed by a second stage of highstand deposits in a broader, shallow epeiric sea. Lastly, the mid-Famennian interval (Stage III) was characterized by progressive sea-level rise (a third transgression) and the full inundation of the basin, which continued to nearly the top of the sequence. Furthermore, we identify four anoxic pulses characterized by increase in redox proxy enrichment factors and increases in API units in gamma ray signals during deposition of the Upper Devonian mudrocks: the first upon initial flooding of the basin in the Frasnian, a second in the middle of the Frasnian (Stage I) likely not associated with sea-level change, the third upon sea-level rise immediately following the FFB, and the fourth within a general retrogradational context in the mid-Famennian. These key markers were also recognized in the adjacent Iowa and Appalachian basins, and a similar reconstruction was made. More broadly, in the Anadarko and Permian basins, we identified the key markers but the general trends are slightly different which, nevertheless, was not an obstacle for correlation. The recorded trends provide evidence for substantial eustatic fluctuations controlling the sequence stratigraphic architecture and development of anoxia in the Late Devonian epicratonic basins of North America.

Paleoenvironmental reconstructions based on chemostratigraphic correlations: Based on a detailed facies association analysis, we reconstructed the environmental variations across four time slices using described correlations across the North American Seway, demonstrating that the development of anoxic conditions is restricted to certain time intervals. Moreover, we showed significant variation in the mud-size components of different mudrocks across the basins which highlights the importance of unravelling the origin of the sediments for a better understanding of the sedimentary processes involved in mud delivery in large ancient epeiric seas. Finally, we were also able to tie some of the anoxic pulses to key biotic crises of the Late Devonian such as the Rhinestreet, Upper Kellwasser, and Enkeberg events. Overall, this study provides a novel and integrated chemostratigraphic framework for the Late Devonian North American Seaway and will serve as an example of using key geochemical signals for correlation and paleogeographic reconstruction in ancient mud-dominated epeiric seas.

A UNIQUE OCCURRENCE OF *SCHIZOPHORIA* (KING, 1850) IN LOWER GIVETIAN STRATA OF EASTERN NY

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POSTER

A unique occurrence of the brachiopod *Schizophoria* (King, 1850) occurs at several localities in the lower Givetian strata in eastern NYS [1]. A preliminary examination of the brachiopod was undertaken to attempt to determine what species are present in eastern New York. Goldring [2,3] listed *Schizophoria* cf. *striatula* (Girty, 1900) from Albany and Greene counties. From this, we examined descriptions of *Schizophoria striatula* from various occurrences in eastern North America. Some occurrences for this species were reported from Upper Devonian strata [4] in the Appalachian Basin. Middle Devonian reports of *Schizophoria* are most abundant from the Michigan Basin. Stewart [5] reported this species, along with a smaller variant she named *S. striatula* var. *parvum* (Stewart, 1927), from the Silica Shale of northwestern Ohio. *Schizophoria striatula* was also reported from the Illinois Basin by Kindle [6] who listed this species from the Sellersburg Limestone of southern Indiana, possibly from the Eifelian Stony Hollow-equivalent Speeds Member. A single report of this species from Middle Devonian strata of the Appalachian Basin was made by Prosser et al. [7] from rather poorly preserved material from the Romney Formation in Maryland, which is also possibly from Eifelian Stony Hollow-equivalent strata of the Purcell Member.

Imbrie [8] made a thorough study of Middle Devonian brachiopods from the Michigan Basin, specifically from northern Michigan and northwestern Ohio. In that work, Imbrie redescribed Stewart's specimens of *S. striatula* and *S. striatula* var. *parvum* from the Silica Formation as a new species *Schizophoria ferronensis* (Imbrie, 1959), aligning these specimens with those he collected from coeval strata of the Ferron Point Formation of northeastern Michigan. Imbrie [8] also redescribed *S. striatula* var. *traversensis* (Grabau, 1931-1933), originally described by Grabau [9] from the Middle Devonian Genshaw Formation of northeastern Michigan as the species *Schizophoria traversensis* (Imbrie, 1959). Kesling and Chilman [10] reported *S. ferronensis* from the Silica Shale at several localities in northwestern Ohio and southeastern Michigan, noting that specimens are found in the lowermost portions of the formation and in a bioherm in the upper portion of the formation.

Stigall Rode [11] conducted the most recent examination of species of the genus *Schizophoria* from the Devonian of eastern North America. In this work, she synonymized various species of *Schizophoria* along with redescribing various forms from across the Iowa, Illinois, Michigan, and Appalachian basins. In this report, Stigall Rode mentioned *S. striatula* in a discussion on the paleoecology of *Schizophoria* but did not list it as a recognized species in her list of the genus, though she did include *S. ferronensis* and *S. traversensis*. Recent correspondence with Alycia Stigall indicates that the omission of *S. striatula* from the species list of *Schizophoria* from eastern North America was the result of too few specimens having been examined during the study and that *S. striatula* is still viewed as a valid species of *Schizophoria*.

Due to a lack of specific details of the morphology of *S. striatula*, being unable to examine the type material or find detailed descriptions, we have made a comparison to the detailed morphology described by Imbrie [8] for the two major species erected from this species from coeval strata in the Michigan Basin. We collected specimens *Schizophoria* from near Westerlo in Albany County and Lapla in Ulster County from what we interpret to be the upper *Schizophoria* fauna interval. Our correlations indicate that the *Schizophoria*-bearing strata in eastern New York are from: 1) upper Mount Marion strata correlative with the regression of the Solsville Member in central New York – lower *Schizophoria* fauna interval; and 2) strata in the interval proximal to basal Panther Mountain strata coeval with the regression to initial transgression associated with the Morrisville Station to Mottville members of the Oatka Creek and Skaneateles formations, respectively – upper *Schizophoria* fauna interval. In relation to the specific stratigraphic level of the Michigan Basin specimens to which comparisons were made, current understanding indicates that the basal strata of the Silica Formation in northwestern Ohio and southeastern Michigan correlate to the basal Panther Mountain Mottville-equivalent interval and specimens from the Ferron Point and Genshaw formations in northeastern Michigan are correlative to lower Skaneateles/lower Panther Mountain strata [12]. As no other occurrences of *Schizophoria* are known from eastern North America in strata equivalent to the Oatka Creek-Mount Marion interval, we are only able to make comparison to specimens from Skaneateles-Panther Mountain equivalent strata.

We measured specimens of *Schizophoria* from the upper *Schizophoria* fauna interval in eastern New York from Lapla in Ulster County for width, length, and number of ribs per given width on the exterior of the shells for comparison with descriptions from Imbrie [8] and Stigall Rode [11] of *S. ferronensis* and *S. traversensis* from the Michigan Basin. From the data, it appears that specimens of *Schizophoria* from eastern New York from the upper *Schizophoria* fauna interval are rather large overall, with some variation in size from about 30 mm to over 40 mm in width, and all specimens examined have the same number of exterior ribs/mm, no matter of size of the specimen. Comparing this data to the descriptions of coeval Middle Devonian *Schizophoria* from the Michigan Basin, it seems as though our eastern New York specimens are either in between *S. ferronensis* and *S. traversensis* in size or about the same size as *S. traversensis*. However, they have distinctly fewer external fine ribs than those found in Michigan Basin species. We also note that our large specimens are very similar in description to those of *S. striatula* from Clarke and Schwartz [4] from the Upper Devonian of Maryland. Based on these differences it does not seem possible to assign our specimens to either *S. ferronensis* or *S. traversensis.* As our specimens most closely resemble *S. striatula* from the Upper Devonian of Maryland, we will deem it best to refer *Schizophoria* from the Middle Devonian of eastern New York to *Schizophoria* cf. *striatula* as per the nomenclature of Goldring [2,3] until such time as an examination of specimens assigned to *S. striatula* can be examined.

References:

[1] Bartholomew, A.J, and Ver Straeten, C. V. (2023) *Bull. Amer. Paleo.*, [2]Goldring W. (1935) *NYSM Bull.*, 303, 238 [3] Goldring W. (1943) *NYSM Bull.*, 332, 374 [4] Clarke J. M. and Schwartz C. K. (1913) *MD Geol. Sur.,* 539-699 [5] Stewart G. (1927) *OH DNR 4th-series Bull.*, 32, 1-76 [6] Kindle E. M. (1900) *Ann. Rept. of the Dept. Geol. and Nat. Resc. IN*, 247 [7] Prosser C. A. et al. (1913) *MD Geol. Sur.,* 23-108 [8] Imbrie J. (1959) *Bull. AMNH*, 116, 345-409 [9] Grabau A.W. (1931-1933) *Palaeontologia Sinica*, Ser. B, 3:3, 545 [10] Kesling R. B. and Chilman R. V. (1975) *Univ. MI Pap.on Paleo.*, 8, 408 [11] Stigall Rode A. L. (2005) *Jour. Syst. Palaeo.*, 3, 133-167 [12] Brett C. E. et al., *Bull. Amer. Paleo.*,

BASAL EMSIAN GSSP – POSSIBILITIES IN THE PRAGUE SYNFROM

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ORAL

Introduction: The basal Emsian GSSP defined in the Zinzil'ban Gorge in the Kitab State Geological Reserve (South Tien-Shan, Uzbekistan) is based on FAD of conodont *Polygnathus kitabicus* Yolkin et al. [1]. According to subsequent detailed correlations with Mauro-Ibero-Armorican, Rheno-Ardennan and Barrandian faunas it lies far below the base of the classical Emsian in German sense [2]. At the same time, the current GSSP correlates with a level in the lower half of the Praha Formation [3], [2]. But, the Pragian Stage has been originally deviced to correspond entirely to well lithologically and biostratigraphically confined Praha Formation (i.e. "the original Pragian"), and, similarly as the Lochkovian Stage, it has been defined in the Prague Synform (Barrandian area, Czechia), see e.g. [4]. These traditional Bohemian (Hercynian) stages represent classical megasequences which are characterized by significant environmental turnovers, e.g., [5], [6], [7]. Historically, P. Carls and J.I. Valenzuela-Ríos demonstrated (in materials submitted to the Subcommission on Devonian Stratigraphy – SDS/ICS) that the present boundary GSSP is much older than the formerly used German Siegenian-Emsian boundary and, that it correlates with middle parts of the traditional Early Siegenian (= approximately lower part of the Praha Formation). According to conodonts, the present GSSP corresponds to the middle of F.I. 5 in Nevada [8] which is close to faunal horizon COP II 295' [9]. This horizon coincides with the highstand of global T-pulse Ia and is older than T-pulse Ib of [10] Johnson et al. (1985), e.g., [11], [2], [12]. These arguments started a long discussion and doubts concerning the current basal Emsian GSSP, but following attempts to find a new appropriate level by repeated resamplings for GSSP redefinition in the Zinzil'ban Gorge section did not yield promising results. In 2019, the SDS decided to search for alternative section for the replacement of the basal Emsian GSSP. The most promising candidates seem to be located in the Spanish Central Pyrenees and in the Prague Synform.

Prague Synform: Lower Devonian successions in the Prague Synform were extensively studied for conodont biostratigraphy as well as palaeontological, sedimentological, geochemical and petrophysical record, e.g. [4], [6], [7], [13], [14], [15] and references therein. [13] summarized the conodont data from the Early Devonian from the Prague Synfrom and provided the most recent conodont zonation in this area. They proposed the *gracilis* Event as the alternative marker approximately corresponding to the traditional boundary between originally defined Pragian and Emsian stages. The team concentrated on the Pragian-Emsian sections in the Prague Synform in order to obtain large biostratigraphical, geochemical and petrophysical datasets. The Bohemian Graptolite Event (BGE) is a representative correlation horizon in the upper parts of the Praha Formation with a great potential for future redefinition of the Basal Emsian global stratotype (GSSP) also because of close entries of conodont taxa *Polygnathus excavatus excavatus* Carls & Gandl and *Latericriodus bilatericrescens gracilis* Bultynck, which might be critical for potential definition of new basal Emsian GSSP.

Sections and data: In regard of presence of the BGE with good accessibility and diverse sedimentology, the most eligible are Pod Barrandovem, Mramorka Quarry and Požár 3 Quarry sections. These sections were sampled for microfacies study and faunal content: conodont samples in dense intervals, sampling of available microfauna and macrofauna, samples for magnetic susceptibility logs, samples for isotopes δ13C and δ18O, samples for INAA geochemical analyses and GRS measurements. In some sections we used also previously obtained data (from MS and GRS). The microfacies study of the Mramorka section showed an increased dolomitization in studied interval of the uppermost part of the Praha Formation. New conodont material obtained enabled more precise recognition of the *steinachensis beta – brunsvicensis, brunsvicensis – celtibericus* and *celtibericus – gracilis/excavatus* Zones. Bulk carbonate samples from the

Mramorka, Požáry-3 and pod Barrandovem sections have δ18O and δ13C in the range of -10,45 to -2,08‰ V-PDB and -1,43 to 2,43‰ V-PDB (n = 175), respectively. The δ13C values show a marked increase within and/or close above the BGE interval in the Mramorka and Požár 3 sections. The isotope record also correlates with the estimated BGE equivalent in the Pod Barrandovem section. GRS measurements have been already evaluated in all three studied sections and MS samples have been measured. The contents of radionuclides 40K (expressed in %), 238U, 232Th (expressed in ppm) and total natural gamma-ray (tot eU expressed in ppm) were determined. The studied sections show similar GRS patterns around the BGE. The most promissing secrtion for the prospective GSSP redefinition will be presented.

References: [1] Yolkin, E.A., Kim, A.I., House, M.R, Weddige K and, Talent, J.A. (1997) *Episodes*, 20(4), 235-240. [2] Carls, P., Slavík, L. and Valenzuela-Ríos, J.I. (2008) *Bulletin of Geosciences*, 83(4), 383-390. [3] Slavík, L., Valenzuela-Ríos, J.I., Hladil, J. and Carls, P. (2007) *Geological Journal*, 42, 499-512. [4] Chlupáč, I., Havlíček, V., Kříž, J., Kukal, Z. and Štorch, P. (1998) *Czech Geological Survey*, 183 pp. [5] Slavík, L., Valenzuela-Ríos, J.I., Hladil, J., Chadimová, L., Liao, J.-C., Hušková, A., Calvo and H., Hrstka, T. (2016) *Palaeogeography Palaeoclimatology Palaeoecology*, 449, 300-320. [6] Bábek, O., Faměra, M., Hladil, J., Kapusta, J., Weinerová, H., Šimíček, D., Slavík, L. and Ďurišová, J. (2018) *Sedimentary Geology*, 364, 71-88. [7] Bábek, O., Faměra, M., Šimíček, D., Weinerová, H., Hladil, J. and Kalvoda, J. (2018) *Global and Planetary Change*, 160, 75-95. [8] Johnson, J.G. (1977) *Western North America: Devonian, University of California, Riverside Campus, Museum Contribution 4*. [9] Murphy, M.A. and Matti, J.C. (1982) *University of California Press*, 123, 1-83. [10] Johnson, J.G., Klapper, G. and Sandberg, C.A. (1985) *Geological Society of America Bulletin*, 96, 1349-1359. [11] Carls P. and Valenzuela-Ríos, J.I. (2002) *Palaeozoic conodonts from Northern Spain. Instituto Geológico y minero de España, serie Cuadernos del Museo Geominero*, 1, 315-333. [12] Valenzuela-Ríos, J.I. and Carls, P. (2010) *SDS Newsletter*, 25, p. 19. [13] Slavík, L. and Hladil, J. (2020) *Palaeogeography Palaeoclimatology Palaeoecology*, 549, 109-148. [14] Weinerová, H., Hron, K., Bábek, O., Šimíček, D. and Hladil, J. (2017) *Sedimentary Geology*, 354, 43-59. [15] Weinerová, H., Bábek, O., Slavík, L., Vonhof, H., Joachimski, M.M. and Hladil, J. (2020) *Palaeogeography Palaeoclimatology Palaeoecology*, 560, 110-136.

Acknowledgements: The research was financed by the Czech Science Foundation (21-21829S) and was conducted within institutional support RVO 67985831 of the Institute of Geology of the Czech Academy of Sciences.

GEOLOGIC CROSS SECTION A-A' FROM GENESEE COUNTY, WESTERN NEW YORK, TO LYCOMING COUNTY, NORTH-CENTRAL PENNSYLVANIA, SHOWING THE REGIONAL STRUCTURAL AND STRATIGRAPHIC FRAMEWORK OF THE ALLEGHENY PLATEAU AND VALLEY AND RIDGE PROVINCES IN THE NORTHERN APPALACHIAN BASIN

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POSTER

Introduction: In 2019, the U.S. Geological Survey (USGS) published geologic cross section A-A' that runs from northwest to southeast from Genesee County in western New York, through Livingston and Steuben Counties in New York, Tioga, Potter, and Clinton Counties in Pennsylvania, and ends in Lycoming County in north-central Pennsylvania. It is the fifth in a series of USGS Appalachian Basin geologic cross sections. This geologic cross section is 176 miles (283 km) long, running semi-perpendicular to the structural trend of the Appalachian Mountains. Stratigraphic correlations between ten wells were based on gamma ray well logs, core, and mud log records. Previously published geologic cross sections, stratigraphic correlation charts, and exploration reports for oil, gas, and coal were also used to interpret the structural and stratigraphic relationships of the study area. Several new cross sections in this series are currently under construction for locations in Alabama.

Cross section A-A' displays several important structural features including: (1) crystalline basement rocks in a homoclinal ramp that dips gently from the interior craton to the external margin of the fold-and-thrust belt, (2) normal faulting of crystalline basement rocks in the Rome trough and adjacent horst blocks, (3) numerous normal faults that extend from basement rocks up through Paleozoic rocks and were reactivated at least once during the Paleozoic to produce renewed subsidence and (or) small-scale inversion, and (4) large-scale thrust faults with basal detachment in Silurian, Ordovician, and Cambrian strata, and associated ramp foreland-vergent thrust faults that extend northwestward from Pennsylvania into New York. The cross section provides information about the structural and stratigraphic framework that can be used for exploration of energy resources (e.g., coal-bed methane in Pennsylvanian coal beds, and shale gas in the Ordovician Utica Shale and Devonian Marcellus, Rhinestreet, Dunkirk, and other shales); potential CO2 storage reservoirs in sandstone, salt, and carbonate formations; and the dynamics of fluid flow in the northern Appalachian Basin.

THE QUEST FOR THE DEVONIAN MAGNETIC FIELD: AN UPDATE

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ORAL

Abstract: The search for high-quality Devonian paleomagnetic data has been occupying paleomagnetists for nearly half a century, but acquiring accurate data from this time period remains problematic to this day. The lack of data has been traditionally interpreted as caused by pervasive overprinting during the late Carboniferous to Permian. Overprinting is indeed a common problem, but an overprinting mechanism is sometimes lacking. The absence of high quality paleomagnetic data in this time period prevents the understanding of the behaviour of Earth's magnetic field in this key interval for Earth evolution, and hampers the use of paleomagnetism as a tool for dating and correlation. A recurring observation in Devonian paleomagnetism is that magnetisations are often extremely weak, sometimes below the sensitivity limits of traditional magnetometers. This makes them effectively unmeasurable with standard techniques. I hypothesise that scarcity of Devonian paleomagnetic data does not reflect a lack of dedicated effort or community interest, but is an intrinsic manifestation of a significant natural process not yet clearly identified or adequately understood.

Measurements of the strength of Earth's magnetic field show that the Devonian magnetic field was likely as weak as that of the Ediacaran. A weak magnetic field may have poorly protected Earth's atmosphere, and in this way could have influenced the biosphere. The drivers behind a weak field in the Devonian are still poorly understood, and more data are urgently needed. I will give an overview of the present status of paleomagnetism research in the Devonian, the hypotheses that are currently being investigated and outline the challenges for the coming years.

NORTHWEST THINNING OF FAMENNIAN BEDS IN WESTERN NEW YORK STATE

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Famennian beds south of Buffalo in western New York State thin to the northwest and dip generally westward, unlike the older Devonian and Silurian beds in New York that dip generally southward. The unexpected shift in dip direction of these Famennian beds, particularly the interval from base of the Dunkirk Member to base of the Laona Member (both within the Canadaway Fm.), has hindered geologic recognition of the continuity of beds such as the Laona that lie above the Dunkirk. The shift in dip direction is neither abrupt nor lacking in explanation; it's an inevitable geometric result of stacking northwest-thinning beds onto the older/deeper Devonian and Silurian beds that dip southward. The northwest thinning, in turn, is clearly demonstrated by outcrop and well log data but not fully understood; it needs further investigation.

The present study area, wherein the Famennian beds thin to the northwest and dip generally westward, spans southern Erie County, northern Cattaraugus County, and northeastern Chautauqua County, New York. North of this study area, the Famennian beds have either pinched out or been erosionally removed. In other directions, the trends described here are not yet fully investigated. The study area itself is part of the Allegheny Plateau, highly dissected by valleys and gorges wherein the Famennian beds have been erosionally removed.

Evidence: Outcrop in the South Branch gorge of Cattaraugus Creek provides key evidence that the Laona Member continues farther east than Buehler & Tesmer [1], Tesmer [2], Meyers [3], and others have recognized. Despite their assumption that the Laona dips southward and their conclusion that the Laona cannot be reliably traced east of Perrysburg, New York, they possessed at least part of the evidence that shows otherwise. Buehler & Tesmer's three main Laona outcrops in Perrysburg (42.4905°, -79.0338°; 42.4895°, -79.0164°; 42.4707°, -78.9915°) lie essentially on a line that can be projected southeastward to the South Branch gorge (42.4208°, -78.8807°) where the Laona, unrecognized by them, is found high on the cliff wall. See Fig. 1. Such southeastward projection of elevation above sea level (or elevation above base of the Dunkirk, as inferred from well logs such as 31-009-20369) confirms the northwest thinning and points to the approximate Laona elevation near the top of the South Branch gorge wall.

Additional evidence within the same gorge comes from both the identification by House [4] of the Corell's Point Goniatite Bed at 42.4126, -78.8878°, 294 m elevation, and, immediately upstream, the brink of the South Branch waterfall which is an analog of the Lamberton Falls Bed identified by Baird. Eastward projections from their respective type localities show substantial thickening consistent with the overall northwest thinning of these Famennian beds. Far more evidence of northwest thinning is found in well logs.

Results: Fig. 2 shows isopachs of the interval between base of the Dunkirk and base of the Laona. Detailed listings of the data points cannot be presented here due to space limitations. Note the northwest thinning of about 7 m/km shown by the isopachs. Such thinning, if projected into Lake Erie, shows full pinchout of the beds between the base of the Dunkirk and base of the Laona. About 30 km inland, these Famennian beds range up to 250 m thick, yet within the footprint of the present-day lake they apparently thin to zero. Does this mean that the eastern basin of Lake Erie is at least partly a non-depositional feature rather than an erosional feature? A direct answer is difficult because the beds in question are entirely or almost entirely gone, due to non-deposition and/or erosion, from the footprint of the lake and immediate lakeshore area. Indirect evidence, as in Fig. 2, may thus be helpful.

The work summarized here has generated many measured sections within the study area. The work is locally important as a bridge between the stratigraphic characterizations west of the present study area by Baird and east of the study area by Jacobi. Within the study area, additional work on depositional facies, geochemical and radiometric correlations, and conodonts and other fossil evidence would be useful.

In addition to its local importance, the work presented here may be of broader interest in understanding the Appalachian and Michigan Basins, the origin of Lake Erie, and the bedrock geology – including configuration of the Niagara Escarpment – on the Canadian side of Lake Erie. The stratigraphic/structural patterns in Fig. 3, adapted from Roberts [5], are certainly influenced by the Algonquin Arch, and flexure of this arch may relate as well to the northwest thinning found within the present study area.

Conclusion and potential tests: The work presented here sets forth a reinterpretation of the Famennian stratigraphy within the study area. If tests are needed to demonstrate its validity, one such test involves the "Ledge A" siltstone bed shown in Fig. 1. This bed exhibits lateral continuity across the study area while remaining a proportionate distance below the Laona. Similarly, the author's identification of the Corell's Point Goniatite Bed at about 42.5898°, -78.6845°, 393 m elevation, fits the reinterpretation in terms of continuity and proportionality but would not otherwise be an expected location for the goniatite bed. Overall, the reinterpretation's recognition of northwest thinning leads to the various local effects and regional implications described here.

References: [1] Buehler, E. J. and Tesmer, I. H. (1963) *Bull. Buffalo Soc. Nat. Sci. (BBSNS) 21*. [2] Tesmer, I. H. (1975) *BBSNS 27*. [3] Meyers, M. J. (1999) *NYSGA Guidebook*, F2-F6. [4] House, M. R. (1967), in D. H. Oswald, ed., *Int'l Symp. on Devonian System*, 1066. [5] Roberts, A. (1988) *BBSNS 33*, 284.

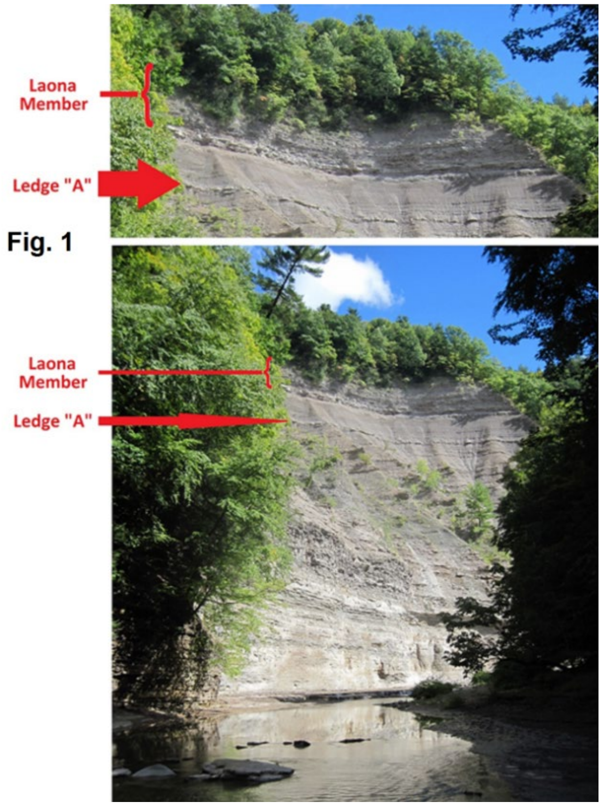

Fig. 1

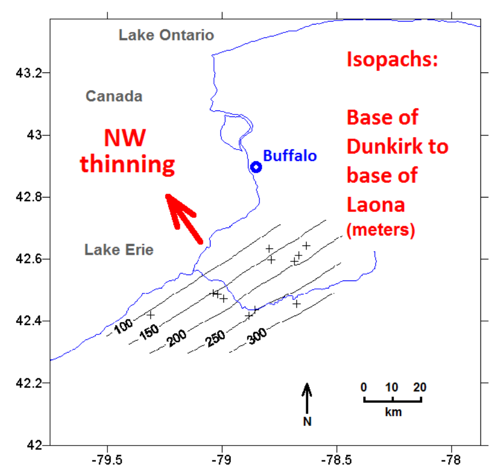

Fig. 2

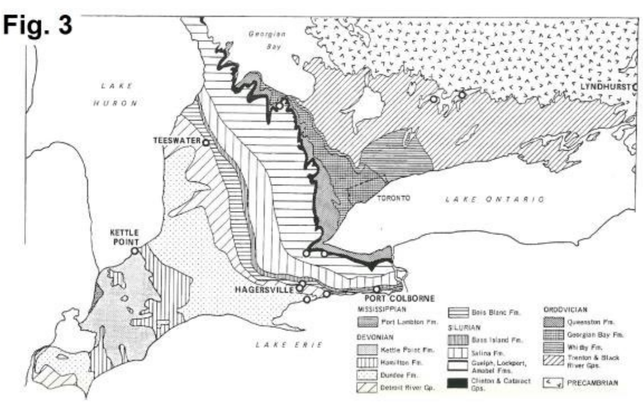

Fig. 3

THE DEVONIAN TERRESTRIAL SYSTEM IN NEW YORK STATE

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Late 18th to early 19th century reports on the rocks of the Catskill Mountains in eastern New York were followed by over 180 years of scattered geological and paleobiological studies of the Devonian terrestrial succession, in the state and up and down eastern North America. Yet, nearly 230 years later these estimated ca. 2.4 km- (1.5 mi-) thick, homogenous strata of the Catskills region in New York largely remain an unknown frontier (Ver Straeten [1]).

The Catskills terrestrial succession is lower Givetian (upper Marcellus-correlative) to an unknown position in the (upper?) Frasnian. Strata are fluvial-dominated, chiefly characterized by sandstones and shales and mudstones, largely deposited in fluvial channels and flood plains, respectively. Conglomerate increases upward through the succession. Relatively rare CaCO3 occurs as cement locally, as small nodules which locally amalgamate to form hardpan limestones, and rare freshwater lacustrine/palustrine limestones. Shales range in color from black to dark gray, green, and red, largely reflecting deposition on flood plains in wetlands, and below or above Devonian water tables, respectively. Paleosols are common, sometimes with a pattern of alternating vertic and non-vertic soil development. The overall 2.4 km- (1.5 mi-) thick Catskill succession appears, low to high, to represent a marine-terrestrial transition zone, and lower to perhaps mid alluvial plain deposition. Overlying strata deposited during the Devonian are eroded

Devonian terrestrial research in New York during the last century resulted in two different stratigraphic frameworks. The first, by George Chadwick (1930s–1940s), focused on the Catskill Front to the vicinity of Slide Mountain, highest peak in the Catskills. The second, by Rickard and Fletcher in the 1960s to mid-1970s, attempted to create a broader, more geographically inclusive chronostratigraphic nomenclature throughout the entire Catskills outcrop belt. Recent work indicates that in the field this latter model, based on thick lithosomes of red and gray rocks and conglomerates, is problematic. It can be seen as representing a "second draft" stratigraphic framework, in need of additional work and refinement. At this time, however, too little remains known to better ground the existing stratigraphy, or to propose a well-grounded alternate stratigraphic framework for the Catskills succession.

Other major foci in the Devonian terrestrial of New York include paleobotany (1950s–today), petrography (1960s–1980s), fluvial systems (1970s–1990s), and terrestrial arthropods (1980s–2000s). Broader paleobiological studies, in part associated with the Red Hill site in northern Pennsylvania, burgeoned in the 1990s and continue today. Recent Catskills terrestrial research of impact is perhaps largely paleobiological and includes the first complete Eospermatopteris ("Gilboa") tree, mapping of two well-preserved forest floors at Cairo and Gilboa (the former is currently the oldest known fossil forest globally), and increasing research on paleosols.

Difficulties in the research of Devonian terrestrial strata in New York include: 1) the lateral discontinuity of terrestrial facies and the lack of documented, distinctive marker beds for correlation; 2) little biostratigraphic and geochronologic control; 3) extensive cover in sometimes rugged terrain; 4) too few researchers; and 5) a need for greater cross-disciplinary perspectives and communication.

The purpose of recent and ongoing research by the author is multifold. First to systematically gather various data, such as event deposits, petrography, detrital zircon dating, and palynological biostratigraphy, top to bottom through the succession, initially in the classic Catskill Front to the vicinity of Slide Mountain, in the "Slide Mountain Wilderness" of the large "Catskill Park." Second within that succession, to better document depositional history, provenance, and biostratigraphy, and to know the succession more closely. Through this, the larger goal is to test the existing stratigraphic framework and try to ground that stratigraphy in the regional rock record better, or to develop a new stratigraphic framework.

Key issues that remain largely unresolved in Devonian terrestrial strata of New York include: 1) lack of a well-tested, viable, and correlatable stratigraphic framework; 2) a general lack of chronostratigraphic data from palynological/microvertebrate biostratigraphy and radiometric ages from altered air fall volcanic tephra beds; and 3) no systematic documentation of the vertical Catskill succession. New advances in numbers 1 and 2 include the introduction of rotatable 3-d lidar technology, which penetrates through forest cover and thin soils to show bedrock features, permitting lateral correlation of layers mountain to mountain. In addition, the author has begun to recognize altered air fall volcanic tephras in terrestrial strata; a new project of dating will help to constrain ages of the strata. Other future studies could include lateral, inter-state/province comparisons of variations in provenance/drainage evolution along the Acadian (Acadian-Neoacadian) Foreland Basin and its subbasin known as the Appalachian Basin, via petrography, detrital mineral dating, and other methods.

Reference:

Ver Straeten, C. A. (2023) Bulletins of American Paleontology, 407-408. 211-330.

THE DEVONIAN IN NEW YORK AND NORTH AMERICA/LAURENTIA

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ORAL

Devonian strata in New York State comprised the standard North America section for over 100 years. They remain a significant regional to global reference for correlation and research. Since publication of L. V. Rickard's [1] New York Devonian correlation chart, various higher-resolution stratigraphic analyses have been employed, sometimes at bed-by-bed scale. These include sequence-, bio-, event-, chemo-, and other -stratigraphic approaches, along with increasingly finer-resolution geochronologic dating of airfall volcanic tephras. Results have led to many new interpretations and insights of the succession.

This talk, based on Ver Straeten [1], briefly examines the Devonian in North America ("Laurentia") and New York State. The former includes the United States, Canada, Mexico, and Central America. Devonian history of the continent includes sedimentary aspects, paleobiology, orogenesis, metamorphism, silicic igneous activity, exotic terranes of Mexico and Central America, and Appalachian/Eastern Americas Realm faunas that extended into South America.

Devonian strata are widespread around the ancient continent "Laurentia." At that time, the equator was positioned over Laurentia, with New York State and the Appalachian region somewhat north of 30° south latitude. Shallow epicontinental seas covered large but varying portions of the continent over the period. Mountain belts formed on the eastern, northern, and western margins of Laurentia, due to plate tectonic collisions with smaller continental masses/exotic terranes +/-a volcanic island arc.

Through the Early to Middle Devonian, seas in western and eastern Laurentia were separated by a "transcontinental arch," and had distinctly different marine faunas. In the latest Middle Devonian, sea level transgressed over the land barrier of the Laurentian Transcontinental Arch and the Canadian Shield, and those marine faunas mixed, leading to a more global cosmopolitan fauna in the Late Devonian. Anomalously, Early and Middle Devonian Laurentian shallow marine faunas are found in Devonian rocks in Central and South America, which were part of the southern Gondwana continent, interpreted by some to be separated from Laurentia by oceanic water depths at that time.

During the Devonian, eastern Laurentia was an active tectonic margin, related to continent-continent collisions with various terranes/smaller continental masses. The Caledonian, Acadian, and Neoacadian orogenies resulted in compressional and some transpressional tectonics, and the uplift of an extensive mountain belt from east Greenland to Alabama and Georgia. Crustal loading of the mountain belt led to subsidence and formation of a retroarc Acadian-Neoacadian Foreland Basin. Initially the basin was filled with marine waters. However, massive volumes of synorogenic sediments from the orogen gradually overfilled the basin to above sea level by. The resulting lands were the site of some of the earliest forests on Earth, preserved at several sites in New York State, and early forest ecosystems.

Large-scale deformation, seismic activity, and metamorphism in the mountain belt were accompanied by igneous processes, including explosive eruption of felsic volcanic ash and other material, collectively termed "tephra." These explosive Devonian eruptions sent volcanic tephra high into the atmosphere, and easterly winds spread airfall volcanic "tephra layers" across the eastern United States.

Devonian rocks in New York occur at or just below the surface across approximately 40% of the state (~50,500 km^2/19,500 mi^2). The strata are generally undeformed and gently dipping, and while often covered by soil, glacial sediments, and vegetative cover, they are visible in natural and man-made exposures. Three relatively thin intervals of carbonates are accompanied by eastward thickening wedges of synorogenic mudrocks, sandstones, and minor conglomerates.

The history of geological and paleontological observation and study of the Devonian in New York began in the late 18th century. The first professional geologists appeared in the early 19th century. Since the advent of the first geological survey of New York State in 1836, the Devonian Period (nearly termed the "Erian Period" for New York's Devonian-age rocks) has been the focus of a great volume of research which continues to-day.

Strata from all seven stages of the Devonian are preserved in New York, with erosional gaps of small to major significance. In addition to a range of marine facies, nearly one quarter of the entire area of Devonian bedrock in New York was deposited in terrestrial settings. These strata feature the fossils of Earth's oldest known forest ecosystems.

Beginning with the work of James Hall, stratigraphic philosophy in New York has evolved toward a hybrid classification, wherein groups, formations, and bed-level units are largely time-rock/allostratigraphic to occasionally chronostratigraphic, with lithostratigraphy often ascribed to member-level divisions (e.g., Pragian to Givetian strata, middle Lower to upper Middle Devonian). In some intervals, such as Frasnian strata (lower Upper Devonian), group-level units are time-rock units, and formation-level units within groups are largely lithostratigraphic.

Forty-eight years of research since Rickard's [1] New York Devonian correlation chart permits development of a new, more refined chart (forthcoming), and also permits a new synthesis of Devonian rocks and fossils in New York, presented in this work of twelve chapters, with additional digital appendices.

[1] Rickard, L. V. (1975) New York State Museum, Map and Chart, *24*, 1-6, 4 plates.
[2] Ver Straeten, C.A. (2023) Bulletins of American Paleontology, *403-404*, 11-102.

SUMMARIZING A DECADE OF DEVONIAN SUBSURFACE MAPPING IN OHIO BY THE OHIO GEOLOGICAL SURVEY

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ORAL

Introduction: Over the past decade the Ohio Geological Survey (OGS) extensively remapped the Devonian interval in the Appalachian Basin (eastern) part of the state, research primarily driven by governmental projects assessing the region for carbon sequestration and CO_2 enhanced oil recovery potential. Products of this past work include subsurface maps, cross sections, and curated well log datasets, among other items. In the first part of my talk I will provide a brief overview of map and subsurface data products available through the OGS (Table 1; inset map in Fig. 1). The second part of the talk will focus on the lower part of the Huron Member of the Ohio Shale.

Mapping depositional cycles in the lower Huron Shale: The lower Huron consists of repetitively-stacked black and gray shale. These cyclic lithological changes correspond closely to gamma-ray cycles and bulk density variation on geophysical logs (Fig. 1). Eight of these gamma/bulk density cycles can be correlated across the eastern half of Ohio, and were picked in 789 wells across eastern Ohio. Structure and isochore maps for each cycle were created using Kriging and hand-contouring.

The lower Huron represents 2.95–3.6 myr, so the duration of each of the 8 cycles likely represents no more than 450 kyr [1]. Therefore maps of these cycles capture extremely precise time slices across a large geographic area, and can be useful for determining the timing of basin structure changes. Reorientation of depositional strike beginning in Huron cycle 3 indicate reactivation of faults associated with the proto-Cambridge Arch and the Akron Magnetic Boundary (#s 1 and 2 on Fig. 1 inset map, respectively). Additionally, a consistent thin zone present in all but 1 cycle between the Smith Township, Suffield, Akron, and Highlandtown fault systems (#3 and 4 on Fig. 1) may also indicate local-scale structural influence, but further mapping is required to determine the impact of those fault systems.

References: [1] Waid C.B.T. (2018) *OGS GN-13*, 18p. [2] Hull, D.N. (1990; rev. 2000 by Larsen, G.E. and 2004 by Slucher, E.M.) Generalized Column of Bedrock Units in Ohio, 1p. [3] Boswell, R.M and Pool, S.E. (2018), *WVGES RI-35,* 47p.

Table 1. Devonian maps available from the Ohio Geological Survey

Unit	Structure	Isochore	Publication
Berea Sandstone	Y	N	PG-5C
Cleveland Shale	Y	Y	PG-6A (structure); PG-6B (isopach)
Chagrin Shale	Y	Y	PG-6A (structure); PG-6B (isopach)
upper Huron Shale	Y	Y	PG-6A (structure); PG-6B (isopach)
middle Huron Shale	Y	Y	PG-6A (structure); PG-6B (isopach)
lower Huron Shale	Y	Y	PG-6A (structure); PG-6B (isopach)
Individual depositional cycles (1--8) in lower Huron shale	Y	Y	OFM 314–321 (structure); OFM 328–335 (isochore)
Java Formation	Y	Y	OFM 313 (structure); OFM 327 (isochore)
upper Angola Member	Y	Y	OFM 312 (structure); OFM 326 (isochore)
lower Angola Member	Y	Y	OFM 311 (structure); OFM 325 (isochore)
Rhinestreet Member	Y	Y	OFM 310 (structure); OFM 324 (isochore)
Sonyea Formation	Y	Y	OFM 309 (structure); OFM 323 (isochore)
Genesee Formation	Y	Y	OFM 308 (structure); OFM 322 (isochore)
Onondaga Limestone	Y	Y	PG-5B (structure); OFM 360 (isochore)
Oriskany Sandstone	Y	Y	OFM 354 (structure) OFM 359 (isopach)
Helderberg Group	Y	Y	OFM 353 (structure) OFM 358 (isopach)

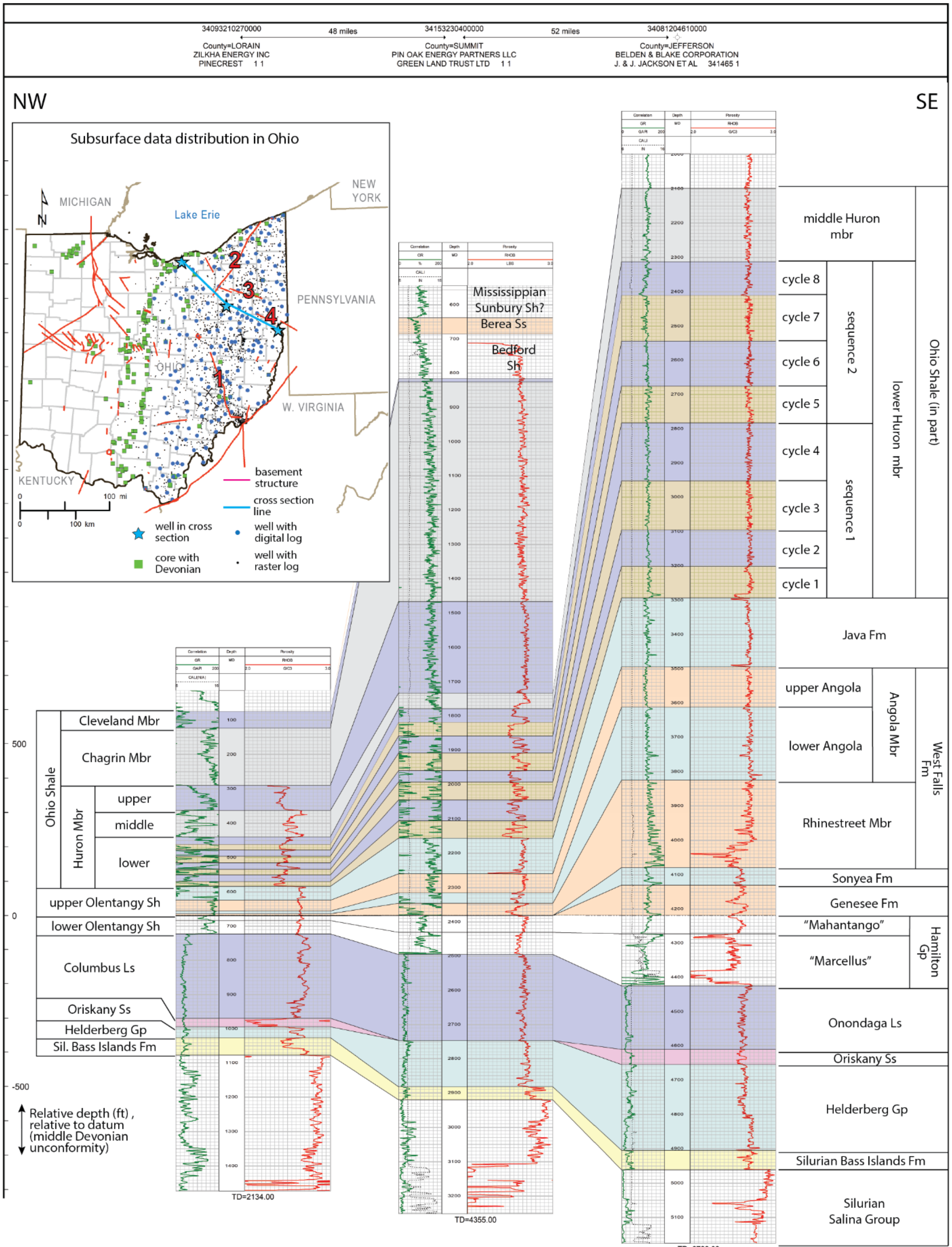

Figure 1. Example cross section showing the Devonian of northeastern Ohio. Color fill indicates units mapped by the OGS. Different colors are used to make correlations easier to distinguish. Stratigraphic terminology based on OGS[1,2] and WVGES[3] correlations. Red numbers on inset map referenced in abstract text.

THE CENTRAL ASIAN OROGENIC BELT (WESTERN CHINA AND MONGOLIA) WAS A BIODIVERSITY HOTSPOT IN THE LATE DEVONIAN

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ORAL

Extinction events at the end of the Givetian, Frasnian, and Famennian devastated tropical marine ecosystems and rank in the top ten in taxonomic and ecological severity. The close stratigraphic association between the extinction events and anoxic events, particularly the Kellwasser Anoxic Events and the Hangenberg Anoxic Event, supports a link between oceanographic anoxia and extinction in the Middle and Late Devonian. Faunas from the Central Asian Orogenic Belt (CAOB) demonstrate that central Asia acted as a refugium for marine organisms in the Late Devonian, became a diversity hotspot in the Famennian, and a center of radiation for marine life prominent in the Mississippian.

The CAOB is a Palaeozoic accretionary orogenic belt, which extends from Kazakhstan in the west, through Kyrgyzstan, Uzbekistan, northwestern China, the Altai-Sayan region and Transbaikalia in Russia, Mongolia, and northeastern China to the Russian Far East. The accretionary system includes oceanic island arcs, fragments of Precambrian microcontinents and collisional and post-collisional complexes as well as continental margin arc terranes.

Late Devonian sediments in Xinjiang Province, China, are part of an accretionary wedge deposited on a Marianas Island type island arc complex and are well exposed at the Boulongour Reservoir and other localities in the vicinity of Hoxtolgay. These are among the very few Famennian localities in the world with richly fossiliferous sedimentary rocks deposited in a shallow marine setting.

The Late Devonian sequence near Hoxtolgay is characterized by an abundant and diversified fossil flora and fauna consisting of acritarchs, spores, radiolarians, sponges, corals, trilobites, ostracods, gastropods, cephalopods, brachiopods, bryozoans, echinoderms (blastoids and crinoids), conodonts and fish teeth. The biota was very diverse (more than 198 genera and 285 species), acted as a refugium for some elements of the fauna and as a hotspot for rediversification of Famennian and Mississippian marine ecosystems.

Two benthic groups that define the Mississippian are the bryozoans and echinoderms. Crinoids reached their highest diversity and abundance in the Mississippian, which has been called the Age of Crinoids. During the Mississippian, crinoids dominated carbonate depositional systems producing regional encrinites tens of meters thick extending over hundreds of km^2. Bryozoans were also abundant and diverse. Bryozoans and echinoderms underwent extensive changes in faunal composition and diversity in the Devonian. Both suffered more significant extinction at the Taghanic Event and Givetian-Frasnian boundary than either at the Frasnian-Fammenian boundary or at the Devonian-Carboniferous boundary. Both bryozoans and echinoderms show patterns of significant global rebound in the Famennian. Data suggest that the CAOB was a biodiversity hotspot for both groups.

Biodiversity hotspots are important for understanding how areas of high species richness form, but disentangling the processes that produce them is difficult. Four hypotheses can be to explain the biodiversity hotspot in th CAOB. The center-of-origin hypothesis states that more new species originated in the CAOB than surrounding regions. The center-of-accumultion hypothesis states that lineages originating elsewhere preferentially colonized the CAOB. The center-of-overlap hypothesis states that species have widespread ranges that overlap in the CAOB. The center-of-survival hypothesis states that lineages in the CAOB experienced less extinction than those in surrounding regions. These four hypotheses differ in the biogeographic origin of species (within the CAOB, elsewhere, or no prediction), and in the processes ultimately responsible for high richness in the CAOB (colonization, speciation, or extinction).

Differentiating among these hypotheses requires more data than is currently available as the CAOB has not been studied with the intensity of North America or Europe. The CAOB in the Devonian was an amalgam of actively volcanic islands surrounded by oceans with diverse marine ecosystems similar to modern Indonesia.

Recent collections from the Devonian terranes in Mongolia support the hypothesis that the Famennian diversity hotspot extended beyond the arc complexes in Xinjiang Province. Lower Devonian coral stromatoporoid biostromes are present at Shine Jinst in the Mandalovoo Terrane, although ongoing volcanic activity limited their geographic and stratigraphic success. Relatively diverse echinoderm communities in the same section document their presence prior to the Middle and Late Devonian extinction events. Sparse collections from Shine Jinst document the presence of survivor Famennian echinoderm communities. The Hushoot Shiveetiin Gol locality in Baruunhuurai Terrane yielded a relatively abundant and diverse Famennian echinoderm community that has many genera in common with localities in Xinjiang Province, but endemic genera as well.

Echinoderm communities in the CAOB contain taxa that derived from Devonian lineages. However, many taxa represent the oldest members of their lineage and seem to form the basis of the dramatic increase in echinoderm diversity seen in the Mississippian. Although admittedly based on limited data, our current feeling is that the center-of-origin hypothesis best explains the echinoderm communities in the CAOB.

DECIPHERING THE ROLE OF TERRESTRIAL/ATMOSPHERIC INTERACTIONS IN LATE DEVONIAN KELLWASSER BLACK SHALE DEPOSITION: A HIGH-RESOLUTION CYCLOSTRATIGRAPHIC STUDY OF THE WINSENBERG SECTION (RHENISH MASSIF, GERMANY)

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ORAL

Abstract: The Late Devonian oceans were susceptible to the development of anoxic conditions, as evidenced by repeated widespread organic-rich shale deposition. Understanding how these anoxic facies were deposited will provide insight into Devonian climatic modes. To this end, we constructed a high-resolution cyclostratigraphic model based on portable XRF-generated elemental ratio records from a Frasnian-Famennian (~372 Ma) black shale section. These black shales are associated with the Kellwasser Crisis, one of the largest mass extinctions of the Phanerozoic, which is not fully understood to this day. The studied section at Winsenberg is located in the Rhenish Massif in Germany and represents a basinal setting at southern low paleolatitudes. Spectral analysis was carried out on the SiO_2/CaO ratios generated by XRF, which is interpreted as the detrital (distal) vs carbonaceous (local) input. The resulting astrochronology suggests a duration of ca. 1 Myr from the base of the Lower Kellwasser black shale to the F-F boundary at the top of the Upper Kellwasser level, or ca. 900 kyr between the starting points of both $\delta^{13}C$ excursions. This corresponds to an average sedimentation rate of 0.9 cm/kyr. Both the Lower and Upper Kellwasser shales occur at the onset of a 405 kyr eccentricity cycle. We further interpret the TiO_2/Al_2O_3 record as a riverine runoff signal, as titanium is associated with the coarse-grained fraction, and K_2O/Al_2O_3 as a chemical weathering signal, as potassium is leached easier than aluminium. Both tuned records exhibit eccentricity-modulated precession cycles. The riverine runoff response on precessional and 100 kyr eccentricity timescales is linked to wet/dry cycles controlled by monsoonal climate variations. The chemical weathering signal is anti-phased with runoff on these timescales, which may be explained by additional controls (sea level fluctuations, temperature, mechanical weathering in the hinterland). On 405 kyr timescales, longer wet and dry periods are observed in both riverine runoff record and chemical weathering signals, which are in-phase on these timescales. Both Kellwasser intervals occur within more arid, but also more fluctuating climates. In-between the two black shales a stable, humid climate developed. The humidity is evidenced by high runoff rates and high chemical weathering rates, and corroborated by high kaolinite content from XRD analysis. Relatively low variability in all proxy records indicates stable conditions. A long stable, humid period paced by 405 kyr eccentricity that occurs just prior to the Upper Kellwasser event is in line with the 'eccentricity-minimum hypothesis' for the Crisis, as postulated by [1]. This hypothesis states that a 2.4 Myr eccentricity node prior to the Upper Kellwasser resulted in the prolonged absence of seasonal extremes, allowing for the build up of nutrient-rich regoliths on the land that were subsequently eroded away as the Earth came out of the eccentricity minimum and the hydrological cycle intensified once again. This sudden nutrient influx would have led to eutrophication and subsequent

anoxia (a ‘top-down’ mechanism for anoxia).The current study suggests an orbital control on the timing of the Kellwasser Crisis. As Devonian carbon cycle perturbations did not occur exactly every 2.4 Myr, there must be additional or underlying control mechanisms. Seed plant evolution is a potential candidate of one such mechanism for the Kellwasser Crisis: the timing is consistent, and it fits with a terrestrial source of nutrients linked to enhanced weathering that is observed at Winsenberg. The influence of widespread volcanism, however, cannot be discounted. Further research will investigate whether this relationship between orbital configuration, Devonian climate, and widespread anoxia holds for subsequent Late Devonian carbon cycle perturbations.

References: [1] De Vleeschouwer et al. (2017) *Nat. Commun., 8,* 2268.

USING $\delta^{13}C_{TOC}$ CHEMOSTRATIGRAPHY TO RECOGNIZE DEVONIAN GLOBAL EVENTS IN THE NEW ALBANY SHALE (ILLINOIS BASIN, U.S.A.)

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ORAL

Introduction: A defining feature of the Devonian is repeated global extinctions of varying magnitude [1,2]. Since these extinctions manifest differently at regional scales, and are studied at varying temporal resolutions and using different techniques (e.g., paleobiology, stratigraphy, geochemistry, etc.), the Devonian literature of these named extinctions applies terms 'crisis' and 'event' (both sometimes with the prefix bio-) interchangeably when describing these extinctions [1,2,3]. Seeking a meaningful consistency for extinction terminology, Walliser [3, see also 4], proposed the hierarchical scheme that multi-biozone crises are comprised of (typically) intra-biozone events which could include black shale deposition, sea level change, carbon cycle fluctuations, and/or extinction.

Inter-disciplinary studies at stratigraphically high-resolution are crucial for applying this 'events-within-crisis' framework to understanding the nuances of extinctions globally and regionally. Carbon isotope stratigraphy is a key, and complimentary, tool for this approach because carbon-cycle perturbations (excursions) tend to occur within a single biozone or at biozonal boundaries and this tool also serves as a proxy for extinction-causing climate change [e.g., 5].

In carbonate dominated successions, inorganic carbonate carbon isotopes ($\delta^{13}C_{CARB}$) provide a relatively reliable record of seawater isotopic composition; organic carbon isotopes ($\delta^{13}C_{TOC}$) can also be utilized if some organic matter is present [6,7]. In contrast, many marine stratigraphic successions of extinctions contain carbonate-poor black shale, and are therefore often not applicable for inorganic carbonate carbon isotopic analysis [e.g., 7]. This can be problematic because the isotopic composition of organic matter at the regional scale is derived from marine sources as well as dissolved and particulate terrestrial organic matter fluxed to marine settings via rivers [8]. In the Devonian, when forests were evolving and progressively colonizing upland settings, terrestrial organic matter and nutrient flux to the marine realm were likely exceptionally variable both temporally and spatially [9].

This study, focused on the black, organic-rich New Albany Shale from eastern Illinois Basin drill cores, combines $\delta^{13}C_{TOC}$ analysis of bulk organic matter with elemental proxies for detrital input (Si, Ti, Zr, and K, each plotted as concentrations or standardized to Al; Si serves as a quartz sand and silt proxy, Ti and Zr proxies for silt, and K a proxy for clay). In the Devonian greenhouse world, terrestrial organic matter was isotopically heavier (more positive) than marine organic matter [10,11]. Since terrestrial organic matter and detrital input would both flux to marine settings via rivers, a similar trend in $\delta^{13}C_{TOC}$ and detrital input proxies would suggest that the $\delta^{13}C_{TOC}$ pattern is recording local changes in marine versus terrestrial organic matter (assuming marine organic matter production and preservation are relatively constant; Fig. 1). Correspondingly, when there is no change in detrital input or when $\delta^{13}C_{TOC}$ and detrital proxy trends are opposite any $\delta^{13}C_{TOC}$ trends observed may represent global carbon cycles changes. Combining $\delta^{13}C_{TOC}$ analysis of bulk organic matter with elemental proxies for detrital input can therefore be a useful tool for interpreting a $\delta^{13}C_{TOC}$ stratigraphic profile in the absence of $\delta^{13}C_{CARB}$ data. Confidence in global carbon cycle trends interpreted from $\delta^{13}C_{TOC}$ is strengthened when biostratigraphic data is also available, though retrieving conodonts from siliciclastic facies is challenging [7, 12].

Results: A transect of four cores along the eastern Illinois Basin was examined, focusing on late Givetian through early Famennian strata of the New Albany Shale; this interval contains notably high environmental and paleobiological volatility and frequent carbon cycle perturbations [1,13]. As far as siliciclastic dominated intervals are concerned, there is relatively good biostratigraphic control for this succession [12,14].

Under the assumptions of the simplified model presented in Figure 1, $\delta^{13}C_{TOC}$ trends was interpreted in the context of detrital input proxy data. In all four cores studied, aspects of the repeated carbon isotope excursion events associated with the Frasnes Crisis were observed in the Blocher Member, though in some cores it is unclear if the carbon isotpe excursions observed were instead associated with the Middlesex and Rhinestreet Events due to limited biostratigraphic control. In the overlying Selmier Member the *semichatovae* and Lower Kellwasser Events are recognized in the $\delta^{13}C_{TOC}$ data, with the Upper Kellwasser Event identified at the base of the overlying Morgan Trail Member.

References: [1] Becker R. T. et al. (2016) *Geol. Soc. Spec. Publ.*, *423*, 1-10. [2] House M. R. (2002) *Palaeogeogr. Palaeoclimatol. Palaeoecol.*, *181*, 5-25. [3] Walliser O.H. (1996) *Global Events and Event Stratigraphy in the Phanerozoic,* 225-250. [4] Abboussalam Z. S. and Becker R. T. (2011) *Palaeogeogr. Palaeoclimatol. Palaeoecol., 304,* 136-164. [5] Zambito J. J. et al. (2016) *Geol. Soc. Spec. Publ., 423,* 223-233. [6] Biebeshmeier E. J. et al. (2021) *Chem. Geol., 576,* 120256. [7] Hartenfels S. et al. (2022) *Paleobiodivers Paleoenviron, 102*, 763-829. [8] Burdige D. J. (2007) *Chem. Rev., 107,* 467-485. [9] Algeo T. J. and Scheckler S. E. (1998) *Proc. R. Soc. Lond., 353,* 113-130. [10] Maynard J. B. (1981) *Geol., 9,* 262-265. [11] Murphy A. E. et al. (2000) *Paleoceanography, 15(3),* 280-291. [12] Over D. J. et al. (2019) *J. Paleont., 81(6),* 1194-1217. [13] Brett C. B. et al. (2020) *Palaeogeogr. Palaeoclimatol. Palaeoecol., 549*, 108843. [14] Sandberg C. A. et al. (1994) *CFS, 168,* 227-253.

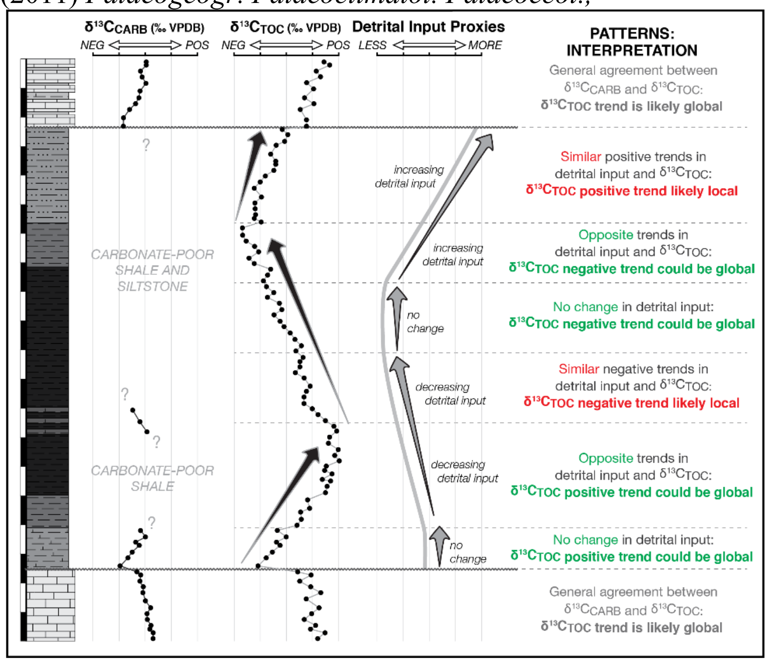

Figure 1: Schematic model for interpreting $\delta^{13}C_{TOC}$ trends in the context of detrital input proxies. Red patterns and interpretations indicate scenarios when local terrestrial versus marine organic matter processes are likely controlling the $\delta^{13}C_{TOC}$ trend and therefore comparison with global patterns should be avoided. Green patterns and interpretations indicate scenarios when $\delta^{13}C_{TOC}$ trends are not related to local terrestrial versus marine organic matter processes and therefore comparison with global patterns can proceed.

INTEGRATED STRATIGRAPHY OF MIDDLE DEVONIAN STRATA IN THE CARGILL TEST #17 CORE (LANSING CORE) OF NEW YORK STATE

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POSTER

Introduction: The Middle Devonian of New York State is an iconic succession in North America which has contributed key concepts in stratigraphy, sedimentary geology, tectonism, paleoecology, and evolution [e.g., 1-4]. Despite the vast body of previous work, the Middle Devonian of New York is rather poorly constrained chronostratigraphically owing to the relative rarity of conodonts and goniatites. This succession, from oldest to youngest, includes the Onondaga Formation, Hamilton Group, Tully Formation, and the lower portion of the Genesee Group. Within these strata, the Choteč Event has been recognized in the Onondaga Formation [5], the Kačák Crisis and the preceeding Bakoven and Stony Hollow Events recorded within the black shale-dominated Marcellus subgroup of the Hamilton [6], and the Taghanic Crisis observed in the Tully Formation and immediately sub- and suprajacent strata [7]. The *pumilio* Events, which are estimated to have occurred during deposition of the upper part of the Hamilton Group, are currently unidentified.

This Study: We have recently undertaken an integrated stratigraphic study of the Cargill Test Core #17 (more commonly known as the Lansing Core) with the goal of better constraining the chronostratigraphy of the Middle Devonian of New York State. This core was drilled in the central New York State Town of Lansing (just north of Ithaca), Tompkins County. This drill core provides a nearly continuous record of the entire Eifelian and Givetian stage interval in approximately 457m (~1500') of mainly fossiliferous gray mudstone to black laminated shale, with lesser siltstone and limestone facies.

The Lansing Core is located in a depositional setting conducive for this chronostragraphic project. The core is relatively proximal in the basin so that the overall succession is not condensed and major intervals are not removed by unconformities as seen in more basinward cores [8], yet it is distal enough that carbonate cements conducive for isotopic analysis appear to be present throughout most of the succession. Though some previous studies of the core have been undertaken, including sedimentological [e.g., 9] and carbon isotope stratigraphy through the Taghanic Crisis [10], the majority of this core has not been studied.

To date, the core has been lithostratigraphically described at a decimeter-scale. A high-resolution magnetic susceptibility dataset has been collected at 1-foot intervals (~1500 analyses) and a total of ~900 sample powders obtained for elemental and isotopic analysis.

Preliminary results indicate that nearly all litho- and allostratigraphic units identified in outcrop can be recognized in the core, although there are notable differences in thickness (e.g., Skaneateles Formation is nearly twice as thick as thickest outcrop successions to the north). Much of the core is highly fossiliferous and many of the distinctive epiboles and marker beds have been recognized. Magnetic susceptibility indicates the presence of cyclic alternation at the scale of meters and decameters.

Current and future work includes collection of a cm-scale spectral gamma log as well as carbonate carbon isotopic and pXRF elemental analysis of sample powders. This combined data set will then be used for cyclostratigraphic analysis to identify orbital cycles (precession, obliquity, eccentricity) and to build an astrochonological time scale, allowing the estimation of the pace and duration of the succession of events.

References: [1] Ver Straeten, C. A. (2010) *Mem. Geol. Soc. Am., 206,* 251-282. [2] Ettensohn, F. R. (1985) *Geol. Soc. Am. Spec. Pap.*, *201*, 39-49. [3] Eldridge, N. and Gould, S. J. (1972) *Models in Paleobiology*, 82-115. [4] Brett, C. E. and Baird G. C. (1995) *New Approaches to Speciation in the Fossil Record*, 285-315. [5] Brocke, R. et al. (2016) *Geol. Soc. Spec. Publ., 423,* 123-169. [6] DeSantis et al. (2007) *Geol. Soc. Spec. Pub.*, *278,* 83-104. [7] Bird, G. C. and Brett, C. E. (2008) *Bull. Geosci, 83(4),* 357-370. [8] Sageman, B. B. et al.

(2003) *Chem. Geol., 195,* 229-273. [9] Wilson, R. D. and Schieber, J. (2014) *JSR, 85,* 1393-1415. [10] Zambito J. J. et al. (2016) *Geol. Soc. Spec. Publ., 423,* 223-233.

INTEGRATED STRATIGRAPHIC AND PALEOENVIRONMENTAL STUDY OF THE MIDDLE-LATE DEVONIAN CARBONATE TO BLACK SHALE TRANSITION IN THE MICHIGAN BASIN

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POSTER

Introduction: Devonian climate trends have long been studied within the context of biological change. For example, the End-Devonian glaciation is typically thought to be related to CO_2-drawdown due to the evolution of forests during the Middle-Late Devonian [e.g., 1]. However, more recent paleoclimate reconstructions indicate that the Devonian climate story is more complex. Even though it has now been shown that the Middle Devonian was cooler than the end-Devonian and glacio-eustatic sea-level dynamics operated during the Middle Devonian [2,3], only Late and end-Devonian evidence for glaciation has been documented [4]. In order to better understand these long-term patterns, a current focus within the Devonian research community is the study of the repeated, short-duration, globally-recognized events that resulted in marine anoxia, extinctions, and carbon-cycle perturbations [5-7], especially within the context of local environmental change and tectonics [8,9].

This Study: We are currently focused on recognizing these events, and reconstructing the environmental change associated with them, in Middle Givetian through Lower Famennian strata of the Michigan Basin. The Michigan Basin is one of four depocenters in the northeast and upper Midwest United States. In the northern Appalachian Basin (New York State), Devonian strata are well exposed in an outcrop belt that is perpendicular to depositional strike of siliciclastic sediment input from the Acadian Mountains; these strata are therefore not only better-studied than contemporaneous strata in the Michigan Basin, but New York strata are the type examples for which many global events are named [5,6]. However, the Appalachian Basin was also tectonically active at this time and local environmental change associated with basin subsidence and sediment supply often overprints global environmental changes [8]. Conversely, the Middle-Upper Devonian transition from Traverse Group shallow marine carbonates to the Antrim Formation anoxic black shale in the Michigan Basin is unlikely the result of continental-margin tectonism, and more accurately reflects the signal of global environmental change.

The Michigan Basin Devonian succession has a long history of lithostratigraphic study and basin-wide correlation, though there is recognition that the stratigraphic nomenclature originally defined with the limited outcrops available at the northern basin margin is not easily applied to the subsurface [10, and references therein, 11, 12]. Furthermore, Michigan Basin type-section outcrops are rare, stratigraphically short, and generally lack exposure of formation and member contacts. However, a variety of cores exist as a result of active oil and gas exploration [12]; this project is therefore focused on the study and sampling of the extensive drill core available at the Michigan Geological Repository for Research and Education (MGRRE) at Western Michigan University.

This study is being undertaken through the Keck Geology Consortium, a multi-college collaboration focused on enriching undergraduate education through development of high-quality research experiences. Potential student research projects as part of this study include sedimentological and microfacies analysis, lithostratigraphy, chemostratigraphy (pXRF, carbon isotopes), magnetic susceptibility stratigraphy, and reconstructing diagenetic history and basin evolution.

References: [1] Algeo T. J. and Scheckler S. E. (1998) *Proc. R. Soc. Lond., 353,* 113-130. [2] Elrick, M. et al. (2009) *Palaeogeogr. Palaeoclimatol. Palaeoecol., 276,* 170-181. [3] Joachimski, M. M. et al. (2009) *Earth Planet. Sci. Lett., 284*, 599–609. [4] Ettensohn F. R. et al. (2020) *Geol. Soc. Am. Spec. Pap., 545*, 05. [5] House M. R. (2002) *Palaeogeogr. Palaeoclimatol. Palaeoecol., 181*, 5-25. [6] Becker R. T. et al. (2016) *Geol. Soc. Spec. Publ.*, *423*, 1-10. [7] Brett C. B. et al. (2020) *Palaeogeogr. Palaeoclimatol. Palaeoecol., 549*, 108843. [8] Zambito, J. J. et al. (2012) *Earth and Life*, 677–703. [9] Chen B. et al. (2021) *Ear.-Sci. Rev., 222*, 103814. [10] Wylie, A. S. and Huntoon, J. E. (2003) *AAPG Bull., 87*, 581-608. [11] Catacosinos, P. A. et al. (2000) *Mich. Bas. Geol. Soc.*, 1 Plate. [12] Swezey, C. S. et al. (2015) *USGS DDS, 69-T*, 1-162.

Pre-meeting Field Trip

26 July (Wed) to 29 July (Saturday) - Features will be the Devonian-Carboniferous boundary, clastic strata in northeastern Ohio and northwestern Pennsylvania, Upper Devonian offshore clastic-dominated strata in western New York that contain the Middlesex event, Rhinestreet event, Kellwasser bed equivalents, and the Frasnian-Famennian boundary.

26 July – Depart Geneseo or Rochester 1:00, Arrive La Quinta on 150th Street and I-71 4222 W 150th St, Cleveland, OH 44135 (216) 251-8500 where rooms for participants have been reserved.

27 July – Depart from La Quinta Inn at 8:00. Stops in greater Cleveland, Ohio area. Dinner at Black Jax Sports Bar. Lodging at Quality Inn – Erie, PA.

28 July – Depart Quality Inn – Erie at 8:00. Stops in Union City, PA, Titusville, PA, and Panama, NY. Dinner at Buddy Brewster's Ale House, Lodging at Quality Inn – Fredonia.

29 July – Depart Quality Inn – Fredonia at 8:00. Stops in Silver Creek, NY, Pike Creek, NY, Sturgeon Point, NY, and Eden, NY. Dinner in Eden, NY. Lodging as arranged by participants in Geneseo.

Intra-meeting field trip

Field trip to Frasnian-Famennian boundary strata in northern Pennsylvania or Niagara Falls and Silurian strata; includes transportation and lunch.

Post-Meeting Field Trip

02 August (Wednesday) to 06 August (Sunday) - Features will be the disconformable Devonian-Silurian contact in western New York, Middle Devonian reef, Middle Devonian black shales, platform clastic and carbonates through the Finger Lakes region, and then Lower and Middle Devonian carbonate- to siliciclastic-dominated to thick terrestrial strata in eastern New York State. The trip will start in Geneseo, New York, and finish in Catskill, New York, about 3 hours north of New York City. Transportation will be provided back to Geneseo or Rochester. Participants may also opt to be dropped off in Albany, Hudson, or Poughkeepsie, where the bus or train services New York City.

02 August - Depart Quality Inn – Geneseo at 8:00. Stops in LeRoy, NY, Geneseo, NY, Trumansburg, NY, Banquet at PRI-Museum of the Earth. Lodging at Quality Inn – Ithaca

03 August – Depart Quality Inn – Ithaca at 8:00; dinner at Heuga's Alpine Restaurant

04 August – Depart Quality Inn – Tully at 8:00; dinner at Bull's Head Inn

05 August – Depart Quality Inn – Schoharie at 8:00; dinner at Zicatellas

06 August – Depart Comfort Inn – Saugerties at 8:00; dinner at Hunter Mountain Brewery (must arrive by 6:30)

07 August – Depart Comfort Inn – Saugerties at 8:00

GENESEO
THE STATE UNIVERSITY OF NEW YORK
1871

FREDONIA
STATE UNIVERSITY OF NEW YORK

University of CINCINNATI

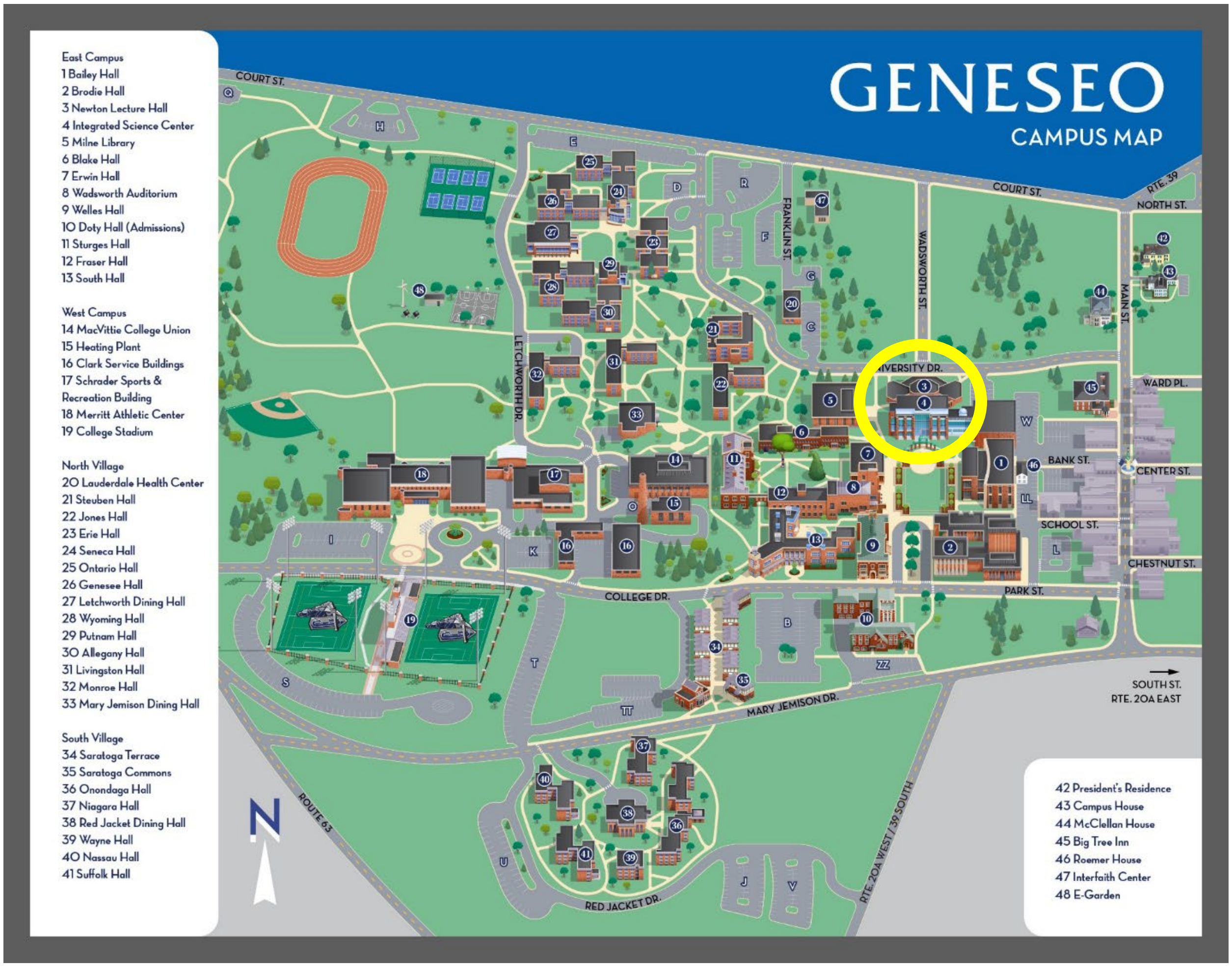
PALEONTOLOGICAL
RESEARCH INSTITUTION

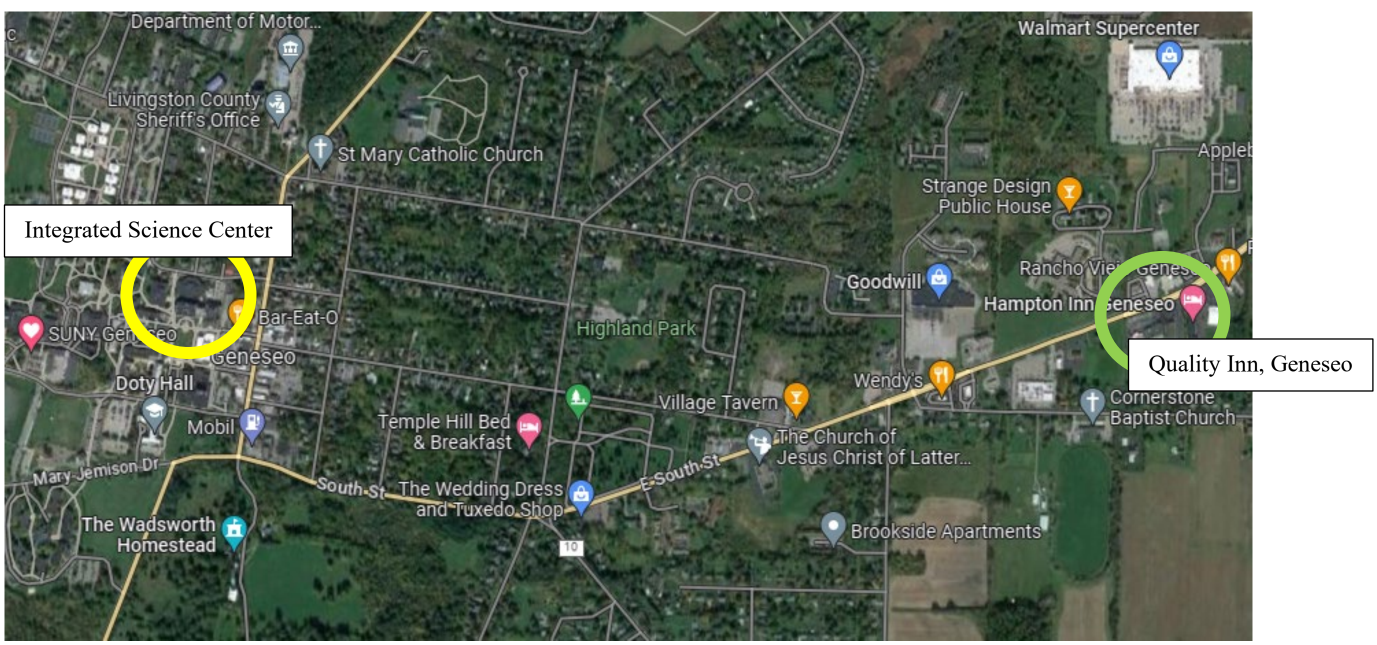
NYS M
New York State Museum

UCONN
UNIVERSITY OF CONNECTICUT

New Paltz
STATE UNIVERSITY OF NEW YORK

Beloit
College


GENESEO
CAMPUS MAP
East Campus
1 Bailey Hall
2 Brodie Hall
3 Newton Lecture Hall
4 Integrated Science Center
5 Milne Library
6 Blake Hall
7 Erwin Hall
8 Wadsworth Auditorium
9 Welles Hall
10 Doty Hall (Admissions)
11 Sturges Hall
12 Fraser Hall
13 South Hall
West Campus
14 MacVittie College Union
15 Heating Plant
16 Clark Service Buildings
17 Schrader Sports & Recreation Building
18 Merritt Athletic Center
19 College Stadium
North Village
20 Lauderdale Health Center
21 Steuben Hall
22 Jones Hall
23 Erie Hall
24 Seneca Hall
25 Ontario Hall
26 Genesee Hall
27 Letchworth Dining Hall
28 Wyoming Hall
29 Putnam Hall
30 Allegany Hall
31 Livingston Hall
32 Monroe Hall
33 Mary Jemison Dining Hall
South Village
34 Saratoga Terrace
35 Saratoga Commons
36 Onondaga Hall
37 Niagara Hall
38 Red Jacket Dining Hall
39 Wayne Hall
40 Nassau Hall
41 Suffolk Hall
42 President's Residence
43 Campus House
44 McClellan House
45 Big Tree Inn
46 Roemer House
47 Interfaith Center
48 E-Garden
COURT ST.
NORTH ST.
RTE. 39
FRANKLIN ST.
WADSWORTH ST.
MAIN ST.
LETCHWORTH DR.
WARD PL.
BANK ST.
CENTER ST.
SCHOOL ST.
CHESTNUT ST.
PARK ST.
COLLEGE DR.
MARY JEMISON DR.
RED JACKET DR.
ROUTE 63
RTE. 20A WEST / 39 SOUTH
SOUTH ST. RTE. 20A EAST
N


Integrated Science Center
Quality Inn, Geneseo
Department of Motor...
Livingston County Sheriff's Office
St Mary Catholic Church
Walmart Supercenter
Strange Design Public House
Goodwill
Hampton Inn
Bar-Eat-O
Highland Park
Doty Hall
Mobil
Temple Hill Bed & Breakfast
Village Tavern
Wendy's
Cornerstone Baptist Church
The Church of Jesus Christ of Latter...
The Wedding Dress and Tuxedo Shop
Brookside Apartments
Mary Jemison Dr
South St
E South St
The Wadsworth Homestead
10