Subcommission on Devonian Stratigraphy
and
IGCP 499 Devonian Land Sea Interaction: Evolution of Ecosystems and Climate

Eureka, Nevada, 9-17 September 2007

Program and Abstracts

Compiled and edited by D. Jeffrey Over and Jared Morrow

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and
IGCP 499 Devonian Land Sea Interaction: Evolution of Ecosystems and Climate

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Program and Abstracts

Devonian Global Change: compelling changes in the Devonian world, highlighting new findings in the terrestrial and marine biomes: fish, invertebrates, plants, terrestrial vertebrates, global warming, mass extinction, bolide strikes, and global correlation.

Organizers

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Welcome! Welcome to Eureka, Nevada, a historic mining town on the loneliest road in America and the meetings of the Subcommission on Devonian Stratigraphy (SDS) and IGCP 499, Devonian Land Sea Interaction: Evolution of Ecosystems and Climate.

Welcoming BBQ and Reception
14 September, 6:00, Owl Club, 61 North Main Street.

Conference Site
The conference will be held at the Eureka Opera House, 31 South Main Street, a restored historic building built in 1880. Wally Cuchine is the Director of the Opera House. Technical sessions will be held in the Grand Hall Auditorium. Presentations will be by PowerPoint. Posters will be displayed in the Grand Hall Auditorium, as well as the Diamond and Prospect meeting rooms on the lower floor. Light refreshments and coffee will be provided at mid-morning and mid-afternoon in the Diamond and Prospect rooms.

Sunday Excursions
The 16 September afternoon field trips to Devil's Gate and the Ruby Hill Gold Mine will leave from the Best Western Eureka Inn at 1:30. Sturdy shoes and suitable clothing are required – expect sun, wind, rain, possibly snow. Water and some sample bags will be provided.
Devil's Gate Devonian Strata - *leader Jared Morrow*
Ruby Hill Gold Mine - *leader Jeff Over*

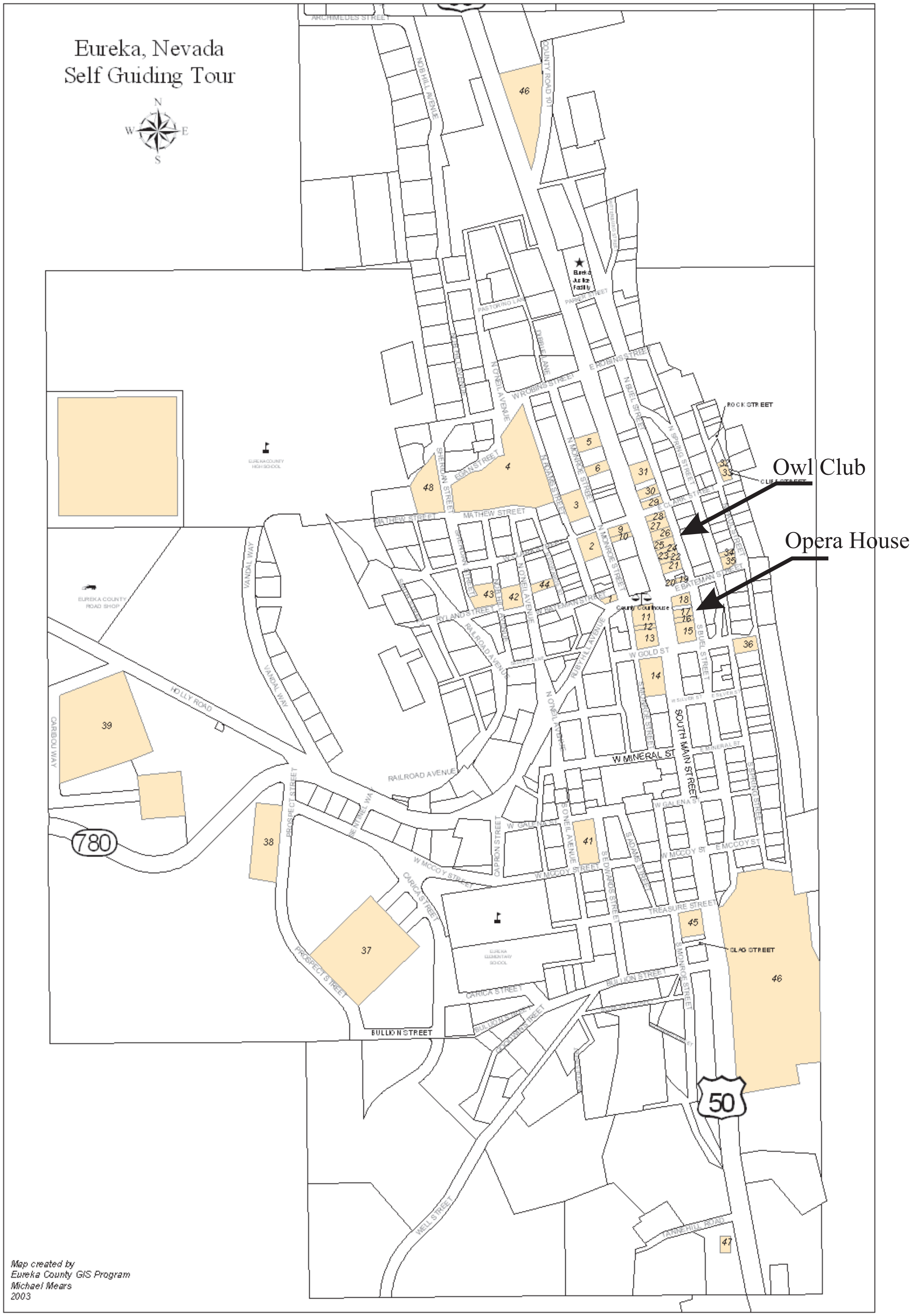
Dining
Breakfast is not provided as part of the conference. A continental breakfast is served in the Best Western Inn for its guests. The Owl Club, 61 North Main Street, serves a sit-down breakfast. Lunch and dinner will be served in the Owl Club – Ron Carrion (owner) - as ticketed events. The banquet, included in the registration fee, will be in the Opera House, catered by Biltoki – Ramon Zugazaga (owner) - of Elko, Nevada.

Lodging
There are three hotels in Eureka – Eureka Best Western Inn on Main Street at the north end of town, the Sundown Lodge on the west side of Main Street, and the Ruby Hill Motel, also on Main Street at the north end of town.

Transportation
Public transportation does not serve Eureka. Taxi, busses, and air service can be found in Elko. The best way to get around Eureka is by walking – the following pages have a map of the city and guide to historic sites.

Emergencies
Eureka County Sheriff, 20 South Main St., (775) 237-5330
Eureka Medical Center, 250 South Main St., (775) 237-5313

Post Office
51 South Main Street


Eureka, Nevada
Self Guiding Tour
Owl Club
Opera House
SOUTH MAIN STREET
W MINERAL ST
780
50
Map created by
Eureka County GIS Program
Michael Mears
2003

Walking tour sites on Eureka street map.

1. Sentinel Museum
2. Colonnade Hotel
3. Sadler House
4. Eureka County High School
5. Stone and Brick Building
6. Tognini and Company Building
7. Louie's Lounge
8. Lucky Stiff Bar
9. Eureka Cafe
10. Rendezvous
11. Eureka County Courthouse
12. The Annex
13. Eureka Senior Center
14. Rebaleati Garage
15. San Francisco Brewery
16. Eureka Post Office
17. Eureka Opera House
18. Jackson House
19. Ryland Building
20. Crew Car No. 29
21. Foley-Rickard-Johnson-Remington Building
22. Tommyknocker
23. Eureka Services
24. The Hanging Tree
25. Owl Bar and Steak House
26. Nevada Club Bar
27. Raine's Market
28. Wells Fargo Bank
29. Masonic Building
30. R. J.'s
31. Al's Hardware
32. Stone Building
33. Skillman House
34. The Parsonage House
35. Methodist Church
36. Saint James Episcopal Church

37. - 40. Cemeteries

41. Zadow and Morrison House
42. Saint Brendan's Catholic Church
43. Mary Wattles Home
44. Presbyterian Church
45. General Store
46. Slag
47. Taneill Log Cabin

The Subcommission on Devonian Stratigraphy is an international organization under the International Union of Geological Sciences, concerned with all Devonian stratigraphic matters that has been a major instrument for international and regional Devonian studies over the last 40 years. International Geoscience Programme (IGCP) Project 499 is a multidisciplinary project that aims to contribute to a better comprehension of the Devonian climate variations and complex ecosystems. The International Geoscience Programme is a joint endeavour of UNESCO and the International Union of Geological Sciences (IUGS) and operates in about 150 countries, involving several thousands of scientists. IUGS is a member of the International Council of Scientific Unions. IUGS promotes and encourages the study of geological problems, especially those of world-wide significance, and supports and facilitates international and interdisciplinary cooperation in the earth sciences.

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Technical Sessions: 15-17 September 2007, Eureka Opera House, Eureka, Nevada
Theme Sessions: Rapid Global Change, Devonian Sea Level Curve, Famennian Subdivisions, Land-Sea Environments, Devonian Correlation, general topics
Business Meeting Subcommission on Devonian Stratigraphy: 17 September 2007
Business Meeting IGCP 499: 17 September 2007

Instructions to Presenters

Oral presentations

All presentations will be in PowerPoint 10 or compatible. Be sure to give your presentation CD or flash disk to the projectionist to load onto the hard drive of the computer the day 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 120 cm x 150 cm maximum dimensions. Posters will be displayed for the duration of the conference on the rear wall of the Grand Hall Auditorium, as well as the Diamond and Prospect rooms. Wall adhesive or Velcro tabs will be provided.

Publication of proceedings: *Paleontographica Americana*, 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 October 2007. The target publication date is 1 March 2008. Instructions for authors are at http://www.priweb.org/bookstore/author_instructions.html

conference web page - http://www.geneseo.edu/CMS/display.php?dpt=frasnian

Schedule:
08 Sept – field trip participants arrive Las Vegas, NV
09 Sept – field trip departs, spends night in Alamo, NV
10 Sept – field trip, night in Ely, NV
11 Sept – field trip, night in Ely
12 Sept – field trip, night in Ely
13 Sept – field trip, night in Eureka
14 Sept – field trip, night in Eureka: *non-field trip conference participants arrive in Eureka, NV*
15 Sept – conference begins, stay in Eureka
16 Sept – conference, PM at Devil's Gate Devonian section or Ruby Hill Mine tour, stay in Eureka
17 Sept – conference, stay in Eureka
18 Sept – depart for Las Vegas/Elko, night in Las Vegas

Program

15 September 2007 (Saturday)

8:15 Welcome and Introduction
D. Jeffrey Over

Sea-level change and cycles - Maya Elrich and Charles Ver Straeten presiding.

8:20 EVALUATING THE ORIGINS OF EARLY-MIDDLE DEVONIAN 3RD-ORDER SEA-LEVEL CHANGES USING OXYGEN ISOTOPES OF CONODONT APATITE
Maya Elrick, V. Atudorei, S. Berkyova, J. Fryda, and Z. Sharp

8:50 PALEOENVIRONMENTAL AND EUSTATIC CONTEXT OF MIDDLE DEVONIAN BIOEVENTS IN EASTERN NORTH AMERICA, GERMANY, AND MOROCCO
Alex Bartholomew, and Carlton Brett

9:20 FAUNAL AND CYCLICITY CONTROLS FOR THE CALIBRATION OF THE EARLY DEVONIAN
Peter Carls

9:40 T-R CYCLE IB: THE "LUMPING" OF EMSIAN SEA LEVEL HISTORY
Charles A.Ver Straeten

10:00 – 10:30 coffee/posters

10:30 MAGNETIC SUSCEPTIBILITY AND INSIGHTS INTO DEVONIAN SEA LEVEL AND CLIMATE CHANGE, ALBERTA ROCKY MOUNTAINS, WESTERN CANADA
Michael T. Whalen, James E. Day, Rebecca Missler and D. Jeffrey Over

10:50 BURBANK HILLS, UTAH, U.S.A., PROVIDE A PARADIGM FOR MIDDLE AND LATE DEVONIAN EVENT STRATIGRAPHY.
Charles A. Sandberg, Jared R. Morrow and Forrest G. Poole.

11:10 THE PRECISE POSITION AND STRUCTURE OF THE BASAL CHOTEC EVENT: LITHOLOGICAL, MS-AND-GRS AND GEOCHEMICAL CHARACTERISATION OF THE EMSIAN-EIFELIAN CARBONATE STRATAL SUCCESSIONS IN THE PRAGUE SYNCLINE (TEPLA-BARRANDIAN UNIT, CENTRAL EUROPE)
Leona Koptikova, Jindrich Hladil, L. Slavik and J. Frana

11:30 COMPARATIVE STRATIGRAPHY OF LATE EIFELIAN SUCCESSIONS IN SOUTHERN MOROCCO AND THE APPALACHIAN BASIN: IMPLICATIONS FOR GLOBAL EVENTS.
Gordon C. Baird, Carlton E. Brett, R. Thomas Becker, Sarah Aboussalam-Becker, Michael DeSantis and Alex J. Bartholomew

11:50 CAN THE REWORKED CONODONTS OF THE NORTH EVANS LIMESTONE (CONODONT BED OF HINDE, 1879) HELP SOLVE THE GEOLOGICAL PUZZLE OF DEVONIAN EXTINCTIONS?
William T. Kirchgasser, Gordon C. Baird, D. Jeffrey Over and Carlton E. Brett

12:30 – 1:30 lunch

Rapid Global Change and other Devonian topics - Alex Bartholomew and Sandra Kaiser presiding

1:30 RAPID ENVIRONMENTAL CHANGE DURING THE LATEST FAMENNIAN - IMPLICATIONS FROM CONODONT BIOFACIES AND STABLE ISOTOPE ANALYSES
Sandra I. Kaiser, R. Thomas Becker and Thomas Steuber

2:00 SUCCESSION OF BIOSTRATIGRAPHIC MARKS FOR THE EARLY EMSIAN
Peter Carls, L. Slavík and Jose I. Valenzuela-Ríos

2:20 EMSIAN CONODONTS FROM LA GUARDIA D'ARES (SPANISH CENTRAL PYRENEES, LOWER DEVONIAN)
Carlos Martínez-Pérez and Jose I. Valenzuela-Ríos

2:40 PRIDOLIAN TO MID-LOCHKOVIAN BIOSTRATIGRAPHIC TIME MARKS IN BOHEMIA
Peter Carls, L. Slavík and Jose I. Valenzuela-Ríos

3:00 A MULTIPLE-PARAMETER APPROACH TO ANALYZING THE MID-PUNCTATA ZONE ANOMALOUS SIGNATURES IN PURE LIMESTONES (MORAVIAN KARST, BRUNOVISTULIAN TERRANE, CENTRAL EUROPE)
Jindrich Hladil, Leona Koptikova, M. Gersl, A. Langrova, P. Pruner, A. Galle, O. Babek, J. Frana, J. Otava and M. Chadima

3:20 – 4:00 – coffee/posters

4:00 UPPER SILURIAN TO MIDDLE DEVONIAN OF THE RHENISH MOUNTAINS, GERMANY: NEW BRACHIOPOD DATA AND IMPLICATIONS.
Ulrich Jansen

4:20 BRYOZOAN DIVERSITY IN MAIN DEVONIAN REGIONS OF FRANCE
Françoise P. Bigey

4:40 AFTERMATH OF THE LATE FRASNIAN MASS EXTINCTION ON BRACHIOPODS AND CORALS IN THE NAMUR-DINANT BASIN (SOUTHERN BELGIUM)
Bernard Mottequin and Edouard Poty

5:00 THE FRASNIAN/FAMENNIAN BOUNDARY INTERVAL FROM THE XOM NHA CAVE SECTION, QUANG BINH PROVINCE, CENTRAL VIET NAM: CORRELATION TO THE TYPE KELLWASSER LOCALITY, OKER RESERVOIR, HARZ MOUNTAINS, GERMANY, USING MAGNETIC SUSCEPTIBILITY DATA SETS
Brooks B. Ellwood, Eberhard Schindler, Luu Thi Phuong Lan and Ta Hoa Phuong

Dinner – 6:30 evening speaker at 7:30
ALAN CHAMBERLAIN “Hunting Great Basin Elephants: hydrocarbon potential and structural geology of Devonian reservoir rocks”

16 September 2007 (Sunday)

IGCP 499 Devonian Land Sea Interactions - Peter Konigshof and Eberhard Schindler presiding.

8:30 UNESCO NEWS AND A CRITICAL REVIEW OF IGCP 499
Peter Königshof

9:00 PALYNOLOGY AND ENVIRONMENT: A CASE STUDY OF THE EIFELIAN-GIVETIAN TRANSITION IN ITS TYPE AREA (EIFEL HILLS, GERMANY)
Rainer Brocke, W. Riegel, C. Hartkopf-Fröder, C. E. Brett, E. Schindler and V. Wilde

9:20 THE TERRESTRIAL TAGHANIC EVENT AS A HIGH RESOLUTION ARCHIVE OF CLIMATE CHANGE AND ITS CORRELATION WITH THE TULLY FORMATION
John E.A. Marshall, J.F. Brown and T.R. Astin

9:40 MIDDLE AND EARLY UPPER DEVONIAN CONODONTS FROM LA GUARDIA D'ARES (SPANISH CENTRAL PYRENEES)
Liao Jau-Chyn and José I. Valenzuela-Ríos

10:00 – 10:30 coffee/posters

10:30 WHY THE TERRESTRIAL UPPER FAMENNIAN IS IMPORTANT TO THE SDS
John E.A. Marshall and T.R. Astin

10:50 STRATIGRAPHY AND FACIES OF DEVONIAN SEQUENCES FROM THE NORTHERN MARGIN OF GONDWANA (CENTRAL TO EASTERN TAURIDES, TURKEY)
Eberhard Schindler, A. Wehrmann, I. Yilmaz, M. N. Yalcin, V. Wilde, G. Saydam, R. Özkan, A. Nazik, G. Nalcioglu, H. Kozlu, I. Gedik, K. Ertug and N. Bozdogan

11:10 THE DEVONIAN OF TURKEY – AN ATTEMPT FOR COMPARISON OF LAURUSSIAN AND GONDWANAN CONTINENTAL MARGINS
Isak Yilmaz, M. N. Yalcin, V. Wilde, A. Wehrmann, M. F. Uguz, E. Schindler, G. Saydam, R. Özkan, U. Mann, A. Nazik, G. Nalcioglu, H. Kozlu, P. Königshof, Ö. Karslioglu, U. Jansen, I. Gedik, K. Ertug, R. Brocke, N. Bozdogan and I. Bahtiyar

11:30 THE LOWER DEVONIAN BRACHIOPOD GENUS ACROSPIRIFER HELMBRECHT AND WEDEKIND, 1923 – GLOBALLY DISTRIBUTED OR HIGHLY ENDEMIC?
Mena Schemm-Gregory

11:50 EARLY DEVONIAN OSTRACODES FROM SPAIN
Claudia Dojen and Jose I. Valenzuela-Ríos

12:10 DEVONIAN OSTRACODES FROM DEVILS GATE (EUREKA, NEVADA)
Jean-Georges Casier, Ivan Berra and Alain Préat

12:30 – 1:30 lunch

1:30 – **Afternoon excursion. Vans depart from Best Western Eureka Inn:**
Devil's Gate - Jared Morrow
Ruby Hill Gold Mine - Jeff Over

7:00 – dinner banquet - evening speaker at 8:00
CHARLIE SANDBERG **–** "Devonian studies of the western United States: a six-decade personal retrospective."

17 September 2007 (Monday)

Famennian subdivisions and other Devonian topics - Carlo Corradini and Hanna Matyja presiding

8:30 FAMENNIAN EVENT STRATIGRAPHY (WESTERN POMERANIA, NW POLAND) – IMPLICATIONS FOR A PROPOSED SUB-STAGES DIVISION
Hanna Matyja

9:00 TIMING OF SEA-LEVEL CHANGES IN THE UPPER FAMENNIAN OF EUROPE AND SE MOROCCO
Sven Hartenfels and R. Thomas Becker

9:20 PELAGIC BIVALVES OF THE LATE DEVONIAN
Judith Nagel-Myers

9:40 PALAEOBIOGEOGRAPHIC IMPLICATIONS OF UPPERMOST FAMENNIAN AMMONOIDS FROM OKLAHOMA
R. Thomas Becker and Royal H. Mapes

10:00 GENERAL PROBLEMS IN CONODONT STRATIGRAPHY AROUND THE DEVONIAN/CARBONIFEROUS BOUNDARY AND POSSIBLE SOLUTIONS
Sandra I. Kaiser and Carlo Corradini

10:20 – 10:50 coffee/posters

10:50 THE INTER-REALM BARRIER IN NORTH AMERICA WAS SELECTIVELY BREACHED BY THE STROMATOPOROID *HABROSTROMA CENTROTUM* DURING THE LOCHKOVIAN AGE.
Carl W. Stock and Judith A. Burry-Stock

11:10 FAUNAL TURNOVER BETWEEN TWO E.E. SUBUNITS: INVESTIGATING THE TIMING OF LARGE-SCALE FAUNAL TURNOVER IN THE LATEST EIFELIAN OF EASTERN NORTH AMERICA
Mena Schemm-Gregory, Alex Bartholomew, and Thomas Schramm

11:30 PRELIMINARY DATA ON THE LOWER-MIDDLE DEVONIAN CONODONT BIOSTRATIGRAPHY OF SOUTH-EAST SARDINIA (ITALY)
Sofie Gouwy and Carlo Corradini

11:50 PROTOSALVINIA IN THE EASTERN UNITED STATES
Jeff Over, Remus Lazar, Juergen Schieber and Gordon Baird

12:30 – 1:30 lunch

1:30 SDS business meeting to be followed by break and then IGCP 499 business meeting

Dinner – 6:30

POSTERS

1] COMMENTS ON THE DEVONIAN/CARBONIFEROUS AND FRASNIAN/FAMENNIAN BOUNDARY STRATOTYPE SECTIONS (LA SERRE AND COUMIAC, MONTAGNE NOIRE, FRANCE)
Jean-Georges Casier and Alain Préat

2] FIRST OCCURRENCES OF RADIOLARIANS AND CONODONTS IN FRASNIAN SILICICLASTIC SEQUENCES OF THE RUDNY ALTAI (SOUTH OF WEST SIBERIA, RUSSIA)
Olga T. Obut, Nadezhda Izokh, and E.A. Yolkin

3] ISOTOPE COMPOSITION δ13C AND δ18O IN THE UPPER DEVONIAN (F/F) SECTION FROM THE NORTH-WESTERN KUZNETSK BASIN (SOUTH OF WEST SIBERIA, RUSSIA)
Olga Izokh and Nadezhda Izokh

4] SHELL MORPHOLOGIES OF JUVENILE BRACHIOPODS FROM THE UPPER HELDERBERG GROUP (NEW YORK, LOWER DEVONIAN)
Mena Schemm-Gregory, and Alex Bartholomew

5] ON THE GENUS RHENORENSSELAERIA KEGEL, 1913 (BRACHIOPODA, LOWER DEVONIAN)
Mena Schemm-Gregory

6] ECOLOGICAL CHANGE DURING THE EARLY EMSIAN (DEVONIAN) IN THE ANTI-ATLAS (MOROCCO) AND THE ORIGIN OF THE AMMONOIDEA
Christian Klug, Björn Kröger, Dieter Korn, Martin Rücklin, Mena Schemm-Gregory, Kenneth de Baets, Royal H. Mapes

7] EYE-EVOLUTION OF *ACUTICRYPHOPS*, A LATE FRASNIAN PHACOPID TRILOBITE.
Catherine Crônier, Raymund Feist, and K. J. MacNamara

8] DETAILED CONODONT BIOSTRATIGRAPHY AND CARBON ISOTOPE CHEMOSTRATIGRAPHY THROUGH THE KLONK EVENT AND ACROSS THE SILURIAN/DEVONIAN BOUNDARY IN SOUTHWESTERN LAURENTIA
James E. Barrick, D. J. Jacobi, Mark A. Kleffner, and Hal R. Karlsson

9] REEF BUILDING POTENTIAL OF DEVONIAN BRYOZOANS: AN EXAMPLE FROM SOUTHERN MOROCCO
Andrej Ernst and Peter Königshof

10] RE-EXAMINATION OF THE TYPE ITHACA FORMATION (FRASNIAN) USING A SEQUENCE STRATIGRAPHIC APPROACH: POSSIBLE CORRELATIONS WITH SECTIONS IN WESTERN NEW YORK AND IMPLICATIONS FOR FAUNAL CONTROL
J. J. Zambito IV, A. J. Bartholomew, C. E. Brett, and G. C. Baird

11] LATE DEVONIAN DIAMICTITES AND CONTEMPORANEOUS QUARTZ-RICH SANDSTONES IN PENNSYLVANIA AND MARYLAND: RESPONSES TO IMPACT OR OTHER, SURFICIAL PROCESSES?
Don Woodrow and John Richardson

12] MIDDLE-UPPER DEVONIAN (MIDDLE GIVETIAN-EARLY FAMENNIAN) RECORD OF RELATIVE SEA LEVEL AND CLIMATE CHANGE IN THE IOWA AND WESTERN ILLINOIS BASINS, WESTERN LAURUSSIA
Brian Witzke, Jed Day, and Bill Bunker

COMPARATIVE STRATIGRAPHY OF EIFELIAN SUCCESSIONS IN SOUTHERN MOROCCO AND THE APPALACHIAN BASIN: IMPLICATIONS FOR GLOBAL EVENTS.

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ORAL

A new Middle Devonian section has been discovered in the western Dra Valley (SW Morocco) during a mapping project of geology students from Münster. A detailed measurement and sampling of rhythmic shale-carbonate outcrops of the Eifelian to early Givetian Timrhanrhart succession SE of the Rich Touimiliht and S of Hassi Mouf (S of Aouinet Torkoz) was subsequently undertaken by a joint American-German research group. This investigation has the following objectives: first, to document the detailed pattern of sequence and cycle stratigraphy; second, to document the succession of faunas and to establish biostratigraphic relationships, third, to make detailed comparisons between the Moroccan sections and classic Middle Devonian successions in the Appalachian Basin, and thereby, fourth, to shed light on the local vs. global origin of cycles, facies changes, and bioevents. Although much of this analysis is preliminary, a detailed lithostratigraphy has been established and the sampling for conodonts and goniatites permits comparison with coeval sections of the eastern Dra Valley, SE Morocco (Tafilalt) and the Onondaga Limestone and Marcellus Shale (lower Hamilton Group; Eifelian-lower Givetian) in the Appalachian Basin of eastern North America [1], [2].

The new Hassi Mouf-south section is exposed along a south-trending tributary wadi to the Oued Draa, approximately 11 km S of Torkoz. Above a thick siliciclastic succession of upper Emsian to basal Eifelian units (topmost Khebchia Fm., Rich 4 Sandstone Mbr.) is a 46 meter-thick interval of repetitive limestone-shale alternations spanning the Eifelian to lower Givetian Yeraifa and lower Ahrerouch Formations [1]. Resistant sandstones of the Rich 4 Member grade upward into a gray, calcareous shale and siltstone unit yielding shell lags characterized by crinoid ossicles, rhenopyrgid edrioasteroids, diverse brachiopods, proetid (*Gerastos* n. sp.) and phacopid trilobites, gastropods, solitary rugose corals, and large, distinctive ostracodes. This argillaceous interval (Crinoid Marl Mbr., basal Yeraifa Fm.) is abruptly overlain by shell and pelmatozoan-rich limestones (*Pinacites* Limestone Mbr.); calcareous shale and limestone beds rich in robust bivalves (*Panenka* sp.), goniatites (*Fidelites* sp.), rugosans, rhynchonellids, bryozoans, trilobites, and pelmatozoans characterize this basal interval. These beds contain an admixture of pelagic (goniatites, nowakiids, polygnathids) and rich benthic faunal elements. This interval is approximately equivalent to the richly fossiliferous upper Onondaga Limestone. Above this interval, succeeding limestones become distinctly darker and marly, nodular or concretionary (Grey Marl Member). The diverse benthos gives way to a biota of styliolines, very small brachiopods, some phacopids, and both straight and coiled cephalopods. This dysoxic facies continues to the highest strata examined at this section but there are distinctive changes between dark grey, black and light grey beds and changes in fossil content.

Approximately 10.9 meters above the base of the *Pinacites* Limestone Mbr., a large arthrodire skull and shoulder girdle was discovered by one of us (Baird) in a dark limestone interval with the goniatite *Fidelites*, small ambocoeliid brachiopods, orthocones and small solitary rugose corals. It overlies directly a marly limestone with large orthocones that is characterized by the first mass occurrence of a small, smooth brachiopod, which resemble forms of the two Givetian “*pumilio* Beds” of southern Morocco and

Germany. Eifelian “*pumilio* Beds” have previously been found at Bou Tserfine near Assa and in the eastern Dra Valley.

Approximately 1.6 m above the arthrodire bed is a thin limestone with numerous small and poorly preserved cabrieroceratids suggesting, at least, a middle Eifelian age for this unit. A higher, black, marly limestone with abundant well-preserved *Agoniatites* and other goniatites (*Cabrieroceras, Parodiceras*) on its upper surface is upper Eifelian in age and allows correlation with the latest Eifelian *Agoniatites* Zone of the Tafilalt [1]. It may also correlate with the dysoxic Cherry Valley Member (“*Agoniatites* Limestone”) of the New York succession [3], [4]. Overlying shales and black marls of the basal Ahrerouch Fm. are much less fossiliferous but include some *Trevoneites*, a genus which first enters in the Kacak Event beds of the eastern Dra Valley and southern Algeria. The subsequent gradual return to light grey, marly nodular limestone with pyrite-filled burrows, crinoid stems, brachiopods, solitary Rugosa, phacopids and goniatites (*A.* aff. *vanuxemi*) give evidence for an episodically improved seafloor ventilation in the basal Givetian, perhaps correlating with the Halihan Hill Bed of the New York section [2-4]. Above a covered interval, limestones with pyritic burrows and nodules, black marls and thin “*pumilio* layers” return, indicating a brief episode of pronounced dysoxia during the basal Givetian.

Overall, comparisons between the Moroccan section and those of the late Eifelian-earliest Givetian in the Appalachian basin [5-11] provide a test of cycle and bioevent patterns. Such comparison indicates strong similarities of sequence and cycle stratigraphy, as well as bioevents that support a global origin for these features.

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DETAILED CONODONT BIOSTRATIGRAPHY AND CARBON ISOTOPE CHEMOSTRATIGRAPHY THROUGH THE KLONK EVENT AND ACROSS THE SILURIAN/DEVONIAN BOUNDARY IN SOUTHWESTERN LAURENTIA

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POSTER

Detailed sampling for conodonts and carbon isotopes at three carbonate sections in southwestern Laurentia provides a wealth of biostratigraphic and chemostratigraphic information through the Klonk Event and across the Silurian/Devonian boundary. Two southern Oklahoma outcrop sections span the Henryhouse-Haragan formational boundary and comprise a succession of argillaceous carbonate mudstone and wackestone deposited in an outer carbonate ramp setting that grade upward into interbedded wackestone and packstone. A core of the upper Frame Formation from Andrews County, Texas, contains a succession of carbonate mudstone and wackestone deposited in a slope setting south of a shelf margin that grade up into interbedded wackestone and packstone.

Three conodont faunal units characterize the Silurian/Devonian boundary interval, which ranges from two to five meters thick: 1. A diverse late Pridoli conodont fauna characterized by *Oulodus elegans detorta, Belodella coarctata, B. anfracta, Dapsilodus*, and *Dvorakia amsdeni* extends below the boundary interval. 2. The abrupt disappearance of many Pridoli species results in a lower diversity fauna in which *Dapsilodus and O. e. detorta* range slightly above the base, *B. resima*? and *Dv. philipi*? appear, and acmes of *Decoriconus fragilis* and *Pseudooneotodus beckmanni* occur near the top. This interval comprises the Klonk Event. 3. The appearance of the early Lochkovian species *Icriodus postwoschmidti* marks the base of the third unit, which lies near where coarser skeletal carbonates appear. Carbon isotope ($\partial^{13}C$) values fluctuate irregularly below conodont faunal unit 1 and show a small shift near the base of fauna unit 2. Through fauna unit 2, carbon isotope values remain remarkably consistent, varying less than 0.5 per mil. Near the base of faunal unit 3, carbon isotope values show more distinct shift of +1 per mil that forms a short-lived peak in faunal unit 3.

Graphic correlation shows that the base of the Devonian lies within conodont faunal unit 2, within the Klonk Event, near the extinction level of *Dapsilodus* and below that of *O. elegans detorta*. Without graphic correlation precise placement is not possible because comparable biostratigraphic detail for conodonts from other boundary sections, such as Klonk, does not exist. The small shifts in carbon isotopes recorded here do not compare well with carbon isotope excursions reported near the Silurian/Devonian boundary at sections in Europe, Nevada, and the Appalachians, and cannot be used to correlate to those sections. The major turnover in coniform conodont species at the Klonk Event, however, may provide the most reliable means by which to recognize the base of the Devonian in carbonate sections lacking graptolites.

PALEOENVIRONMENTAL AND EUSTATIC CONTEXT OF MIDDLE DEVONIAN BIOEVENTS IN EASTERN NORTH AMERICA, GERMANY, AND MOROCCO

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ORAL

Although, much attention has been focused on the cyclicity and bioevents of the Late Devonian, it is becoming increasingly evident that the Middle Devonian was also a critical interval in physical and life history, characterized by both intervals of strong local stability as well as episodes of abrupt change. Recent detailed comparative studies of stratigraphic and faunal patterns in eastern Laurentia, Avalonia, northern Gondwana , and elsewhere, have documented comparable patterns that point to the global nature of climatic, eustatic and biotic events within this interval. A refined, high-resolution record of sea level changes has been elucidated in recent years, providing evidence for high order cycles with probable Milankovitch periodicities, despite the fact that the Middle Devonian lies solidly within a “greenhouse”phase of global climatic history. The present review considers the paleoecological and paleoenvironmental contexts of three major Middle Devonian bioevents: the early Eifelian Chotek, the late Eifelian Kacak, and the late Givetian Taghanic events, in eastern North America, Germany, and Morocco.

Within the generally warm Mid Devonian interval, there is also accumulating evidence for periods of abrupt temperature change, especially in the late Eifelian and even more markedly in the late Givetian . These thermal events are associated with episodes of transgression to highstand, and expansion of dysoxic to anoxic environments as evidenced by widespread black shale deposits, again, in the late Eifielian and in the Givetian-early Frasnian. Such hypoxic intervals appear to have global expression and to coincide with severe extinctions, immigrations and accelerated speciation. The linkage of intervals of biotic overturn, hypoxia, climatic, and sea level fluctuation provides evidence for integrated global change and ecological-evolutionary response.

UPPERMOST DEVONIAN AMMONOIDS FROM OKLAHOMA AND THEIR BIOGEOGRAPHIC AFFINITIES.

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ORAL

The upper part of the Woodward Shale of southern Oklahoma has yielded the first diverse North American ammonoid fauna from the Uppermost Famennian (Upper Devonian VI, Wocklumian of old German terminology). It is composed of six species from three clymenid and from one goniatite family: *Cyrtoclymenia* cf. *procera* Czarnocki 1989 (Cyrtoclymeniidae), *Riphaeoclymenia* n. sp. I and *R. polygona* n. sp. II (Biloclymeniidae), *Kielcensia* n. sp. (Wocklumeriidae), N. gen. n. sp. I, (Sporadoceratidae), and a poorly preserved different juvenile sporadoceratid that may represent a second new genus. A second new species (n. sp. II) of the first new sporadoceratid genus occurs as a very rare form in slightly older beds of the Rhenish Massif. *Kielcensia* specimens from Oklahoma represent the first uncontested record of triangularly coiled wocklumeriids from North America. Conodonts from the ammonoid level are not conclusive but by comparison with the Moroccan, Polish and Russian ammonoid record the faunal assemblage can be correlated with the *Parawocklumeria* Genozone (UD VI-C) [1].
Based on *Kielcensia* and *Riphaeoclymenia*, the Oklahoma fauna has unusual similarities and biogeographical links with the far distant Holy Cross Mountains of Poland [2]. Both genera are missing from the diverse contemporaneous ammonoid faunas of Middle and Southern Europe, which were situated between the Oklahoma and the Polish occurrences. Geographically intermediate contemporaneous Moroccan faunas also show a fundamentally different faunal composition [3] but the Afro-Appalachian migration route must have been viable in the Uppermost Famennian. The lack of *Cymaclymenia* in the fauna is remarkable since this genus normally has the widest biogeographical range of all clymenid groups and it has been recorded from younger eastern North American levels (basal Bedford Shale) [4] that may correlate with the Hangenberg Blackshale of Europe-North Africa.

Migrations of pelagic faunal groups through regions without leaving a trace in available very rich fossil records (“ghost distributions”) create a serious bias for the palaeobiogeographical analysis of free-swimming nektonic organisms. The unexpected faunal composition of the Woodford Shale suggests a control of ammonoid distribution patterns by palaeoecological factors, such as trophic structures, that are currently not recognizable in the lithofacies.

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BRYOZOAN DIVERSITY IN MAIN DEVONIAN REGIONS OF FRANCE

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ORAL

Most Devonian bryozoan faunas of Armorican Massif are located in the Central Synclinorium. In the eastern part (Laval area), the Saint-Cénéré Formation (Pragian) yields a balanced diversity between fistuliporids, trepostomes (leioclemids, eridotrypellids) and fenestrates. More westerly (Gahard), the Marettes Formation (Emsian) yields a quiet diverse fauna fistuliporids, trepostomes (aisenvergiids, dyscritellids, amplexoporids, atactotoechids), fenestrates, rhabdomesids and ptilodictyids as well. In the western part (Roads of Brest area) occurs the best preserved bryozoan fauna, especially from the reefal environment from the Armorique Formation (Pragian) with a good diversity : trepostomes (leioclemids, dyscritellids, atactotoechids), fenestrates and rhabdomesids.

One of the best regions that yielded Middle and Upper Devonian bryozoan faunas is Boulonnais (northern France). The diversity exists in Blacourt Formation (Givetian), Beaulieu and Ferques Formation (Frasnian) respectively. It is more pronounced in Beaulieu Formation with trepostomes (ulrichotrypellids, atactotoechids) and in Ferques Formation with fenestrates and rhabdomesids.

In Montagne Noire (southern France) bryozoan localities are more scattered. In Cabrières Klippen, bryozoan diversity from Falgairas Formation (Pragian) is not significant unlike in Mont Peyroux where Bissounel Formation (Emsian) shows bryozoan-rich build-ups, dominated by fenestrates.

Current knowledge of bryozoan diversity depends on sedimentary environment. Mention of tectonics may be quoted because of strata disruption.

PALYNOLOGY AND ENVIRONMENT: A CASE STUDY OF THE EIFELIAN-GIVETIAN TRANSITION IN ITS TYPE AREA (EIFEL HILLS, GERMANY)

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ORAL

Successions of rhythmically layered limestones and mudstones from several quarries in the Hillesheim Syncline (Rhenish Massif, Germany) have been analyzed by palynological and sedimentological methods. The sequences comprise the Eifelian-Givetian boundary including the late Eifelian Kacak bioevent. This critical time interval is characterized by stable conditions with episodic physical and biotic changes of the paleoenvironment.

Extraordinarily well exposed sections of stratigraphically equivalent layers in the Middle Devonian, comprising the Junkerberg, Freilingen, Ahbach, Loogh and Cürten formations, were measured and sampled in detail. The palynological samples provided well to moderately preserved and rich assemblages of terrestrial and marine organic walled microfossils (OWM) and allow a bed to bed evaluation for palynofacies studies.

Overall, within the palynological assemblages land derived miospores and phytoclasts (cuticles and tissue fragments) are prevailing (up to 90 %), whereas higher amounts of marine elements, e.g., acritarchs, prasinophytes, chitinozoans, scolecodonts and other zooclasts are limited to distinct levels.

The quantitative analysis of relative abundance and occurrence of this specific palynological group, including amorphous organic matter, and the terrestrial/marine index, clearly indicate paleoenvironmental changes. In some samples prasinophytes like *Leiosphaeridia* or *Tasmanites* dominate, while the abundance and diversity of miospores, phytoclasts and acritarchs is low. These data may reflect specific environmental or depositional parameters related to changes in oceanographic conditions (e.g., sea level changes) or climatic variations as otherwise well known from the Middle Devonian. In some sections, thick-walled miospores (e.g., *Retusotriletes*) are more frequent than other miospore morphotypes and may suggest differences in the hydrodynamic system and/or in climatically controlled terrestrial environments. Thus, taking data into account from the biology of different fossil groups and from sedimentology, the paleoenvironment in general can be attributed to a shallow marine depositional system. However, the proportion of terrestrial input in the palynofacies spectrum is surprisingly high.

In addition, the miospores also contribute to local and regional biostratigraphic correlation, especially in comparison with other index fossils (e.g., conodonts). They also relate to the lithological development of the successions.

FAUNAL AND CYCLICITY CONTROLS FOR THE CALIBRATION OF THE EARLY DEVONIAN

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ORAL

Radiometry of marine ash beds furnishes the basis for the calibration of the Early Devonian time, but its analytical errors require to adapt the intervals between measured data to the limits cogently set by (bio)stratigraphy. Therein, shortfalls of Early Devonian conodont zonations must be overcome.

Sedimentary cycles allow proportional subdivisions for control. An average of 1260 Early Devonian couplets of limestone and marls was counted in the Barrandian Synform [1]. Average shares are: Lochkovian 35 %, original Pragian 29 %, Zlichovian 12 %, Dalejian 25 %. (Note: the German Early Emsian began almost 1 Ma before the Zlichovian.) There is a problem with the Barrandian Late Lochkovian (after *Ancyrodelloides*): Locally (Požáry quarries), the Late Lochkovian is very thin and its couplets hardly contribute to the notwithstanding high Lochkovian total, whereas in the Radotin valley the Middle and Late Lochkovian are better represented [1,2]. Thus, the Lochkovian counts must be evaluated with reserve.

Alternating limestones and shales in Celtiberia exhibit almost 60 cycles through the Zlichovian (about 50 m thick); their nature differs from that of the 150 Barrandian couplets and is unknown. But they indicate proportions of the durations between numerous marks set by conodonts and dacryoconarids etc. They help to control the accumulation rates in the Zinzilban section in SE Uzbekistan, which fluctuate notably. The high rate of the *serotinus* Zone there forbids to use it for calibrations (contra [3]).

Also weighted steps of evolutionary progress (= ES) allow to balance the spans between successive radiometric data [4]. For this purpose, the Lochkovian-Zlichovian (= L-Z) time is subdivided in proportion to numbers of ES. Provisionally, a L-Z total duration of 15 Ma is assumed; the total and partial durations can be adapted in proportion to future reliable data. The progress of evolution in European L-Z successions of conodonts and of trilobites and brachiopods of shallow neritic seas was coined into six independent scales with a total of 119 weighted ES (conodonts 22, Acastavinae and Asteropyginae 20, Spiriferida 23, Orthida 17, Chonetacea 16, other significant brachiopods 21 ES). The duration of an interval is proportional to the total number of steps from the 6 successions (including estimated fractions) that fall in it. The combination of the 6 successions balances fluctuations between stasis and progress of evolution. Sharp time marks in the successions enable correlation and testing in graphic equal-increment time scales. According to this method, the Lochkovian ends at 33 % of the L-Z time; the actual Zinzilban GSSP for the Emsian is near 53 %; the German Emsian begins at 83 %; the Zlichovian begins at 89 % of this scale.

Direct counts of unweighted conodont zones are not apt for the calibration of the Early Devonian, as the zones are too different. Similarly, the dacryoconarids have not been built into the L-Z calibration, because their succession is unsteady.

Radiometric ages are here quoted after [3], but only with their analytical errors and ommitting a routine of "additional uncertainty of 2 Ma" for stratigraphic errors, because free biostratigraphic correlation, without zonation, is accurate enough.

The attribution of the Appalachian Kalkberg bentonite datum of 417.6 Ma to the "upper half of the *woschmidti* Zone" is unsharp, as its index appears late and ends (type stratum) almost 2 Ma above the

Silurian-Devonian boundary. The equivalence of the bentonite with the New Scotland Fm. (and thereby with late F.I. 2 in Nevada) is more significant and the S-D boundary is near 419 Ma.

According to its array with T-R cycle Ib and Highland Mills Mbr. brachiopods, the Esopus Fm. in New York begins near the German entry of the Early Emsian. Application of the minimum of its laboratory age of 408.3 ± 1.9 Ma modifies the basal Esopus datum to 406.5 Ma; that accords with the high number of ES in the traditional Siegenian counted in Ibero-Armorican lineages [4], after which the German Emsian begins at 83 % of the ES or 5/6 of L-Z time.

The laboratory result for the German Bundenbach horizon of 407.7 ± 0.7 Ma concerns late Zlichovian = late Early Emsian ammonoids, less than 0.4 Ma older than the *Nowakia cancellata* boundary with the Late Emsian. The merely 0.6 Ma between the Esopus and Bundenbach core data cannot match the almost entire German Early Emsian, namely 2.5 Ma. A Bundenbach age of only 404.4 Ma approaches the *cancellata* boundary to 404 Ma, and is in line with the above arrays. A reduction of the Bundenbach age also contributes to shorten the too long durations recently postulated for the Late Emsian. On grounds not specified, the age of the high Stadtfeld Fm. in Germany, with ammonoids of Bundenbach age, was estimated at 399.5 Ma [5]; this would conveniently shorten the Late Emsian, but differs too drastically from the above measurements. The problem remains open.

In any case, the Late Emsian (Dalejian) begins hardly 0.4 Ma after the Bundenbach horizon. The estimate for the Emsian-Eifelian boundary GSSP is 391.9 ± 1.4 Ma, little above the measured final Emsian Hercules I ash bed with 392.2 ± 1.5 Ma [3]. This age is in harmony with the consistent set of ages from the Eifelian Tioga Ashes in Appalachian regions. But a Late Emsian duration, even corresponding to the above modified Bundenbach datum would vary about 12 Ma. That is much too long, as compared to the average of 25 % of the Early Devonian sedimentary cycles counted in the Barrandian [1]. The evolution of Rhenish Spiriferacea shows only 4 (provisionally conceived) successive ES in the Late Emsian; these are also expressed in the 4 regional "Gruppen" (Lahnstein, Laubach, Lower and Upper Kondel). Successions of Rhenish trilobites as well as of conodonts, ammonoids, and dacryonarids also do not manifest more than an average of 4 relevantly progressive steps in their lineages. Thus, the Late Emsian faunal development observed in Europe confirms the share of 25 % of Early Devonian time found in the Barrrandian [1]. Accordingly, the Late Emsian might have a duration of about 5 Ma, hardly 6 Ma. The former biostratigraphic image that it was very long, was due to many highly diverse coeval faunas, but not to the succession of particularly numerous ES.

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SUCCESSION OF BIOSTRATIGRAPHIC MARKS FOR THE EARLY EMSIAN

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ORAL

The recent treatments of the Pragian-Emsian boundary, of the Early Emsian, and of its conodont zonation have led to some ambiguities. Therefore it may be useful to have a succession of biostratigraphic marks as a guide through this interval with so many problems of stratigraphic correlation. Several of these problems are related to the *dehiscens* Zone s.l.

1. The actually official GSSP of the Pragian-Emsian boundary is marked by the origin of *Polygnathus kitabicus* from *Pol. pireneae*. This is difficult to identify, but in the immediate proximity of early *Pol. kitabicus*, *Pelekysgnathus serratus* and *Pedavis mariannae* had their short ranges just above the GSSP. This corresponds to the middle of F.I. 5 in Nevada and to scarcely the middle of the Praha Fm. in the Barrandian Synform. It is below the occurrence of *Oriskania* in Nevada (in F.I. 6). In Ibero-Armorica the formerly abundant *Pelekysgnathus serratus* ends just below the equivalents of the boundary d2c-alpha/beta of the Nogueras Fm. in spite of improving biofacies; this is towards the entry of *Icriodus simulator*. In Ibero-Armorica this marks the start of a T-pulse, which is comparable to T-pulse Ia in Nevada.

2. The spiriferacean marking the origin of *Euryspirifer* appears at the top of the Nogueras Fm., at the highstand of the latter T-pulse.

3. *Icriodus curvicauda* and "*Acrospirifer beaujeani*" s. [1] begin.

4. *Sieberella sieberi* is one of the last representatives of the Barrandian Konjeprusy Limestone to occur in Celtiberia.

5. The oldest *Arduspirifer*, *Boucotstrophia herculea*, *Rhenorensselaeria strigiceps*, *Multispirifer solitarius*, and "*Acrospirifer* aff. *primaevus*" s. [2] occur in unit d3b-gamma of the Santa Cruz Fm. [1,2], close to last *Icriodus angustoides* and within the range of *Icr. curvicauda*. In any case, this association is very close to the German Middle Siegenian, most probably it corresponds to the Early/Middle Siegenian passage.

6. In the Zinzilban section, *Pol. e. excavatus* enters 92 m above the GSSP. This should correspond to the T-pulse Ib established in Nevada and at the base of the Esopus Fm. in New York. *Pol. excavatus* ssp. 114 (non *Pol. gronbergi*, contra [3]) enters at 114 m above the GSSP. In the basal bed of the Celtiberian Mariposas Fm. both are present; thus this bed is younger than T-pulse Ib, which cannot be identified in Celtiberia. The Celtiberian shelly fauna does not yet contain distinctive taxa of the German Emsian. Brachiopods and crinoids correlate the boundary between Santa Cruz Fm and Mariposas Fm. of Celtiberia with the middle of the "Monster Beds" near the top of the Le Faou Fm. at the Rade de Brest.

7. From 1.3 m above the base of the Mariposas Fm. onward, *Guerichina* sp., often with *Peneauia* sp., is found (as steinkerns); its range is, essentially late original Pragian. As *Guerichina* and latest *Nowakia* e.g. *acuaria* were reported from little over 134 m above the GSSP in the Zinzilban section, most probably from latest original Pragian, the Zlichovian begins there about 134 m above the GSSP.

8. About 1 m above the Celtiberian entry of *Guerichina, Filispirifer fallax* enables the first reference to the traditional German Emsian. In the basal 15 m of the Mariposas Fm., a radiation of *Arduspirifer* sp. sp. produces forms close to *Ard. prolatestriatus,* which characterizes the earliest Emsian in Germany, the Ulmen-"Gruppe". The German Erbsloch-Grauwacke with highly developed *Filispirifer fallax* and surrounded by shales with *Guerichina* [4] furnished *Arduspirifer* sp. sp. that are also known 1 m above the limestone of the following level 9.

9. *Icriodus gracilis* and "*Ozarkodina*" *miae* enter in a limestone level amid the unit d4a-beta of the Mariposas Fm. with *Guerichina*.

10. *Icr. bilatericrescens* s.s. enters 1.3 m above the base of unit d4a-gamma of the Mariposas Fm., at the top of the first of almost 60 sedimentary high frequency cycles. It has also been found in lowest levels of the Zlichovian in the Barrandian [5, pl.21 fig.5, pl. 23 fig. 7].

11. *Icr. latus*, *Pol. gronbergi* s.s. and first *Nowakia (Dmitriella*) enter at the boundary between members d4a and d4b of the Mariposas Fm. This is in the 15th cycle. In the Zinzilban section *Pol. gronbergi* was figured from 144 m above the GSSP [6, pl. 75 fig.4].

12. *Criteriognathus steinhornensis* appears 5 m above the latter, in the 21st. cycle, whereas *Icriodus sigmoidalis* ends.

13. *Nowakia (Dmitriella) praecursor* ranges in middle parts of unit d4b-alpha of the Mariposas Fm..

14. *Nowakia barrandei*, *Anetoceras*, *Palaeogoniatites* and *Mimagoniatites* enter closely together high in d4b-alpha, in the 51st Zlichovian cycle. This means a late Zlichovian age and warrants correlation with the Bundenbach Horizon as well as with *Anetoceras* in the Stadtfeld Fm. of the Rhenish Facies in the late Early Emsian of Germany.

15. *Nowakia elegans* low within unit d4b-beta of the Mariposas Fm. indicates the final Zlichovian; disappearance of limestones corresponds to the climax of the Daleje Event. In contact with *Now. elegans*, the Rhenish trilobite *Rhenops lethaeae* is the first guide fossil of the Late Emsian. Celtiberian reports of *Now. cancellata* need re-examination.

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PRIDOLIAN TO MID-LOCHKOVIAN BIOSTRATIGRAPHIC TIME MARKS IN BOHEMIA

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ORAL

Several conodont zones of the latest Silurian and Early Devonian are not unanimously understood. The taxonomic concepts of some index taxa require revision, and their entries must be assessed. Entries and ranges of additional guide fossils can provide controls. We list successions of significant fossils from the Požáry section in the Barrandian Synform, from the Pyrenees, and from Celtiberia (incl. Guadarrama), correlate them with other sections and refer them to stage boundaries.

Latest Silurian: Pd1. *Zieglerodina*? *zellmeri* (in press) appears with late "*Ozarkodina*" *crispa* in Nordic erratics of final Ludlow, and has its holotype from the basal bed (GSSP) of the Pridolí; it has formerly been included in genus *W. eosteinhornensis*. - Pd2. *Ziegl.*? *ivochlupaci* (in press) and *Delotaxis detorta* occur together in a Nordic erratic and enter 14.5 m above the Pridolí GSSP. - Pd3. Genus *W. eosteinhornensis* begins 17 m above the Pridolí GSSP and abounds within 2 m, which corresponds to the restricted ranges in the Cellon and Klonk sections; a reappearance in one sample about 5 m below the S/D boundary is enigmatic, but also exists just above the type bed of *Monograptus uniformis angustidens* in the U topolu section. From the Cellon type stratum of genus *W. eosteinhornensis* onward *Zieglerodina* sp. 40 aff. *remscheidensis* is known that reaches up to the basal Lochkovian. - Pd4. *Ziegl.*? *klonkensis* = "*Ozarkodina steinhornensis remscheidensis* sensu nov." Jeppsson, 1989 ranges from 28.5 m above the GSSP through ca. 10 m up to 3 m below the S/D boundary. *Del. detorta* ends at the boundary.

Lochkovian: *Acastella heberti* lived only in the early part of the range of *Monograptus uniformis*; in Celtiberia it marks the earliest Lochkovian together with the first form of *Platyorthis monnieri*, *Podolella rensselaeroides* and *Howellella mercurii*; these shelly fossils are accompanied by conodonts: late *Zieglerodina* sp. 40 and very early *Icriodus* e.g. *woschmidti*. These *Icriodus* radiate in the earliest Lochkovian, but without *Icr. woschmidti* s.s. - In the Požáry section, the following marks are found, measured from the first find of *Icriodus* near the S/D boundary upward:

L1. The first *Icriodus* sp. e.g. *woschmidti* is used as zero mark; *Delotaxis*? e.g. *cristagalli* begins. – L2. At 0.3 m *Icr. hesperius* enters. – L3. At 1.2 m a form transitional from *Icr. hesperius* to *Icr. transiens* appears and is followed by *Icr. transiens* at 1.5 m; *Zieglerodina repetitor* enters. - L4. At 2.5 m the first Devonian *Warburgella rugulosa* was formerly used to mark the start of the Devonian. - L5. At 5 m, Pa elements approaching "*Ozarkodina" optima* enter, *Icr*. aff. *bidentatus* belong to the early radiation of *Icriodus,* and there are loboliths of scyphocrinitids. - L6. From near 7 m to 8 m "*Oz." paucidentata* and from 8 m to 10.8 m *Icriodus* sp. C Uyeno, 1981 are links to Nevada and the Canadian Artic. - L7. At 10.8 m *Pedavis*? *biexoramus* is another Nevadan taxon, and "*Oz*." *optima* with well developed anterior fans begin to be frequent. - L8. Slender *Icr. transiens* are found at 16.5 m; these show that the occurrence in the type stratum at the base of unit d1c-gamma in Celtiberia is a delayed local record, due to lack of older limestones. - L9. Between 22.5 m and 24.2 m *Pedavis* cf. *breviramus* s. Murphy & Matti, 1982 appear; *Lanea* sp. have distinct terraces. - L10. Between 33.5 m and 35.5 m *Ancyrodelloides carlsi* enters and ranges up to ca. 47 m; regardless of the *Icr. transiens* and *Icr.* aff. *bidentatus* mentioned above, it is the first conodont to suggest correlation with the basal bed of unit d1c-gamma in Celtiberia. According to the passage from *Acastella elsana* to *Ac. tiro* in Celtiberia and in Germany, this level is close in age to the type strata of *Icriodus woschmidti* and Zie*glerodina remscheidensis*, but neither is found in the Požáry section. After forerunners, *Wurmiella wurmi* is now well developed. - L11. Between 38 m and 40 m initial bulbs of Dacryoconarida with long spines appear as the oldest record of this group in this section. - L12. Between 40 m and 42 m "*Oz." boucoti* and n. gen. aff. *Eognathodus* with a median furrow and two rows of free round denticles in most of the blade occur. - L13. Between 51.8 m and 53.5 m *Ancyrodelloides transitans* appears; it reaches up to the end of the section. - L14. Between 63.3 m and 65.5 m *Ancyrodelloides trigonicus* appears. - L15. At 65.6 m *Pelekysgnathus elongatus* occurs that still has a slightly reduced posterior cusp; in the Guadarrama the posterior cusp gets lost towards the appearance of *Anc. trigonicus* closely before the end of *Anc. tiro*. - L16. At 66.0 m to 66.3 m *Anc. trigonicus* and *Anc. kutscheri* coexist, which they do in the Guadarrama just after the end of *Anc. tiro*. -- The section was sampled unto 70 m, where *Anc. transitans* still abounds.

The sampling has been continued in the active quarry Požáry 3 and has furnished *Masaraella pandora beta* that marks the beginning of the Late Lochkovian, hardly 4 m below the base of the Praha Fm.

The above Lochkovian succession will be completed through analysis of abundant material of *Delotaxis*?, *Wurmiella*, *Lanea*, and the "*Oz*." *optima* stock. In spite of careful searching, no Sa elements of *Zieglerodina* were found, so that Pa elements resembling *Z. remscheidensis* could not be attributed to this taxon.

As *Icr. woschmidti* is different from the reported taxa of the group that was comprised under its name, and as it ranges rather late, the *woschmidti* Zone is better not applied. It would probably begin after the entry of the *postwoschmidti* Zone as recognized in Podolia. The appearance of *Anc. carlsi* seems to be a relevant mark for the separation of the Early from the Middle Lochkovian.

Differences between the Celtiberian and Podolian successions of icriodids are notable. Both together on one side differ from the Bohemian succession on the other side. Correlations must rely also on brachiopods and trilobites.

DEVONIAN OSTRACODES FROM DEVILS GATE (EUREKA, NEVADA)

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ORAL

Introduction: About 6,500 ostracodes were extracted from 80 samples collected in the Frasnian and in the base of the Famennian of the Devils Gate section located close to Eureka. Their study has been the subject of 5 papers [1-5]. The collected ostracodes belong exclusively to the Eifelian Mega-Assemblage indicative of relatively shallow marine, semi-restricted or lagoonal environments. The distribution of ostracodes in this mega-assemblage is controlled principally by the energy, the salinity, the oxygenation and by the nature of the substrate.

No ostracodes indicative of deep and (or) cold environments (Thuringian Mega-Assemblage) have been observed, but ostracodes belonging to the Myodocopid Mega-Assemblage indicative of poorly oxygenated water conditions have been recognized close to the Frasnian / Famennian boundary by Sandberg [written com., Nov. 6, 1995].

The ostracodes in the lower member of the Devils Gate Limestone [1]: Below the 29-cm thick Alamo Event Bed, ostracodes are present in 30% of samples with a relative abundance of Platycopids indicative of very shallow water conditions. Ostracodes are abundant only in a sample collected in the upper part of the Late *fasiovalis* Zone and in a second sample in the *transitans* Zone. *Voronina*? *eureka* CASIER and OLEMPSKA, 2006, is virtually the sole species present in the first one. This mono-specificity is indicative of semi-restricted water conditions. The second rich sample contains five species of Podocopid, three of Platycopid and one of Palaeocopid, indicating of very shallow marine water conditions. The rarity of ostracodes in all other samples indicates shallow semi-restricted water conditions; their absence may indicate very stressful lagoonal conditions. Close to the Alamo Event Bed, the rarity of ostracodes is probably linked to the high energy of the environment as displayed by the sedimentological analysis.

In the upper part of the lower member of the Devils Gate Limestone, and above the 29-cm-thick Alamo Event Bed, ostracodes are present in quasi all the collected samples. Platycopids, indicative of shallow environments, are relatively abundant and diversified until sample numbered 19 by Sandberg *et al* [6]. In this last sample, two species, *Serenida dorsoplicata* CASIER and OLEMPSKA, 2006 and *Youngiella* cf. *mica* ROZHDESTVENSKAJA, 1972, dominate the ostracode fauna. However, the presence of several species of Podocopid in all these samples suggests strong marine influence. The carbonate platform was still very shallow, becoming progressively more marine.

The ostracodes in the upper member of the Devils Gate Limestone [2-5]: Below a 10 m shale sequence with large carbonate-rich silststone flows overlying the F/F boundary, ostracodes are very abundant and diverse. Seventy ostracode species were recognized in the Late *rhenana* Zone and in the *linguiformis* Zone [2,3]. They are indicative of a well oxygenated marine environments below fair weather wave base, probably on the outer platform.

In the 10 m sequence of shales, mudstones, and debris flows crossing the Frasnian / Famennian boundary, a rapid sedimentation rate is probably responsible for the dissemination of silicified ostracodes, and for the absence of ostracodes in several samples.

Sandberg [*op. cit.*] has recognized entomozoid ostracodes in a dissolution residue for conodonts from a sample a few cm below the F/F boundary. Unfortunately these ostracodes have been lost, and the dissolution of several new samples has failed to produce entomozoid ostracodes. The presence of entomozoids is consequently not confirmed, but is probable because they belong to the Myodocopid Mega-Assemblage indicative of hypoxic conditions, and that mega-assemblage is present close to the F/F boundary in several sections worldwide.

In the lowest part of the Famennian, the increase of the sedimentation rate is also in part responsible for the absence of ostracodes. Then abundant shallow marine ostracodes mixed with reworked conodonts typical of a deeper environment give evidence for a dramatic environmental change, *i.e.* the collapse of the platform margin. Fifty-none ostracode species are recognized in the base of the Famennian at Devils Gate [4].

Ostracodes and the Alamo Event: The rarity and low diversity of ostracodes in samples collected from the lower part of the lower member of the Devils Gate Limestone are not favourable to demonstrate whether or not an extinction event occurred close to the Alamo Event Bed [1]. Nevertheless the greater abundance and diversity of ostracodes above this bed seems to indicate the absence of extinction in this shallow setting.

Ostracodes and the Late Frasnian Event: The extinction of ostracodes was relatively abrupt at the F/F boundary [5]: of the 70 ostracode species recognized in the Late Frasnian, only 16 survived the mass extinction (= Lazarus species), 12 at Devils Gate, and the 4 in other sections. Moreover the ostracode fauna recovered rapidly after the Late Frasnian extinction [4]: 45 species appeared for the first time in the Early Famennian, whereas 14 others were known from the Late Frasnian. The majority of these Lazarus species appears higher in the section probably when environmental conditions came back to normal.

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COMMENTS ON THE DEVONIAN/CARBONIFEROUS AND FRASNIAN/FAMENNIAN BOUNDARY STRATOTYPE SECTIONS (LA SERRE AND COUMIAC, MONTAGNE NOIRE, FRANCE)

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POSTER

1. The Devonian/Carboniferous boundary section is located on the southern flank of the La Serre Hill, 2.4 km south of Cabrières, in the Montagne Noire. The section exposes about 7.5 m of limestones beds pertaining to the Cabrières klippen area, and the D/C GSSP has been fixed at the base of bed 89 of Flajs & Feist [1] in a sequence of predominantly bio-detrital oolitic limestone within a pelagic matrix of shale and cephalopod bearing calcilutites [2].

Recently Kaiser *et al.* [3] have re-sampled in detail the D/C boundary stratotype section, and based on new conodont records, they fixed the base of the *sulcata* Zone at an older stratigraphical level, in reality at the base of bed 85 of Flajs & Feist [1]. Consequently the study of Kaiser *et al.* requires a re-positioning of the GSSP level in the stratotype section, or the search for a new D/C boundary stratotype [3].

We want to draw SDS TM and CM's attention to the presence of a tectonic discontinuity less than 70 cm below bed 85 [4], and to the microfacies of the two beds situated between 70 cm and 103 cm below bed 85. These ones are not in accordance with the general evolution of microfacies observed in the section [*ibid*.]. Between bed 85 and the discontinuity, the energy of the environment was also very high as indicated by the absence of ostracodes, by the rarity of conodonts, by the presence of microbreccias and broken oolites, and by lamination patterns. Consequently all the fauna present at this level is certainly reworked.

Paproth *et al.*[5] and Ziegler & Sandberg [6] arrived also to the conclusion that the La Serre section is far from being an ideal stratotype for the D/C boundary.

2. The Frasnian/Famennian boundary section is located on the south-eastern border of the disused upper marble quarry of Coumiac, 1.5 km east north east of Cessenon, also in the Montagne Noire [7]. The F/F GSSP has been fixed at the base of bed 32a in a highly condensed section containing several hardgrounds in the Late Frasnian, and the F/F GSSP even is fixed precisely above a hardground [8]. Unfortunately, the duration of the break of sedimentation is unknown, and consequently correlations with other sections are difficult.

For example: where is the F/F boundary in the type region for the Frasnian and Famennian Stages (Dinant Basin, Belgium)? In the base of member 2 of the Senzeille Fm (= Senzeilles shales *s.s.*) where Bultynck found the first *P. triangularis* [9]? 70 cm below in the top member 1 of the Senzeille Fm (= transition shales) where Gosselet [10] fixed the historic F/F boundary corresponding to the recovery of the macrofauna after the Late Frasnian Event? 2.5 m below at the base of member 1 of the Senzeille Fm where the recovery of the benthic ostracodes belonging to the Eifelian Mega-Assemblage is observed [11]? As a minimum of 3 m below where the recovery of the necto-benthic entomozoid ostracodes belonging to the Myodocopid Mega-Assemblage is recorded in the Matagne Fm [11]? In reality, correlations with the Schmidt quarry - the unfortunate candidate for the GSSP located in the Kellerwald, Germany - are easier and privilege this last hypothesis because the *splendens* Zone and the *sigmoidale* Zone of the Parachronology established on the Entomozoid ostracodes are now recognized in the Matagne Fm exposed in the Neuville section close to Senzeilles [11].

Note that Ziegler & Sandberg [6] also pointed out the serious sedimentologic and biostratigraphic mistakes arising from selection of the Coumiac F/F GSSP.

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EYE-EVOLUTION OF *ACUTICRYPHOPS*, A LATE FRASNIAN PHACOPID TRILOBITE.

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POSTER

Introduction: The gradual regression of the visual complex leading to blindness is an evolutionary trend often observed in different lineages of Upper Devonian trilobites [1], [2]. Along these lineages, it has been shown that the development of the visual complex is delayed being the result of paedomorphosis, *sensu* Gould [3]. This feature seems to coincide with periods of pronounced eustatic deepening which culminated in the terminal Frasnian prior to the Kellwasser event [4].

As a result, the great majority of trilobites known from the latest Frasnian consist of reduced-eyed and blind forms. It is likely that these deeper-water faunas were eliminated by the sudden spread of oxygen-depleted deposits associated with the Upper Kellwasser Event [5].

Among the species that became extinct during the Upper Kellwasser mass extinction was *Acuticryphops* that hitherto dominated late Frasnian trilobite communities in outer shelf sections of widely distributed regions such as mid-European Avalonia and Armorica as well as the North Gondwana margin [5], [6], [7]. And recently, it was discovered in an inner shelf section of western part of Australia (investigation by two of us: Feist and McNamara).

Methods: The distribution pattern of eye lenses in different morphs was investigated using biometric parameters. This has been realized in order to obtain a quantitative approach to the degree of diversity or variation of different morphs (defined by the number of their eye-lenses) in the crucial period immediately preceding the extinction of the group.

Results and discussion: The specimens were collected from the latest Frasnian preceding the Upper Kellwasser global extinction event in the Frasnian/Famennian stratotype section at Coumiac, southern France [8]. In six successive populations a gradual reduction in the mean number of lenses occurs within the short time span of a single conodont Zone. This morphological change cannot be imputed either to the size of individual specimens or to variation in cephalic morphology. However, the intra-populational percentage relation between morphs does not remain constant, as the coefficient of variation in lens number continuously increases from one population to the next.

In the Moroccan Meseta (Mrirt), the population restricted to a single bed immediately below the Upper Kellwasser horizon, is characterized by a high degree of variability in the number of eye-lenses. In a sample of 23 recovered adult specimens with preserved visual surfaces, the lens number ranges from 1 to 8 (mean: 4.52). The contemporaneous level at Coumiac yields 62 specimens with lens numbers ranging from 1 to 18 and a mean of 4.79 lenses [8].

The discovery of *Acuticryphops* in the Canning Basin (Western part of Australia) permits investigating distributional patterns of eye-lens variation in a community from an inner shelf section. Populations, from two beds equivalent to first levels at Coumiac, are characterized by the same high mean lens number. Moreover, 4 specimens situated immediately below the Upper Kellwasser extinction level, are characterized by a lower mean lens number. Additionally, the populations from the Canning Basin exhibit a low degree of variability in the number of eye-lenses and a more stable morphology than populations from Coumiac.

Conclusion: As the phenomenon of eye reduction is not constrained by local conditions at Coumiac (south of France) but occurs contemporaneously in Morocco (Northern Gondwana) and Australia (North-East Gondwana), it may constitute an adaptation to global eustatic deepening that occurred in the terminal Frasnian just before the global extinction event. Moreover, this result demonstrates the potential of using mean lens numbers for fine-scaled intrazonal correlations

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EARLY DEVONIAN OSTRACODES FROM SPAIN

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ORAL

Early Devonian ostracodes are here reported from four areas in Spain: the Eastern Iberian Chain (EIC), the Eastern Guadarrama (GU), the Spanish Pyrenees (SP), and the Zone of Ossa Morena (ZOM). The Devonian of Spain has a great biostratigraphical potential and offers reference successions for global correlation, which are now made available for the work with ostracodes. About 150 taxa from more than 100 beds in about 20 sections of earliest Lochkovian to late Early Emsian age have been studied. The faunas are of different facies, from harsh neritic level bottom to hemipelagic low energy environments. They are well dated by conodonts, brachiopods, dacryoconarids etc. that warrant correlation between different facies and regions in Europe, Africa and North America. In other European regions the correlation between local ostracode successions and the standard conodont zonation is often hindered because many strata rich in ostracodes are poor in conodonts.

The ostracode collections from the EIC and the GU are the largest ones known from the Lochkovian and Pragian of Western Europe. About 7000 specimens of nearly 100 neritic taxa have been evaluated. The record starts early in the Middle Lochkovian, where *Ulrichia bugnueli* occurs together with *Icriodus transiens* and the trilobite *Acastella tiro*. The youngest ostracode faunas with abundant *Eridoconcha* aff. *spinosa* are from just above a limestone bed with first *Anetoceras*, *Mimagoniatites* and *Nowakia barrandei* (late Zlichovian age). A few meters above the ostracode bed *Nowakia elegans* entries.

In both areas, benthic ostracodes of near shore environments ("Eifelian ostracode Ecotype") occur. Among the level bottom environments three recurring associations can be distinguished. In shallowest neritic harsh biofacies oligospecific faunas mostly with *Zygoberichia* s.l. and *Poloniella* occur (beyrichiid complex). In shallow water environments, just below wave base, highly diverse ostracode faunas are found. They are dominated by metacopines, especially *Polyzygia*, *Jenningsina*, and *Ponderodictya*, but also palaeocopines like *Bollia*, *Ulrichia*, and *Placentella* are frequent. In hemipelagic environments the benthic ostracodes are less diverse. Some forms have small spines, e.g. *Loquitzella* and *Eridoconcha* aff. *spinosa*, but spinose taxa of true Thuringian ostracode Ecotype do not occur.

There are close relations between the benthic ostracodes from EIC and GU to numerous other Early Devonian ostracode faunas from all over Europe. Ostracode taxa common with NW Africa and Armorica corroborate the continuity of the Ibarmaghian (= Mauro-Ibero-Armorican) faunal province. The occurrence of *Zygobeyrichia* s.l. from the middle Lochkovian (*Ancyrodelloides trigonicus – Masaraella pandora*-beta conodont zone) onward disproves an Early Devonian "Rheic Ocean" between Baltica-Avalonia and "Perigondwana".

The ostracodes from the Ossa Morena Zone are similar to those of the EIC and GU; *Ulrichia bugnueli*, *Leptoprimitia velillana*, and *Eridoconcha argensolai* are known from these regions only. Besides, some new taxa and *Polyzygia normannica*, *Polyzygia grekoffi* and *Bollia bezagora*, which are widespread in the Pragian of Europe, are registered as well.

The studied Lochkovian ostracodes from the SP have mainly short ranges through only 1 to 3 conodont zones, and in some genera phylogenetic successions are present. Several of the taxa, like *Semibolbina* or *Tricornina*, belong to thin-walled, frequently spine-bearing, benthic or nectobenthic ostracodes of the Thuringian Ecotype (low energy environments). Such ostracodes are used already for supraregional correlation in the Late Devonian. However, for the biostratigraphical application of the Pyrenean ostracode data more information on coeval European ostracodes is needed. Most interesting is the occurrence of *Rectella*? sp. 2, aff. R.? *heteroclita* within the *Pandora-gilberti* conodont zone (early Late Lochkovian). It seems to be the phylogenetic link between the Siberian *R.*? *heteroclita* from the Early Lochkovian in the Salair and *R*?. sp., aff. *R*.? *heteroclita* sensu GROOS-UFFENORDE 1973 from the uppermost Lochkovian of Marburg in Germany. Thus, it suggests Lochkovian migrations paths between these regions. Besides, the faunas are related to those from Thuringia and the Carnic Alps.

At the Lochkovian/Pragian boundary in the SP a faunal change is evident. Common Pragian taxa like *Jenningsina planocostata, "Cytherellina" incontans, Eridoconcha* aff. *spinosa* and *Berdanella* sp. enter. Only some long ranging taxa as, e.g., *Praepilatina* ex gr. *sibirica* and *Berounella spinosa* cross the L/P boundary.

All in all, Early Devonian ostracode faunas of Iberia manifest potentials for biostratigraphy, palaeoecology, and palaeogeography that encourages further research.

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THE FRASNIAN/FAMENNIAN BOUNDARY INTERVAL FROM THE XOM NHA CAVE SECTION, QUANG BINH PROVINCE, CENTRAL VIET NAM: CORRELATION TO THE TYPE KELLWASSER LOCALITY, OKER RESERVOIR, HARZ MOUNTAINS, GERMANY, USING MAGNETIC SUSCEPTIBILITY DATA SETS

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ORAL

We report the magnetostratigraphy susceptibility (MS) for two Frasnian/Famennian (F/F) boundary sequences: (1) measurement of 147 samples collected at 5 cm intervals over 7.3 m, with 23 samples at < 2 cm across the Frasnian-Famennian (F/F) boundary interval, at the Xom Nha Cave entrence, Quang Binh, Middle Vietnam; and (2) measurement of 92 samples collected at ~ 2 cm intervals over 1.82 m at the Type Kellwasser locality within the Oker Reservoir area in the Harz Mountains, Germany. Biostratigraphic control for high-resolution chronocorrelation is provided by conodont zonation for both sections. MS zonation when compared with the biostratigraphic zonation for these sites indicates that within the Xom Nha sucession, first appearance of *P. triangularis* falls slightly higher (later) in Viet Nam than in Germany. Spectral analysis using a Fourier Transform (FT) method resulted in identification of Milankovitch cyclicity in the eccentricity (E2; ~100,000), obliquity (~41,000) and precession (~20,000) bands for both data sets (obliquity and precession corrected for the Upper Devonian; Berger et al., Science, 1992). Graphic comparison between these two F/F boundary sections resulted in an excellent correlation, with differences resulting from slight relative sediment accumulation rate variations at each site. Graphic comparison of each MS data set against an obliquity-based MS climate standard zonation produced a striking similarity between the MS zonation for each site and the climate zonation. Results from these comparisons indicate that there is a change in the lowest Famennian in sediment accumulation rate at both the Germany and Vietnamese sites toward slightly lower rates.

EVALUATING THE ORIGINS OF EARLY-MIDDLE DEVONIAN 3RD-ORDER SEA-LEVEL CHANGES USING OXYGEN ISOTOPES OF CONODONT APATITE

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ORAL

The Johnson et al. [1] sea-level curve remains the most the commonly used and reliable standard for delineating sea-level changes during the Devonian. The curve was constructed using distinctive facies shifts at five widely spaced outer shelf regions (western U.S., western and Arctic Canada, New York state, Germany, and Belgium), which were correlated by their contained conodonts. Twelve sea-level cycles (TR cycles Ia – IIf) and resultant sedimentary sequences (several 10's to ~100 m thick) were recognized and range in duration from ~1-10 My (3^{rd}-order). These sequences bundle to form parts of three "depophases" or 2^{nd}-order sequences (~20-30 My). Johnson et al. (1985) also recognized that some of the 3^{rd}-order sequences are composed of 1-5 m thick upward-shallowing cycles (5^{th}-order), which they equated to punctuated aggradational cycles or PACs [2].

Because direct evidence for Devonian continental glaciation is limited to the Famennian, Johnson et al. did not invoke glacio-eustasy as a mechanism to explain the global sea-level changes. Instead, they called upon changes in seafloor spreading rates to explain the 2^{nd}-order sea-level fluctuations, "mid-plate thermal uplift and submarine volcanism"(e.g., large oceanic plateaus/seamounts) to generate the 3^{rd}-order changes, and "numerous instances of volcanic edifice building" to generate the 5^{th}-order changes. Each of these mechanisms calls upon tectonically driven changes in submarine volcanism and resultant variations in ocean basin volume to generate the sea-level oscillations (tectono-eustasy).

These interpretations are problematic because the rise and fall rates of typical Devonian 3^{rd}-order sea-level changes are on the order of 1-10 cm/ky and are significantly faster than rates estimated for eustatic fluctuations caused by changes in mid-ocean ridge spreading rates or mid-plate oceanic plateaus eruption rates. When the Devonian sea-level curve is viewed in context with other Paleozoic 3^{rd}-order sea-level curves, and in particular the Ordovician, Silurian and Mississippian, it is apparent that the Devonian changes are similar in facies expression, duration, and relative magnitude/coastal onlap. This suggests that the process(es) generating 3^{rd}-order eustatic change are repetitious and persistent over >150 My time spans and further questions cyclic tectonics as a driving mechanism. To date, the only known eustatic driving mechanism that operates on a cyclic basis and continuously over geologic time spans is climate change and includes thermal expansion/contraction of seawater (thermo-eustasy) and/or storage of water as continental ice (glacio-eustasy) or groundwater/lakes.

To understand the origins of Paleozoic 3^{rd}-order sea-level changes, we are using oxygen isotopes from conodont apatite contained within 3^{rd}-order transgressive-regressive sequences. Our work has focused on sequences from Middle Devonian ("greenhouse"), Middle Pennsylvanian (icehouse) and transitional (Upper Ordovician) climate periods. In each of these examples, the 3^{rd}-order transgressive-regressive sequences are well documented and regionally to globally correlative. We are testing the hypothesis that climatically controlled glacial eustasy and seawater temperature changes controlled 3^{rd}-order sequence development. If our hypothesis is correct, then oxygen isotope values should decrease within transgressive and maximum flooding facies (warmer sea-surface temperatures and melting glaciers) and values should increase within highstand and lowstand facies (cooler sea surface temperatures and growing glaciers).

To date we have sampled through two Early-Middle Devonian 3rd-order sequences (late Emsian-Eifelian, TR cycles Ic and Id) in central Nevada, the Prague Basin in the Czech Republic, and the Montagne Noire of southern France (all deposited in subtropical paleolatitudes). Similar isotopic trends from these widely spaced regions will evaluate whether the isotopic signature is global. Oxygen isotopic trends from central Nevada (*serotinus* through *kockelianus* zones) record
1-1.5‰ shifts towards smaller values during sea-level rise/highstand and 1-1.5‰ shifts to larger values during falls and lowstands. Preliminary results from the Prague Basin across the *patulus* to *costatus* zones record similar isotopic relationships within transgressive and regressive facies, though the magnitudes of isotopic shifts are slightly smaller (~0.7-1.0‰). Preliminary results from the Montagne Noire (*serotinus* through *kockelianus*) are more complicated with short-term isotopic shifts of up to 1.0‰ . Using the Quaternary as a guide, the 0.7 -1.5‰ Middle Devonian isotopic shifts correspond to glacio-eustatic sea-level changes on the order of ~50-100 m combined with sea surface temperature shifts of ~3-6°C. These results are particularly intriguing because of the lack of evidence for Middle Devonian continental glaciers; however, there is no other known mechanism to explain the isotopic shifts that co-vary with the widely correlated and significant transgressive-regressive facies shifts. If these glacio- and thermo-eustatic interpretations are correct, then this challenges the conventional ideas of a warm, ice-free Early-Middle Devonian greenhouse climate and it also implies the existence of a repetitive My-scale climate driver during the Devonian.

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REEF BUILDING POTENTIAL OF DEVONIAN BRYOZOANS: AN EXAMPLE FROM SOUTHERN MOROCCO

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POSTER

Bryozoans are aquatic colonial animals, usually with calcitic skeleton, occurring mainly in marine habitats. The earliest bryozoans are known from the Lower Ordovician. They deliver an impressive fossil record with more than 20 000 extinct species, and more than 6 000 extant species are known at the present day. In the Palaeozoic, bryozoans inhabited various biotopes, being often rock-building. In different time intervals bryozoans played a relatively important role as reef-building organisms, e.g., in the Carboniferous and Permian. During the Silurian and Devonian, corals and stromatoporoids were the main reef-builders, apparently because of their quick growth. In fact, the Devonian signs a minimum in reef-building potential of bryozoans. In only few cases bryozoans were substantively involved in reefs and bioherms (e.g. Heddinger, 1989, McKinney & Kříž, 1986). However, they played an important role in pioneer communities of many reefs. They stabilised and trapped the sediment, herewith paving the way for the main reef builders (Cuffey 1970, 1977, 2006). Furthermore, bryozoans dwelled cryptic habitats and interspaces in reefs showing often a high diversity.

In the Devonian bryozoans underwent significant changes in their taxonomic composition. The Silurian faunas were clearly dominated by trepostome bryozoans. Bifoliate cryptostomes were also abundant and diverse in Silurian communities. In the Devonian, the group of fenestrate bryozoans became important, whereas trepostomes and bifoliate cryptostomes diminished strongly. These changes marked also a shift from manly branched, massive ore encrusting colony forms to planar unilaminate ones, like those of mashed fenestrates. Such colonies provided a significant success for fenestrates in the Late Palaeozoic (McKinney, 1986). Evident advantages of these colony forms are an improved feeding (due to occupying higher water stages and larger volumes per substrate unite), and avoiding of a competition on the substrate (McKinney & Jackson, 1989). Erect fenestrate colonies also affect sediment trapping with their feeding currents, essentially contributing to mud mound building (McKinney et al, 1987). Fenestrates were involved significantly in Carboniferous and Permian reefs and bioherms. Erect rhabdomesine bryozoans became also diverse during the Devonian. However, due to their small sizes, they could not reach the importance of fenestrates in reefal structures.

The majority of Devonian bryozoans were described from various stratified sediments such as shaly limestones and calcareous shales, argillites, pure and sandy limestones (e.g. Boardman, 1960, Morozova, 1960, Volkova, 1974). Contrary, the role of bryozoans and their taxonomic composition in Devonian reefs remain poorly understood.

In the newly discovered Middle Devonian reefs in Sabkhat Lafayrina, Southern Morocco (Scholz et al. 2005, Königshof & Kershaw 2006), we found abundant and diverse bryozoans in different parts of reefs. Preliminary taxonomic analysis shows the presence of 20 bryozoan genera. Some are preserved still upright in growth position. Bryozoans appeared in pioneer communities, being sediment trappers (fenestrates) and sediment stabilisers (encrusting cystoporates and trepostomes). Fenestrate colonies reached significant sizes possessing apparently a large potential for sediment trapping. Encrusting bryozoans, e.g., *Fistulipora*, *Leioclema* covered large areas, and stabilised in this way fine-grained sediment. Large branched trepostomes and cystoporates stabilised the sediment additionally by their colonies, providing also a suitable substrate for other organisms which finally led to a stromatoporoid-dominated reef structure.

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PRELIMINARY DATA ON THE LOWER-MIDDLE DEVONIAN CONODONT BIOSTRATIGRAPHY OF SOUTH-EAST SARDINIA (ITALY)

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ORAL

The most complete Middle Palaeozoic sequence of Sardinia is exposed in the Gerrei Tectonic Unit, in the south-eastern part of the island. A continuous sedimentary succession from Upper Ordovician to lowermost Carboniferous is documented there. Lithostratigraphic units have not been formalized in this sequence, so informal, traditional names are used to define the different parts of the succession: "Lower Graptolitic Shales" and "Ockerkalk" are discriminated in the Silurian and "Upper Graptolitic Shales", "Tentaculitic Shales and Limestone" and "Clymeniae Limestones" belong to Devonian. Among these, the "Tentaculitic Shales and Limestones" are by far the less studied unit: in fact only a small amount of data on tentaculites ([1], [2]) is available in literature. This is probably due to the lack of macrofossils and the bad exposure of the unit; it is almost impossible to find undisturbed and continuous sections.

The "Tentaculitic Shales and Limestones" are an alternation of shales and thin levels of nodular limestones, with a progressive increasing of the calcareous content in the upper part of the unit. On the geological maps all deposits from Silurian to Middle Devonian are comprised in one unit, which makes it difficult to locate possible Middle Devonian outcrops. The "Tentaculitic Shales and Limestones" were also more affected by the strong Hercynian orogeny than the adjacent lithologies because of their shaly nature.

Up till now, the most interesting area is the area of Pranu Scandariu, South of the village of Armungia. Here, two highly tectonised sections of Emsian to Famennian age have been preliminary studied. Other outcrop are being studied: Givetian strata near the village of Villasalto, and Lower Devonian deposits west of the Mulargia Lake and close to the Silius village.

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TIMING OF SEA-LEVEL CHANGES IN THE UPPER FAMENNIAN OF EUROPE AND SE MOROCCO.

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ORAL

The Devonian is characterized by a complex succession of global eustatic and hypoxic events [1], [2], some of which, such as the Kellwasser and Hangenberg Events or Crises, are associated with first order mass extinctions. Unfortunately, many 2nd to 3rd order events are not yet widely known in the broader scientific community although they show important similarities with the mass extinctions, such as rapid eustatic pulses. One of the smaller scale episodes of global faunal overturn is the hypoxic Dasberg Event [3], which occurred at the Hembergian/Dasbergian (UD IV/V) boundary. Originally it referred to fossiliferous black shales with the oldest ammonoids of the *Endosiphonites* Genozone (UD V-A1), where early Gonioclymeniidae and Biloclymeniidae suddenly replaced the formerly widespread Platyclymeniidae. The Dasberg Event has been recognized without detailed faunistic and sedimentological investigations in various regions throughout the globe, such as Europe (Rhenish Slate Mountains, Ardennes, Franconia, Thuringia, Wildenfelser Zwischengebirge, Holy Cross Mountains, Montagne Noire, Carnic Alps), North Africa (Morocco, Algeria), North America, Asia (Mugodzhary Mountains, Iran, perhaps South China), and western Australia.

The famous "Johnson et al. sea-level curve" [4], by contrast, recognized an overall shallowing in the Lower and Middle Famennian T-R Cycle IIe that reverted into a strong transgressive pulse, dated as basal Lower *expansa* Zone, and marking the start of T-R Cycle IIf. Justification for this eustatic transgression came mostly from North America and supposed European equivalents, such as the Epinette Shale of Belgium and the base of the Wocklum Limestone of the Rhenish Massif, do not really correlate. The global sea-level curve for the Upper Famennian, here taken to include the interval from the L. *postera* to M. *expansa* Zones, clearly needs to be revised. We investigated sections in Germany, Austria, and Morocco, which provide contrasting high-resolution data that point to a rather complex pattern of regional sea-level changes.

In the Maider Basin of SE Morocco (section Mrakib), two brief anoxic maxima and transgressions have been recognized above the *Annulata* Event beds and *Annulata* Limestone, at the top of UD IV-B (*Procymaclymenia pudica* Zone) and within UD IV-C1 (*Sporadoceras orbiculare* Subzone) [5]. At least the upper transgressive pulse falls in the L. *expansa* Zone but still well within the range of *Platyclymenia* faunas. The following, regionally widespread *orbiculare* Bed represents a short interval of regression and condensation high in UD IV-C1 but lacks index conodonts. The next higher *Protoxyclymenia wendti* Bed falls in the latest Hembergian UD IV-C2 and still has scaphignathids. It is followed by a regressive phase that resulted in the formation of a haematitic and sideritic red crust. This is overlain by a thick shaly package with pyritic ammonoids of the *Endosiph. muensteri* Zone (UD V-A1) that represents the true Dasberg Event Interval. The sporadoceratid *Erfoudites* is the dominant goniatite.

On the central Tafilalt Platform (Bou Tchrafine, Hamar Laghdad), the Hembergian is represented by condensed red cephalopod limestones and the Dasberg Event Interval is marked as a significant transgression and by a sudden change to poorly fossiliferous shales or cherts [5]. On the eastern Tafilalt Platform (Ouidane Chebbi) there may be a minor deepening within the limestones with platyclymenids and the last solid limestone with *Sp. orbiculare* (UD IV-C2) falls already in the basal M. *expansa* Zone. This is confirmed by conodonts from limestone nodules in the upper part of the overlying red shales with *Endosiphonites, Nanoclymenia*, and others, which represent the transgressive Dasberg Event Interval.

In the southern part of the platform (Oum El Jerane) [6], mass flow, brachiopod and crinoidal limestones are overlain by a three-fold, black, thin-bedded, condensed, very fossiliferous *Endosiphonites* Limestone. Ammonoid faunas suprisingly yielded an admixture of last Hembergian (e.g., *Prionoceras*) and first Dasbergian (*Endosiphonites*, *Discoclymenia*) genera. Based on the combined appearance of *Bispathodus stabilis* Morphotyp 3, last scaphignathids, and *Bispathodus aculeatus*, these Dasberg Event layers fall in the basalmost M. *expansa* Zone. Towards the SE (Jebel Ouaoufilal) the limestones grade into an approximately 300 cm thick hypoxic shale unit with a very rich, secondarily haematitic, pelagic fauna with *Endosiphonites*, *Clymenia*, *Discoclymenia* (UD V-A1), and last *Prionoceras*, but, again, dominated by *Erfoudites*. Below, a succession of grey crinoidal debris limestone with intercalated debris flow units is overlain by a thin dark grey, detritic limestone with *Cymaclymenia pudica* and *Protactoclymenia* of latest Upper Devonian IV. Microfacies analysis suggest a significant deepening in the L. *expansa* Zone. Gold to yellow, "*Frutexites*-style" microbial incrustations indicate a deep photic, calm sedimentation. Towards the Southeast (Hassi Nebech), Upper Famennian conodont faunas become rather undiagnostic but solid limestones indicate a topmost Hembergian (top L. *expansa* Zone) shallowing, followed by subsequent, nodular Dasberg Event Beds with *Endosiphonites*.

In the northern Rhenish Massif (Oese) [7] there is evidence for a transgressive couplet near the top of the L. *expansa* Zone. The upper pulse is a laminated black shale with *Guerichia* bivalves, overlain by two layers of regressive nodular limestones with the last *Po. styriacus*. 50 cm higher, *Nodosoclymenia* was found together with *Bi. aculeatus*, the marker of the M. *expansa* Zone. A very similar situation was observed at Effenberg, where there is a well-developed black shale, followed by two limestones with the last *Po. styriacus*, and, somewhat higher, by the M. *expansa* Zone. A sample from the first limestone with *Endosiphonites* and *Nanoclymenia* (UD V-A1) at Malpasso (Carnic Alps) still has *Pa. perlobata maxima*, as an indicator of the L. *expansa* Zone, and various bispathodids, but no *Bi. aculeatus* or *Bi. costatus*.

In summary, German, Austrian and Moroccan sections give no evidence for any basal L. *expansa* Zone deepening. There is conflicting data concerning the age of significant transgression around the L./M. *expansa* Zone boundary. In Morocco, the main Dasberg Event falls in the basalmost M. *expansa* Zone, whilst it still falls in the highest range of *Po. styriacus* or other L. *expansa* Zone markers in the Rhenish Massif and in the Carnic Alps.

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A MULTIPLE-PARAMETER APPROACH TO ANALYZING THE MID-PUNCTATA ZONE ANOMALOUS SIGNATURES IN PURE LIMESTONES (MORAVIAN KARST, BRUNOVISTULIAN TERRANE, CENTRAL EUROPE)

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ORAL

Introduction: The late Early and early Middle Frasnian reef limestones of the Moravian Karst have a number of original depositional facies and faunal characteristics in common with other tropical shallow-water and highly productive carbonate factories worldwide, inclusive of links to Ardennes-Rhenish and SE Poland regions. Since the *punctata* Zone, new faunal similarity features were gradually emerging, pointing to terranes in Romania/Bulgaria and Turkey.

Sections: In the punctata Zone, three sections in three different sectors and environments of the Moravian Karst reef complex are compared: Mokra Quarry West with deposition on very shallow gently inclined ramp, Ochoz Skalka Quarry with a deep lagoon in middle of the reef complex and Svazna Studna Cave behind and around an exposed reef front. The thicknesses related to the Palmatolepis punctata Zone time-correlative intervals do not exceed 10, 15 and 30 m, respectively, i.e. less than ~60m thickness in HV-105 Krtiny fore-reef facies.

Stratigraphical markers: The first proxies to determine the position of the punctata interval in reef areas were derived from the 1960-1980's geological survey base data on conodonts from peri-reef areas (Palmatolepis punctata with Mesotaxis asymmetrica and Ancyrodella gigas above; former Middle asymmetricus Zone) together with tracing a subsequence boundary at the base of an important 1st Frasnian level of intralagoonal biohermal reefs and mounds. The base coincides with the following faunal replacements: Rugosa - *Hexagonaria* and *Thamnophyllum monozonatum* / *Alaiophyllum* and *Tabulophyllum* spp.; Tabulata - *Alveolites suborbicularis* and *Crassialveolites evidens* / *Alveolites complanatus* group; Stromatoporoidea - *Actinostroma dehorneae* / *Amphipora moravica* and *Syringostroma vessiculosum*. *Amph. rudis* repopulated sheltered areas in the upper third of the *punctata* Zone, and the first detectable occurrences of *Multiseptida* and *Paratikhinella* or very similar foraminifers can be at present set as deep as to the *punctata/hassi* laterally correlated levels. In isolated lagoonal environments, *Disphyllum* rugose corals persists and evolve, and also some other faunal elements among corals, stromatoporoids and amphiporids display conservative, "Givetian-Lower Frasnian" tendencies in evolution of their morphological traits.

Sediment composition and fabrics: Limestones are very pure, with minimum detrital admixture. The calculated mean contents of non-carbonate impurities in the Mokra and Ochoz puctata intervals of the sections are 84 (27) and 53 (13) g/kg, respectively. The lower, bracketed values correspond to few-cm-sized samples and the higher ones are to dm-m-sized ones and GRS logging. This difference is caused by localized stylolites and disseminated occurrences of thin discontinuous lamellae and pocket fills after exceptional dust deposition episodes in shallow and often protected areas of otherwise detrital-flux-starved conditions. Mokra - The shallowest facies contain stromatolites and beachrocks, and the deepest ones are marked by *Amphipora* packstones. Within this range a number of types of foramol-like facies occur, typically with micritized grains, algal or bacterial mats or rare stromatoporoid and coral incursions. However, erosional remnants of dunes, bars or channels are very rare and almost all those reported have doubtful probative value. Relatively low content of large metazoan reefbuilders is typical. Ochoz - Caliche fragments and subaerally altered bioclasts mark the shallowest sources, and the *Amphipora*-

rugose coral packstones with trilobites the deepest ones. Inbetween these two extremes a number of foraminiferal sand, packstone and floatstone varieties occur. Predominance of amphiporids and stachyodids. Svazna Studna - From laminar algal coatings and reef rubble bind by secondary framework builders to rubble, sands and even stromatactis-bearing sediments. In this range, a number of other facies is indicative of environments between moats, reef flat and reef front. Predominance of stachyodids.

Interpreted fluctuations of water depth: After a vigorous shallowing and flooding at the base, three to four major parasequences can be traced in the lower half of the zone, mainly according to shallowing upward trends in sediments. With the terminal stage of the first one, a thick series of shallowing and coarsening upward stromatoporoid-bearing banks deposited. One relatively faster and stronger oscillation seem to precede the major shallowing followed by an exceptional flooding which was recorded after the middle part of the zone. Here, a series of thick, event-deposited beds with fining and thinning upward trends developed across all these areas. Then, the sea level fall was slow, smoothing at least two parasequence intervals. Next sharper flooding came before the end of the zone and was continued by descending parasequence peaks, with shallowest markers just above the punctata/hassi boundary intervals. The occurrence of stromatactis sediments in the Svazna Studna Cave coincides with the eustatic change from lowstands to anomalous mid-punctata flooding. Subsequently deposited rubbles have many Entobia borings.

Whole-rock element concentrations based on INAA analysis: Our study presents two relatively new approaches for analysis: 1/ The abundances of ~35 major, trace and ultra-trace elements, when normalized to their averages in this zone, show a quite homogeneous (correlative) band in their plotted concentration variations. In most general terms, these concentrations have a decreasing tendency in the lowermost part of the zone, with major elevation around the lower third levels and major depression (followed by slow increase) near the middle levels of the zone. A visible, stepwisely arranged increase is typical for the uppermost parts of the zone and upper boundary interval. Some specifics were found only for U, Sb, As, etc. 2/ If the same is seen as normalized to K (= 1, throughout), the higher contents of impurities often correspond to relative surplus of all other elements, but the mid-zone interval shows a major anomaly where actually the lowest bulk concentrations of impurities (very pure limestones) correspond to an extreme and more structured over-abundance of Fe, trace and rare elements. Elevated concentrations (x10-100; to 1.5 micro-g/kg) of Ir are scattered, but marks this anomaly and one other different above the punctata/hassi boundary.

Combined magnetic susceptibility and gamma-ray spectrometric analysis: The plots of smoothed stratigraphic variations of magnitudes of bulk MS values are roughly similar to geochemically detected concentrations of non-carbonate impurities: They also show a longbow shape, with in 50-70% probability to copy parasequence HST-LST variations (lower and higher MS magnitudes, respectively), but the mid-zone levels are marked by rapid increase of these MS values with slower, stepwisely arranged decrease above. This mid-zone rapid shift and MS maximum are in contradiction to facies and petrological records, but corresponds to geochemically indicated surplus of trace and rare elements compared to K abundances. The GRS logging K, Th detections often follow (in 70-80%) the trends from sample-based geochemistry, being indicative also of separate U peaks in the lower and upper parts of the zone, but there is again this mid-zone anomaly where U and Th are strongly elevated. The GRS-and-MS based insights to frequencies and amplitudes also clearly separate these highly anomalous levels from the background, although several discrepancies can be traced also below and above.

Mineral and chemical composition of non-carbonate impurities: Extraction of non-carbonate impurities from the anomalous mid-punctata levels led to documentation of grains of rare compositions. Fifty-kilogram samples were used for these purposes, from Mokra and Ochoz sections. Svazna Studna Cave was not sampled (agitated water near reef front; natural protection reasons). The mean concentrations of these rare particles in the mid-punctata Zone anomalous levels correspond approximately to 20-70 mg/kg. It is only one thousandth of the normal (average) concentration of impurities embedded in these reef-associated limestones. These data are only averages, as the real distribution of rare grains in these rocks is more complicated on the cm-dm scale, particularly due to slightly detectable, variable, much disseminated occurrences of discontinuous and often diffuse lamellae and pocket fills. This assemblage of rare grains contains, e.g., iron-rich and silicate microspherules and drops (with magnetite, hematite and pyrrhotite; onion peels, striae), devitrified glasses of An-rich plagioclase, diopside or more complex mixtures (fluid-plastic, wrinkled, foam; rich in Ti, Ba), fragments of well crystallized minerals or rocks (olivines and plagioclases, dotted with symplectic exsolutions, ablation, striae; pyroxenes with iron-rich lamellae, Widmanstatten patterns). Phlogopites, and various Ti, Ba, Fe-enriched secondary minerals and subcrystalline mixtures are present in ultrafine, nanometre fractions, rimming also the relatively rare grains of 5 to 150 (55) micro-m dimensions. This particular assemblage of grains may correspond either to material upwells from Earth's interior which was vigorously torn from the Earth surface, or, very speculatively, to olivine-phyric to basaltic and Ni-, Cr-depleted siderolite materials of possible, although a little suspect, meteoritic origin. The compositions of these rare grain assemblages are roughly comparable in the Mokra and Ochoz sections, only the latter provided slightly greater amounts of olivines and devitrified glasses, the latter mainly with fluid-plastic deformation structures.

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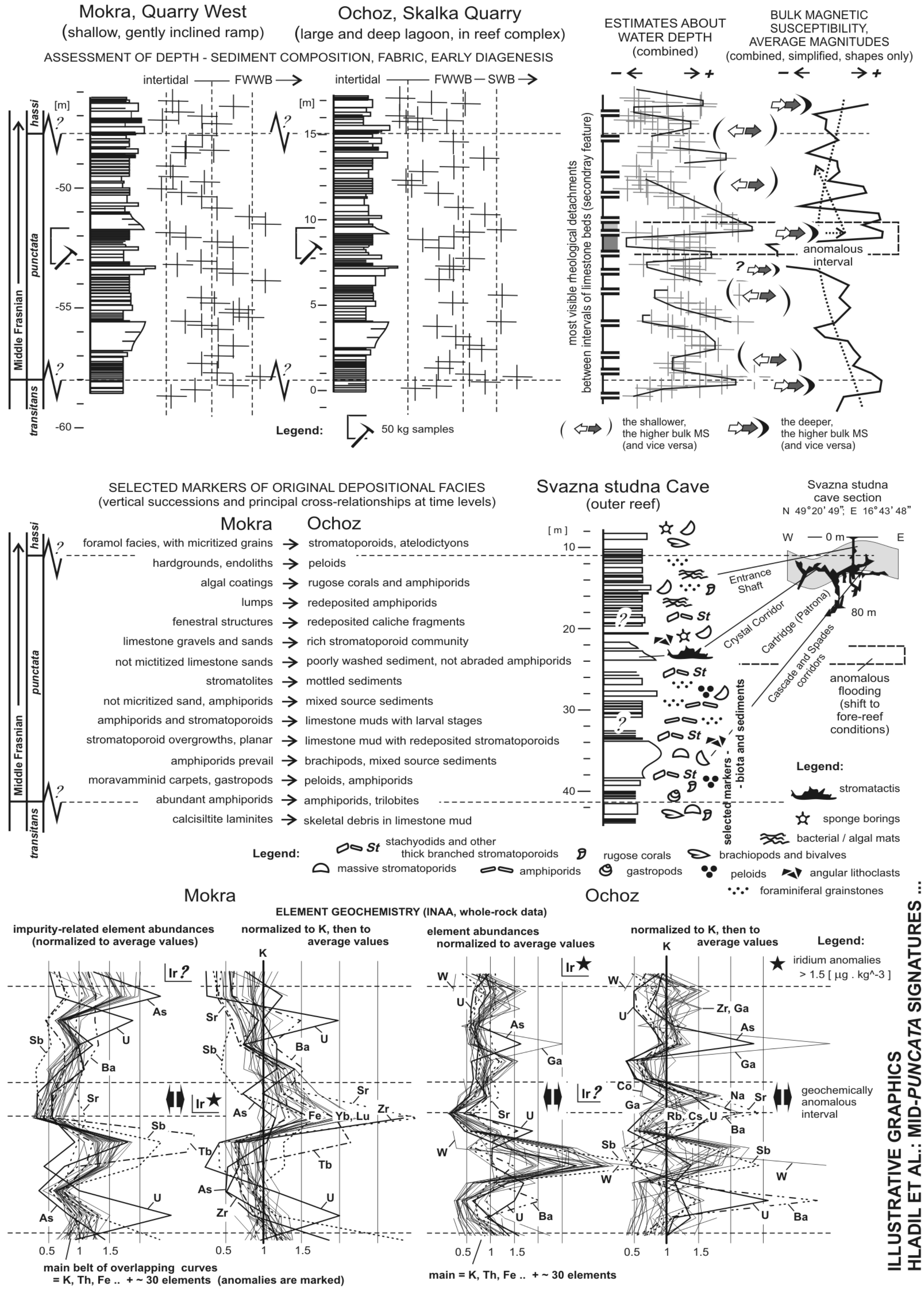

Mokra, Quarry West
(shallow, gently inclined ramp)
Ochoz, Skalka Quarry
(large and deep lagoon, in reef complex)
ASSESSMENT OF DEPTH - SEDIMENT COMPOSITION, FABRIC, EARLY DIAGENESIS
intertidal FWWB
intertidal FWWB SWB
ESTIMATES ABOUT WATER DEPTH (combined)
BULK MAGNETIC SUSCEPTIBILITY, AVERAGE MAGNITUDES (combined, simplified, shapes only)
most visible rheological detachments between intervals of limestone beds (secondray feature)
anomalous interval
Middle Frasnian
hassi
punctata
transitans
[m]
Legend:
50 kg samples
the shallower, the higher bulk MS (and vice versa)
the deeper, the higher bulk MS (and vice versa)
SELECTED MARKERS OF ORIGINAL DEPOSITIONAL FACIES
(vertical successions and principal cross-relationships at time levels)
Mokra
Ochoz
foramol facies, with micritized grains → stromatoporoids, atelodictyons
hardgrounds, endoliths → peloids
algal coatings → rugose corals and amphiporids
lumps → redeposited amphiporids
fenestral structures → redeposited caliche fragments
limestone gravels and sands → rich stromatoporoid community
not mictitized limestone sands → poorly washed sediment, not abraded amphiporids
stromatolites → mottled sediments
not micritized sand, amphiporids → mixed source sediments
amphiporids and stromatoporoids → limestone muds with larval stages
stromatoporoid overgrowths, planar → limestone mud with redeposited stromatoporoids
amphiporids prevail → brachipods, mixed source sediments
moravamminid carpets, gastropods → peloids, amphiporids
abundant amphiporids → amphiporids, trilobites
calcisiltite laminites → skeletal debris in limestone mud
Svazna studna Cave
(outer reef)
selected markers - biota and sediments
Svazna studna cave section
N 49°20′49″; E 16°43′48″
W 0 m E
Entrance Shaft
Crystal Corridor
Cartridge (Patrona)
Cascade and Spades corridors
80 m
anomalous flooding (shift to fore-reef conditions)
Legend:
stromatactis
sponge borings
bacterial / algal mats
brachiopods and bivalves
angular lithoclasts
foraminiferal grainstones
stachyodids and other thick branched stromatoporoids
rugose corals
massive stromatoporids
amphiporids
gastropods
peloids
Mokra
Ochoz
ELEMENT GEOCHEMISTRY (INAA, whole-rock data)
impurity-related element abundances (normalized to average values)
normalized to K, then to average values
element abundances normalized to average values
normalized to K, then to average values
Legend:
iridium anomalies > 1.5 [μg . kg^-3]
geochemically anomalous interval
main belt of overlapping curves = K, Th, Fe .. + ~ 30 elements (anomalies are marked)
main = K, Th, Fe .. + ~ 30 elements
ILLUSTRATIVE GRAPHICS
HLADIL ET AL.: MID-PUNCTATA SIGNATURES ...

ISOTOPE COMPOSITION δ13C AND δ18O IN THE UPPER DEVONIAN (F/F) SECTION FROM THE NORTH-WESTERN KUZNETSK BASIN (SOUTH OF WEST SIBERIA, RUSSIA)

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POSTER

One of the largest mass extinction events in Phanerozoic occurred at Late Devonian, close to the Frasnian-Famennian (F-F) boundary. Almost all over the world it coincides with the appearance of the black shales that reflects the anoxic conditions in the sedimentary basin (Lower and Upper Kellwasser events). The only exclusions are the Chinese [1] and North-Western Kuznetsk Basin (South of West Siberia, Russia) sections where black shale horizons are not observed. Besides the black shale horizons, Kellwasser Event boundaries correspond to major positive excursions of δ13C trend, whose values are up to 3-4 ‰ [2, 3].

Data on the major excursions of δ13C near F-F boundary are obtained for many sections all over the world. Isotopic studies for the Siberian Frasnian and Famennian sequences were not carried out until recently.

The Frasnian and Famennian carbonate section cropped out in the North-Western Kuznetsk Basin was investigated. It is represented by the dark-grey and grey limestone nodules yielded carbonate algae, brachiopods, pelecypods, conodonts, vertebrates and gastropods [4].
Materials and methods

Oxygen and carbon isotope analyses were performed with a preparation line (Gas Bench II) connected online to a Thermo Finnigan 253 mass spectrometer. Micritic carbonates were used for the isotopic analysis. We choose this particular rock as data on the shells analysis do not provide high accuracy for the sample selection. Also, petrographic studies and chemical composition investigation of the carbonate have been done. They are very effective for allocation of diagenetically altered samples, and thus to exclude them from the further interpretation of the obtained data.

Carbon isotopes - Carbon isotope analyses showed that in the investigated section directly before and at the F-F boundary δ13C values are increased from – 0,5‰ to 0,5‰, and up to the upper part of the section the rapid rise exceeding 1,5‰ is observed. Then positive excursions display high values 5 – 5,3‰ until Lower triangularis Zone. The increase of values coincides with enhanced bioproduction resulted from input of large amount of the nutrient to the ocean, and with accumulation of the organic matter [3]. Higher values of δ13C in this section (North-Western Kuznetsk Basin) in comparison with other regions most probable are connected either with different position of this basin (higher latitudes) or with more large-scale processes of changes in this basin.

Oxygen isotopes - Oxygen isotope composition variation in this section partly mirrored that of carbon isotope. Directly before and at the F-F boundary δ18O values increase from – 9 to – 8‰, and then its value remains within – 8,5 ± 0,2 ‰. Approximately near the maximum of the δ13C curve, values δ18O sharply increased to – 7,3‰ and in the upper part of the section remains within – 7,3 ± 0,3‰, only in the uppermost part they drop to – 8,3‰.
In conclusion it should be mentioned that in the studied section absolute δ13C and δ18O values differ from those reported from the other regions of the world. Observed values of δ13C are higher on 1,5- 2 ‰, and values of δ18O are lower on 4‰ than in other regions.

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UPPER SILURIAN TO MIDDLE DEVONIAN OF THE RHENISH MOUNTAINS, GERMANY: NEW BRACHIOPOD DATA AND IMPLICATIONS

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ORAL

Introduction: Upper Silurian (Pridolian) to lower Middle Devonian (Eifelian) strata of the Rhenish Mountains (Germany) reflect a broad spectrum of shallow-marine to non-marine, siliciclastic-dominated environments. The area was situated in lower latitudes and represented by a neritic “Rhenish” shelf along the southern margin of the Old Red Continent. The latter was eroded, and large amounts of siliciclastic debris were transported by fluvial deltas on the subsiding Rhenish shelf. The shelf was subdivided into swells and troughs changing their position during the time interval considered. In certain depocenters, as the Mosel and Lenne troughs and the Siegerland area, enormous sediment piles locally reaching several thousands of meters could be accumulated. Islands are suggested to have existed, as the Hunsrück Island in the southwestern Rhenish Mountains [1]. Extensive intertidal flats existed at least temporarily (Klerf Formation, uppermost Lower Emsian, Eifel Hills). The interplay of locally different rates of subsidence caused by synsedimentary tectonics, varying rates of sedimentation, and sea-level changes mainly determined the palaeogeographic constellation and the facies development. The variation in facies is reflected in the diversity of faunas and floras. Most abundant and diverse are benthic marine invertebrates as brachiopods, bivalves and trilobites. The Rhenish successions have been deformed and disturbed tectonically in Carboniferous time. Faults and unfavourable outcrop conditions hamper stratigraphic studies.

Brachiopod biostratigraphy: Articulate brachiopods are regarded as the most significant index fossils in the Rhenish successions considered. Faunas have been studied for several years by the author. The thick sequences with little faunal changes could give the impression, that the biostratigraphic resolution is very low. But, if one would reduce the enormous thicknesses before one’s mind’s eye to a few decameters comparable to some contemporaneous sections in the Barrandian area, the resolution of the Rhenish brachiopod stratigraphy would look quite respectable in comparison to the Bohemian pelagic biostratigraphy. In fact, the Early Devonian was a time of radical evolutionary change within the Brachiopoda. As sessile suspension feeders they are commonly discredited by the biostratigraphers because of their dependence on facies conditions. However, many studies show, that they can well be used without serious problems in biostratigraphy on a regional scale, when they occur in sufficient abundance and diversity. Especially, when whole faunas are studied, and each taxon is evaluated in view of its phylogenetic development and age, there will be a better control, and the risk of wrong age assignments will be reduced to a minimum. Presently, 23 spiriferid zones and corresponding 12 faunal intervals (assemblage zones) are distinguished.

New brachiopod data and implications: Recent studies have resulted in numerous taxonomic revisions, biostratigraphic refinements, correlations and re-assignment of strata. The *Quadrifarius dumontianus* Zone as the first spiriferid zone corresponds to the Faunal Interval A. The biozone has been recognized in the Hautes-Fagnes (Belgium), Ebbe and Remscheid anticlines, Müsen Horst and southern Taunus Hills. The find horizons have commonly considered as Gedinnian. The zone fossil *Quadrifarius dumontianus* (de Koninck, 1876) is accompanied by the athyridid *Dayia shirleyi* (Alvarez & Racheboeuf, 1986) (formerly determined as *Dayia navicula*) and the stropheodontid *Shaleria rigida* (de Koninck, 1876). *D. shirleyi* represents a step within the evolutionary development of the genus *Dayia* Davidson, 1881. Correlation with faunas from drilling cores in the Artois area (northern France) [2] allows a datation as latest Silurian (Pridolian). The genus *Protocortezorthis* Johnson and Talent, 1967 shows a phylogenetic development within the corresponding Faunal Interval B and may help in the future in the recognition of the local Silurian/Devonian boundary. The *Howellella mercurii* Zone and Faunal Interval B could be identified in sections of western Europe and even in the Zonguldak area (northern Turkey). The concept of *Acrospirifer primaevus* (Steininger, 1853) has changed significantly [3], and, accordingly, the scope of the *Acrospirifer primaevus* Zone changed; it corresponds to Faunal Interval C. A lowermost Lower Emsian form could be separated as a new species [4], and, as a result, the regional base of the Emsian stage is better ascertainable now; it correlates with the base of Faunal Interval D1. In the northern Rhenish Mountains, for example in the Bergisches Land, deltaic sediments of the Odenspiel Formation are widespread. The terebratulid "*Rhenorensselaeria*" *crassicosta* (Koch, 1881) as a main index of the faunal interval C, is assigned to a new genus [5]. This taxon is euryoecious allowing correlation of this level from normal-marine to intertidal or brackish environments of the Odenspiel Formation. At one recently discovered locality it is even associated with horizons showing early land plants *in situ*. In another case, thin shell layers with fully marine brachiopod faunas are intercalated in intertidal successions with red colours of the Klerf Formation. These layers are interpreted as storm layers. The *Arduspirifer antecedens stadtfeldensis* Zone and Faunal Interval D 3 could be recognised here, and an age assignment to the latest Early Emsian could be approved. A new species of *Pachyschizophoria* Jansen, 2001 has been identified which is a good new index for the recognition of the lowermost Upper Emsian; very closely related forms occur in the Moroccan Anti-Atlas Mountains allowing to identify the base of the Upper Emsian there.

Future prospects: Future research will lead to refinements of the proposed biozonations. Combination with other biostratigraphies (ichthyostratigraphy, palynostratigraphy) or even sequence stratigraphic studies, hardly having been tackled in the Rhenish Mountains so far, is promising. The idea of "holostratigraphy" is worth following for the integration of the Rhenish Devonian in global stratigraphic schemes and ecological-evolutionary units. The brachiopod stratigraphy may increasingly be connected with facies analyses in order to reconstruct depositional and biotic environments in space and time.

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GENERAL PROBLEMS IN CONODONT STRATIGRAPHY AROUND THE DEVONIAN/CARBONIFEROUS BOUNDARY AND POSSIBLE SOLUTIONS

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ORAL

In the recent years several kind of difficulties arise to those working with conodonts around the Devonian/Carboniferous boundary. These problems can be mainly referred to two categories: conodont taxonomy in the early *Siphonodella* group and application of the standard conodont zonation.

Problems in discriminating *Si. praesulcata* from *Si. sulcata* are due to the high variability and to the amount of specimens that appear to be transitional between the two taxa: therefore in many cases the attribution of a specimen to one or to the other species is subjective. Since the D/C boundary is defined by the first occurrence of *Si. sulcata*, it results that the position of the boundary depends on personal interpretations. Furthermore, due to major environmental changes during the Hangenberg Event interval, and changing depositional environments, widespread siliciclastic deposits and stratigraphical gaps worldwide, in some places (i.e. the Carnic Alps) *Siphonodella sulcata* is absent at the D/C boundary transition. The absence of Si. sulcata at the D/C boundary indicates that the definition of the boundary by the first occurrence of *Si. sulcata* has to be reconsidered. It requires a new conodont zonation and a revised definition of the boundary.

Problems with the conodont zonation arise because in several areas some index conodonts in the Upper Famennian are too rare for defining biozones. Dependent on the depositional environments, they appear after their first global range, in respect to other associated conodonts. Therefore, the index fossils have to be replaced by other biostratigraphically significant taxa, and/or regional zonations have to be established (Corradini, 2007). The main problems occur with the *postera* Zone and the Middle *praesulcata* Zone, but in places also the discrimination of the Middle and Upper *expansa* Zone, the Lower *praesulcata* and even of the *sulcata* Zone (= D/C boundary) should be done on the basis of different taxa than the marker. The marker of the *postera* Zone is often absent in Europe, or makes its entry in a younger level (i.e. in the Carnic Alps together with *Pa. gr. expansa*). The Middle *praesulcata* Zone, which is defined by the extinction of *Pa. gr. gonioclymeniae*, cannot be delineated in many sections due to the absence of this species. In the Carnic Alps, the conodont biostratigraphy was complemented by new ammonoid faunas (Kaiser, 2005), which indicate that the Middle *praesulcata* Zone is not recorded at the topmost part of the sections, although *Pa. gr. gonioclymeniae* is absent.

Possible solution to these problems should be:
- a refinement of the Upper Famennian-Lower Tournaisian conodont zonation taking in account only the first occurrences of the most common taxa, even if they belong to different genera.
- a redefinition of the D/C boundary, drawn with the biostratigraphically significant protognathodid fauna instead of the problematic and in places low abundant siphonodellid fauna conventionally used: the boundary can be placed at the entry of the *Prothognathodus* fauna, or at the first occurrence of *Protognathodus kuehni*. The latter placing is chronostratigraphically close to the present one, while the first hypothesis will make it older, near the deposition of the Hangenberg Shales.

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RAPID ENVIRONMENTAL CHANGE DURING THE LATEST FAMENNIAN - IMPLICATIONS FROM CONODONT BIOFACIES AND STABLE ISOTOPE ANALYSES

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ORAL

A biostratigraphic correlation of D/C boundary sections from the Carnic Alps, the Graz Palaeozoic, Montagne Noire and Pyrenees resulted in a high-resolution record of the carbon isotopic composition of micrites (d13Ccarb), of sedimentary organic matter (d13Corg), as well as of oxygen isotope ratios of conodont apatite (d18Ophosph). The studies focused on the interval between the Upper postera Zone (Upper Famennian) and sandbergi Zone (Lower Tournaisian). For the first time, a weak but significant positive carbon isotope excursion in micrites is reported from the Middle and Upper expansa Zone of the Carnic Alps. It coincides with a positive carbon isotope excursion measured in the sedimentary organic matter, as well as with a decrease in the oxygen isotope values of conodont apatite and conodont biofacies change.

The excursions do not correlate with lithological change in the Carnic Alps and post-dates the global, transgressive Dasberg Event at the base of the Middle expansa Zone. But it indicates changes in the global carbon cycle during an episode of high seawater temperatures and stepwise eustatic rise. High carbon isotope values were also measured in limestones from the Graz Palaeozoic in the Upper praesulcata Zone, immediately following the Hangenberg mass extinction Event. This excursion is time-equivalent with positive carbon isotope excursions measured in limestones from different regions, as well as with a sea-level rise and locally preserved black shales in the Rhenish Massif after the main glaciation episode in Gondwana.

The regional correlation of the geochemical records of environmental change during the Late Famennian as well as interpretations of these records on a global scale are discussed. The data indicate that changes in conodont biofacies of Upper Famennian limestones were caused by a complex pattern of oceanographic and climate changes, which culminated in one of the most severe extinction event of the Phanerozoic. Perturbations of the carbon cycle due to an enhanced Corg burial are evidenced by the positive carbon isotope excursions in the expansa and Upper praesulcata Zone. These time spans are characterized by transgressive pulses in Euramerica during periods of high seawater temperatures. A combination of several factors, terrestrial nutrient supply, oxygen deficiency of shelf areas, and climate or salinity-driven upwelling and eutrophication, can have caused the different episodes of enhanced Corg burial. Changes in sea level in the expansa Zones cannot be explained by glacio-eustasy, because there is no evidence for glaciation. Oceanic shelf anoxia and perturbations in the carbon cycle in the Upper praesulcata Zone were possibly caused by glacio-eustasy after the main glaciation episode of the Hangenberg Event and a high nutrient influx due to enhanced terrestrial erosion.

CAN THE REWORKED CONODONTS OF THE NORTH EVANS LIMESTONE (CONODONT BED OF HINDE, 1879) HELP SOLVE THE GEOLOGICAL PUZZLE OF DEVONIAN EXTINCTIONS?

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ORAL

At the Appalachian Basin margin in western New York, the change from the Middle Devonian neritic Hamilton Group deposits to the Middle to Upper Devonian dark dysoxic basin facies of the Genesee Group is abrupt and profound. This is the interval of the diachronous and composite Taghanic Unconformity, marked by the erosion of the upper Hamilton and subsequently, of the Tully Limestone. The post-Tully lower Genesee succession, with the Leicester Member pyritic lag deposit at its base, progressively onlaps the Taghanic Unconformity westward, becomes internally condensed, and is also beveled to a feather edge below a still younger erosion surface beneath the mid-Genesee Genundewa Limestone. This strongly telescoped succession also corresponds to the interval of the Taghanic Bioevent, a major, global-scale, mid-Devonian faunal-turnover event.

Sandwiched between the Taghanic and sub-Genundewa erosion surfaces is the North Evans Limestone (Conodont Bed of Hinde, 1879) a thin crinoidal-bone lag facies long recognized as a concentrate of conodonts and fish debris. The North Evans spans an interval of some six conodont zones whose representative taxa, known from other horizons in the region, are here missing or present in a range of preservation states. The taphonomic age of the North Evans is Frasnian (MN Zone 2) but the unit is full of Givetian elements, particularly the long-ranging, cosmopolitan, *Polygnathus linguiformis* Hinde.

Polygnathus linguiformis should be a prime candidate for testing the new biogeochemical techniques reported at the Pander Symposium at the 2006 meeting of the Geological Society of America. The growth lamella of conodont denticles show fine-scale patterns of trace elements (like tree-rings) and oxygen isotopes, that appear to be primary (and not modified by diagenesis), thus reflecting environmental conditions and biotic response during life. If biologically coeval specimens (geochemical specimen groupings) can be recognized in the North Evans by their trace-element patterns, it may be possible to track environmental changes through their counterparts in the Hamilton, Tully, and Leicester where these conodonts are either *in situ* or are in subsidiary lag deposits.

Reduced oxygen levels and related chemical changes associated with temperature changes and global sea-level rise (which are recorded in sediments) are believed to have been the principal trigger of Devonian extinctions such as the Taghanic event. Detecting fluctuations in ocean conditions in the apatite of conodonts will be a challenge for a new generation of paleobiologists. For the North Evans conodonts the application of fine-scale biochemical analysis may bring new life to old faunas, and help solve the puzzle of the Devonian extinctions.

ECOLOGICAL CHANGE DURING THE EARLY EMSIAN (DEVONIAN) IN THE ANTI-ATLAS (MOROCCO) AND THE ORIGIN OF THE AMMONOIDEA

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POSTER

Early Emsian claystones and marls of the Tafilalt yielded two diverse and prolific faunas with nearly 5000 specimens belonging to at least 100 species having been recovered. The older of the two faunas contains what may be the oldest bactritoids, a number of rare fossil groups and a diverse and largely infaunal bivalve assemblage. The younger fauna is marked by the appearance of the first ammonoids, which are represented by the genera Chebbites, Erbenoceras, Gracilites, Gyroceratites, Irdanites, Lenzites, and Metabactrites (see Klug 2001b). These are accompanied by other cephalopods such as the bactritoids Devonobactrites and Cyrtobactrites, predominantly epibyssate bivalves, and gastropods; infaunal organisms are rare in this fauna.

Based on the differences in the identified faunal elements of the two assemblages, the preservation of the fossils and the lithology from which the fossils were recovered, it can be concluded that the paleoenvironment had more or less normal oxic conditions with intermittent dysoxic and anoxic phases. Both phases produced reducing conditions that allowed some of the organisms to be preserved as pyrite (later transformed into limonite), and the latter phase resulted in local accumulations of minute bivalves that died shortly after hatching. Based on the sedimentology, the water depth was moderate with the deeper part of the photic zone being below storm wave base. The high diversity of the infaunal benthonic community of the older fauna and the sediment itself indicate a soft bottom paleoenvironment.

The older fauna is represented by machaerids, infaunal bivalves, hyolithids, brachiopods, trilobites (low diversity), phyllocarids and stalked edrioasteroids. The younger fauna, in addition to the bactritoids and ammonoids previously mentioned, contains numerous invertebrate taxa including gastropods, epibyssate bivalves, brachiopods, and much more abundant orthocones (Klug et al. in press). By comparison, the younger fauna has fewer infaunal representatives compared to the older fauna. In addition to the arthropods and echinoderms, vertebrates are less abundant in the younger fauna; this is not surprising given that these animals were part of the nektobenthonic community (as can be demonstrated by the worn tips of their fin spines).

The change in faunal composition between the two faunas strongly suggests that the paleoenvironment of the younger fauna had a decreased oxygen content in the sediment and possibly also in the deepest part of the water column. It is possible that the environmental stresses created regionally by the periodic oxygen reduction in the deeper part of the water column facilitated and stimulated the early radiation of bactritoids and ammonoids during the Emsian. When looking at bactritoid abundance (42% in the older fauna) compared to ammonoid and nautiloid abundance (16% in the older fauna), it appears the bactritoids (3% in the younger fauna) were largely displaced by the other two cephalopod groups (64%) in the younger fauna. This dramatic faunal shift in bactritoid abundance and the extraordinary rapid radiation of the Ammonoidea seen in the younger fauna may be partly explained by the presumed life mode differences of the two cephalopod groups (see also Klug 2001a and Klug and Korn 2004) and the fluctuating oxygen levels. Bactritoids probably had a demersal life style and they probably suffered near extinction when anoxic phases developed. The ammonoids and nautiloids probably had a more flexible life style and could live higher in the water column (nektoplanktonic). This allowed the ammonoids and nautiloids to escape most of the lethal effects of the anoxic bottom waters. When bottom waters became more oxygenated, the ammonoids and nautiloids were able to exploit the nearly empty paleoenvironmental niche previously occupied and dominated by the bactritoids. Globally, the rising sea level and the radiation of the Gnathostomata also played additional important roles (Kröger 2005) in early bactritoid and ammonoid evolution in early Devonian time.

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UNESCO NEWS AND A CRITICAL REVIEW OF IGCP 499

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ORAL

The International Geoscience Programme (IGCP) is a joint endeavor of UNESCO (United Nations Educational, Scientific and Cultural Organization) and IUGS (International Union of Geological Sciences). The IGCP is now looking back on over 34 years of existence and the field of Earth Sciences has evolved very much since inception of the programme. Projects initially focused on basic geoscience research and the correlation of events in the Earth's history. More recently, the emphasis changed towards societal-oriented themes. This was also reflected by the change of name from "International Geological Correlation Programme" to "International Geoscience Programme". The last external evaluation of IGCP, which was presented to UNESCO's Executive Board in 2004 (document 169 EX/22) confirmed the need to further improve the mode of operation of the IGCP, including the efficiency of its strategic plan and governing mechanisms. The former Devision of Earth Sciences which hosted the IGCP was grouped together with the Devision of Ecological Sciences in Dezember 2004 into a new Division called the Division of Ecological and Earth Sciences. As a cost-saving measure, no call for IGCP projects have been launched in 2005. New guidelines for project proposal formulation are being finalized to assist the international earth science community to propose more interdisciplinary and applied projects.

IGCP 499, which has been accepted in 2004 is a successful project which reflects the main prerequisites and requirements of an international network. The project focuses on the evolution and interaction of Devonian marine and terrestrial ecosystems. The project include specific case studies from international sites, involving cooperation from many scientific disciplines, such as sedimentology, palaeontology, stratigraphy, palaeoclimatology, palaeogeography and structural geology, in collaboration with the Subcommission on Devonian Stratigraphy (SDS). Research activities are centered around case studies in a number of countries, such as Morocco, China, Central Asia, Siberia, North and South America, and Europe. The talk will present the main results of the project within the last years e.g., conferences, publications, cooperation programmes and will give an overview of upcomming meetings and planned research activities.

THE PRECISE POSITION AND STRUCTURE OF THE BASAL CHOTEC EVENT: LITHOLOGICAL, MS-AND-GRS AND GEOCHEMICAL CHARACTERISATION OF THE EMSIAN-EIFELIAN CARBONATE STRATAL SUCCESSIONS IN THE PRAGUE SYNCLINE (TEPLA-BARRANDIAN UNIT, CENTRAL EUROPE)

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ORAL

Introduction: The Prague Syncline is an area where the Basal Chotec Event was first defined and Lower-Middle Devonian boundary parastratotype was adopted, near Chotec and Prague-Holyne, respectively. However, three principal outcrops of these Emsian-Eifelian strata are in different structural zones and original sediments were deposited in different sedimentary environments. The main differences are between the Cerveny Quarry near Suchomasty and Na Skrabku Q. near Chotec & Prastav Q. near Prague-Holyne [abbreviated as S., Ch. and H., respectively], because the latter two belong to calciturbidite fills of deep, inner basins which were imperfectly separated by sea-floor highs and archipelagos while the former represent depositional areas on slopes which were well exposed to the ocean. These differences are also formally involved in the present stratigraphic schemes, where the change from Trebotov Limestone to Chotec L. are typical for inner basins while the transition from Suchomasty L. to Acanthopyge L. marks the different slopes in these ocean-exposed outer parts.

Lithology and sedimentology: The Emsian Trebotov L. consists of many "calcisiltite" beds deposited as distal sediments from low-density gravitational flows. A variety of recycled carbonate muds delivered from diverse slope environments slowly accumulated there, and also the pelagic carbonate muds with fragile shells of fauna deposited from calm water column were well represented. The occurrence of fine grained distal calciturbiditic and pure bioclastic facies is much more typical for the lower parts of the sections than for their upper parts. The overlying, Lower Eifelian calciturbidites (Chotec L., lower part) consist to a larger extent of fine to medium size carbonate-detritus materials (mainly well sorted angular and diversely altered carbonate clasts and other particles; calcilutites to calcarenites with tightly packed particles which alternatively have bright and dark appearance in transmitted light). The determinable small shells and their fragments are disseminated in these rocks, but to a much lesser extent. Almost all of Bouma sequence members are well-distinguished – Ta – Te). An apparent change from only moderate to a strong influx of lithoclastic-skeletal carbonate-detritus material characterizes all these three sections, i.e., both in the inner facies and outer facies. In general, the Na Skrabku Q. (Ch.) section shows features corresponding to relatively more proximal depositional conditions where the Ta Bouma members have erosion bases and contain the lithoclasts derived from underlying beds, Tb, Tc occur but only transitions Td to Te are preserved. The occurrence of Chondrites isp. (burrows) is typical for Prastav Q. (H.), indicating the more distal parts where colonisation of substrate was possible. The Suchomasty L. represents a stratigraphic equivalent of the Trebotov L., but these thin bedded bioclastic (crinoidal) limestones containing often the purple coloured micrites (and diverse packstones with biomorphs) differ in many characteristics, e.g., by presence of up to metre-sized orthoconic nautiloid shells abundant, bedding-parallel swarms of stromatactis. It gives and evidence about depositional conditions just below the storm wave base. On the other hand, a certain similarity of Trebotov L. to Suchomasty L. consists in rose colour of many beds, increased activity of microborers and presence of microbially mediated formation of hematites. In the Eifelian Acanthopyge L., gravitational flows delivered coarse grained (mm-size) bioclastic material from the upper slope aprons. The sediment was well washed, and the light grey particles and rocks show almost no effects of micritization or hematite precipitation. This limestone member represents a stratal succession with a shallowing upward trend, as inferred also from the upsection emergence of allochems of very shallow origin (e.g. coated grains or reef coral and stromatoporoid fragments).

Combination of MS-and-GRS methods: The overall magnitudes of magnetic susceptibility (MS) values measured on rock samples are considerably varying according to presence or absence, sizes and detailed parameters of ferro- and ferrimagnetic magnetic carriers. But even the raw-data plots of the Chotec and Holyne sections yield a number of correlative patterns with a good linkage to Schoenecken GSSP in Germany. In particular, the pattern of the Basal Chotec E. regularly consists of a remarkable depression on both the MS magnitudes and amplitudes near the base, being followed by a long elevation on the MS values in the upper part of thin-bedded event interval. The detailed fitting of amplitude and frequency records (the proper MS correlation) requires a numerical approach and was published by B.B. Ellwood et al. in 2006. The gamma-ray spectrometry (GRS) outcrop logging provided a set of considerably stable stratigraphical patterns which have a great correlative values. The point of reversal of GRS Th/U ratio (from values >>1 to those which are <<1) lies very close to the levels with the Basal Chotec E. beds. The event interval is well defined by joint Th-&-U GRS maxima. Particularly the stable position of the GRS uranium peak is worthy of attention, because it does not mark only the thin bedded, blackish Basal Chotec E. beds in the "inner" sections Ch. and H. but also the event-related beds in the "outer" section S., where almost all these markedly visible lithological features are missing.

Geochemical features: In each section, ten levels were sampled for forty-element INAA analyses, where the selection of these levels covered both the places with low and high MS and GRS values. The proxies to amounts of non-carbonate admixtures can be exemplified by average concentrations of potassium [0.10 (0.12), 0.24 (0.47) and 0.32 (0.60) wt.% for Suchomasty, Chotec and Holyne, respectively]. The lower values are based on cm-sized samples and the higher values (bracketed) correspond to GRS-related dm-dimensions. A similar gradation is seen in concentrations of iron [0.22, 0.32 and 0.42 wt.% for S., Ch. and H., respectively]. The calculated amounts of complex impurity in these limestones are about 2.5, 11 and 14 wt.%. The REE distributions are very uniform, and the plots of their PAAS and Lu normalized values are perfectly fitting to uniform, sub constantly delivered, background inputs of eolian type. Only the effects of sea water (solutes) slightly modify this pattern (Ce down, HREE/LREE up). The signatures of originally riverine suspensions and/or deposition of other detrital grains are practically absent here, with one exception of a few disseminated clasts of very late Emsian submarine basalts (Chotec; in closely overlying beds only). Similarly, the relative composition of all other minor and trace elements remains almost the same within the ranges of the Trebotov–Chotec (and Suchomasty–Acanthopyge) limestones, inclusive of the Basal Chotec E. interval. The upper Emsian beds differ only by slightly increased concentrations of Mn and Th/U ratio > 1. The mean K/Al ratio is remarkably constant across the syncline and throughout the sections (0.37), being enhanced by one fourth when compared with the most common background-sedimentation related values in general. The Ti/Al ratios are only slightly varying in the sections, with a very slight increase near the base of the Basal Chotec E. interval. However, the mean values are a little different in the sections (0.10, 0.19 and 0.06; for S., Ch. and H). The same is seen on Th/Al ratios (0.00023, 0.00059 and 0.00044; for S., Ch. and H).

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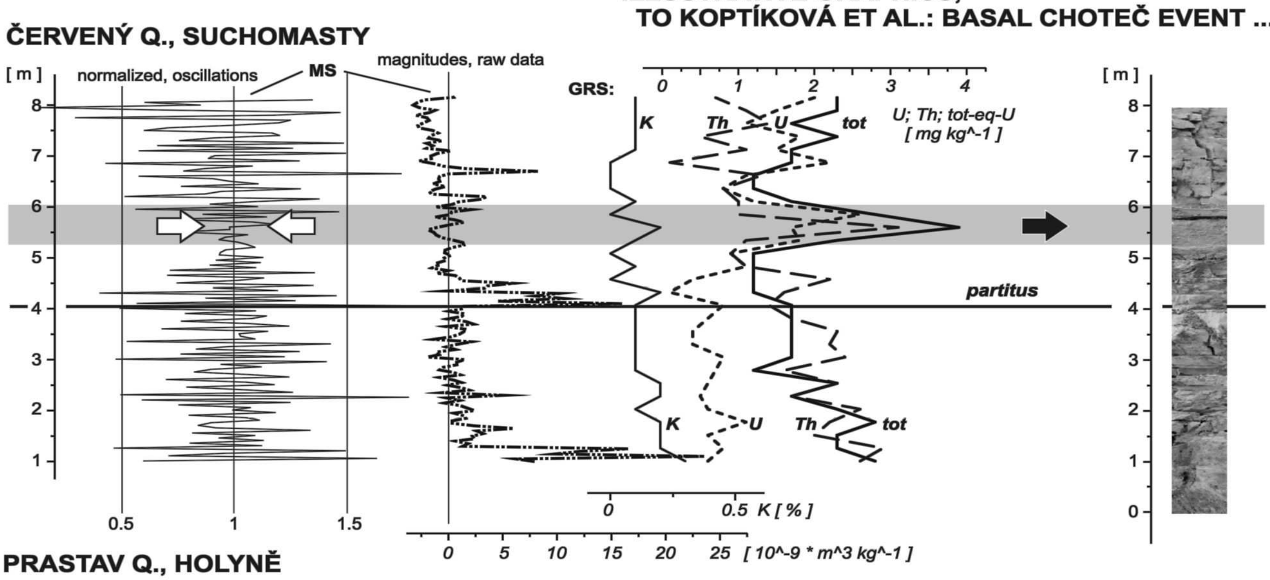
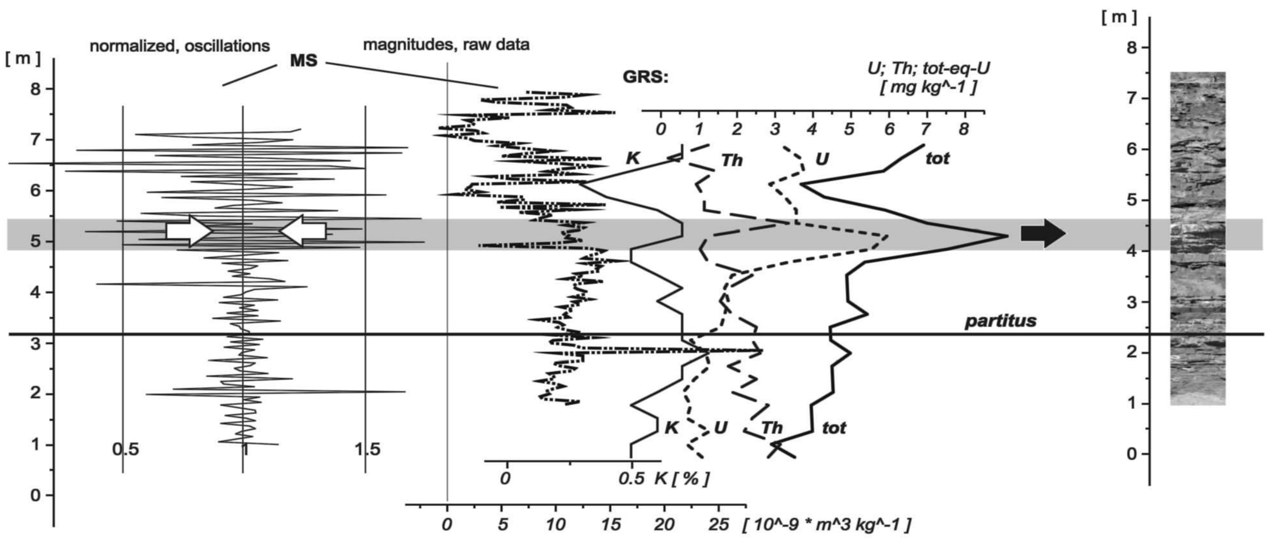
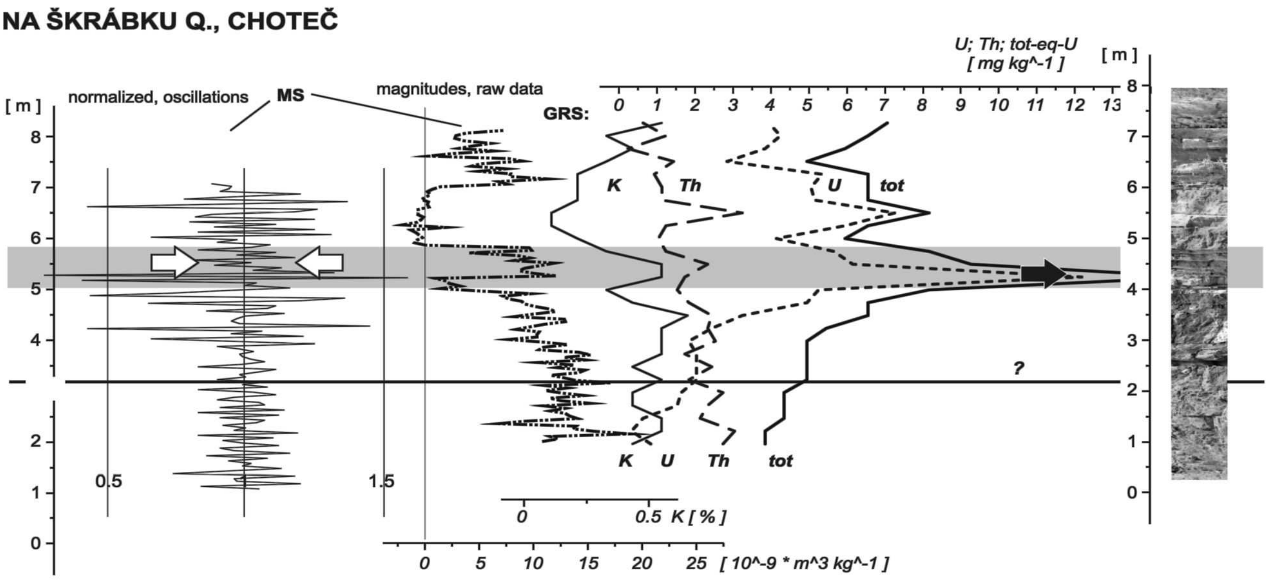
ILLUSTRATIVE GRAPHICS,
TO KOPTÍKOVÁ ET AL.: BASAL CHOTEČ EVENT ...







MIDDLE AND EARLY UPPER DEVONIAN CONODONTS FROM LA GUARDIA D'ARES (SPANISH CENTRAL PYRENEES)

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ORAL

In the La Guardia d'Àres area there is a set of outcrops exhibiting rocks from the Lower Devonian to the Carboniferous. Due to tectonics, a continuous section cannot be studied, but different blocks can be dated by conodonts. The interval considered herein comprises rocks from the upper Eifelian to the early Frasnian and belong to the Comabella Fm., which in this area consists of dominant clear colour wackstones, some of them nodular, with a few brecciated layers, especially in the upper part. Thickness varies from centimetric to metric beds. The conodont sequences from two sections (LGA and LGA-I) are briefly described below.

In the LGA section, the studied conodont sequence starts with an upper Eifelian association (beds 175-178a) characterized by *Polygnathus angusticostatus, Pol. angustipennatus, Pol. ling. linguiformis, Pol. ling. klapperi*, *Pol. pseudofoliatus, Icriodus platyobliquimarginatus*, *Icr. obliquimarginatus* and *Tortodus kockelianus*. All taxa, except the latter, reach the Lower Givetian *hemiansatus* Zone (or higher), but *T. kockelianus* restricts this association to the Eifelian; moreover, the record of *Icr. obliquimarginatus* in bed 178a hints at a position close to the Eifelian/Givetian boundary. The lowest record of *Pol. eiflius* in bed 178b is not diagnostic of either Eifelian or Givetian age. Rocks of the *rhenanus* and *ansatus* zones tectonically overlain the Eifelian rocks; therefore, the Eifelian/Givetian boundary cannot currently be documented by means of conodonts at LGA.

Above beds of the *ansatus* Zone, only conodonts of, most probably, the *hermanni* Zone are recognized. As the index of the *hermanni* Zone is lacking, this zone is first recognized through the presence of *Pol. limitaris* in bed 200c and *T. weddigei* in bed 201.

The *disparilis* Zone is identified by its index *Klapperina disparilis* in bed 214c; within this bed the delayed entry *Pol. cristatus* is also registered. The lowest record of *Pol. dengleri* in middle parts of bed 219 enables the recognition of the two-fold (lower and upper) subdivision of the *disparilis* Zone.

The Givetian/Frasnian boundary is traced 122 cm above the base of the bed 221 with the entry of *Ancyrodella binodosa*, which also allows recognition of MN1 Zone. A sequence of *Ancyrodella* containing *A. pristina*, *A. rotundiloba* and *A. alata* is also documented; the entry of *A. rotundiloba* at the top of bed 222 traces the base of MN2 Zone.

LGA-I is a short section spanning the Givetian/Frasnian boundary. The basal bed (1a) furnished *Skeletognathus norrisi*, indicating the uppermost Givetian. The record of *A. pristina* in bed 1b indicates the beginning of the Frasnian. Lack of *A. rotundiloba* does not allow identification of MN2 zone, but physical continuity of some beds between LGA and LGA-I projects this boundary at the base of bed 6.

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WHY THE TERRESTRIAL UPPER FAMENNIAN IS IMPORTANT TO THE SDS

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ORAL

Introduction: The Famennian Celsius Bjerg Group of East Greenland is internationally famous for its early tetrapods. More importantly, for the SDS, these terrestrial sediments record cyclic climatic variation at a number of Milankovich frequencies including groups of the longer period e_2 eccentricity climate cycles (405 ky) which are already being used to define Tertiary time. If these cycle groups can be identified within marine successions then it gives the potential to develop a unified series of Famennian sub-stages. This integration with the formal IUGS sub-division of geological time will create a floating time scale that will ultimately become linked into an astronomical based real time scale for the entire Phanerozoic.

Elsa Dal Formation. This is a sandy alluvial braid-plain system that has in its upper part widely distributed black mudstone layers that represent standing water and hence the wettest climatic condition. It follows on from a prolonged interval of fluvial conditions and is succeeded by the increasing aridity of the Aina Dal Formation. These mudstones yielded GF Zone spores[1].

Aina Dal Formation. This marks a transition to meandering rivers with a significant proportion of more mud-dominated overbank deposits.

Wimans Bjerg Formation. This was deposited in alternating lacustrine and inland playa conditions, with a high water table giving rise to the dark sediment colour. Some 38 climate cycles can be recognised within the formation (i.e. two 405 ky e_2 eccentricity cycles) and represents a trend to more arid conditions.

Britta Dal Formation. This is a transition to a large, terminal alluvial fan accumulating extensive mud-rich flood plains. Intense vertisols formed on these plains. Occasional sheet sandstones formed in extensive, poorly-confined rivers created by episodes of high river discharge. The environment remained arid to semi-arid. It is the Britta Dal Fm that has the longest and most spectacular occurrence of climate cycles within the group. These are defined by alternations in the thickness of red and green vertisols that are bundled into groups of 20 precessional cycles to define six 405 ky e_2 eccentricity cycles. The transition to the overlying Stensiö Bjerg Formation is marked by a group of three bright red intensely arid cycles that are immediately succeeded by a grey shale that represents an interval of temporary flooding. The shale contains palynomorphs including *Retispora lepidophyta* and marks the base of the LL spore zone. These are the first palynomorphs after a barren interval of 700 m and 102 samples without palynomorphs.

Stensiö Bjerg Formation. This shows a marked change to overall less arid conditions. Intervals of organic-rich mudstone represent periods when stratified permanent lakes formed which contain abundant fossils of fish, plants and spores. The thickest of these mudstones is the overlying Obrutschew Bjerg Formation where 4-6 m of organic-rich sediments with limestones were deposited in two precession cycles. It represents a single, deep, permanent lake of considerable size and stability. This lake is coincident with the Devonian-Carboniferous (D-C) boundary and the Hangenberg Event. Nested with these lake cycles are thick intervals of nodular calcrete. Hence these cycles represent climatic extremes between aridity when the monsoon system was weakest contrasted with times of maximum lake development when it was strongest and bringing intense seasonal rainfall into the basin. There are some four such couplets in the Stensiö Bjerg Formation that define four more 405 ky eccentricity cycles. Above the D-C boundary the section changes in character to become much wetter with an established fluvial system.

Correlations: The Britta Dal Formation is a time of extreme and sustained aridity. Its upper boundary is constrained by the LL zone i.e. *R. lepidophyta*. In Belgium there is an interval of climatic aridity beneath the LL zone equivalent to the Evieux Formation [2,3]. This occupies a position between the Wocklum/Epinette and *annulata*/Bocq events. These are black shale events that are recognised widely within marine sediments. Therefore we can place the base of the Stensiö Bjerg Formation at the Wocklum Event coincident with a return to wetter conditions. The interval encompassing the Britta Dal, Wimans and Aina Dal Formations is the arid equivalent to the Evieux Formation with the wettest conditions in the uppermost Elsa Dal equivalent to the *annulata* event. The Stensiö Bjerg Formation has a duration of four long eccentricity cycles i.e. 1.6 my whilst the Britta Dal to Aina Dal interval occupies some eight climate cycles and 3.25 my. These climate cycles are tied to the D-C boundary and can be extended down through the Devonian to create a floating astronomical based time scale. A $De_2$1 etc nomenclature is suggested with sub-stage definitions for the upper part of the Famennian at the *annulata* and Wocklum Events.

Late Famennian climate history: In the southern hemisphere we have an incomplete and poorly dated record of glacial sediments. There is normally a single thick diamictites (e.g. the Tupambi Formation of Bolivia) that is very latest Devonian in age and represent the deposits of a glacial collapse. It is succeeded by Carboniferous sediments[4] and represents a major episode of deglaciation that is coincident with the lower latitude insolation high of the Obrutchew lake. In Bolivia there is normally a long erosive gap beneath this diamictite. In Brazil this interval is represented by a condensed sequence[5]. We can now interpret the Stensiö Bjerg Formation as a time when there were high amplitude short duration (precession) orbitally forced couplets between very arid states and very warm states. This would gives a series of perhaps four deglaciations that culminated in the end Devonian glacial collapse followed by sustained warmer conditions until the mid Tournaisian Lower Alum Shale. The calcrete level couples representing more arid conditions and a time of enhanced glaciation. The Britta Dal and Wimans Bjerg Formation are quite different and represent a long period of sustained aridity coincident with the stratigraphic gap/condensation at high palaeo-latitude. It is an interval of sustained (8 my) low latitude aridity and hence low insolation and a time when ice was building in the southern hemisphere but without any higher insolation events and hence no production of distinctive diamictites.

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THE TERRESTRIAL TAGHANIC EVENT AS A HIGH RESOLUTION ARCHIVE OF CLIMATE CHANGE AND ITS CORRELATION WITH THE TULLY FORMATION

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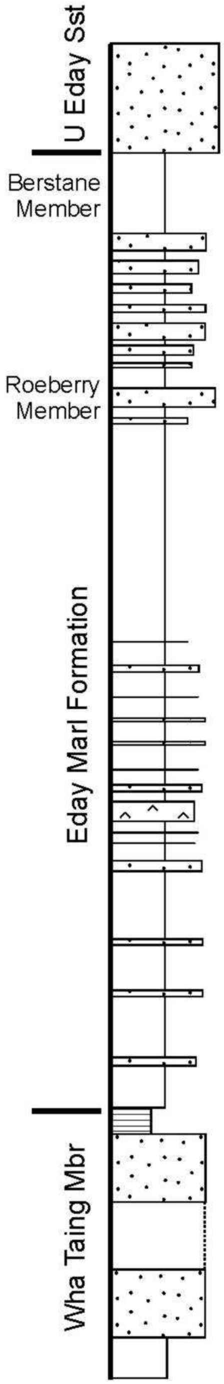
ORAL

The late Mid Devonian Eday Marl Formation from Scotland is a terrestrial equivalent of the marine Devonian Taghanic Event. The onshore Eday Marl (Orkney) contains a high resolution archive of climatic change that was controlled by the relative strength of the seasonal insolation. At times of high insolation the monsoonal system reached into the basin and resulted in significant precipitation. Conversely at times of low insolation the monsoon became inactive at the palaeolatitude of Orkney and a cool arid climate system dominated. This gives the counter intuitive association of continental aridity with lower average temperatures. There were several distinct and discrete episodes of basin flooding within the Eday Marl as demonstrated by the deposition of lacustrine laminites, bedded evaporites, marginal sheet flood sands and marine influenced bioturbated sheet sands. These flooding events are intercalated with the intense and sustained episodes of aridity.

Analysis of cycles within the Eday Marl demonstrates their climatic origin and shows that the main event has a duration of some four 100 ky e_1 eccentricity cycles, i.e. one long 405 ky e_2 cycle. Interpretation of the palynological assemblages combined with the sequence of marine transgressions and aridity events enable a detailed correlation to be made with the Tully Formation of New York State. The recognition of the significance of aridity provides a new explanation for the deposition of Tully shallow water carbonates with emergence in what was otherwise a clastic depositional system. Comparison of the Eday Marl events with the pelagic marine record shows that the latter can, as yet, only give limited resolution within the Taghanic Event.

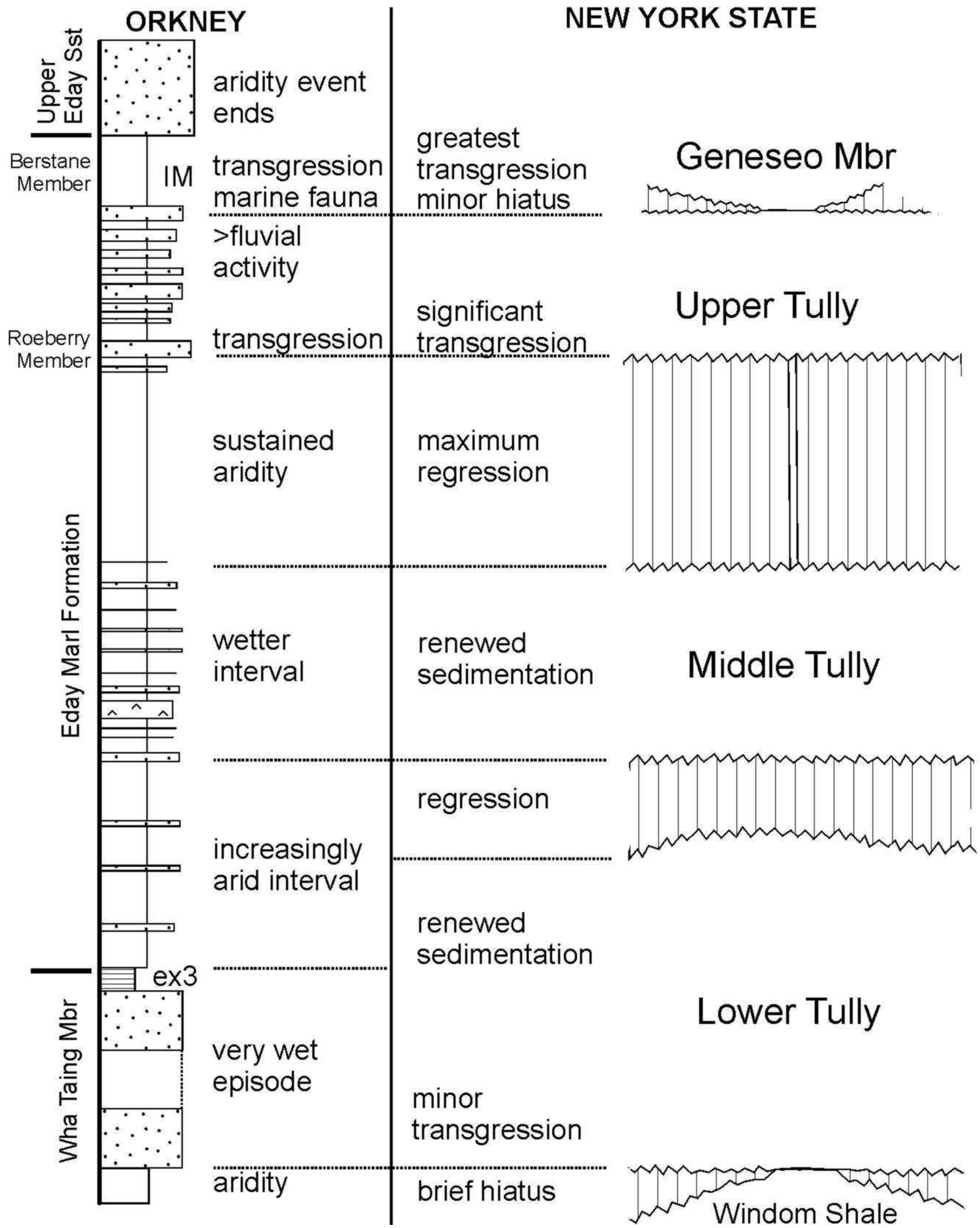
Recognising the Taghanic as an alternation of cool arid and hot pluvial events with the associated collapse in the terrestrial vegetation parallels faunal changes in the marine realm and provides an underlying mechanism to explain both groups of extinctions. It would appear that the orbital forcing which drives the system is characterized by an increased amplitude for both the insolation highs and lows, hence the extremes of aridity and basin flooding which are closely spaced in time and thus cause the maximum environmental perturbation.

CLIMATIC EVENTS RECOGNISED IN THE EDAY MARL OF ORKNEY



Environment	Hydrological Trend	Climate
sandy fluvial system rare overbank	P/E reduced but persistent monsoon, fluvial systems re-established	'seasonal' monsoon re-established proximal fluvial systems permanent
halite pseudomorphs & marine microfossils	>>P/E, basin floods, mixes with sea-water, direct marine influence	intense monsoon, standing water evaporitic
sheet floods common aeolian dunes proximally	active fluvial systems	monsoon active
extensive sheet sand & trace fossils	>>P/E system floods marine margin overtopped	first transgression, strong monsoon
monotonous marl sheet floods rare calcite content high	P/E very low fluvial activity very limited	most arid insolation minimum monsoon does not reach Orcadian Basin
sheet floods more common in proximal locations Rare evaporitic pools in a few distal locations	P/E increased restricted fluvial input seasonal standing water in brine pools	wetter, persistent insolation peaks monsoon active, brief fluvial events
occasional sheet floods into marl	<P/E, arid occasional sheetfloods minor monsoon influence rare standing water	arid, minor insolation peaks minor monsoon influence
stratified lake with AOM	>>P/E, short lived perennial lake	very wet
fluvial sandstone with reworked lacustrine top	> P/E active fluvial system that floods to a shallow lake	wet
marl in the South Isles		arid

AN EDAY MARL TO TULLY CORRELATION



EMSIAN CONODONTS FROM LA GUARDIA D'ARES (SPANISH CENTRAL PYRENEES, LOWER DEVONIAN)

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Over one hundred samples from three sections in La Guardia d'Arés area (Spanish Central Pyrenees) have yielded important conodonts spanning from the upper Pragian to the lower Eifelian. These sections (LGA, LGA-X and LGA-XI) exhibit rocks from the top of the Castanesa Fm. to the top of the Villech Fm.

The lowest conodont record comes from the Castanesa Fm. near the base of the section LGA-X; there, bed 4 has yielded Polygnathus pireneae in association with Icriodus celtibericus; this level is close to the Pragian-Emsian boundary. Bed 16 has yielded Po. excavatus, Ic. celtibericus and Icriodus of the bilatericrescens group, which clearly indicates a lower Emsian age. The lack of Po. kitabicus doesn't allow the establishment of the Pragian-Emsian boundary according to GSSP (Yolkin et al., 1994), but it could probably be located even below bed 4 (see Carls & Valenzuela-Ríos, 2007).

The base of LGA-XI correlates with the upper part of LGA-X, thus it has to be Emsian in age, but the rich conodont record from this section doesn't provide fine zonation details. Section LGA follows above LGA-XI, but they are separated by a tectonic contact. The bed 10 corresponding to the Castells beds (Villech Fm.) has yielded a rich fauna of the Po. mashkovae-catharinae group (they range up to bed 24c) indicating the gronbergi zone according to Bultynck (1989). Bed 15 contains Po. nothoperbonus which is the index of the the nothoperbonus zone (upper lower Emsian). Bed 26 registers the joint entry of Po. inversus and Po. laticostatus; this datum is important for the ongoing discussions regarding the Emsian subdivision into two substages.

Next important record comes from the upper part of the Villech Fm. Beds 170 to 180 contain numerous specimens of the Po. costatus group, which are relevant for the Emsian/Eifelian boundary. Besides them, Po. quadratus occurs in bed 171 and Po. linguiformis is registered from bed 172 and up.

This preliminary study shows the relevance of this area for further discussions on the Emsian subdivisions, and increases the number of relevant Pyrenean sections for a better understanding of the Emsian boundaries.

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FAMENNIAN EVENT STRATIGRAPHY (WESTERN POMERANIA, NW POLAND) – IMPLICATIONS FOR A PROPOSED SUB-STAGES DIVISION

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ORAL

During the Devonian times the Western Pomerania area (NW Poland) was a fragment of an elongated epicontinental marginal basin which surrounded the south-eastern side of the Old Red Sandstone Continent (ORSC). The Middle and Late Devonian evolution of the Pomeranian basin and its facies sequences, while being mainly controlled by the ORSC have also been influenced by local factors.

Facies analysis of the Famennian sequence was focused on finding a common pattern in the scale of the Pomeranian basin. The turn points in the development of the Pomeranian basin were then compared with the eustatic curve [1], as well as with commonly recognized Famennian bioevents [2 - see review]. The course of events is presented here according to the terms of the standard conodont zonation.

There is no marked facies turnover at the end of the Frasnian when the whole area was covered by open shelf sediments. However, the critical interval near the *linguiformis/triangularis* boundary displays several features that may be related to the Frasnian/Famennian Late Kellwasser Event, during which mass extinction in many fossil groups took place.

The regressive trend observed at the end of the *linguiformis* Chron was reversed during the Middle *triangularis* Chron. The whole area was then covered by offshore black shales. This transgressive event was synchronous with the beginning of the T-R cycle IIe.

Despite the lack of distinct facies turnover by the end of the *triangularis* Chron, a clear change of the conodont biofacies is observed between the *triangularis* and *crepida* Chrons, from relatively shallow-water icriodid-polygnathid to deep-water palmatolepid-polygnathid assemblages. This bioevent was synchronous with the Nehden Event.

The next event took place probably during the Middle *crepida* Chron and was influenced by tectonically controlled rapid subsidence of the basin floor and beginning of cyclic limestone-shale sedimentation. This event, although partly dependent on local tectonics, is contemporaneous with one of the transgressive pulses of the T-R cycle IIe.

Prominent regressive trends took place over a prolonged period of time, from the end of the *crepida* Chron till the Middle *expansa* Chron. This extended regression during the T-R cycle IIe was reversed, however, by a deepening event within the Early *marginifera* Chron. The short-term transgressive pulse resulted in the formation of mud-mound type carbonate buildups on tectonically controlled submarine highs. Tabulate corals and ramose stromatoporoids have been found within these buildups, supplying additional evidence on the survival of some stromatoporoids and coral builders in the Late Famennian, *i.e.* distinctly after the Frasnian reef extinction event. This event is synchronous with one of the transgressive pulses of the T-R cycle IIe and is contemporaneous with the Enkeberg Event.

A strong regressive event, reflected by the overall distribution of marginal-marine environments, abruptly affected the Pomeranian basin by the end of the Middle or at the beginning of the Latest *marginifera* Chron. The conodont biofacies changed from relatively deeper polygnathid-palmatolepid biofacies during the Early and Late *marginifera* Chrons to the very shallow-water polygnathid biofacies in the Latest *marginifera* Chron. This bioevent is marked also by the immigration of plurilocular foraminifers of the

Df3β Zone, with the index form *Quasiendothyra communis*. The event was also related with the definitive retreat of the offshore genus *Palmatolepis* from the Pomeranian shelf at the end of the *marginifera* Chron.

It is not certain whether a hiatus exists between the Latest *marginifera* Chron and the Early *expansa* Chron or whether the deposition was more or less continuous, taking into account a low net sedimentation possibly taking place during the *trachytera* and *postera* zones. It should be noted that this event is contemporaneous with a regression that ended the T-R cycle IIe.

In the beginning of the Early *expansa* Chron, the study area was covered by marginal- and shallow-marine environments. This ?transgressive event is synchronous with the beginning of the T-R cycle IIf.

Very shallow-water environments, which existed from the Early up to the Middle *expansa* Chrons, were drowned in the Late *expansa* Chron. Offshore marly fossiliferous limestones and shales, contemporaneous with the Etroeungt facies in France and Belgium, covered the entire area. The foraminifers *Quasiendothyra kobeitusana*, miospores *Retispora lepidophyta*, trilobites *Phacops accipitrinus* and stromatoporoids are observed here. The change of the conodont biofacies is not very distinct between the Middle and Late *expansa* Chrons. The bispathodid-polygnathid biofacies still prevailed in the Late *expansa* Chron, although the biofacies was composed mainly of ubiquitous forms in comparison to the Middle *expansa* Chron biofacies, where many shallow-water polygnathids occurred. This event is synchronous with the transgressive pulse within the T-R cycle IIf.

Despite no marked facies turnover within the Middle *praesulcata* Chron, regressive siltstones with plant detritus are observed in all sections, synchronous with a eustatic sea-level fall that terminated the T-R cycle IIf, which ended the Devonian Period. The early Middle *praesulcata* regression was probably followed by a stillstand or minor onlaps through the Middle *praesulcata* (Famennian) up to the *sandbergi* Chron (Tournaisian). Again, no distinct facies turnover is observed during this time interval, although a stratigraphic gap and development of condensed sequences is noted. The event partly corresponds to the Hangenberg Event, which is probably responsible for the decline and extinction of many faunal groups at the end of the Devonian and often compared with the Kellwasser Event at the end of the Frasnian.

The Subcommision of Devonian Stratigraphy has previously recommended to place the four Famennian sub-stage boundary levels “close to or at major Famennian eustatic events”.

According to the presented analysis, the Middle Famennian boundary could be placed at the base of the Lower *marginifera* Zone, the Upper Famennian boundary would be closest to the base of the Uppermost *marginifera* Zone (or possibly at the base of the Lower *expansa* Zone), and the base of the Uppermost Famennian could correspond to the base of the Upper *expansa* Zone.

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AFTERMATH OF THE LATE FRASNIAN MASS EXTINCTION ON BRACHIOPODS AND CORALS IN THE NAMUR-DINANT BASIN (SOUTHERN BELGIUM)

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ORAL

Due to their diversity and their abundance in the Frasnian communities, brachiopods and corals are prime tools for highlighting the extinction events related to the late Frasnian mass extinction whose causes are still disputed [1]. Both phyla have been studied in detail within the Namur-Dinant Basin (Namur and Dinant synclinoria, Vesdre area) which corresponds to the historical type area of the Frasnian and Famennian stages. The latter was located on the south-eastern margin of Laurussia during Devonian time. In the course of the Frasnian, the facies succession reflected a ramp setting with a mixed siliciclastic-carbonate sedimentation and several breaks of slope as well as the development of carbonate mound levels in its distal part (southern flank of the Dinant Synclinorium) [2] whereas the lower Famennian is represented by argillaceous sediments deposited mainly offshore on a shallow platform [3].

In the Namur-Dinant Basin, Frasnian brachiopod decline occurred in three steps within the interval spanning the Lower *rhenana* Zone to the *linguiformis* Zone. Most brachiopod orders suffered severely and the major losses occurred at the top of the Upper *rhenana* Zone. These extinction episodes were linked principally to diachronous regional facies changes related to transgressions. Atrypids and pentamerids became extinct within the Upper *rhenana* Zone in the shallow parts of the basin (south-eastern and northern flanks of the Dinant Synclinorium, Philippeville Anticlinorium and Vesdre area) whereas they had already disappeared at the top of the Lower *rhenana* Zone in its distal part (southern border of the Dinant Synclinorium) [4], just before the deposition of the dark shales of the Matagne Formation indicative of hypoxic bottom conditions. However, these orders vanished in the *linguiformis* Zone in other areas of the world [5, 6]. In the Philippeville Anticlinorium, the *linguiformis* Zone yielded only productids (Chonetidina), rhynchonellids and lingulids. At present, only one surviving athyridid species (Lazarus taxon) is definitely recognized in the lower Famennian. Nevertheless, some productids, craniids and lingulids may have crossed the Frasnian/Famennian boundary but this still needs confirmation. Post-extinction brachiopod recovery was rapid in the basal Famennian but, despite their great abundance, their diversity was quite low. New cosmopolitan genera appeared at this time especially among the spiriferids, athyridids and rhynchonellids concomitantly with new species of pre-existing orthid and orthotetid genera.

The initial decline of the rugose corals within the Namur-Dinant Basin is recognized in the Lower *rhenana* Zone and corresponds to the extinction of the colonial disphyllids and to their replacement mainly by members of the family Phillipsastreidae [7]. This is probably related to a cooling of the sea water [8] and occurred prior to the Lower Kellwasser Event, which had no direct influence on the stratigraphic distribution of the corals and brachiopods. Just after this first crisis, the rugose corals were still abundant but their generic and specific diversity remained low. They disappeared, along with the tabulates, in the Upper *rhenana* Zone. In the investigated area, rugose corals were absent from the *linguiformis* Zone to the Middle (?)/Upper *crepida* zones in which rare small solitary forms re-appeared. It is only close to the base of the Strunian Substage that their recovery actually started [7]. Auloporids (Tabulata) have been observed in the Middle *triangularis* Zone.

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PELAGIC BIVALVES OF THE LATE DEVONIAN

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ORAL

The low diverse but characteristic deeper water benthos association of the Late Devonian pelagic realm is rich in peculiar bivalves. They are common in condensed limestones of outer shelf ramps and seamounts, in nodular limestones of the basin margins, and in basin deposits such as fine siliciclastics. Despite their abundance and their global distribution, these bivalve taxa have not been in the focus of the paleontological research for more than a century. Therefore, the current knowledge mostly dates back to their first description (e.g., Münster 1840; Barrande, 1881; Clarke ,1904). But apart from the introduction of names, no details of the internal morphology or species concepts have been presented yet.

This study presents the first detailed revision based on old museum collections and new material from Germany, France, Morocco, and North America. Other records are from Russia, Poland, and Australia.

The taxonomic revision showed that commonly used taxa such as e.g. Praecardium do not withstand scrutiny, because the included species actually belong to a new genus consisting of small radially ribbed bivalves. This genus first appeared in the upper Kellwasser beds of the latest Frasnian and its extinction coincided with the regressive phase of the Condroz Event. It is most common in the early Famennian of the western Prototethys and of the Appalachians Upper Devonian II-B/E of the ammonoid zonation.

A second group of examined bivalve taxa are the lunulacardiids. These, amongst others, are an indicator that the previously assumed continuation of pelagic bivalve taxa from the Late Silurian of Bohemia into the Late Devonian has to be carefully reconsidered. Lunulacardium is a widely used taxon in the Late Silurian and Late Devonian pelagic facies, but the re-study of this genus as well as the family clarifies its the actual definition and clearly excludes the Silurian species.

Another characteristic bivalve group of the Late Devonian pelagic facies are the loxopteriids, which occur frequently in the cephalopod limestones of the pelagic facies. They occurred in the Frasnian and disappeared within Upper Devonian IV, at the end of the hypoxic global annulata Event. These bivalves belong to one of the most peculiar Late Devonian taxa. Their bauplan is characterised by strong inequivalve shells. Due to this morphological feature, the correlation of right and left valves remains almost impossible without the knowledge of articulated specimens. In the past, this caused nomenclatural confusion as left and right valves have been often regarded as separate taxa. Fortunately, several well-preserved specimens offer the rare opportunity to study, besides many details of external and internal morphology, the actual soft tissue attachment areas of this group. This allows a reconstruction of the loxopteriid morphology as well as their possible life habits, which is based on their soft body organisation.

The ongoing research on pelagic bivalve groups provides new data on their morphology, systematics, phylogeny, paleoecology and biostratigraphy. As in associated faunal groups, it suggests a significant control of global events on their distribution in space and time. Furthermore, it can be concluded that some of the studied bivalve taxa show the potential for providing a basis of a future bivalve biozonation.

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FIRST OCCURRENCES OF RADIOLARIANS AND CONODONTS IN FRASNIAN SILICICLASTIC SEQUENCES OF THE RUDNY ALTAI (SOUTH OF WEST SIBERIA, RUSSIA)

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POSTER

In Late Devonian the Rudny Altai (part of South of West Siberia) was developed in the ocean marginal sea environments on the periphery of the Siberian Craton [1]. Thick volcanic-sedimentary rocks deposited here during Givetian-Frasnian as well as intrusions are associated with the volcanics. Epochs of the intensive volcanic activity alternated with epochs of extinction and further deposition of the fine-terrigenous sediments and reef accumulations on the slopes of the volcanoes and oceanic highs.

Lower and Middle Frasnian strata of the south-western part of the Rudny Altai, near Gornyak Settlement, are represented by two sedimentary types: mainly reef carbonates and deep-water terrigenous-siliciclastics. The former are characterized by limestones and clayey-carbonate rocks with mostly diverse benthic and pelagic (conodont and ammonoid) fauna [1, 2]. Limestones, yielded abundant conodont associations, belong to four their biofacies: polygnathid-belodellid, ancyrodellid-mesotaxid, polygnathid-palmatolepid, polygnathid-mesotaxid, defined Upper *falsiovalis, transitans, punctata*, *hassi* and *jamieae* zones [2]. More deep parts of the basin possess diverse radiolarians [3]. First data on conodonts from the same samples with radiolarians have been obtained recently. These samples are yet under investigation. However it should be noted that radiolarian association included *Trilonche davidi* (Hinde), *Tr. minax* (Hinde), *Tr. hindea* (Hinde), *Tr. echinata* (Hinde), *Tr. vetusta* Hinde, *Astroentactinia stellata* Nazarov, *Palaeoscenidium cladophorum* Deflandre is recovered together with Middle Frasnian conodonts *Palmatolepis hassi* Muller et Muller and *Polygnathus* sp.

In Late Frasnian the deep-water shales, siliceous mudstones, cherts, tuff sandstones, associated with acid volcanics are predominant. Well preserved diverse radiolarian associations obtained from siliceous sediments were already reported [3, 4]. It should be mentioned that in previous reports stratigraphic position of this radiolarian association, regarded as transitional uppermost Frasnian-Lower Famennian, was based on taxa that are ranged into Famennian-Lower Carboniferous in different regions [3]. It is necessary to note as well that ranges of many genera and species of Devonian radiolarians require more precise specification. One of important steps towards this direction were the first findings of conodonts in the same samples with radiolarians (section S-0011, [1]), that allow to specify the age of bearing strata. Conodonts *Palmatolepis* gr. *Pa. delicatula* Branson et Mehl (beds 10, 25), *Pa.* cf. *Pa. rotunda* Ziegler et Sandberg (beds 18, 27), *Palmatolepis* ssp. (beds 10, 18, 25, 27) и *Polygnathus* sp. (beds 10, 18, 25) recovered from the siliceous rocks characterize Upper *rhenana* - *linguiformis* zones of the Upper Frasnian. The radiolarian association revealed with conodonts includes various spherical form *Trilonche guangxiensis* (Li et Wang), *Tr. vetusta* Hinde, *Tr. echinata* (Hinde), *Tr. davidi* (Hinde), *Tr. minax* (Hinde), *Tr. tanheensis* Luo, Aitchison et Wang, *Astroentactinia stellata* Nazarov, *A. vishnevskayae* Afanasieva, *Moscovistella allbororum* Afanasieva, *Borisella* cf. *maximovae* Afanasieva, *Entactinia* sp. A as well as other forms *Haplentactinia rhinophyusa* Foreman, *Palaeoscenidium cladophorum* Deflandre, *Pal. delicatum* Aitchison, *Pal. tabernaculum* Aitchison, *Ceratoikiscum avimexpectans* Deflandre, *Cer. mirum* Cheng, *Cer. labyrintheum* Cheng, *Cer. delicatum* Cheng, *Circuliforma robusta* Cheng, *Nazarovites bioculus* Afanasieva, *N. pinnula* Afanasieva, *Polyentactinina circumretia* Nazarov et Ormiston, *P.* cf. *kossistekensis* Nazarov. The characteristic species for the Upper Frasnian association *Ceratoikiscum avimexpectans* Deflandre, *Cer. delicatum* Cheng, *Moscovistella allbororum* Afanasieva, *Nazarovites bioculus* Afanasieva, *Trilonche guangxiensis* (Li et Wang), *Tr. tanheensis* Luo, Aitchison et Wang, *Entactinia* sp. A., *Borisella* cf. *maximovae* Afanasieva, and recovered recently *Polyentactinina* *circumretia* Nazarov et Ormiston and *Cancellientactinia acifera* Obut et Shcherbanenko sp. nov. [4] were not found still in the Lower-Middle Frasnian strata of the Rudny Altai. Presence of the species *Polyentactinina circumretia* Nazarov et Ormiston together with conodonts specify Late Frasnian age of the bearing strata. This species was proposed earlier as index-species for the Upper Frasnian zone *Bientactinosphaera engindyensis-Polyentactinina circumretia*, established in the Timan-Pechora Basin, Russian Platform and Canning Basin of Western Australia [5], as well as in Middle-Upper Frasnian of the North Mugozhary, Urals [6]. Species *Trilonche guangxiensis* (Li et Wang) was described from the Upper Frasnian Liukiang Formation, Guangxi Province, China [7] and Middle-Upper Frasnian of the Timan-Pechora Basin, Russian Platform [5]. Another species *Tr. tanheensis* Luo, Aitchison et Wang was reported from the Lower-Middle Devonian (Tanhe Formation) of the Guangxi Province, southwest China and from Middle-Upper Devonian of the New England Orogen, eastern Australia [5, 8].

Quantitatively among Upper Frasnian radiolarian genera, representatives of spherical *Trilonche* Hinde prevails, then follow *Astroentactinia* Nazarov, spiny *Palaeoscenidium* Deflandre and *Ceratoikiscum* Deflandre. Less abundant are representatives of *Entactinia* Foreman, *Moscovistella* Afanasieva and *Borisella* Afanasieva. Spherical radiolarians dominate in Frasnian at all. The characteristic feature of the Rudny Altai association is enriching taxonomic diversity of the spiny radiolarians up to upper part of Frasnian.

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PROTOSALVINIA IN THE EASTERN UNITED STATES

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ORAL

Protosalvinia Dawson, 1884, also widely known by the junior synonym *Foerstia* White, 1923, are the thallophytes of a Late Devonian marine alga (Phillips et al., 1972), although evidence suggests a possible terrestrial origin (Romankiw et al., 1988). The macroscopic organic remains are known from numerous localities in the eastern United States, largely from offshore marine mudrocks, in a relatively narrow stratigraphic interval, as well as North Dakota, Montana, Oklahoma, southern Ontario, and Brazil. Collections of *Protosalvinia*-bearing strata in New York, Pennsylvania, Ohio, Indiana, Kentucky, and Tennessee yielded conodonts that indicate the Upper *trachytera* Zone or Lower *expansa* Zone. In the Ellicott Shale of the northern Appalachian Basin *Protosalvinia* first occurs with conodonts that include *Polygnathus experplexus*, which would suggest the Lower *expansa* Zone, but also *Palmatolepis distorta*, which does not range above the Upper *trachytera* Zone. Also present is a new species of *Pelekysgnathus* and *Polygnathus semicostatus*. In the Chattanooga Shale of the southern Appalachian Basin *Protosalvinia* is found no lower than the Upper *marginifera* Zone or associated with conodonts of the Middle *expansa* Zone. In the Clegg Creek Member of the New Albany Shale, from cores in Indiana and outcrops in northern Kentucky, as well as the Ohio Shale in Kentucky, *Protosalvinia* is found below the Three Lick Bed associated with a diverse conodont fauna of the Upper *trachytera* Zone. The occurrence of *Palmatolepis rugosa rugosa* and *Polygnathus experplexus* associated with conodonts of the Upper *trachytera* Zone indicates a lower range extension for these taxa or reworking of taxa from the *marginifera* and *trachytera* zones into the Lower *expansa* Zone in these fine-grained offshore strata.

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BURBANK HILLS, UTAH, U.S.A., PROVIDE A PARADIGM FOR MIDDLE AND LATE DEVONIAN EVENT STRATIGRAPHY.

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ORAL

Introduction: Our study of the Burbank Hills Upper Devonian sequence began in 1968 and a co-worker presented a preliminary measured section[1]. We showed the relation of this sequence to a depositionally distinct, coeval sequence in the nearby Confusion Range and to the developing Pilot basin in the hinterland of the Antler orogeny through a successively improved, conodont-dated, time-rock block diagram[2,3,4]. Herein, we present an updated measured section (Figs. 1, 2) dated by the standard conodont zonation. Most known global[5] and Nevada[6] events, beginning with the late Givetian Middle *varcus* Zone Taghanic onlap, are well displayed by the Burbank Hills depositional sequence. Paleotectonic settings changed upward during the Frasnian and early Famennian from carbonate platform to stromatoporoid reef to basinal slope to backbulge basin. After a continent-wide 4–5 m.y. erosional episode, here involving the middle Famennian Late *marginifera* to Late *postera* Zones, a thin, complex unit, dated as Early *expansa* to *praesulcata* Zones, was deposited. This unit evidences transgressive onlap (dysaerobic black chert) followed by stillstand (oncolite-brachiopod bank) and regression (aerated bypass siltstone).

Major eustatic rises: Cardinal numbers (shown in the columnar sections) refer to numbered Nevada events[6]; Roman numerals refer to numbered Transgressive-Regressive cycles[7]. The Taghanic onlap (1, IIa) is documented by an open-marine crinoidal wackestone, containing brachiopods and rugose corals, overlying a 200-m-thick sequence of peritidal micrite and evaporite-solution breccias. At the base of the Guilmette Formation, the *disparilis* Zone rise (3, IIb) is displayed by a yellow siltstone that commonly contains *Spirorbis* worm tubes and columnar stromatolites. The punctata Zone rise (5, IIc) within a shallow carbonate-platform sequence is evidenced only by thicker limestone beds containing a more diverse fauna than the underlying beds. The *semichatovae* rise (8, IId) is displayed by a 23-m-thick sequence (probably the thickest known in North America) of nodular slope limestones containing the ammonoid *Manticoceras*. *Palmatolepis semichatovae* does not range above this interval. Within the lower Pilot Shale, the Early *marginifera* Zone rise (14), which coincides with expansion of the basin, is evidenced by coarser clastics and more limestone interbeds. The Early *expansa* Zone rise (18, IIf) rivals the Taghanic onlap as the major Devonian transgression in North America. This rise is part of an Upper Devonian black shale depositional complex that onlapped the margins of the North American craton[8]. In Utah and Nevada, this rise is evidenced in the Leatham Member of the Pilot Shale by a basal lag sandstone, containing abundant conodonts and ichthy- oliths and an overlying sequence of black chert and chertified shale, siltstone, and sandstone. It is displayed, as described, in the southern Burbank Hills, whereas in the Confusion Range, the black chert contains large micrite concretions. In the northern Burbank Hills, however, the beds that evidence this rise are truncated by a slightly younger unconformity below the basal Late *expansa* Zone quartzitic lag sandstone.

Alamo Breccia Impact Event (6): A couplet of anomalous, chaotically bedded channel deposits, containing hematite-studded and shocked-quartz sand grains, is interpreted to be derived from the Alamo Impact fallout, ensuing megatsunami runoff, and possible post-event torrential rain.

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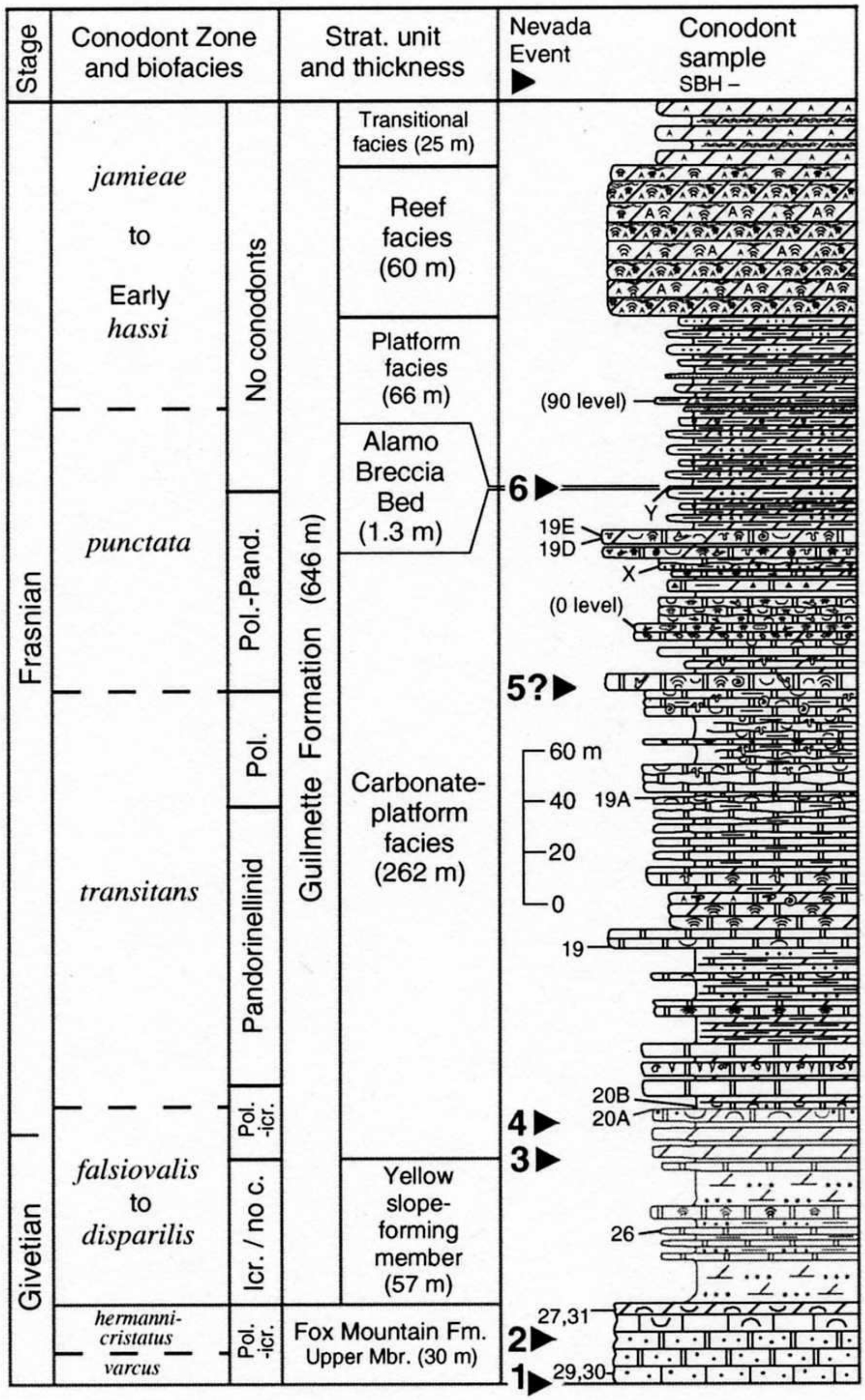
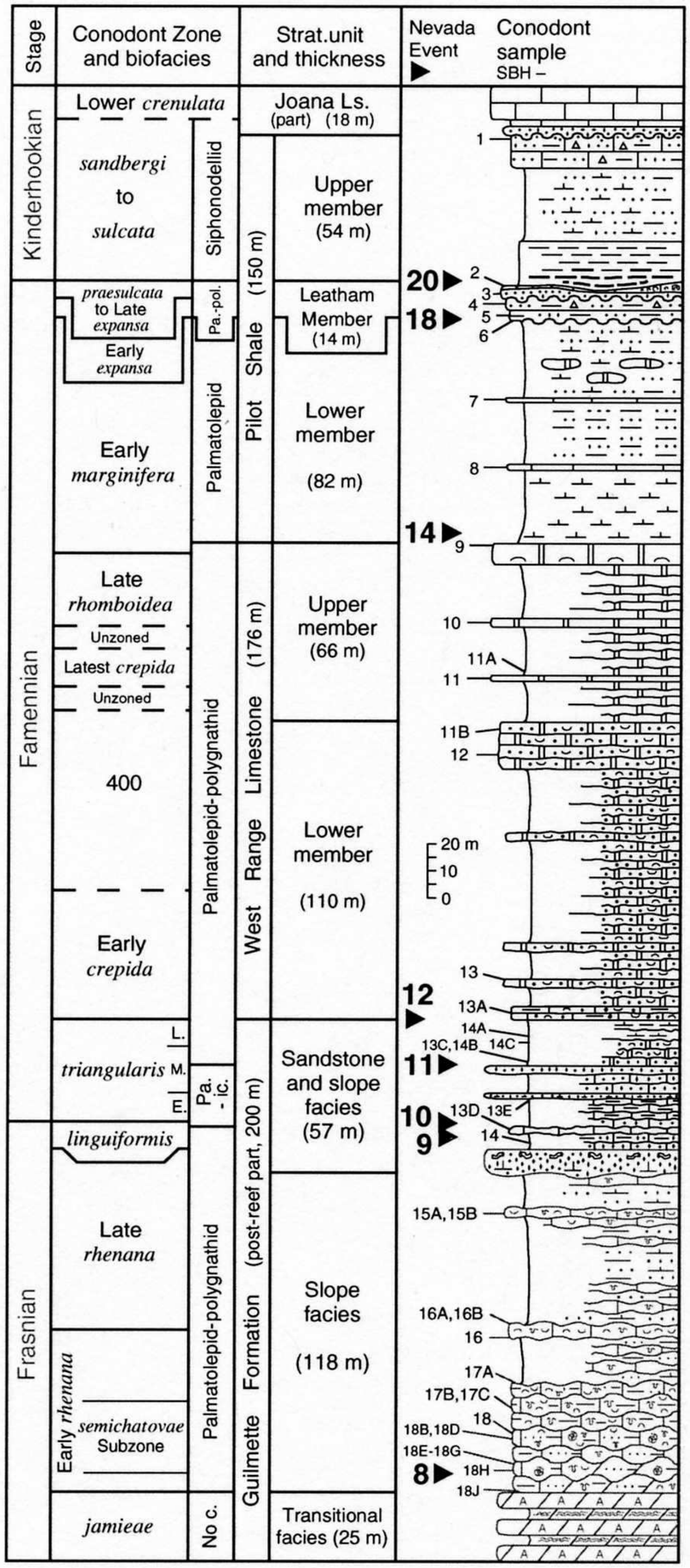


Figure 1 — Lower part of composite section measured at three locations near Big Jensen Pass, Burbank Hills, Utah. Note difference in scale and repetition of Transitional Facies unit. Numbered Nevada events[6] are indicated by solid triangles. Conodont biofacies: Pa., palmatolepid; Pand., pandorinellinid; Pol., polygnathid; Icr. or Ic., icriodid; no c., no conodonts.



Figures 2 — Upper part of composite section measured at three locations near Big Jensen Pass, Burbank Hills, Utah. Note difference in scale and repetition of Transitional Facies. Numbered Nevada events[6] are indicated by solid triangles. Conodont biofacies: Pa., palmatolepid; Pand., pandorinellinid; Pol., polygnathid; Icr. or Ic., icriodid; no c., no conodonts.

STRATIGRAPHY AND FACIES OF DEVONIAN SEQUENCES FROM THE NORTHERN MARGIN OF GONDWANA (CENTRAL TO EASTERN TAURIDES, TURKEY)

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ORAL

Introduction: Selected sections of Devonian rocks in Southern Turkey have been studied by an interdisciplinary working group of Turkish and German colleagues. Each of the sections is several hundred meters thick. Research is embedded in the bilateral DEVEC-TR project, associated to the IGCP Project 499 'Devonian Land-Sea Interaction: Evolution of Ecosystems and Climate' (DEVEC). The International Bureau of the German Ministry of Education and Research (BMBF) and the Scientific and Technological Research Council of Turkey (TÜBITAK) are gratefully acknowledged for support of this project.

Structural frame. The continuity of the Paleozoic units of Southern Turkey deposited at the northern margin of the Gondwana continent, has been destroyed by the opening of the Neotethys Ocean at the beginning of the Mesozoic. The southeastern part of the former Paleozoic terrane remained at the northern margin of the Arabian Plate to the south of the new ocean, while the Taurus and Menderes Blocks attained a position north of it. Closure of the Neotethys ocean by subduction and the subsequent collision led to an imbrication of the Taurid-Menderes Block and many slices were thrusted onto each other. This collision-related tectonism, caused the complex structure of the Taurides that were – in order to a better understanding of the regional geology – differentiated into tectonostratigraphic units. With regard to characteristics of the sequences and the lithostratigraphic units six tectonostratigraphic units were separated [1], [2].

Eastern Taurid sections. In the Eastern Taurides the Devonian sequences are embedded in a predominantly continuous sedimentary succession ranging from the Ordovician (with rocks of glaciomarine origin) to the Carboniferous. In the late Silurian the input of detritic material increased leading to eolian to littoral sandstones and occasionally shales and dolomites in the early Devonian. During the Middle Devonian, as the environment was deepening, platform carbonates and coral-stromatoporid reefs were formed successively. They are overlain by alternating shales and nodular limestones repeatedly including ferruginous beds in the higher parts of the studied sections.

Central Taurid sections. In the Central Taurides the Devonian developed from alternating shales and sandstones of Silurian age. The Devonian succession at a section close to the coast of the Mediterranean Sea is complicated by faults – investigation of faunas to elucidate the biostratigraphy, however, yielded first results. The section comprises various lithologies. Alternating limestones, siltstones, and silty shales are present in the lower part and show rhythmic sedimentation. They can be attributed to the Emsian. These strata are overlain mainly by dolomites, marls and silt- to sandstones. Physical and biogenic sedimentary structures indicate a deposition under shallow water to intertidal conditions. Above an up to 15 m high domical carbonate structure a thick succession of biolaminated limestones follows which is gradually shifting into dolostones often showing internal brecciation. In other parts of the section dark gray gastropod-rich limestones of the basal Devonian (*woschmidti-postwoschmidti* Zone) and a dolomitized reef core are exposed.

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SHELL MORPHOLOGIES OF JUVENILE BRACHIOPODS FROM THE UPPER HELDERBERG GROUP (NEW YORK, LOWER DEVONIAN)

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POSTER

In a small outcrop around Kingston, New York, brachiopod rich grainstones have been examined. A diverse brachiopod fauna was studied after dissolving the limestone matrix in high concentrated Hydrochloric Acid. The shells are highly silicified indicated by beekite rings. Besides brachiopods, bryozoans as well as solitary rugose and tabulate corals (*Pleurodictyum* sp.) were also found.

At the present state of research, 17 brachiopod taxa can be identified. Most of the fauna is represented by juvenile specimens; many of them are only 1 to 2 mm long. The material consists mainly of single shells; in rare cases, rhynchonellid and terebratulid brachiopods are preserved as articulated shells. Representatives of the genus *Nanothyris* Cloud, 1942, are only preserved as articulated shells, often less than 3 mm long. In one juvenile specimen, parts of the loop are visible through a whole in the shell.

Brachiopods of the order Spiriferida dominate the fauna; the dominant taxon being *Howellella cycloptera* (Hall, 1859). Furthermore, larger spiriferids determined as "*Acrospirifer*" *murchisoni* (Castelneau, 1843) are very abundant. Juvenile specimens of both genera are found in the material, some less than 2 mm wide. Due to the good preservation of the interior of the single shells, the ontogenetic stages of these two genera are well-documented. The development of their cardinalia show the growth of the dental plates as well as their embedding into secondary shell material in the apical region. Unfortunately, only a few dorsal shells are among the material so that the development of the internal dorsal shell morphology, e.g., the growth and development of the crural plates, is less well-documented.

Representatives of the genus *Gypidula* Hall, 1867, make up another large percentage of the fauna. However, mostly only the posterior part of the ventral valves is preserved which makes a determination to species level almost impossible. As in the above described spiriferids, many juvenile specimens of *Gypidula* are among the fauna. The increased thickness of the shell in apical region of the ventral valve as well as the growth and the development of the spondylium, the characteristic feature of the pentamerid brachiopods, is well-documented in the material.
It is remarkable that most of the large brachiopods, especially specimens of *Rhytistrophia beckii* (Hall, 1859) and *Leptaena* sp., are broken whereas the small juvenile specimens even when they consists of thin and fragile shells are mostly entirely preserved.
The brachiopods, especially the occurrence of *Rhipidomella* sp. and *Machaeraria formosa* (Hall, 1857), allow an assignment to the Kalkberg Formation of the upper Helderberg Group (Lower Devonian) of eastern North America.

The study is part of the PPP (Project Based Personnel Exchange Programme) project D/06/29290 of the DAAD (German Academic Exchange Service): "Comparison and correlation of Lower and Middle Devonian sedimentary rocks from the Rhenohercynian Belt (Central Europe) and the Appalachian Basin (Northeastern USA)" and part of the DFG project "Biohistoric evolution of spiriferid brachiopods: A model study of a globally distributed Devonian clade" (Grant JA 987/6-1).

This is a contribution to the IGCP 499 "Devonian land-sea interaction: evolution of ecosystems and climate – DEVEC".

THE LOWER DEVONIAN BRACHIOPOD GENUS ACROSPIRIFER HELMBRECHT AND WEDEKIND, 1923 – GLOBALLY DISTRIBUTED OR HIGHLY ENDEMIC?

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ORAL

In the present study, delthyridoid spiriferids from different faunal provinces are compared side-by-side in order to improve the phylogeny of this Lower Devonian clade. Most attention is paid to spiriferids from the three main regions in this time span: Europe/North Africa, South China, and eastern North America.

The genus *Acrospirifer* Helmbrecht and Wedekind, 1923 is a good example to demonstrate how imprecise studies of taxa lead to wrong conclusions for their systematic position and, as a result, to wrong palaeobiogeographical interpretations. Referring to literature, almost every Devonian spiriferid brachiopod with strong and coarse plications and a deeply impressed ventral muscle field was assigned to this genus since the 1930s. After Gourvennec (1989) had described a capillate (microcostellate) micro-ornament in *Acrospirifer*, Jansen (2001) recognized its fimbriate (microspinous) condition and revised the genus including its type species *A. primaevus* (Steininger, 1953) from the Rheinisches Schiefergebirge (Germany). Even so, *Acrospirifer* is still described as the type genus of a "capillate" family Acrospiriferidae Termier and Termier, 1949, in the recently published Treatise on Invertebrate Paleontology (Kaesler 2006). However, the other two genera of the subfamily Acrospiriferinae, *Mauispirifer* Allan, 1947, and *Xerospirifer* Havlícek, 1978, are truly capillate, whereas the truly capillate European/North African taxa formerly determined as *Acrospirifer* are united in the genus *Filispirifer* Jansen, 2001. At least most of the taxa except A. primaevus belong to other genera than *Acrospirifer,* and the type species may even be the only species of a highly endemic genus.
Several taxa of "*Acrospirifer*" are reported from South China, however, Schemm-Gregory (2006) and Jansen et al. (in press) have shown that delthyridoid spiriferids from South China belong to different evolutionary branches than delthyridoid spiriferids from Europe/North Africa. It is therefore very probable that taxa of the South Chinese "*Acrospirifer*" belong to at least one different genus.

Spiriferids similar to *Acrospirifer* are found in Siberia and Kazakhstan, a seperate faunal province in Lower Devonian time. The recently studied material of gen. nov. frequens (Bublitschenko, 1927), a medium-sized spiriferid with coarse plications, does not belong to *Acrospirifer* either due to its internal morphology. On the other hand, it shows a fimbriate micro-ornamentation although with wider micro-spines than in *Acrospirifer*. At the present state, its systematic position is not yet clarified.

Johnson (1995) established the North American genus *Patriaspirifer* with "*Acrospirifer*" *kobehana* (Merriam, 1840) as type species and included the eastern North American "*Acrospirifer*" *murchisoni* (Castelneau, 1843) in this genus. The comparison with the type material of *Acrospirifer* has shown that *Patriaspirifer* is a valid genus but its diagnosis is to be revised concerning especially the internal morphology. To date, the diagnosis of *Patriaspirifer* is still based on the different micro-ornamentation to *Acrospirifer* which is invalid as both genera are fimbriate. The affiliation of the species *A. murchisoni* to the genus *Patriaspirifer* has to be restudied. Recently collected material emphasises different internal features that may plead for the belonging to another genus. Another question is the systematic position of the eastern North American "*Acrospirifer*" *duodenarius* (Hall, 1843). It is probable that the North American taxa assigned to *Acrospirifer* in former times belongs to a completely separate branch.

The study is part of the DFG project "Biohistoric evolution of spiriferid brachiopods: A model study of a globally distributed Devonian clade" (Grant JA 987/6-1) and part of the PPP (Project Based Personnel Exchange Programme) project of the DAAD (German Academic Exchange Service): "Comparison and correlation of Lower and Middle Devonian sedimentary rocks from the Rhenohercynian Belt (Central Europe) and the Appalachian Basin (Northeastern USA)" (Grant D/06/29290).

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ON THE GENUS *RHENORENSSELAERIA* KEGEL, 1913 (BRACHIOPODA, LOWER DEVONIAN)

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POSTER

Taxa of the terebratulid brachiopod genus *Rhenorensselaeria* Kegel, 1913, are considered as important index fossils for the Rhenish Siegenian (middle Lower Devonian) in the classical German sense. According to the recent study, the genus *Rhenorensselaeria* is now regarded as consisting of two different phylogenetic branches. Palaeobiogeographical interpretations based on brachiopod data are a result of the new phylogeny (Schemm-Gregory in press).

In the Rheinisches Schiefergebirge (Germany), two evolutionary branches of *Rhenorensselaeria* appear. The first one is represented by the type species *Rhenorensselaeria strigiceps* (Roemer, 1844), the second branch appears in the Upper Siegenian with *Rhenorensselaeria demerathia* Simpson, 1940. *Rh. strigiceps* goes extinct at the end of the Upper Siegenian whereas *Rh. demerathia* is reported from the lower part of the Lower Emsian (upper Lower Devonian). *Rh. demerathia* is restricted to the Rheinisches Schiefergebirge whereas *Rh. strigicpes* occurs also in the Ardennes Mountains (Belgian) and the Celtiberian Chains (Spain). Later in Siegenian and also in Emsian times, *Rh. demerathia* from the Eifelian Region (Germany) and *Rhenorensselaeria macgerriglei* Boucot, 1967, from Gaspé (Canada) show close relationships.

During the revision of Rhenorensselaeria, a new species of this genus has been identified that shows closest similarities to the type species *Rh. strigiceps* of the Rheinisches Schiefergebirge and the Celtiberian Chains. It occurs in the Middle/Upper Siegenian Merzâ-Akhsaï Formation of the Dra Valley (Morocco) and the Grauwacke de Montguyon of the Amorican Massif (France). In this area it is the only representative of *Rhenorensselaeria* and goes extinct in the Upper Siegenian. During the lowermost Middle Siegenian or the uppermost Lower Siegenian the ancestor of *Rhenorensselaeria* n. sp. must have migrated through the Rheic ocean from the Rheinisches Schiefergebirge and the Celtiberian Chains into the Armorican Massif and the Dra Valley. The close phylogenetic relationship of these two taxa shows the strong palaeobiogeographical relationship between Central Europe and North Africa/France.

During the Early Siegenian rhenorensselaerid brachiopods must have also migrated through the Rheic ocean to Gaspé (Canada). They represent the second evolutionary branch of *Rhenorensselaeria* with *Rh. macgerriglei* in Gaspé and *Rh. demerathia* in the Rheinisches Schiefergebirge. The first appearance of both taxa is later than the first appearance of the first evolutionary branch of *Rhenorensselaeria*. Although *Rh. macgerriglei* and *Rh. demerathia* are not occurring in the same geographical region, they show a relationship or even faunal exchange between Gaspé and Central Europe during the Lower Devonian. The taxa of Gaspé and Central Europe are not as closely related as the taxa in North Africa and Europe. Nevertheless it suggests a migration corridor between Europe and North America during the Early Devonian. The non-occurrence of *Rhenorensselaeria* in Asia and South China is another implication for less faunal relationships between the eastern and western part of the Old World Realm (Schemm-Gregory 2006).

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FAUNAL TURNOVER BETWEEN TWO E.E. SUBUNITS: INVESTIGATING THE TIMING OF LARGE-SCALE FAUNAL TURNOVER IN THE LATEST EIFELIAN OF EASTERN NORTH AMERICA

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ORAL

The general timing of faunal turnover of ecological-evolutionary sub-units (EESUs) within the Middle Devonian Appalachian Basin is relatively well constrained. However the precise onset of major turnover events is still under investigation. The first appearance of distinct faunal elements of each of the EESUs is locally controlled by facies. Although, distinct faunal associations may transcend facies, barren or very sparsely fossiliferous facies provide no data.

A major faunal turnover in the Middle Devonian of eastern North America occurs between the Stony Hollow-Rogers City Fauna and the Hamilton-Traverse Fauna. This large-scale turnover has been shown to occur across most of ENA in both the Appalachian and Michigan basins, during the latest Eifelian. The first appearance of the Hamilton Fauna has long been identified as occurring in the Halihan Hill Bed of the Oatka Creek Formation, which lies above the East Berne Member (EBM) shale interval.

Recent attention has focused on investigating the precise timing of this turnover in the stratigraphically expanded interval of the EBM. Lying between the top of the Cherry Valley Mbr. and the Halihan Hill Bed in eastern New York State, the EBM is composed primarily of dark-gray to gray shale with thin siltstones and sandstones near the top, interpreted to represent the highstand and falling-stage systems tracts of the lowest 4th-order stratigraphic sequence of the Oatka Creek Formation. The fauna of this interval is very sparse, with a few beds dominated by non-diagnostic small, dysoxic-tolerant bivalves. Of specific interest in this interval is a thin (~30 cm) shell bed near the middle of the interval known as the Dave Elliot bed. This unique concentrated shell bed in the EBM provides critical insight into the interval between the Stony Hollow and Hamilton faunas in ENA. Preliminary investigations of this bed show that it displays a faunal gradient similar to that seen in the overlying Hamilton with biofacies ranging from deeper chonetid-dominated assemblages in gray siltstone to shallower spiriferid-coral bearing sandstones. Thus the biotic turnover is bracketed as occurring within the first small (5th order) cycle above the Cherry Valley Mbr.

THE INTER-REALM BARRIER IN NORTH AMERICA WAS SELECTIVELY BREACHED BY THE STROMATOPOROID *HABROSTROMA CENTROTUM* DURING THE LOCHKOVIAN AGE.

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ORAL

During most of the Early and Middle Devonian, tropical-to-subtropical marine organisms in what is now North America were separated into two faunal realms, the Old World and Eastern Americas Realms, by a land barrier that consisted of the Canadian Shield and the Transcontinental Arch. Lochkovian-age specimens of the stromatoporoid *Habrostroma* from the US Appalachians (Virginia [LaVale Member of the Keyser Formation], New York [Manlius and Coeymans Formations], Maine [Beck Pond Limestone]), and the Canadian Arctic (Bathurst Island [Lochkovian olistostromes in the Pragian-age Stuart Bay Formation], Ellesmere Island [Goose Fiord Formation]) were examined. The most common stromatoporoid genus in all five places is *Habrostroma*.

Cluster analysis of 129 specimens of *Habrostroma* from all the locations mentioned above indicates that there are three species of *Habrostroma* present, *H. centrotum* (Girty), *H. consimile* (Girty), and *H. microporum* (Girty). *Habrostroma microporum* is restricted to only New York, *H. consimile* is found in New York and Virginia, but *H. centrotum* occurs in all five areas (i.e., in both realms).

Realms are defined by mutually exclusive assemblages of genera, so it is surprising to see a species existing simultaneously in two realms. Our conclusion is that *H. centrotum* did not circumvent the transcontinental, inter-realm barrier; rather it selectively breached the barrier. The latter conclusion is strengthened by findings of kimberlite pipes in the Canadian Shield that contain Devonian-age normal-marine carbonate xenoliths. The latter deposits are found hundreds of kilometers from the nearest coeval deposits outside the barrier. In terms of paleobiogeography, the passage of *Habrostroma centrotum* across the barrier is an example of a highly selective filter.

A similar situation appears in the literature, where four species of stromatoporoids (*Stromatoporella peranulata* Galloway and St. Jean; *Stictostroma mamilliferum* Galloway and St. Jean; *Habrostroma proxilaminatum* Fagerstrom; *Parallelopora campbelli* Galloway and St. Jean) found in close proximity to the Emsian-Eifelian boundary, occur in both the Michigan Basin (Eastern Americas Realm) and on Ellesmere Island in the Canadian Arctic (Old World Realm).

T-R CYCLE IB: THE "LUMPING" OF EMSIAN SEA LEVEL HISTORY

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ORAL

"This cycle was long-lasting." So reads the beginning of Johnson et al.'s [1] description of T-R cycle Ib, which represents nearly the entire Emsian Stage. Now, with more knowledge, the real story appears to be "This stage was poorly documented." Studies in the eastern U.S. (Appalachian Basin) clearly show that Cycle Ib comprises 5 major T-R cycles (3rd order depositional sequences), which developed over the ca. 17 million years [2] of the Emsian Stage.

In trying to identify Emsian cycles, Johnson et al. [1] encountered the following problems that led to misinterpretation. In some areas (e.g., western U.S.), they analyzed shallow platform facies, where shallower parts of cycles to complete cycles are likely marked by significant unconformities following the supersequence-scale lowstand at the beginning of the T-R cycle model (below Cycle Ia). In other areas, where facies may better record sea level changes (e.g., Germany, eastern U.S.), details related to sea level history and biostratigraphy were poorly documented.

In the Appalachian Basin (eastern U.S.), five "3rd order" Emsian sequences are clearly delineated. These sequences can be correlated basinwide through intermediate to deeper water facies, in strata of the Esopus and Schoharie formations, lower to middle parts of the Needmore Formation, and the Huntersville Chert [3].

The lower three Emsian sequences occur as separate cycles in the Esopus Formation of New York and eastern Pennsylvania (Spawn Hollow, Quarry Hill, and Wiltwyck members; [4]) in the Beaverdam Member (Needmore Formation) as defined in central Pennsylvania, and in time-rock correlative Needmore strata in Maryland, Virginia, West Virginia; and in the lower part of the chert of the Huntersville Formation (southwest Virginia, southeast West Virginia). The upper two Emsian cycles occur in the Gumaer Island and Aquetuck-Saugerties members (Schoharie Formation) in New York and eastern Pennsylvania; in the calcareous shale member (Needmore Formation) as defined in central Pennsylvania, and in time-rock correlative Needmore strata in Maryland, Virginia, West Virginia; and in the upper cherts of the Huntersville Formation (southwest Virginia, southeast West Virginia). The Bobs Ridge Sandstone Member, at the top of the Huntersville Chert, is equivalent to the Edgecliff Member of the Onondaga Formation (and lies at the true base of T-R Cycle Ic).

These sequences comprise five separate subdivisions of Johnson et al.'s [1] T-R Cycle Ib, with an average duration of approximately 3.5 million years each (based on a 17.2 m.y. duration of the Emsian; [2]). Interestingly, Johnson et al.'s sea level curve (1985, Figure 12) did recognize four subdivision of Cycle Ib. And, at least in the eastern U.S., the uppermost Emsian sequence was wrongly included in Cycle Ic.

These five subdivisions of Cycle Ib should perhaps be identified as Cycles Ib1, Ib2, Ib3, Ib4 and Ib5. Renaming the entire T-R supercycle I succession (Ia-If), by recognizing the five Emsian cycles as Ib, Ic, Id, Ie, and If, etc., would result in a confusion of old versus new terms.

Emsian biostratigraphy in the eastern U.S. is still poorly documented, which inhibits detailed correlation of these cycles internationally. However, new Emsian biostratigraphic work (goniatites, dacryoconariids, ± conodonts, with W. Kirchgasser and R. Lindemann) in the southern part of the Appalachian Basin may help resolve T-R cycle correlations internationally.

The boundary between the third and fourth Appalachian sequences (Esopus-Schoharie formations contact) basinwide marks a more significant sea level change. This is comparable to patterns around the

Zlichov-Daleje contact in the Barrandian, and correlative strata elsewhere globally. Based on these tentative correlations, it appears that T-R Cycle Ib should be subdivided into three lower Emsian sequences (represented by 3 members of the Esopus Formation of New York) and two upper Emsian sequences (lower and upper Schoharie Fm. of New York).

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MAGNETIC SUSCEPTIBILITY AND INSIGHTS INTO DEVONIAN SEA LEVEL AND CLIMATE CHANGE, ALBERTA ROCKY MOUNTAINS, WESTERN CANADA

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ORAL

High-resolution magnetic susceptibility (MS) data from carbonate platform, slope and basin deposits, western Canadian Rocky Mountains (Alberta basin), provide a record of Middle-Late Devonian (upper Givetian-lower Famennian) sea level and inferred paleoclimatic change recently reported by Whalen and Day [1,2], and Whalen et al. [3]. MS data record five major (A-E) and fourteen minor (A1-E5) MS excursions in basinal and carbonate platform deposit that comprise nine 3rd order depositional sequences. Sequence development was controlled by marine flooding events that coincide with most of Johnson et al.'s [4,5] and Day et al.'s [6] Transgressive-Regressive cycles IIa-2 to IIe. MS values track a long-term second order sea level change of Devonian T-R cycle II of Johnson et al. [4] with higher frequency fluctuations associated with shorter-term (3rd-4th order) sea level events associated with Devonian T-R cycles IIa-2 to IIe (lower part).

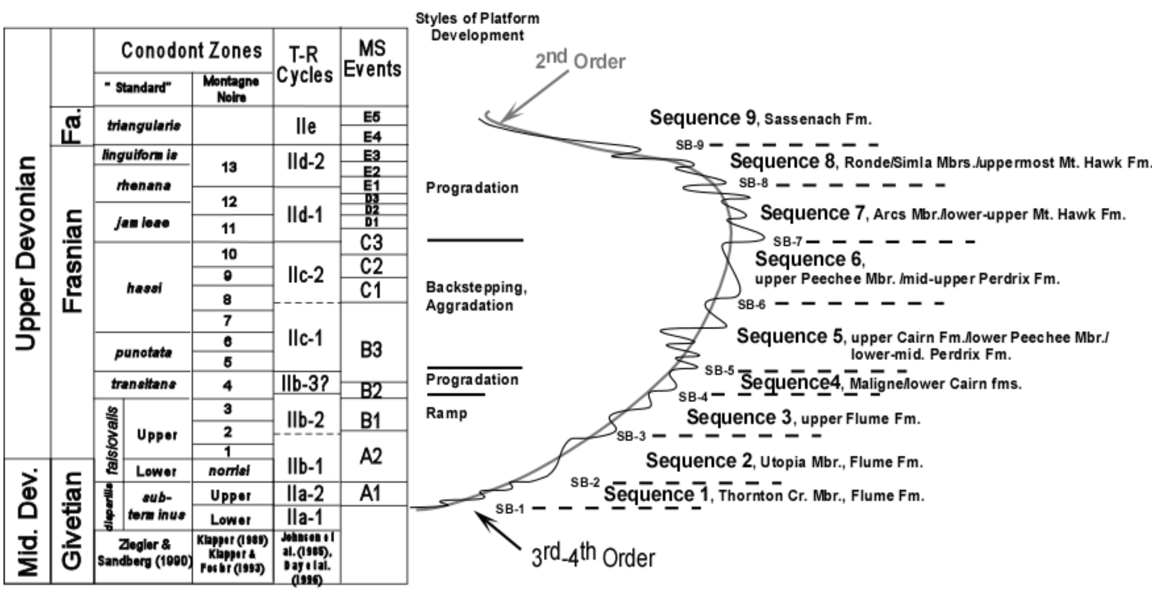

Figure 1.—Upper Devonian conodont biostratigraphy, T-R cycles, and MS events plotted against second and third/fourth order sea level variations, sequence stratigraphy, and lithostratigraphy for western Canada. Frasnian Montagne Noire zonation after Klapper [7] and "standard" zonation after Ziegler and Sandberg [8]. Devonian T-R Cycles after Johnson et al. [4,5]. North American Devonian cratonic T-R cycles IIa-2, IIb-1, IIb-2 after Day et al. [6], divisions of T-R cycle IId from Day [9], subdivision of T-R cycle IIb (IIb1-3) proposed by Day and Whalen [10] and Day [11]. Fm. = Formation, Mbr. = Member, Fa. = Famennian. After text-fig. 6 of Whalen and Day [2].

MS values are generally low through the interval of the late Givetian to middle Frasnian (Upper *subterminus* Fauna to Montagne Noire [MN] Zone 9) in platform and basinal deposits recording Alberta Devonian MS events A to C (Fig. 1, [2]), but shows a significant bimodal MS increase in the middle to late Frasnian basinal deposits of the upper Perdrix and lower Mount Hawk formations (MN zones 10 to 11, MS events D1 to D3) (fig. 1, [2]). MS values return to generally lower levels in prograding ramp (Arcs and Simla mbs., Southesk Fm.) and basinal Mount Hawk deposits with conodonts of late Frasnian

MN zones 12-13, and the early Famennian Sassenach Formation (Lower and Middle *triangularis* zones) recording MS s D3 to E (1-5), respectively (Fig. 1, [2]).

This general pattern of increasing followed by decreasing MS values is interpreted to indicate variations in delivery of magnetically susceptible terrigenous material and variations in carbonate dilution associated with platform progradation. The included terrigenous sediment is very fine-grained (≤ medium silt) and is interpreted to represent eolian influx. The highest MS values (MS event D, Fig. 1) directly correlate to the lithologic change associated with an influx of fine-grained siliciclastics in the basinal Mount Hawk Formation during Frasnian MN Zones 11-12. We interpret this rise in MS values during the interval of late Frasnian T-R cycle IId-1 to be related to progressive late Frasnian climatic warming evidenced by generally decreasing ∂O^{18} isotopic values, leading to higher rates of terrestrial weathering, followed by rapidly increasing ∂O^{18} prior to the relatively rapid Lower Kellwasser global cooling. Along with long-term trends that appear to be linked to climate change there are shorter-term MS events that also appear to mirror oxygen isotopic data excursions recorded by conodont apatites [12] and brachiopod calcites [13] and hence may also be climatically controlled. The late Frasnian is characterized by abrupt negative followed by positive oxygen isotopic excursions implying unstable climate and rapid sea surface temperature changes in the tropical ocean Breisig et al. [14]. MS events D3-E3 record similarly record rapid fluctuations in MS values during the same stratigraphic intervals and may indicate changes in sediment influx modulated by climate.

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MIDDLE-UPPER DEVONIAN (MIDDLE GIVETIAN-EARLY FAMENNIAN) RECORD OF RELATIVE SEA LEVEL AND CLIMATE CHANGE IN THE IOWA AND WESTERN ILLINOIS BASINS, WESTERN LAURUSSIA

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POSTER

The Cedar Valley Group epeiric carbonate platform deposits of the Iowa and western part of the Illinois basins (Fig. 1) accumulated during the interval of the middle Givetian (Middle *varcus* Zone) to middle Frasnian (Montagne Noire Zone 10?) and provide a record of four 3rd order and up to four additional 4th order relative sea level changes (Transgressive-Regressive (T-R) cycles) outlined in studies by Witzke et al. [1], Witzke and Bunker [2, 3, 4], Day [5, 6, 7], and Day et al. [8]. New work provides evidence that Late Frasnian middle shelf ramp platform deposits of the Lime Creek Formation comprise two late Frasnian T-R cycles (Fig. 1). T-R sequences recognized in the Cedar Valley Group and late Frasnian and early Famennian epeiric basin deposits can be correlated across much of North American continent, suggesting that large-scale eustatic changes in sea level were ultimately responsible for the development and cyclic expression of these stratigraphic intervals coinciding in part with Devonian T-R cycles IIa to IIe of Johnson et al. [9, 10], and subdivisions proposed by Day et al. [8], Day [11], Day and Whalen [12], Whalen et al.[13], Whalen and Day [14].

Subtropical epeiric sea surface water temperatures (SST) reconstructed from measured oxygen isotope ratios of conodont apatite from the Cedar Valley Group and Lime Creek Formation (Joachimski et al. [15], Breisig et al. [16]) indicate warm temperatures ranging from 25 to 29° C during the mid-late Givetian with a SST thermal maximum during the *hermanni* Zone coinciding with the sea level maxima of T-R cycle IIa. SST values decrease sharply during the remainder of the late Givetian, followed by resumed SST warming during the Frasnian, with SST values exceeding 30° C and with two significant SST cooling events coinciding with the Lower and Upper Kellwasser bioevents and stepped Kellwasser extinctions of late Frasnian platform shelly faunas in central and western North America Day and Whalen [17]. δ 13C data document two plus 2 per mil excursions associated with Cedar Valley Group marine transgressions in the upper Middle *varcus* Zone, and *hermanni* Zone in the interval of Devonian T-R cycle IIa-1 of Day et al. [8], with minus 2 per mil excursions recorded in deposits representing Devonian T-R cycles IIa-2 and IIb-1 in the intervals of the Upper *subterminus* Fauna (within Upper *disparilis* Zone), and the latest Givetian *norrisi* Zone (Fig. 1).

Significant sea level lowstand events led to Cedar Valley platform emergence and erosional incision and/or karst formation that provide minimal estimates of sea level fall of 35 m during the very late Givetian (very late part of *disparilis* Zone-lowest *norrisi* Zone?) and 90-125 m during the late part of the middle Frasnian (M.N. Zone 10?) that terminated Cedar Valley Group carbonate platform development. Late Frasnian or early Famennian platform emergence eroded platform deposits spanning the Frasnian-Famennian boundary interval in northern Iowa, although a paracomformable F-F boundary is recognized in the lower part of the Grassy Creek Shale at the type locality of the Sweetland Creek Shale (Klapper and Johnson [18]) in offshore positions of southeastern Iowa as documented by Over [19, 20].

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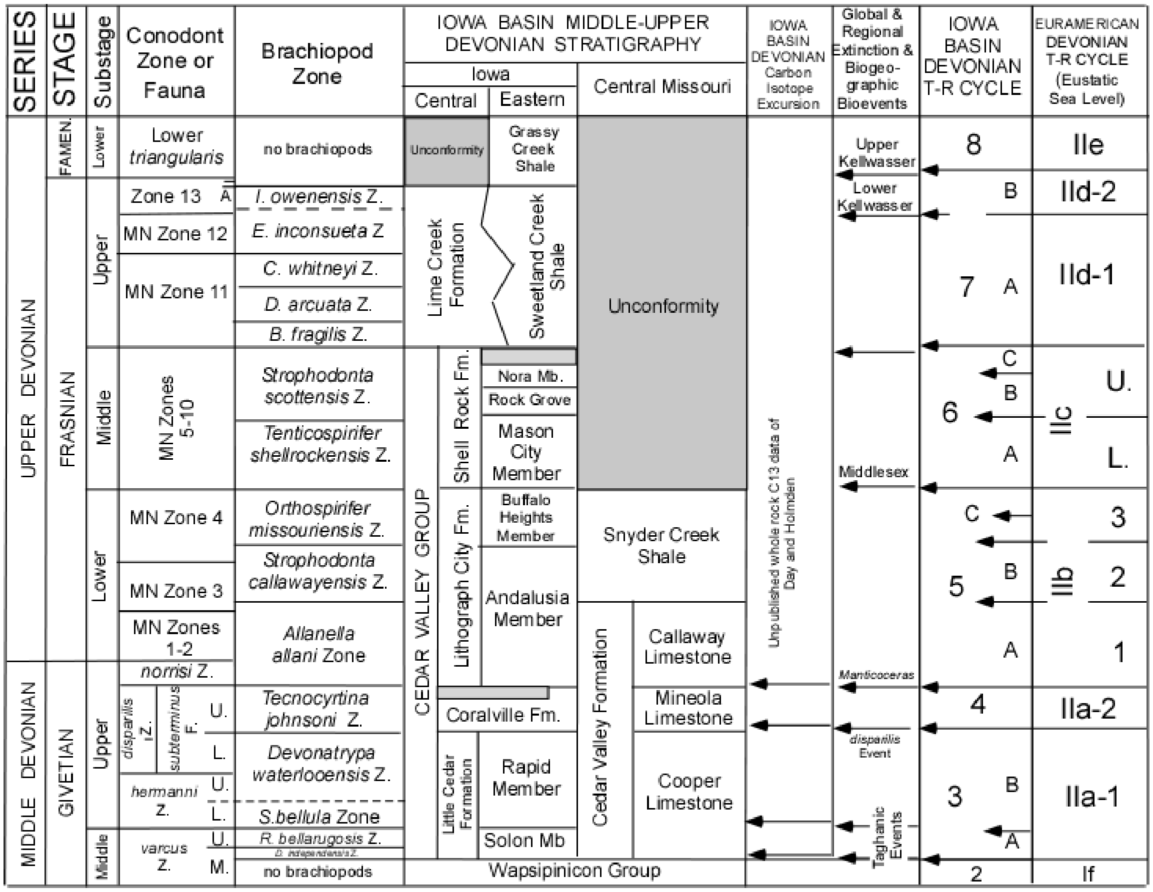

Figure 1.—Stratigraphic and biostratigraphic framework for the Middle-Late Devonian (middle Givetian to early Famennian) strata southeastern Iowa (Iowa and western Illinois basins) showing relationships between: the qualitative eustatic T-R cycles of Johnson *et al*. [9,10], Day et al. [8], Day [7, 11] and Iowa Basin Devonian T-R cycles of Witzke et al. [1], Bunker and Witzke Witzke and Bunker [2,3,4]. Devonian brachiopod biostratigraphy from Day [5, 21]. Iowa Basin Devonian stratigraphy after Witzke et al. [1], Witzke and Bunker [2,3,4], and Day [21]. Modified from Day text-fig. 4 of Day [11] and text-fig. 3 of Day [7].

LATE DEVONIAN DIAMICTITES AND CONTEMPORANEOUS QUARTZ-RICH SANDSTONES IN PENNSYLVANIA AND MARYLAND: RESPONSES TO IMPACT OR OTHER, SURFICIAL PROCESSES?

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POSTER

Unusual strata are the product of unusual sedimentary processes. Late Devonian/Early Mississippian strata in Pennsylvania (PA) and Maryland (MD) provide two examples of unusual strata: 1. widespread, discontinuous diamictite-bearing sequences in the Spechty Kopf Formation of east-central PA and the Rockwell Formation of south-central PA and western MD and 2. quartz-rich sandstones with water-release structures, capped by mounded structures (sand volcanoes?) within the Huntley Mountain Formation of north-central PA. To our knowledge, the diamictite and the particular type of quartz-rich sandstone are unique in the Appalachian sedimentary column. These sequences do not occur in long sections where zonal boundaries can be established with accuracy and the preservation of the spores ranges from excellent to poor, nonetheless they appear to occupy a part of the Retispora lepidophyta – Indotriradites explanatus (LE) palynozone in the upper part of Famennian Stage (Fa2d).

The LE palynozone is found in the Oswayo Formation of southwest New York (NY), but it is not found in the thick overlying Kushequa Shales from northwest Pennsylvania. The Cattaraugus Formation underlying the Oswayo in NY and their equivalents in northwest PA lack LE palynozone assemblages. Preliminary palynological data show that the whole of the Kushequa Shale Formation in northwest PA belongs to the R. lepidophyta - Verrucosisporites nitidus (LN) palynozone. The LN zone is also present just below the Murrysville Sandstone of southwest PA which, in turn, overlies strata with probable Retispora lepidophyta – Indotriradites explanatus (LE) palynozone assemblages. The Kushequa Shale assemblages from the LN palynozone, that is the post – diamictite Devonian, are typified by a high diversity spore-species assemblage and contain many of the taxa occurring in underlying strata in northwest PA, showing that whatever emplaced the diamictite apparently had little effect on the floras of the Catskill Basin and deposition of their spores in marginal marine environments

Any origin scenario proposed for these strata must account for, among other things, their unique character, wide distribution, apparent contemporaneity, and deposition on a coastal floodplain at a low paleolatitude. In addition, both the diamictites quartz-rich sandstones with water-release structures demonstrate rapid delivery to the deposites. Sedimentary processes working rapidly and contemporaneously over a large area for a short period of time are called for. Orogenic processes work relatively slowly, processes related to global cooling might be responsible for deposition at high elevations but not near sea-level at low paleolatitudes, storm-related processes and processes associated with sea-level change should yield similar sequences in the Late Devonian and other Appalachian clastic wedges but we do not see them. We are left to conclude that impact-related processes cannot be dismissed.

THE DEVONIAN OF TURKEY – AN ATTEMPT FOR COMPARISON OF LAURUSSIAN AND GONDWANAN CONTINENTAL MARGINS

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ORAL

Introduction: The Devonian of Turkey exhibits a unique opportunity to compare sequences of coastal to shallow marine and deeper shelf deposits on the continental margins of Laurussia and Gondwana. Sections in Northwestern Turkey (Istanbul and Zonguldak areas) and in Southern Turkey (Eastern and Central Taurides) have been studied in detail. Research is carried out by an interdisciplinary working group of Turkish and German colleagues assembled in the bilateral DEVEC-TR project, associated with the IGPC Project 499 ‘Devonian Land-Sea Interaction: Evolution of Ecosystems and Climate’ (DEVEC).

Structural frame. As part of the Alpine-Himalayan Orogenic belt Turkey is composed of several microplates that are separated by ophiolitic rocks formed during collisional events (Fig. 1). The continuity of the Southern Turkey Paleozoic units deposited at the northern margin of northeastern Gondwana ended due to the opening of the Neotethys Ocean at the beginning of the Mesozoic. The southeastern part of the former Paleozoic terrane remained at the northern margin of the Arabian Plate to the south of the new ocean, while the Taurus and Menderes Blocks attained a position north of it. Closure of the Neotethys Ocean by subduction and the subsequent collision led to an imbrication of the Taurid-Menderes Block and many slices were thrust onto each other. This collision-related tectonism caused the complex structure of the Taurides. In order to gain a better understanding of the regional geology, six tectonostratigraphic units can be differentiated with regard to characteristics of the sequences [1], [2].

The western part of the Pontide Zone in Northern Turkey is represented by the Istanbul-Zonguldak Unit bounded to the North by the Black Sea. In its lower parts the succession is represented by high-grade metamorphic rocks exposed in the Sünnice Massif and Almacık Mountains. The metamorphic association is collectively overlain by a thick sedimentary succession ranging from Early Ordovician to Carboniferous [3]. The Paleozoic sequence is overlain by Triassic continental to shallow marine siliciclastics and limestones. The Paleozoic rocks of the Istanbul-Zonguldak Unit are similar strata of the Laurussian margin and thus represent South-facing passive continental margin deposits [4].
Southern Turkey. In the Central and Eastern Taurides three Devonian sections have been studied (Fig.1). Both areas comprise very shallow to even terrestrial sedimentation in the lower part of the sections (i.e., in the Lower Devonian) with eolian to littoral sandstones, dolomites resembling sabkha-like features such as cellular dolomites, biolamininites, or a restricted shallow-water trace fossil assemblage is present. In both areas reef growth follows, however at different times (Lower Devonian in the Central Taurides, Middle to Upper Devonian in the Eastern Taurides). In the latter area the succession in the Upper Devonian to Lower Carboniferous yields a moderate deepening trend (sandstones, marly limestones, and shales).

Northern Turkey. In the area between Istanbul and Zonguldak Devonian outcrops have been studied in four sections (Istanbul and Çamdağ, Fig. 1). Measured sections around Istanbul allow discrimination of different lithological units. Whereas in the upper Silurian/lower Devonian reefal limestones with minor shale intercalations are prevailing, the succeeding Lower and Middle Devonian consists of alternating laminated limestones and shales, coarse nodular limestones, sandy limestones, and alternating shales and siltstones. The Upper Devonian is composed of cherty limestones, alternating cherts and silicified shales, and alternation of nodular limestones and shales. Altogether they indicate deeper water depositional conditions. In the Çamdağ section, i.e., the Eastern part of the region, the strata assigned to the upper Silurian is characterized by siltstones, shales, laminated and cross-bedded sandstones, and alternations of siltstones with partly fossiliferous limestones. The following Devonian succession is marked by shallow water deposits such as reddish siltstones and thick-bedded sandstones with occasionally ferruginous dolomitic limestones. Succeeding Middle to Upper Devonian strata are mainly composed of nodular limestones, shales (partly black shales), limestones and thick-bedded (calcareous) dolomites.

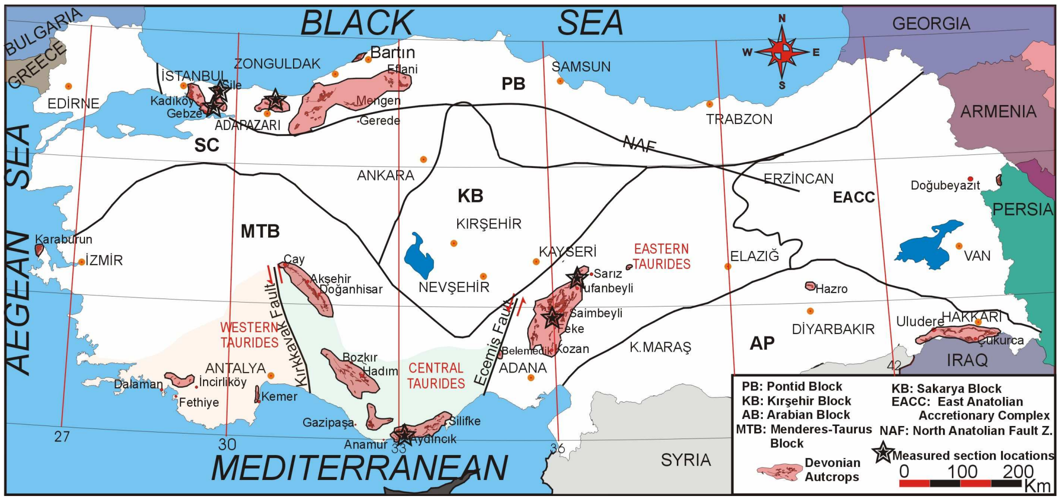

Figure 1. Distribution of Devonian outcrops and Tectonic units of Turkey (modified from [5]).

Conclusions: In both areas, the Devonian successions are mostly represented in shelf facies. In the Northwestern areas the sequences were deposited in high-energy to deeper shelf/ramp environments including deeper water cherts, shales, and nodular limestones. The development of calcareous ramp deposits is restricted to the Istanbul area. In the Southern Turkish areas besides siliciclastic shallow shelf deposits reef development as well as inter- to supratidal sabkha-related sediments (e.g., biolaminites, cellular dolomites) and even eolian sandstones are present. While such kinds of rocks are missing in Northwestern Turkey, rocks of deeper water facies, common in the NW, do not occur in the Southern areas.

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RE-EXAMINATION OF THE TYPE ITHACA FORMATION (FRASNIAN) USING A SEQUENCE STRATIGRAPHIC APPROACH: POSSIBLE CORRELATIONS WITH SECTIONS IN WESTERN NEW YORK AND IMPLICATIONS FOR FAUNAL CONTROL

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POSTER

Stratigraphic correlation of the early Frasnian (Genesee Group) in New York has been ongoing for over 150 years [1], [2]. While recent work has recognized key temporal horizons (e.g., sequence boundaries, condensed sections, flooding surfaces) in western New York sections, correlation of such horizons into the vicinity of Ithaca, New York is currently ongoing [3], [4]. This study focuses on detailed examination of the Ithaca Formation of east-central New York in its type area, using a sequence stratigraphic approach to describe and correlate these strata. Herein we summarize progress in characterizing small-scale sedimentary cycles within the Ithaca Formation, as well as the identification of potential horizons and/or beds that may be correlative with those previously recognized in western New York sections. These include fossil-rich calcareous siltstone and limestone beds that appear to record sediment starved intervals associated with small-scale transgressions. The latter may correlate into condensed, styliolinid-rich pelagic limestones in western New York.

We also place our correlations within the context of the documented Appalachian Basin faunas that are found in these strata; including not only the Frasnian “Ithaca Fauna”, but also observations of the recurrence of an anachronistic fauna dominated by taxa typical of the Middle Devonian Hamilton Group [5], [6], [7]. We will discuss the implications of our stratigraphic correlations to the appearance of these faunas at different times within the Ithaca Formation, as documented in the past literature [1], [5], [6], [7]. Furthermore, we suggest control of sea level fluctuation on faunal immigration, which may allow for an inference of the location of refugia for the “Hamilton-like Fauna” during times of occupation of the “Ithaca Fauna” within the study area. Finally, we present a slightly modified framework of eustatic sea level change and biostratigraphic zonations. This framework has broader implications for global correlation and bioevents, as the Upper Devonian strata of New York is a global reference section for Devonian rocks worldwide.

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