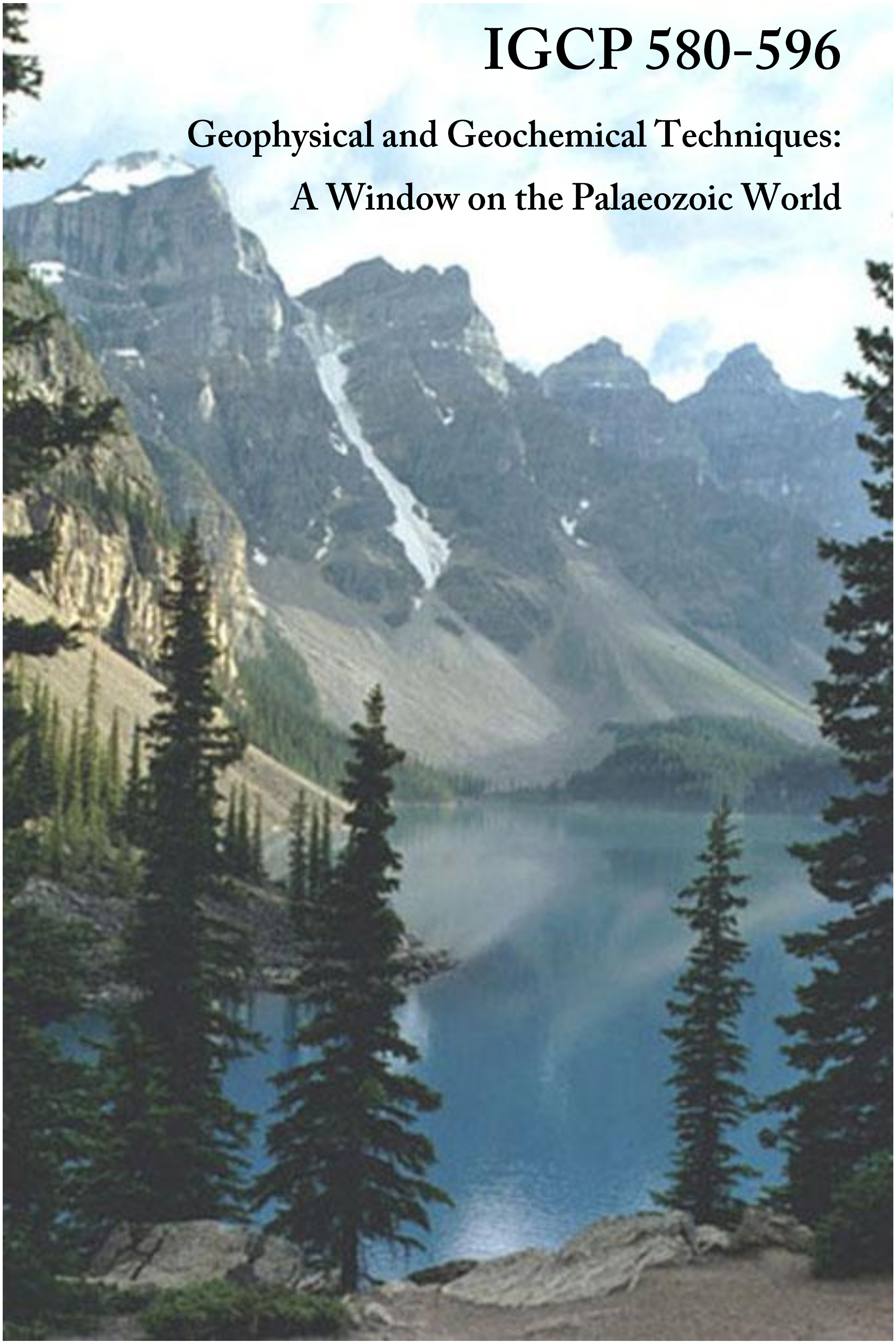
IGCP 580-596

Geophysical and Geochemical Techniques: A Window on the Palaeozoic World



Geological Survey of Canada and ERCB Core Research Center

27 August – 1 September 2013

IGCP 580-596

Geophysical and Geochemical Techniques: A Window on the Palaeozoic World

Programme with Abstracts

Edited by Michael Whalen, Kirk Osadetz, Barry Richards, Pavel Kabanov, John Weissenberger, Ken Potma, Peter Koenigshof, Thomas Suttner, Erika Kido, Anne-Christine Da Silva.

IGCP 580-596
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Welcome to Calgary!

Welcome to the fifth IGCP 580 (Application of magnetic susceptibility as a palaeoenvironmental proxy) meeting being held in conjunction with the IGCP 596 (Climate change and palaeobiodiversity patterns in the Mid-Palaeozoic) here in Calgary, Alberta, Canada. We bring together scientists that apply geophysical and geochemical methods on sedimentary rocks from different time slices with an emphasis on the Palaeozoic. Calgary is an ideal location for our IGCP meeting given its proximity to the amazing exposures of the Canadian Rockies. in an area of foothills and prairie, approximately 80 km (50 mi) east of the front ranges of the Canadian Rockies. Situated on the banks of the Bow River, Calgary has a vibrant downtown area, is home to the University of Calgary, a regional office of the Geological Survey of Canada, the Alberta Research Council, and the Energy Resources Conservation Board's (ERCB) Core Research Center, with one of the largest subsurface drill core collections in the world.

The IGCP-580/596 meeting will entail a two-day technical conference, held on the campus of the Geological Survey of Canada, a one-day core workshop at the ERCB Core Research Center, and a field excursion to excellent outcrops in the area around Canmore, along the mountain front, west of Calgary.

Organization

Organizing committee: Michael Whalen (University of Alaska Fairbanks), Kirk Osadetz, Barry Richards, and Pavel Kabanov (Geological Survey, Calgary), John Weissenberger (Husky Energy), Ken Potma (Esso), Peter Koenigshof (Senckenberg Institute), Thomas Suttner and Erika Kido (University of Graz) and Anne-Christine Da Silva (University of Liège).

Scientific committee: Michael Whalen (U.S.A.), Kirk Osadetz, Pavel Kabanov, John Weissenberger, Ken Potma, Barry Richards (Canada), Anne-Christine Da Silva, Frédéric Boulvain, Xavier Devleeschouwer (Belgium), Jindrich Hladil, Leona Koptikova (Czech Republic), Daizhao Chen (China), Peter Koenigshof (Germany), Thomas Suttner and Erika Kido (Austria).

Contact Information: IGCP 580 Meeting, Michael Whalen, Department of Geology and Geophysics, University of Alaska Fairbanks, Fairbanks, AK 99775, Phone : 907-474-5302, Fax : 907-474-5163

IGCP 580: http://www2.ulg.ac.be/geolsed/MS/meeting.htm

IGCP-596: http://www.senckenberg.de/IGCP-596

E-mail: mtwhalen@gi.alaska.edu

Schedule

27 August – Registration and Ice Breaker 3-7 pm

28 August – Technical Sessions 9:30-11:50, 1:30-3:50

29 August – Technical Sessions 9:30-12:00, 1:30-3:40
– Social Dinner 7:00-10:00

30 August – Core Workshop, ERCB Core Research Center 9:00-4:30

The core workshop will review, with a dozen or so selected long cores, the expression of major time surfaces (sequences and parasequence boundaries), carbonate lithofacies, reservoir quality, source facies (and source rocks as unconventional reservoirs) and a diagenetic model, (dolostones vs limestones) within a sequence stratigraphic framework. The core workshop will touch most major reservoir intervals of the Frasnian in the western part of the Western Canada Sedimentary basin (Swan Hills Formation, Leduc Formation, Duvernay Formation (unconventional) and Nisku Formation.

31 August – 1 September – Field excursion to Canmore Area

31 August – Frasnian reservoir facies Grassi Lakes 9:00-6:00

1 September – Famennian and Carboniferous stratigraphy Jura Creek 9:00-6:00

3-4 September – Additional core sampling, ERCB Core Research Center 9:00-4:00

Technical Session Schedule

Wednesday 28 August

9:00-9:30 Registration desk open

9:30-9:45 Introduction – opening

Morning session – Chairman : De Vleeschouwer, X.

9:45-10:05 Chen & Jiang Cyclic platform carbonate deposition and post-extinction biotic recovery during the Famennian of Late Devonian in Guangxi, South China: Insights from high-resolution cycle and sequence Stratigraphy

10:05-10:25 Bennett et al. Rebuilding terrestrial ecosystems after the end-Devonian mass extinction: insights from the TW:eed Project

10:25-11:00 Coffee Break

11:00-11:30 Key Note: Babek et al. Towards better comprehension of magnetic signal in carbonates: lessons from Palaeozoic and Cenozoic sedimentary archives

11:30-11:50 Whalen et al. Geochemistry and Cyclostratigraphy of Magnetic Susceptibility data from the Frasnian-Famennian event interval in western Canada: Insights into the pattern and timing of a biotic crisis

11:50-12:10 Gilmanova D.M. et al. Sequence-stratigraphy and astronomical calibration of the Middle-Late Permian sediments on the right shore of the Volga River near Kazan city

12:10-1:30 Lunch

Afternoon session – Chairman : Day, J..

1:30-2:00 Key Note De Vleeschouwer, D. et al. The astronomical calibration of the Givetian (Middle Devonian) time scale (Dinant Synclinorium, Belgium)

2:00-2:20 Kumpan et al. Element geochemistry, gamma-ray spectrometry and magnetic susceptibility as correlative tools for the Devonian-Carboniferous boundary interval in Europe

2:20-2:50 Coffee Break

2:50-3:10 Da Silva et al. Characterisation of cyclicity and relative sea-level fluctuations using magnetic susceptibility, Late Devonian (Frasnian) Hull platform, Canning Basin, Australia

3:10-3:30 Devleeschouwer, X. et al. Multi-proxy study of shallow platform carbonates at the Devonian/Carboniferous boundary (Ertoucun and Nanbiancun, South China): a diachronous detrital event

3:30-3:50 Jadot & Boulvain Sedimentology and magnetic susceptibility of recent sediments from New Caledonia

Thursday 29 August

Morning session – Chairman : Babek, O.

9:30-10:00 Keynote: Gouwy et al. Lower and Middle Devonian conodont biostratigraphy and Conodont Apatite δ18O variations in the Southern Illinois Basin, USA

9:50-10:10 Da Silva et al. Spicules or no spicules in Devonian stromatoporoids, that's the question?

10:10-12:00 Poster Session – coffee break

Alekseev A.O. et al. -- Magnetic succeptibility (MS) and XRF characterization of a Viséan – Serpukhovian boundary section in southern Moscow Basin, Russia

Bahrami, A. et al. -- Middle Devonian environment and pre-Taghanic event in Central Iran

Guo, Z. & Chen, D. -- Magnetic susceptibility variations across the Frasnian-Famennian boundary successions of interplatform basinal carbonates, South China

Gouwy, S.A., et al. -- Mid-Devonian biodiversity and the Paleobiology Database

Hubert, B.L.M. et al. -- Macrofauna, rock magnetism and sedimentology in the Etroeungt Limestone ('Strunian', Uppermost Famennian) at Avesnelles (northern France)

Kabanov P.B., e tal. -- Devonian and Carboniferous paleosols of central-southern East European Craton preserving pristine magnetic, mineralogical, and geochemical signatures

Rădan, S.C. et al. -- A magneto-lithological approach of the recent sediments from the Danube Delta, focused on some more or less connected pairs of lakes; environmental inferences

Sunjay S. & Kumar, S. -- Wavelet Analysis of Paleomagnetic Data

Bahrami, A., Boncheva, I., Yazdi, M. & Khan-Abadi, A.E. – Mississipian / Pennsylvanian boundary interval in Central and East Iran

12:00-1:30 Lunch

Afternoon session – Chairman : De Vleeschouwer D.

1:30-1:50 Zaitsev et al. Bulk geochemical expression of Late Visean - basal Serpukhovian cyclothemes of southern Moscow Basin, Russia

1:50-2:10 Day et al. Magnetic susceptiblity and carbon isotope stratigraphies through the Devonian-Carboniferous boundary interval in the western Illinois basin-central North America

2:10-2:30 Devleeschouwer, X. et al. Changes in carbonate production and detrital influx in relation with the Frasnes Event (Sourd d'Ave section, Belgian Ardennes): new insights from multi-proxy analyses

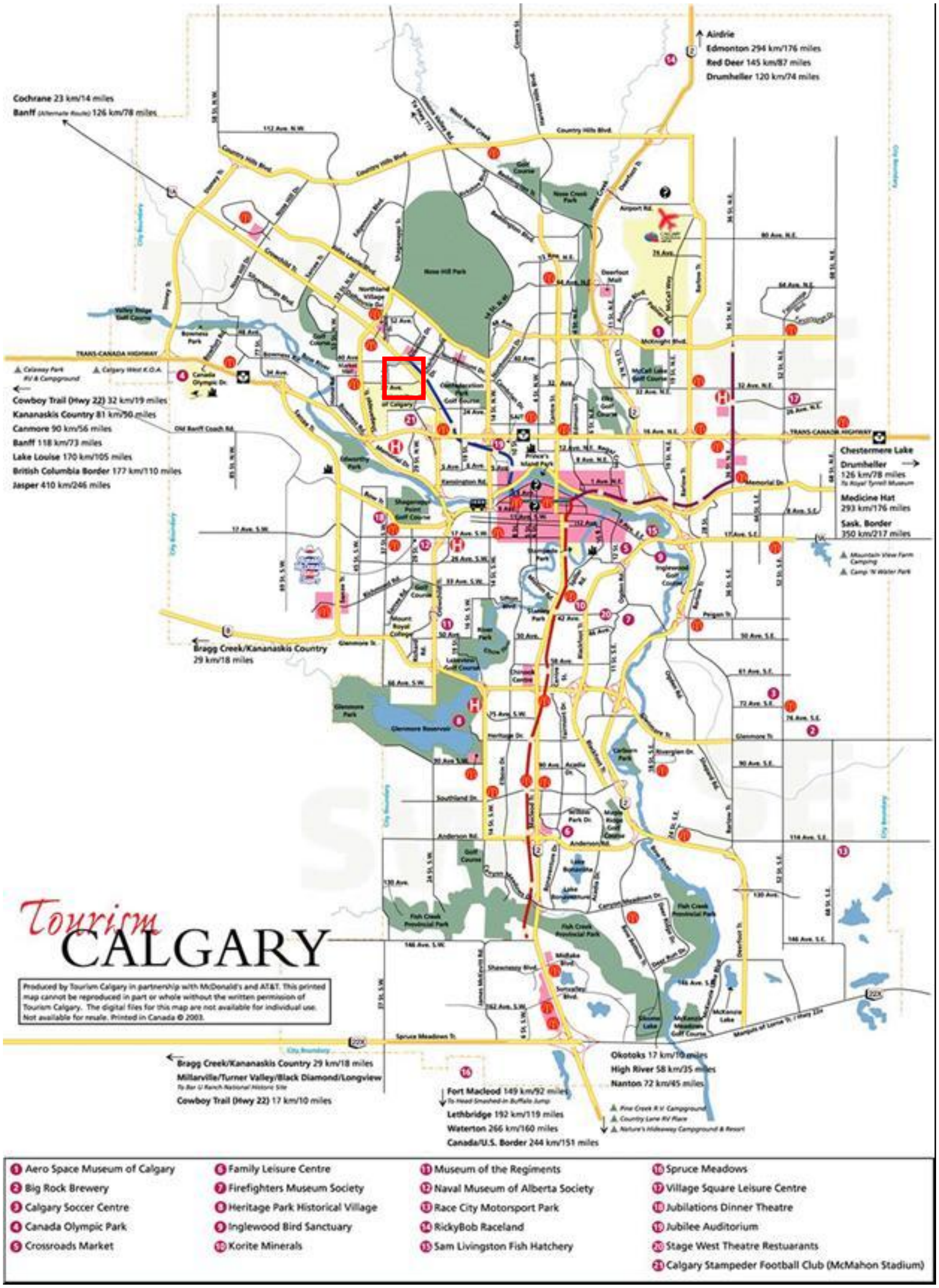
2:30-3:00 Coffee Break

3:00-3:20 Koptikova et al. Petrophysical and sedimentological record of the Late Silurian Lau event in the shallow water carbonate facies (Prague Synform, Czech Republic)

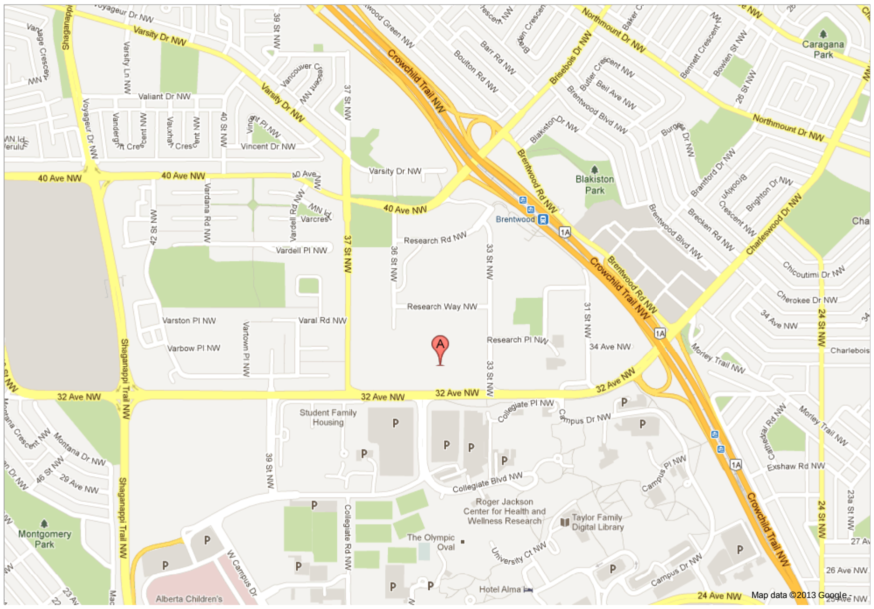
3:20-3:40 Seersma, G. et al. -- Middle to Late Devonian deposits of the Baruunhuurai Terrane, western Mongolia

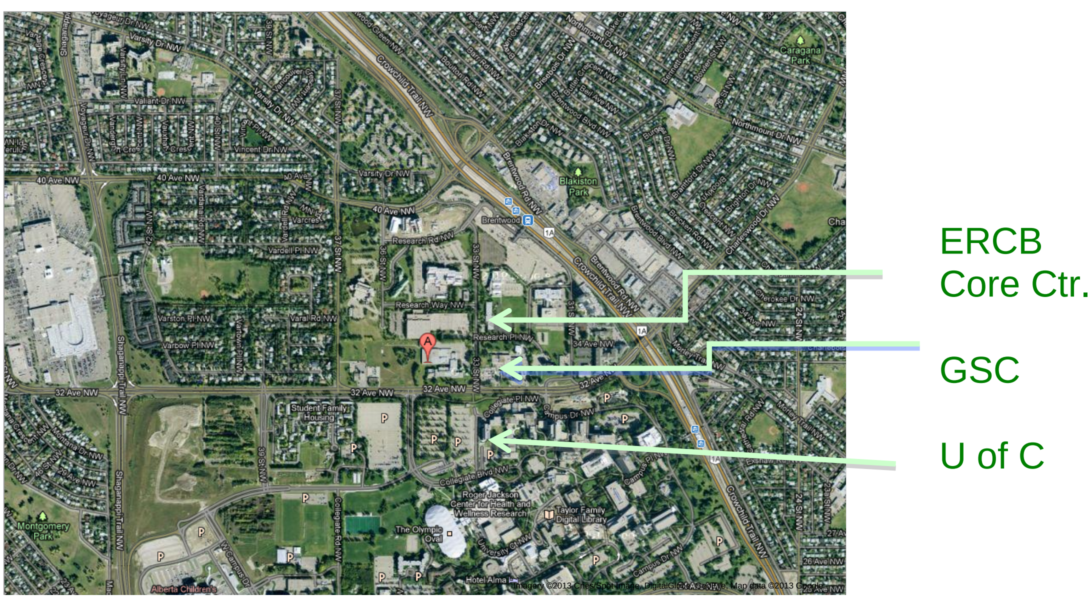
3:40-4:00 IGCP-580, what's next ?

Getting Around Calgary



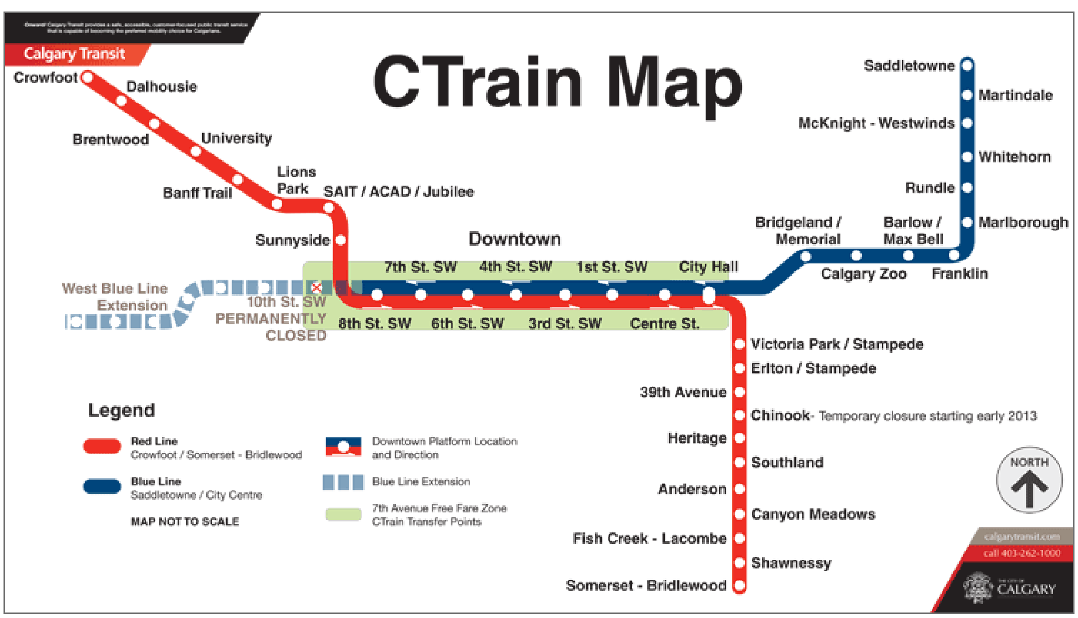
The meeting will be held at the Geological Survey of Calgary (GSC - address: 3303 - 33rd Street N.W., Calgary, Alberta, Canada T2L 2A7, Telephone: (403) 292-7000) and the core workshop will be held at the Core Research Centre (ERCB – address: Energy Resources Conservation Board, 3545 Research Way NW, Calgary, AB T2L 1Y7, Canada, Telephone: (403) 297-6400).





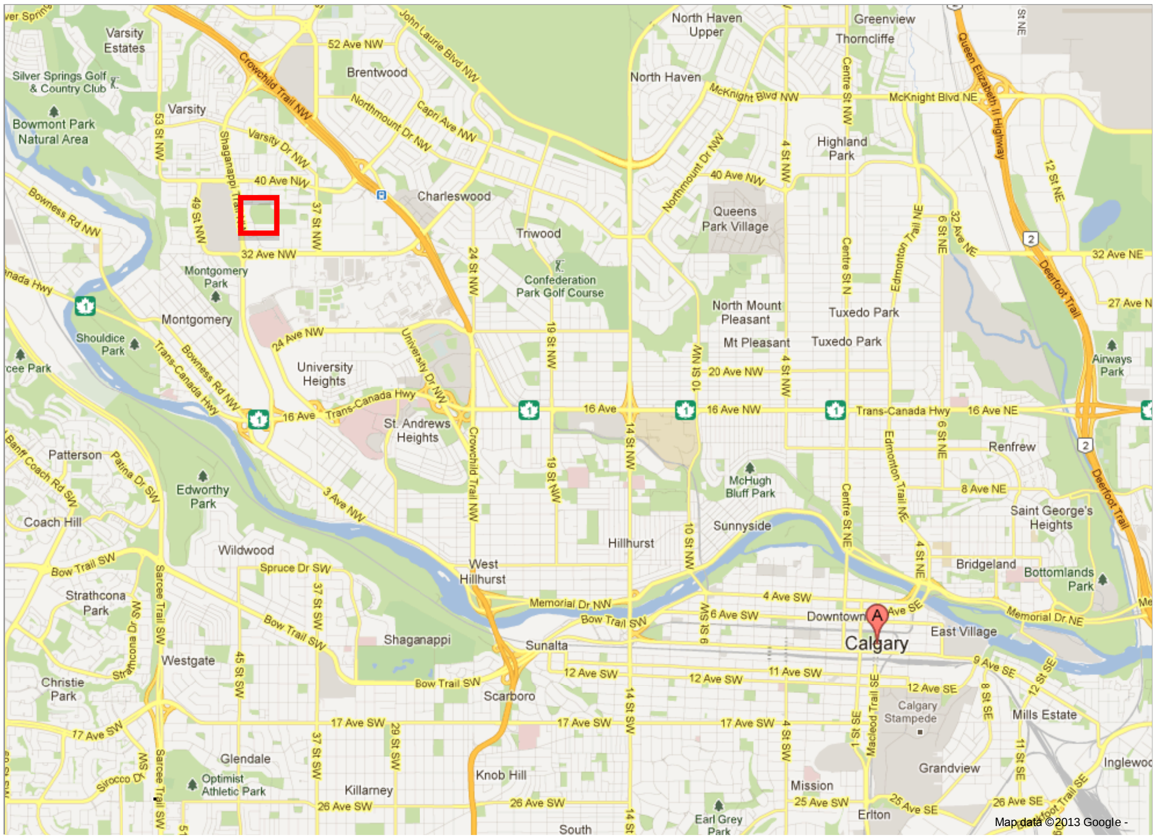
screen, use the "Print" link next to the map.

Close up Google satellite image illustrating the location of the GSC and the ERCB Core Facility just to the north of the GSC.



Map of the CTrain that provides transport downtown and to southern and eastern parts of Calgary.

Location of the Geological Survey of Canada (Calgary) with location of the main CTrain stops. Photo of GSC entrance below.



Indicates the general location of the GSC and ERCB Core Research Center.

Magnetic succeptibility (MS) and XRF characterization of a Viséan – Serpukhovian boundary section in southern Moscow Basin, Russia

Alekseev A.O.[1], Kabanov P.B.[2], Zaitsev T.E.[3], Alekseeva T.V.[2]

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The epeiric Carboniferous succession of southern Moscow Basin is known to have avoided burial diagenesis and preserved many primary mineralogical and geochemical signals. The Polotnyanyi Zavod operating quarry hosts one of upper Mississippian reference sections in the region (Fig. 1; Kabanov et al., 2013). The MS data from 116 samples (KLY-2 instrument) are compared against bulk XRF proxies (Fig. 1).

The MS (X_{init} on Fig. 1) ranges from -1.06 to 26.6 m^3/kg and strongly correlates to bulk iron (Pearson R = 0.94). Highest peaks are observed in thin pedogenized ferric shales that blanket paleokarsts, and also in sooty silts and shales of the lower parts of siliciclastic units. These latter are pedosedimentary facies with extensive slickensiding and *Stigmaria* penetrations, apparently formed in acid mangrove-type marshlands during early phases of marine transgressions. Sulphidophile metals (Pb, Cu, Zn, Ni) do not accumulate, and manganese mostly stays featureless at MS peaks suggesting sustained oxygen supply (sluggish seaward water movement?). However, in the base of bed 15, Mn peaks at 0.25% suggesting an oxygen minimum. Manganese also tends to grow upward from the base of the sequence ZB2 apparently in response to progressing deepening and stratification of the basin (Steshevian highstand). The APB saponitic marl (slightly more arid, siliciclastic-lean palustrine environment) shows MS reaching 2.5 m^3/kg (basal siliciclastic admixture) and in average slightly above clean marine limestones. All magnetization-unreceptive and weakly diamagnetic rocks are marine limestones.

References:
Kabanov P.B., Aleksev A.S., Gabdullin R.R., et al. (2013): Progress in sequence stratigraphy of upper Visean and lower Serpukhovian of southern Moscow Basin, Russia, *Newsletter on Carboniferous Stratigraphy* 2012, v. **30**: 55-65.

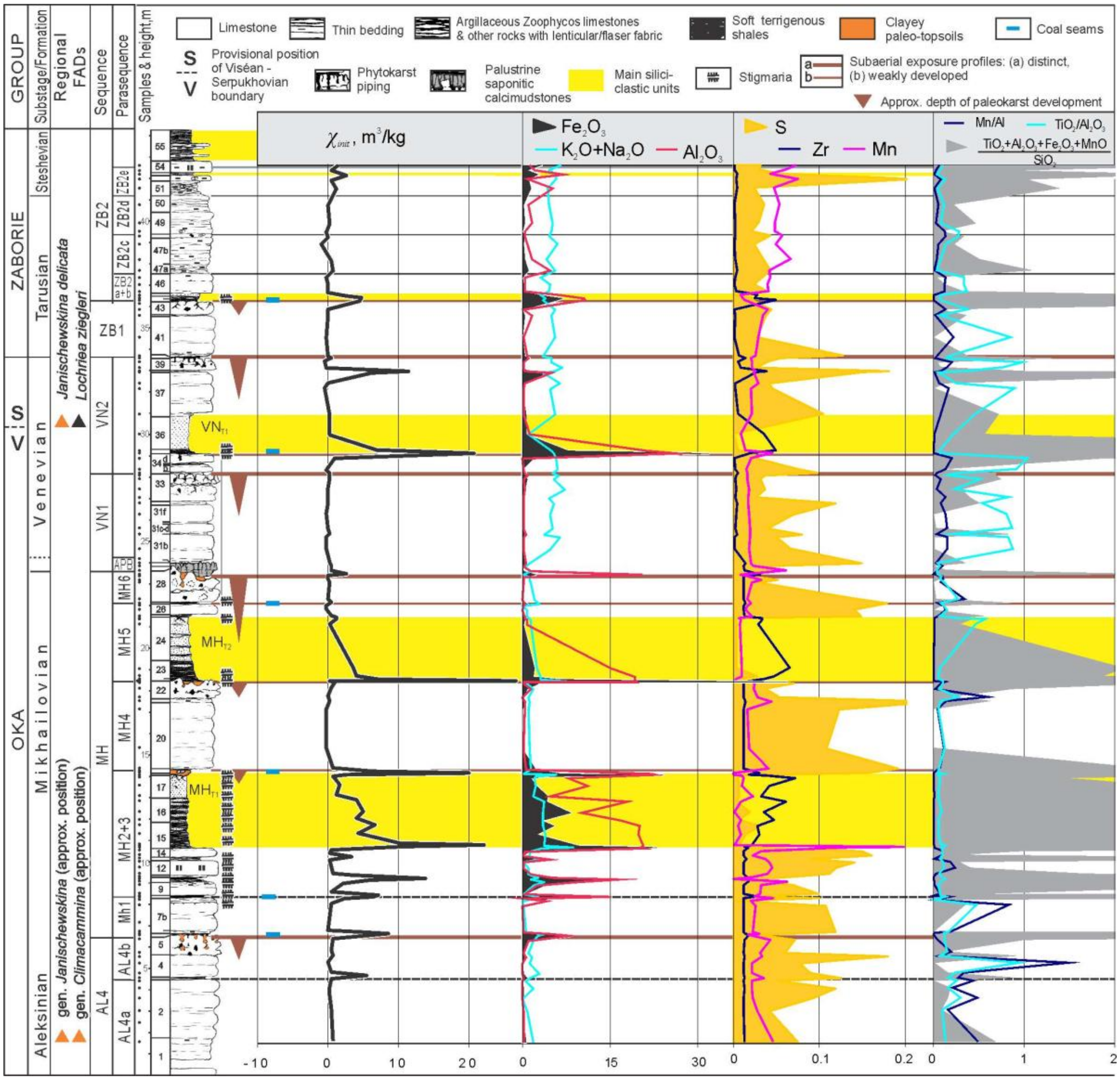

Figure 1. Magnetic susceptibility and geochemical logs of Polotnyanyi Zavod. The litholog, sequence pattern, and stratigraphic information from Kabanov et al., 2013.

Towards better comprehension of magnetic signal in carbonates: lessons from Palaeozoic and Cainozoic sedimentary archives

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With the growing database of magnetic susceptibility (MS) measurements in Palaeozoic carbonate strata, the traditional paradigm of high and low MS values during regressions and transgressions, respectively, is being challenged. Although this concept showed up to work well in several case studies of carbonate platforms, a growing evidence shows that MS is of limited use in stratigraphic correlation and quantification of facies change in carbonate ramps. The Lower Carboniferous ramp systems of British Isles show well-developed vertical facies patterns, which are driven by glacioeustacy with a prominent sea-level fall at the Tournaisian/Viséan boundary. A robust sequence-stratigraphic framework at six ramp- and basinal sections shows that MS roughly increases during transgression and decreases during both normal and forced regressions, i.e. just opposite to the MS paradigm.

However, some regressive strata show relatively unpredictable (facies independent) positive excursions of MS, often associated with dolomitization. In addition, MS patterns often fail to follow the geochemical patterns in carbonates. MS values fail to correlate with detrital geochemical proxies such as K and Th (field gamma-ray spectrometry) and Al, Si, Zr, Ti and Rb (EDXRF). Bivariate plots even show that the highest MS values are attained in pure limestone with extremely low K and Fe concentrations. This suggests that MS is not simply driven by detrital (mostly paramagnetic) grains in carbonates and pure carbonates are especially prone to (post-depositional?) magnetic enhancement. Recent magneto-mineralogical measurements suggest that the MS signal in pure carbonate strata can be largely driven by ferromagnetics.

MS is a widely used proxy in palaeoenvironmental research. Our own observations from Late Cainozoic siliciclastic sedimentary archives may provide some useful hints for the MS interpretations in the deep past. Lacustrine archives show that MS can be used as a proxy of grain size, being driven by the dilution effect of predominantly diamagnetic coarse fraction in predominantly paramagnetic, fine-grained matrix. The loess-paleosol archives show high variability in MS due to provenance of aeolian material and selective wind transport of heavy minerals. Loess in Siberia has an order of magnitude higher MS than loess form Central Europe. In addition, paleosols can be magnetically enhanced or depleted, depending on redox conditions during pedogenesis (hematite/maghemite precipitation, magnetite dissolution, respectively). Increased values of MS are associated with colour changes and elevated Fe/Mn concentrations in sediment cores from Holocene floodplains. These changes coincide with the water table and can be interpreted as magnetic enhancement due to fluctuating redox potential. These observations show that interpretation of MS signal can be very complex even in the very recent world, but a multi-proxy approach can significantly help our MS interpretations.

Middle Devonian environment and pre-Taghanic event in Central Iran

Bahrami, A.[1], Boncheva, I.[2], Safari, Z.[3] & Yazdi, M.[4]

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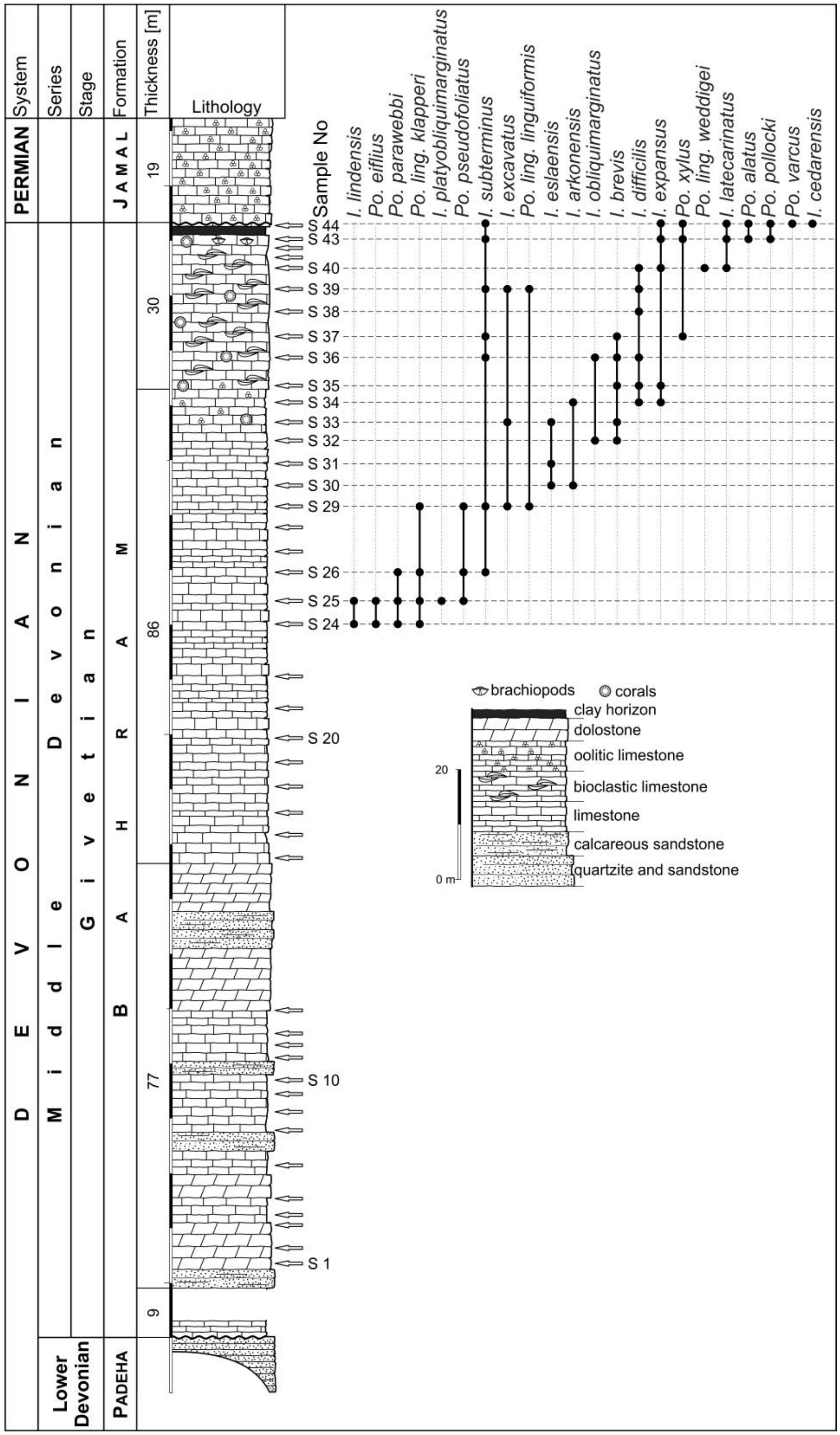
The main Paleozoic sequences in Iran occur in the eastern and central parts of the country. Sedimentary facies analysis for Devonian sections shows that a regression began in the Emisian and culminated in Late Eifelian (Eifelian hiatus). The Givetian time interval is characterized by transgression – regression episodes which are observable by the difference in depositional sedimentary facies and fossil contents. The studied 203 m thick Varcamar section of Middle Devonian calcareous sandstones, bioclastic and oolitic limestones and dolostones, is located in Isfahan area (Central Iran) and is related to the Bahram Formation. The age of the Bahram Fm. comprises the Givetian, Frasnian and Fammennian (Yazdi et al., 2000; Gholamailan, 2003, 2005, 2007; Adhamian, 2003). The Middle Devonian section in the studied area is presented by Givetian succession related to higher part of hemiansatus Zone and varcus Zone. The impact of the global Taghanic Event (upper part of Givetian) on the facies and faunas was studied in sections of Central Iran, where a hemipelagic platform (northern Isfahan area) contains notably rich macrofauna. A significant regressive trend (Upper Eifelian and Lower Givetian) is recorded by shallowing cycles at the lower part of the Bahram Formation. During the pre-Taghanic time interval, a deepening (connected with faunal blooms of macrofauna, especially of brahiopods, trilobites, corals) resulted in the deposition of fossiliferous bioclactic limestones (varcus Zone) on the platform. In the Upper Bahram Formation, bioclastic limestones contain widespread coral-stromatoporoid biostromes and abundance of conodonts, mainly icriodids. There is a correlative horizon of dark shales in the Soh and Varcamar sections corresponding to the conodont hermanni Zone. The overlying organogenic limestone beds are characterized by bloom in branching tabulate corals, phacopid trilobites, (Neocalmonia (Heliopyge) caelata Hass & Mensink, 1970) and plant fossils. It seems that the Taghanic Crisis was a repeatition of fast eustatic fluctuations and climate changes related to them. The presence of land plants ((Sigilaria persica, Lepidodendron sp., Brice et al., 2006), brachiopods (Leptaena sp., Leptagonia sp., Mesodouvellina cf. birmancia) confirms greenhouse heating pulses. In the studied area there is no evidence for global extinction effect in the upper part of the Middle Devonian and probably anoxia played only a local role in extinctions. Taghanic Event can be recognized globally but most probably it had different regional effects leading to variable faunal migrations, blooms, and extinctions.



System
Series
Stage
Formation
Thickness [m]
Lithology
PERMIAN
DEVONIAN
Middle Devonian
Lower Devonian
Givetian
JAMAL
BAHRAM
PADEHA
19
30
86
77
9
Sample No
S 44
S 43
S 40
S 39
S 38
S 37
S 36
S 35
S 34
S 33
S 32
S 31
S 30
S 29
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S 25
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S 20
S 10
S 1
I. lindensis
Po. eiflius
Po. parawebbi
Po. ling. klapperi
I. platyobliquimarginatus
Po. pseudofoliatus
I. subterminus
I. excavatus
Po. ling. linguiformis
I. eslaensis
I. arkonensis
I. obliquimarginatus
I. brevis
I. difficilis
I. expansus
Po. xylus
Po. ling. weddigei
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Po. alatus
Po. pollocki
Po. varcus
I. cedarensis
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corals
clay horizon
dolostone
oolitic limestone
bioclastic limestone
limestone
calcareous sandstone
quartzite and sandstone
20
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Rebuilding terrestrial ecosystems after the end-Devonian mass extinction: insights from the TW:eed Project

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The TW:eed (Tetrapod World: early evolution and diversification) project is a major research initiative that will generate a coherent picture of the biotic, environmental and geological conditions of the 15-20 million years recovery period following the major extinction event at the end-Devonian that was a major turning point in terrestrial evolution. A paucity of terrestrial invertebrates and few fossils of early tetrapods have been found in post-Devonian successions from the immediate aftermath (Romer's Gap) and yet, during a relatively brief time period in the Early Carboniferous, fully terrestrial vertebrates evolved, terrestrial arthropods radiated, ray-finned fishes took over from lobe-finned forms and plant groups diversified. Several new localities in Carboniferous successions in southern Scotland and northern England are providing completely new insights into this pivotal period for the evolution of life on land. Significant new tetrapod material is helping to populate Romer's Gap. Localities are also yielding a diverse fauna of fish (gyracanthids, lungfish, rhizodonts and actinopterygians), invertebrates (malacostracans, eurypterids, ostracods, scorpions and myriapods) and plants. The fossil localities are within the Ballagan Formation, a distinctive unit comprising mudstones with interbedded sandstones, palaeosols and thin beds of dolomitic "cementstone". The sediments were deposited on an extensive low relief, muddy, vegetated floodplain that was traversed by numerous river systems. Periodically the river-derived floods submerged the floodplains generating extensive shallow freshwater lakes. The presence of gypsum and anhydrite indicates that there were occasional marine transgressions across a marginal coastal plain. So far, most of the fossils have been found towards the top of the Ballagan Formation, but a coastal exposure of the entire formation provides a unique opportunity to search for fossils across a time interval of about 15 million years at the base of the Carboniferous.

In addition to the detailed analysis of key outcrops, a drilling program in the Tweed Basin is in the process of acquiring 500 m of continuous core through these earliest Carboniferous successions. A tight stratigraphic framework for tetrapod localities across the region will be generated by integrating the sedimentological (lithostratigraphy), micropalaeontological (biostratigraphy), chemostratigraphical (carbon and oxygen stable isotopes) and petrophysical data from the core and outcrops. The borehole will provide the high-resolution datasets required to investigate the local, and potentially, global palaeoclimate and its evolution through this time interval. This multifaceted project is a unique opportunity to examine the progression, causes and context of the rebuilding of an ecosystem following a major extinction.

Cyclic platform carbonate deposition and post-extinction biotic recovery during the Famennian of Late Devonian in Guangxi, South China: Insights from high-resolution cycle and sequence stratigraphy

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E-mail: dzh-chen@mail.iggcas.ac.cn

During the Late Devonian Famennian in Guangxi, South China, carbonate platforms and interplatform basins were well shaped by transtensional tectonism, forming a complex configuration generally inherited from that of Middle Devonian. As a result of Frasnian-Famennian mass extinction, Famennian successions are characterized by fossil-poor carbonates (mostly fenestral limestones) in the lower-middle part, and fossil-bearing, deeper carbonates in the upper part. Three facies associations, including tidal-flat, semi-restricted to restricted subtidal and open marine subtidal facies are identified, in which fifteen lithofacies are further differentiated in three carbonate platforms. These lithofacies are arranged into the basic meter-scale (or fifth-order), shallowing-upward peritidal and subtidal cycles (or parasequces), in which the former type predominates notably over the lower-middle Famennian successions. These high-frequency cycles are further grouped into fourth-order cycle sets and third-order sequences. Nine third-order sequences (S1 to S9) are identified from the cycle stacking patterns as illustrated by Fischer-plots, and vertical facies changes. These sequences are mainly composed of a lower transgressive part and an upper regressive part. Transgressive packages are dominated by thicker-than-average cycles with higher components of subtidal facies, and regressive packages by thinner-than-average peritidal cycles. The spans of these sequences are temporally calibrated through correlation with basinal sequences well constrained with conodont zonation. Except the newly recognized sequences at bases of lower and upper Famennian, respectively, others are well correlated with the main T-R cycles in Euramerica. Within platform interiors, stacking patterns of these sequences reveal a longer-term (second-order) progressive decrease in accommodation space from S1 to S6 (keep-up sequence set) during the early-middle Famennian (*triangularis* through *postera* zones) and rapid increase in accommodation space from S7 through S9 (catch-up sequence set) during the late Famennian (*expansa* through *praesulcata* zones); this pattern is consistent with the long-term eustatic changes of Famennian. In a deeper open marine (slope) setting, however, the rapid accommodation increase starts earlier from S4 through S9 such that an opposite trend of accommodation changes is indicated from S4 to S6 (*rhomboidea* through *postera* zones) between platform interior and slope-to-basin setting. This pattern indicates that accommodation loss in platform interior was accompanied with accommodation gain in slope-to-basin settings during the middle Famennian, suggesting differential subsidence across the platform likely driven by basement block tilting. Thus, both eustatic fluctuations and local tectonism could have played a role in carbonate platform development. After the mass extinction, biotic recovery of main benthos preferentially took place in the normal marine niches on the nearshore muddy shelves fringing landmasses, and expanded gradually onto offshore restricted platforms. Brachiopods, notably rhychonellids, were the earliest members to be recovered (S1) in normal marine condition, which then were followed by echinoderms (S4), stromatoporoids (S6) and corals (S9), however, even the same fauna generally appeared later in restricted platform interior. Therefore, biotic recovery was diachronous: both taxonomically and ecologically. Cycle and sequence stratigraphy could provide a useful time framework to constrain the timing of biotic origination and lateral migration.

Characterisation of cyclicity and relative sea-level fluctuations using magnetic susceptibility, Late Devonian (Frasnian) Hull platform, Canning Basin, Australia

Da Silva, Anne-Christine[1], George, Annette D.[2], Chow, Nancy[3], Spassov, Simo[4]

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[3] Department of Geological Sciences, University of Manitoba, Canada.
E-mail: n_chow@umanitoba.ca
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Frasnian reef-rimmed platforms evolved during active extension along the northern margin of the Canning Basin of north-western Australia. Back-reef cyclicity is well known in the Lennard Shelf platforms, however, significant variation in the development of cyclic facies arrangements have been identified. Overall evolution of this platform was strongly controlled by syn-depositional faulting and block rotation suggesting a likely complex interplay between local and regional tectonic and eustatic changes.

Magnetic susceptibility (MS) measurements of two ~260 metre sections through the Hull platform were undertaken on samples from well-exposed shallow subtidal carbonate facies and thin bioclastic rudstones-floatstones in recessive (muddier) intervals. MS data from both sections, south-eastern (SE) Hull Range and Guppy Hills, show a number of peaks and a cyclic pattern; but with very low MS values (3.00×10^{-9} m^3/kg), compared to other Devonian examples. For both sections, mean MS values are higher for the basal strata, when ramp conditions prevailed following initial flooding, with mixed carbonate-siliciclastic deposition. I=n both sections, exposure surfaces were recognised during sampling, which are reflected as susceptibility peaks, allowing correlation between both sections. Magnetic hysteresis analyses points to a MS signal clearly dominated by paramagnetic minerals and not influenced by ferromagnetic minerals. These observations support the interpretation that higher MS values mainly resulted from siliciclastic sediment supply during times of lowered relative sea level.

Spicules or no spicules in Devonian stromatoporoids, that's the question?

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We show the first record of demosponge spicule framework in a single specimen of a Devonian stromatoporoid from the Frasnian of southern Belgium (La Boverie Quarry 30 km east of Dinant). The stromatoporoid basal skeleton is similar to the genus *Stromatopora*. The spicules are arranged in the calcified basal skeleton, but not in the gallery space, and are recrystallised as multicrystalline calcite. The spicules fall into two size ranges: 10 - 20 µm diameter and 500 - 2000 µm long for the large ones and between 5 to 15 µm and 50 to 100 µm for the small ones. In tangential section, the spicules are circular, they have a simple structure and no axial canal has been preserved. The large spicules are always monaxons, straight or slightly curved styles or strongyles. The spicules and spicule arrangement most closely resemble halichondrid/axinellid demosponge spicules, and are important rare evidence of the existence of spicules in Palaeozoic stromatoporoids, reinforcing the interpretation that stromatoporoids were sponges. The basal skeleton may have had an aragonitic spherulitic mineralogy. Furthermore, the spicules indicate that this stromatoporoid sample is a demosponge, and indicates that the class Stromatoporoidea may not be a valid taxonomic instrument.

Magnetic susceptiblity and carbon isotope stratigraphies through the Devonian-Carboniferous boundary interval in the western Illinois basin-central North America

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The proposed revision of the Devonian–Carboniferous boundary by the ICS-Subcommission on Devonian Stratigraphy (SDS) would lower the boundary from its current position (base of the *Siphonodella sulcata* Zone) to the base of the Middle *S. praesulcata* Zone. Unlike the current GSSP, the newly proposed GSSP can be widely correlated based on the major faunal turnover of the Hangenberg Extinction Bioevent, and the onset of the global Hangenberg $\delta^{13}C_{carb}$ Excursion.

One of the best records of the Hangenberg Excursion is recorded by subsurface strata of the upper Saverton Shale, English River, Louisiana Limestone and lowermost Prospect Hill formations in the Iowa Geological Survey's (IGS) H-28 and H-32 cores in southeastern Iowa (Fig. 1). Clastic sediments of the lower (Maple Mill) and upper English River comprise a 3rd order sequence overlain by the carbonate platform sequence of the Louisiana Limestone. Sea level changes that initiated deposition of these sequences are associated with glacial eustacy in the Latest Famennian-Early Tournaisian. Louisiana carbonate platform deposition in Iowa and Missouri was terminated by a major sea level low-stand prior to Prospect Hill deposition.

A 26.51 meter (87 feet) split of the H-32 core (Fig. 1) was sampled at 30 cm or less intervals for conodonts; at every 30 cm for $\delta^{13}C_{carb}$ geochemistry, and at 5 cm intervals for bulk magnetic susceptibility (MS). Conodont data support correlation with the Upper *expansa* to Upper *praesulcata* zones (Upper-Uppermost Famennian-Tournaisian?). *Siphonodella sulcata* was not recovered in the IGS core sections, and the Famennian-Tournaisian boundary as currently defined at its GSSP cannot be determined with confidence on the basis of recovered conodonts.

The $\delta^{13}C_{carb}$ chemostratigraphy clearly identifies the position and structure of the $\delta^{13}C_{carb}$ Hangenberg Excursion, with significant changes and trends in MS values occurring at the same position and through the same interval in the H-32 core section (Fig. 1). Inorganic $\delta^{13}C_{carb}$ data (Fig. 1) display Late Famennian base-line values of -1‰ through the upper Saverton, a short-lived shift to +2‰ in the Maple Mill (lower English River). The abrupt increase to +3.5 to +4‰ through the interval of the upper English River mark the onset of the Hangenberg Excursion, with values abruptly increasing to +6‰ (6.67‰ maximum) through the interval of outer shelf platform carbonates of the Louisiana Limestone. The MS data (Fig. 1) display a pattern of numerous small-scale variations in values, with significant and progressive decrease in values in the upper English River, with the largest decrease in MS (Fig. 1) correlating directly to the main part of the Hangenberg Excursion within the interval of the Upper *S.*

praesulcata Zone. These data demonstrate the utility of both $\delta^{13}C_{carb}$ and Magnetic susceptibility stratigraphies in global correlation of the revised Devonian-Carboniferous boundary outside of the region of the GSSP.

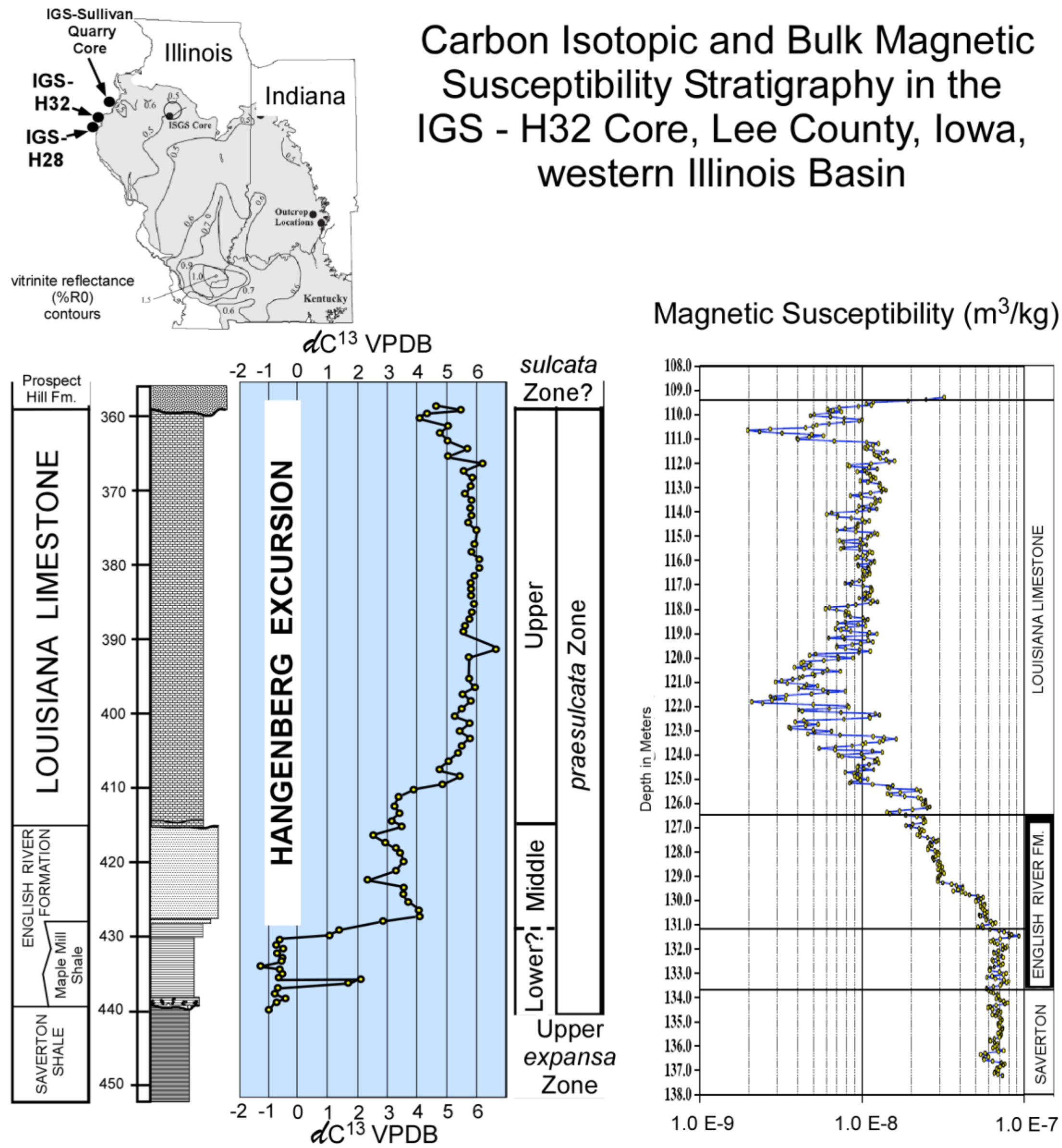

Figure 1. Carbon isotope chemostratigraphy ($\delta^{13}C_{carb}$) and Bulk Magnetic susceptibility stratigraphy in the Devonian-Carboniferous Boundary interval in the subsurface of southeastern Iowa in the western Illinois Basin of central North America. Shaded area in map shows distribution of the New Albany Shale in the main Illinois Basin. Stratigraphic units in the IGS H-32 core in southeastern Iowa are equivalents of upper New Albany strata in Illinois and Indiana.

The astronomical calibration of the Givetian (Middle Devonian) time scale (Dinant Synclinorium, Belgium)

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Good geological time scales are needed to put important evolutionary and geological events in a meaningful chronological framework. Over the last years, recent advances in radiometric dating resulted in significant improvements of the geological time scale. Nevertheless, the uncertainties on the Devonian time scale are still in the order of several millions of years and hamper a detailed understanding of the significant sedimentary, environmental and evolutionary changes that take place during the Devonian. To further improve the chronology of this key-interval, we examined the high-resolution magnetic susceptibility and microfacies signals of four Givetian (Middle Devonian) outcrops of the Dinant Synclinorium (Belgium) for a possible astronomical imprint.

We correlated all four sections based on lithostratigraphy, biostratigraphy and their magnetic susceptibility signal. Wavelet analysis on the magnetic susceptibility and microfacies signals revealed systematic periodicities. Based on temporal constraints from bio- and lithostratigraphy, meter-scale periodicities were interpreted as the result of 100-kyr eccentricity forcing. Decameter-scale cyclicity was associated with 405-kyr eccentricity forcing. The amplitude modulation of the meter-scale cycles at the rhythm of the 405-kyr cycles confirms this interpretation. Subsequently, the highly stable 405-kyr cycles were used to constrain the duration of the Givetian stage and eleven 405-kyr cycles are counted. In other words, these results suggest a duration of 4.5 ± 0.4 Myr for the Givetian.

Changes in carbonate production and detrital influx in relation with the Frasnes Event (Sourd d'Ave section, Belgian Ardennes): new insights from multi-proxy analyses

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Several reference sections, namely Nismes, Sourd d'Ave and Fromelennes, have been investigated in the allochthonous Ardennes fold-and-thrust belt (southern Belgium and northern France). The Sourd d'Ave section is located at the intersection of the Dinant-Neufchateau road (N48) and Han-sur-Lesse-Wellin road (N35). The Givet Group is represented by the upper part of the Moulin Boreux Member (= Mbr) and the Fort Hulobiet Mbr, both belonging to the Fromelennes Formation (= Fm.). The Frasnes Group is represented by the Pont d'Avignon Mbr, by the Sourd d'Ave Mbr and by the base of the La Pree Mbr, all belonging to the Nismes Fm.

The level of the Givetian/Frasnian boundary in the Dinant Synclinorium is still in debate. In fact, the Givetian/Frasnian boundary should be close to the Givet Group/Frasnes Group boundary in the allochthonous Ardennes fold-and-thrust belt. Recently, Casier et al. (2013) have studied the microfacies and ostracod assemblage evolutions along the section. A strong crisis in the ostracod assemblage is observed right at the Givetian/Frasnian boundary and corresponds to a change from semi-restricted to open marine water conditions. Sedimentological and ostracod analyses are in agreement, suggesting greater ostracod diversity in more open facies (MF1–3) in the shaly intervals of the Fort Hulobiet Mbr and in the whole of the Nismes Fm., while only rare ostracods have been observed in the most stressful environments (MF9–13) in most of the Givetian succession. The boundary between the Givet Group and the Frasnes Group is characterized by a dramatic deepening from restricted evaporative lagoonal facies (microfacies 6–13) to open marine interbedded marly shales and nodular limestones (microfacies 1–3). This transgressive event at the G/F boundary is highlighted by argillaceous shales, marly shales and tempestites with open-marine interbedded nodular limestones, and the development of a rich fauna succeeding the endemic communities that prevailed during Givetian times. This transgressive episode corresponds to the Frasnes Event. The objectives of the present paper deal with a multi-proxy approach (rock magnetism, gamma-ray spectrometry, microfacies, organic and inorganic carbon isotopes and faunal biodiversity) trying: 1) to determine the fluctuations and the changes in carbonate production versus detrital influxes during several conodont zones spanning the Upper Givetian - Lower Frasnian interval, 2) to characterize the paleoenvironments before, during and after the Frasnes Event, 3) to precisely identify and decipher detrital influxes (primary signal) from diagenetic influences (secondary signal) creating anomalous MS values in the Fromelennes Formation and 4) sea-level fluctuations and climatic changes will be suggested and should explain the end of the Givetian carbonate platform and the establishment of a mixed ramp at the base of the Frasnian.

Multi-proxy study of shallow platform carbonates at the Devonian/Carboniferous boundary (Ertoucun and Nanbiancun, South China): a diachronous detrital event

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The Nanbiancun section is exposed in a small hill located close to the Nanbiancun village, about 4 km north-west of Guilin city. Based on the evolution of conodont *Siphonodella praesulcata – S. sulcata* community, the D/C boundary is placed between beds 55 and 56 in the top of Rongxian Formation. The Ertoucun section is located 7 km south of Guilin in the carbonate platform while the Nanbiancun section is on the marginal slope of the Guilin Platform.
In Ertoucun, the upper part of the Famennian (Ertoucun Formation, 0 to 23 m) consists mainly of medium-bedded limestones. The lowermost part of the section (0 to ~11 m) comprises algal wackestones with abundant unilocular and multilocular (quasiendothyrid) foraminifers, peloids, bacterial lumps, ostracods and, in places, fenestral fabric. Peloid-foraminiferal wackestones to packstones with brachiopods, crinoids and algae occur higher up the section (11 to 23 m). A thin layer of shale is observed on the topmost part of the Famennian. The overlying basal Carboniferous Yinggoudong Formation (23 to 31.5 m) consists of thin bedded and/or nodular foraminifer-algal wackestones to packstones with peloids, ostracods, crinoids and brachiopods. Low-field magnetic susceptibility (X_{LF}) measurements reveals: 1) fluctuating, weak and sometimes negative MS values during the Famennian, 2) increasing positive X_{LF} values before the D/C boundary, staying positive up to the basal Carboniferous and 3) decreasing upwards to very weak and negative X_{LF} values. These

three-fold subdivisions of the X_{LF} curve are more or less underlined by other rock magnetic parameters including hysteresis, ARM, IRM and S-ratio measurements.

An upward-decreasing trend in K and Th concentrations is observed in the Famennian, followed by a minor enrichment in K and Th before the D/C boundary (18 to 22 m). The overlying end-Famennian and basal Carboniferous strata have again very low K and Th concentrations. The K- and Th-enriched strata below the D/C boundary suggest probably a detrital enrichment in fine-grained aluminosilicate minerals in the carbonates as indicated by a strong and positive Th-K correlation coefficient (r = 0.87). It can be speculated that this zone of impure limestone coincides with decreased carbonate production and increased detrital supply during the Hangenberg shale/sandstone event near the end of the Famennian. However, the gamma-ray and X_{LF} patterns do not fit together, especially in the basal Carboniferous strata (23 to 31.5 m) suggesting that the K, Th and MS signals are driven by different controlling mechanisms.

A similar pattern at large-scale is observed in the Nanbiancun section but the GRS peaks and positive X_{LF} values are present in the basal Carboniferous suggesting a clear diachronous detrital signal recorded between the inner platform and marginal slope settings. Sea-level fluctuations and 3rd order systems tracts should probably explain these differences between sections located in the same basin.

Sequence-stratigraphy and astronomical calibration of the Middle-Late Permian sediments on the right shore of the Volga River near Kazan city

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The paper is devoted to the research of sedimentary sections exposed on the shore of the Volga River. It is observed well-presented boundary between marine and continental sediments of the Permian period in this place. This boundary is presented in the typical cross section of Cheremushkinskiy ravine, which locates in 1.5 km to the West from Pechischii village. This section is traced on the distance of hundreds kilometers along the river. Unique character of these objects is in good exposure with sharp boundary between marine and continental sediments, facial variety of continental sediments and also well-observed stratification of different scale (from 0.1 mm to tens meters). For the investigations the remote sensing methods and software tools of geoinformation systems (ArcGIS 10.1, ERDAS Imagine 2010) and domestic programs have been used to process photos of outcrops. It was received the geological cross section of sediments along about 60 km on more than 30 sedimentary sections. The sequence-stratigraphical reconstruction includes main sequence surfaces and tracts. Also it have been discovered cyclic composition of sediments in different time scales in range of climatic cycles of astronomical nature. Obtained cycles have been correlated with magnetic parameters of ferrimagnetic fractions and presence of nickel-iron alloys.

Mid-Devonian biodiversity and the Paleobiology Database

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The IGCP 596 project focuses on the interaction between climate change and biodiversity in the Mid-Paleozoic (Early Devonian to Late Carboniferous). One of the goals of the project is to increase the record of biodiversity in all kinds of fossil groups and to elucidate the relationship between climate change and biodiversity patterns. One of the specific intervals that IGCP 596 and the closely related project FWF P23775-B17 are analyzing is the Middle Devonian (Eifelian-Givetian). This interval includes several important biotic crises (Choteč, Kačák, Taghanic, Pumilio and Givetian/Frasian boundary events). The primary goal is to document the biodiversity and observe significant changes regarding the biogeographical distribution especially of climate sensitive organisms from tropical and subtropical habitats during this interval. For this purpose the e-infrastructure of the Paleobiology database is used; a non-governmental, non-profit public resource, with data contributed by a multi-disciplinary international group of paleobiology researchers.

Middle Devonian taxa (mainly conodont, brachiopod and coral taxa for the moment) are currently entered in the database by several collaborators of the IGCP 596 Mid-Paleozoic working group (mid-Pz). So far 3332 collections (sample levels) have been entered for the Eifelian-Givetian interval, but of course larger datasets are needed for reliable biodiversity analyses. A larger network of taxonomic workers is being created to help to increase the amount of taxa entered in the database and update the systematics on marine and terrestrial Middle Devonian organisms. These datasets will later be made available to the public by the Paleobiology Database.

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Lower and Middle Devonian conodont biostratigraphy and Conodont Apatite $\delta^{18}O$ variations in the Southern Illinois Basin, USA

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Investigation of conodonts from three Devonian sections through the Clear Creek, Grand Tower and Saint (St.) Laurent formations from the Southern Illinois Basin-Real Foot Embayment (Illinois, USA) refine the interregional biostratigraphic correlations and constrain the timing of 3rd order sea level changes. Genus-specific conodont apatite $\delta^{18}O$ geochemistry was conducted in southern Illinois (Figure 1) and provide estimates of stable oxygen isotopic paleo-temperature changes of Devonian sea surface waters along the southern Ouachita continental margin of Laurussia.

In the White County Core the upper "Clear Creek" Formation faunas are Pragian based on the restricted range of *Latericriodus claudiae* (*sulcata* and *kindlei* zones) with *L. steinachensis*. The FAD of *L. nevadensis* identifies the base of the *dehiscens* Zone and Emsian Stage in upper "Clear Creek". The FAD of *Polygnathus partitus* identifies the Emsian-Eifelian Stage Boundary within the lower "Grand Tower" Fm. (base *partitus* Zone). The base of the *costatus* Zone coincides with the first occurrences of *Icriodus orri* and *I. stephensoni*, succeeded by *P. pseudofoliatus* (base *australis* Zone). The FAD of *Icriodus calvini* approximates the base of the *kockelianus* Zone. At Grand Tower (Jackson County) conodonts from the Devils Bake Oven section indicate an upper Emsian age (*serotinus* Zone) for the lower Dutch Creek Member of the Grand Tower, with the Emsian-Eifelian Stage boundary 7 meters above its base. The upper part of the Dutch Creek is of lower Eifelian age (*costatus* Zone). A major sea level rise initiated deposition of the "upper Member" of the Grand Tower during the *australis* Zone (FAD of *Polygnathus pseudofoliatus*). The first occurrence of *Icriodus calvini* identifies the *kockelianus* Zone in the upper part of the "upper Member". A second marine flooding event occurred within the *kockelianus* Zone. A third Middle Devonian marine flooding event falls within the very Late Eifelian *ensensis* Zone at the base of the St. Laurent. The lowest *I. obliquimarginatus* in the lower St. Laurent suggests a correlation with the *hemiansatus* Zone (Lower Givetian age), followed by the FAD of *P. timorensis* (*timorensis* Zone).

Oxygen isotope analysis of apatite of Icriodid P_1 elements provides $\delta^{18}O$ values ranging between 17.4 and 21.2 ‰V-SMOW through the middle Grand Tower and St. Laurent formations suggesting considerable changes in subtropical Sea Surface Temperatures and/or changes in the isotopic composition of seawater in the southern Illinois Basin during the Eifelian and Early Givetian. Within the mid-upper Grand Tower Formation, $\delta^{18}O$ values decrease by 4‰ then increase by 2.5‰. In the overlying Saint Laurent Formation, values decrease by 1‰. Assuming an ice-free world at this time and a sea-water composition equal to the present one, paleo-temperature calculations give estimated SSTs varying between 16 and 35° C (Kolodny et al., 1983). If solely due to temperature, these values suggest warming of up to 16°C during the middle Eifelian *australis-kockelianus-ensensis* zones, followed by a stepped 11°C cooling in the Late Eifelian, and 4°C warming in the Early Givetian. The magnitude of these changes argue that temperature alone does not control the observed isotopic variability, and we propose significant changes in the isotopic composition of Eifelian and Early Givetian seawater, perhaps related to sea level variations, occurred in the southern Illinois Basin.

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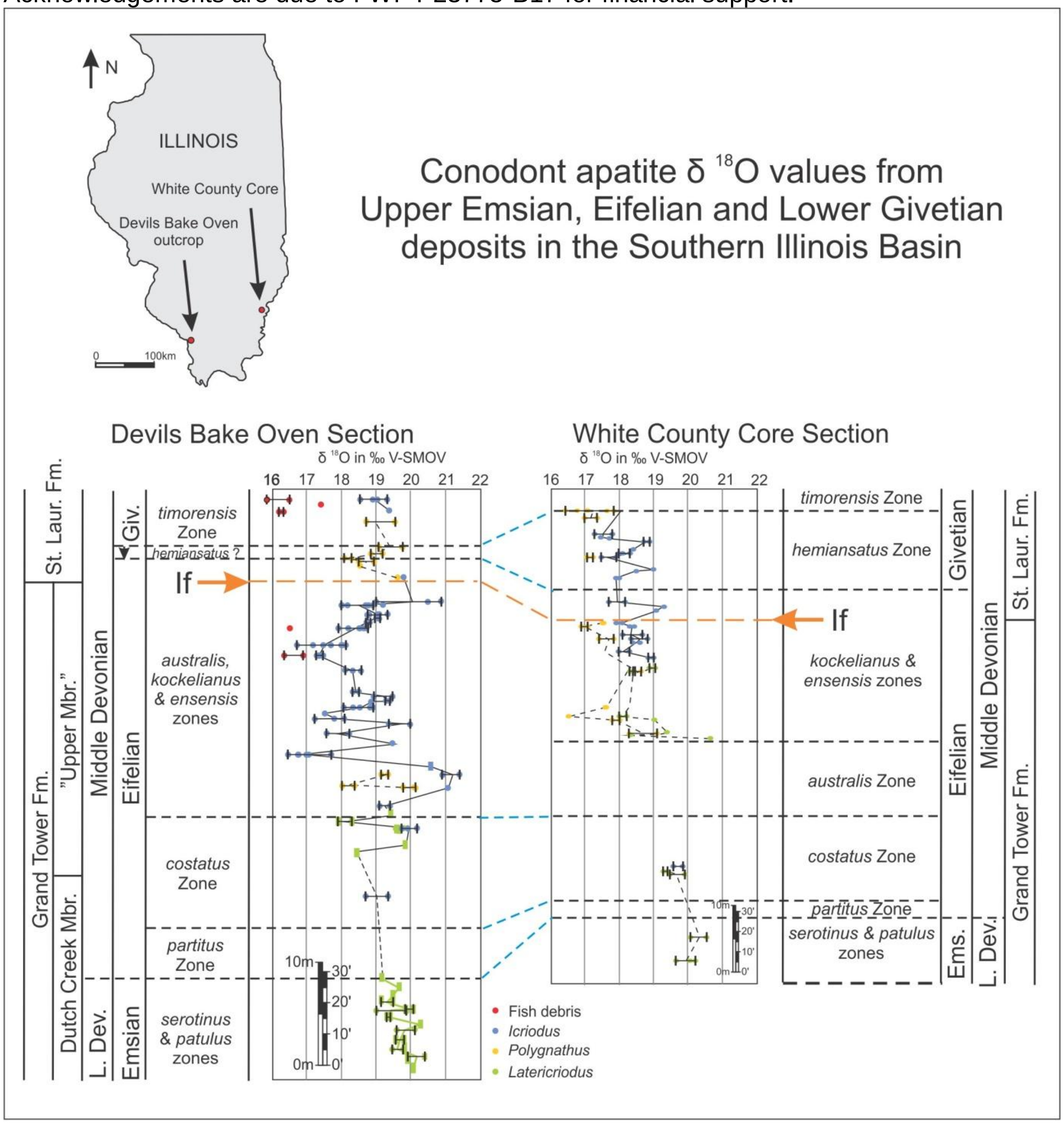

Figure 1 - Oxygen isotope curves based on analysis of conodont apatite of Icriodid, Polygnathid and Latericriodid elements from the Devils Bake Oven outcrop and the White County Core, Southern Illinois Basin.

Magnetic susceptibility variations across the Frasnian-Famennian boundary successions of interplatform basinal carbonates, South China

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In South China, the Devonian Frasnian-Famennian (F-F) boundary defined by the conodont zones is not consistent in different depositional settings (or facies zones), which likely resulted from the facies- or depth-dependent behaviour of the conodonts. To solve this inconsistence, this study presents magnetic susceptibility (MS) records across the F-F boundary from three interplatform basinal carbonate successions at Fuhe, Baisha and Nandong in Guangxi, South China. The Fuhe and Baisha sections, about 10 km apart, were geologically located in a same offshore spindle-shaped basin near Guilin. The Nandong section was located within a basin farther south (Bai et al.,1994). Although, the former two localities were closer to hinterland sources to the north and northeast, they were all surrounded by shallow-water carbonate platforms and isolated from significant continental siliciclastic influxes(Chen et al., 2005). The sampled intervals approximately span from the late *rhenana* to *triangularis* zones(Chen et al., 2013). The basinal F-F boundary successions, in ascending order, are characterized by three lithological units: the basal greenish nodular limestones, the middle darker-coloured calciturbidites and upper greenish to reddish nodular limestones. Of these, the middle unit commonly contains thin horizons of nodular limestones and blacks shales in which the F-F boundary is considered to be placed nearby, although not definitely, in terms of previous conodont zonation and chemostratigraphic data.

The mean MS values in the F-F carbonate successions at Fuhe, Baisha and Nandong are 4.85×10^{-8}, 2.6×10^{-8}, and 2.14×10^{-8} m^3/kg (SI), separately, and show a decreasing trend southward from Fuhe to Baisha, and to Nandong, suggesting a southward decrease in siliciclastic influxes from the hinterlands in the north and northeast(Da Silva et al., 2012). Meanwhile, an apparent negative MS shift was revealed within the middle calciturbidite units at all the three localities, which is likely equivalent to the negative MS shift in response to the Upper Kellwasser Event in Europe and North Africa(Crick et al., 2002). Therefore, these data support the placement of F-F boundary in the upper, but within the calciturbidite horizons, and suggest that the Upper Kellwasser Event in China was induced by the short-term sea-level rise in the context of long-term sea-level fall. These data provide an alternative and better approach to refine the F-F boundary and to understand the related geological events in South China.

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Macrofauna, rock magnetism and sedimentology in the Etroeungt Limestone ('Strunian', Uppermost Famennian) at Avesnelles (northern France).

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The "Avesnelles railway trench" section is located near the eponymic village in the Avesnois, (northern France), about 4 kilometers south-east of Avesnes-sur-Helpe city and along the railway line linking Fourmies and Hirson villages. This section belongs to the southwestern part of the allochthonous Ardennes fold-and-thrust belt. The whole Devonian section is composed of two distinct lithostratigraphical units described by CONIL & LYS (1967, 1970, 1980), which are, in stratigraphic order, the Epinette Shale and the Etroeungt Limestone; both have an uppermost Famennian age ('Strunian'). The Epinette Shale and Etroeungt Limestone have a thickness of about respectively 116.5 and 35.5 meters. The Hangenberg Event is located at the boundary between the Etroeungt Limestone and the black-coloured Avesnelles Limestone. This work focused on the last 20 meters of the Etroeungt Limestone and the first meters above the Devonian–Carboniferous boundary.

The section was investigated for brachiopods, stromatoporoids, rugose corals, foraminifera and also for sedimentological purposes. The upper part of the Epinette Shale is composed of an alternation of shale and lenses of crinoidal limestone in which solitary rugose corals and stromatoporoids are common. The Etroeungt Limestone is mainly composed of slightly argillaceous limestones with common solitary rugose corals and stromatoporoids, and crinoidal limestones with interbedded shales. Besides corals and stromatoporoids, the Etroeungt Limestone also includes brachiopods (orthotetides, rhynchonellides and spiriferides). The Avesnelles Limestone (partly basal Tournaisian) is characterized by an impoverished macrofauna, which mainly includes productidine brachiopods.

Rock magnetism analyses have been conducted on the same samples used for sedimentological purposes. Magnetic susceptibility (MS) data were acquired on about 80 samples with a Kappabridge MFK1-A. Hysteresis measurements and thermomagnetic analyses are in progress on selected samples to determine the magnetic minerals and their grain sizes in order to identify the magnetic mineralogy controlling the MS signal.

Gamma-ray logging realised on the whole section will be compared to MS and microfacies data. K and Th concentrations indicate an increasing trend upwards culminating with the highest values in the latest Famennian beds and a decreasing trend in the basal Tournaisian. U concentrations are apparently following the same evolutions along the section. K and Th concentrations are strongly correlated (r=0.93) suggesting the influx of fine-grained aluminosilicates minerals (detrital) along the section.

Sedimentology and magnetic susceptibility of recent sediments from New Caledonia

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The interpretation of the magnetic susceptibility (MS) signal from ancient rocks is difficult and suffers notably from the scarcity of recent studies. To bring new data, a study of tropical coastal sediments of New Caledonia was launched.

New Caledonia is an island located in the SW Pacific Ocean, close to Australia. This 400 km long and 50 km broad island is surrounded by a nearly uninterrupted reef barrier, isolating a wide lagoon from the open ocean. Depending from the season, the island is influenced by trade winds or by the equatorial low pressure belt. The geological history of New Caledonia is very complex (Cluzel et al., 2012), giving way to extremely varied lithologies, ranging from mantellic rocks to alterites. The erosion of these rocks produces different types of detrital sediments, which are mixed with the indigenous precipitated carbonates. This generates different types of coastal sediments, detritic-, carbonate-dominated or mixed. 22 beaches were sampled (surface sediments and sediments situated at 10-20 cm deep), all around the main island and in the Pin island (S of Grande Terre) and Lifou and Ouvea (Loyalty islands). More than 300 samples were analyzed for granulometry, nature of sediments, MS and geochemistry (major elements). The first results show that:

(1) carbonate sands and silts are characterized by lower MS than detritic sediments;

(2) MS signal of mixed sediments is mostly influenced by the proportion of detritic sediments;

(3) MS signal of carbonate sediments is correlated with granulometry (higher granulometry means higher MS);

(4) if granulometry is constant, MS doesn’t change between 20 cm deep and surface;

(5) when the subsurface sediment is reducing, MS is higher than that from surface sediment.

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Devonian and Carboniferous paleosols of central-southern East European Craton preserving pristine magnetic, mineralogical, and geochemical signatures

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Awareness of numerous paleosols in the Carboniferous of the east European Craton (EEC) grew dramatically over the last decade. Thin paleosols divide the upper Mississippian and Pennsylvanian sections into metre to decametre-scale cyclothems apparently recording the glacioeustatic fluctuations. Last three years brought discovery of several paleosols and pedogenically altered sedimentary beds in the Givetian and at the Frasnian-Famennian (F-F) unconformity of the Voronezh Anticline (south-central EEC). It was found that paleosols in the Givetian – Lower Famennian are rare, and, in difference to the Carboniferous, the meter-scale cyclothemic pattern is lacking.

Thin epicontinental Devonian and Carboniferous formations of the central and central-southern EEC never experienced significant mass transfers, tectonic stress, or burial diagenesis. This makes them excellent objects to study primary environmental signals.

To date, multiproxy data have been obtained from more than 25 Carboniferous and 5 Devonian paleosols and pedogenically altered horizons. These include light and electron microscopy, XRF geochemistry, stable isotopes, XRD mineralogy, and magnetic parameters. This paper describes several examples.

Late Givetian paleosols at Pavlovsk Quarry. Four paleosols have been identified in a 6 m thick section of proximal tuffites and volcaniclastics of the Yastrebovka Formation. All paleosols show peaks in magnetic susceptibility (MS) and Mn/Al ratio. The upper profile includes large (0.5-5 cm thick) sideritic rhizocretions attributed to progymnosperms. Bottom parts of paleosols are enriched in hematite. Siderite shows $\delta^{13}C$ values of -10 to -11‰ PDB and occurs as nodules and veins that range in morphology from decomposed volcanic lapilli to typical pedofeatures. Nodules also contain goethite and quartz.

Unconformity at the F-F boundary has been studied in two localities. This is a composite disconformity composed of a deep paleokarst on the Upper Frasnian Limestone and several thin (5-20 cm) pedogenically altered siliciclastic beds. These ingressive beds are enriched in various forms of Fe^{3+} and contain horizons of ferric ooids. Local stratigraphic gap at this unconformity comprise the two-thirds or even the whole Triangularis zone.

Kholm paleosol and Akulshino palustrine marl of southern Moscow Basin. The Kholm paleosol is a soft montmorillonitic shale that fills karst pockets on the most spectacular disconformity of the late Viséan Oka Group. The Kholm disconformity is blanketed by the dark Akulshino calcimudstone densely penetrated by Stigmaria. Main minerals in this bed are calcite and saponite. Its micritic calcite fraction has very light carbon ($\delta^{13}C$ - 5.9‰ to -10.7 ‰ PDB).

Sennitsa Creek Paleosol at Gory quarry. A well-preserved paleo-pedon of the middle Moscovian age strongly dominated in palygorskite. The profile reveals shallow soil carbonate ($\delta^{13}C$ -4.6‰ PDB), low alumina/bases and Ba/Sr ratios, enhanced Mn and Sr, presence of soil gypsum, and a characteristic MS peak. The profile is weakly magnetic (MS of 1–8 10^{-8} m^3 kg^{-1}, low magnetizations of saturation of 2–4x10^{-5} Am^2 kg^{-1} in bulk samples). Clay fractions of same samples show enhanced values of MS between 10 and 25 10^{-8} m^3 kg^{-1} and SIRM between 20 and 60 10^{-5} Am^2 kg.

Petrophysical and sedimentological record of the Late Silurian Lau event in the shallow water carbonate facies (Prague Synform, Czech Republic)

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Late Silurian (mid-Ludfordian) Lau event (Jeppsson 1998) belongs to important Silurian events reflecting dramatic faunal changes. Due to facies diversity and high-resolution biostratigraphic zonations available, it is also known as *kozlowskii* event (Kriz 1991) in shale facies with graptolite fauna. Generally, the event interval starts just before the last appearance datum (LAD) of the conodont *Polygnathoides siluricus* (Slavik *et al.* 2010) or very close to the LAD of the graptolite *Neocullograptus kozlowskii* (Lehnert *et al*. 2007). These changes are also associated with global positive $\delta^{13}C$ excursion (see Barrick *et al*. 2010). First magnetic susceptibility (MS) measurements combined with gamma-ray spectrometry (GRS) on Lau event sections were reported from Baltica settings by Kozlowski and Sobien (2012) and document negative excursions both for MS and GRS in the event interval. Here we discuss first data from peri-Gondwanan province from two sections in Prague Synform (Pozar 1 and Muslovka quarries) which show different pattern – two-step rise in the MS values. Additional rock magnetic measurements – anhysteretic, isothermal remanent magnetization and S-ratio were applied to obtain information on the MS carriers and their relation to GRS, geochemical and sedimentological signals.

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Element geochemistry, gamma-ray spectrometry and magnetic susceptibility as correlative tools for the Devonian-Carboniferous boundary interval in Europe

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A definition of the Devonian-Carboniferous boundary (DCB) is subject of criticism for many years due to the problems with the index conodont *Siphonodella sulcata*, and should be changed. A multiproxy approach involving geochemical and/or petrophysical correlation methods in combination with biostratigraphy has been successfully used for definition of some Cenozoic stages. Therefore this approach should be used also for seeking for new DCB definition, especially when connected with the global Hangenberg Event (HBE). Presented research has been focused on the element geochemistry (XRF), field gamma-ray spectrometry (GRS) and magnetic susceptibility (MS) survey of DCB sections located in Moravian Karst (CZ), Carnic Alps (A), Ardennes (BE, FR), Montagne Noire and Pyrenees (FR).

The terrigenous elements (e.g. Al, Ti, Zr) measured by XRF show similar component loadings in the principal component analysis, which suggests a common and stable siliciclastic provenance. The negative correlation of these elements with Ca indicates that the variability in the terrigenous elements is driven by the effect of 'dilution' by $CaCO_3$. Regarding the GRS data, covariance between the dose rate ($nGy.kg^{-1}$) and K and Th demonstrates that the GRS signal comes from these elements, which are indicators of siliciclastics content. On the other hand, there is none or very low correlation between the terrigenous elements and MS. Therefore more factors than dilution effect play a role in vertical changes of MS, in contrast to the commonly used paradigm. Very slight covariance shows MS with various paleoredox and paleoproductivity proxies (Mn, Sr, P, Fe, Zn, Ni) which differ between sections. These elements are easily affected during diagenetic processes. Moreover, preliminary rock magnetic analyses (IRM, ARM, s-ratio) show a strong influence of ferromagnetic minerals on MS. Strongly differentiated magnetic mineralogy seems to be a result of diagenetic changes.

The general trends of GRS and XRF values in the DCB sections are as follows: low rates of terrigenous input (e.g. Al, Zr/Al, K/Al) and higher paleoproductivity (e.g. Sr/Al, Mn/Fe) proxies in the Famennian below HBE. Culmination of these values together with increasing Mn/Al proxy was documented in the sections where the HBE interval is dominated by carbonates. Low values of Mn/Al and increase of terrigenous elements take place where the HBE base is associated with shales. It demonstrates the supposed eutrophication that caused carbonate crisis at the base of the HBE *s.s*. An increase in the terrigenous input proxies at the top of the HBE could be connected with sea-level fall (HBE *s.l.*). MS failed to show correlatable patterns.

The XRF and GRS methods are possible to encompass the detrital input or carbonate productivity, which can be correlated between distant areas in the case of global events. The MS signal, in contrary, can be overprinted by local diagenetic features.

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Middle to Late Devonian deposits of the Baruunhuurai Terrane, Western Mongolia

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The Baruunhuurai Terrane in western Mongolia contains a series of Devonian island arc complexes. In 2012, members of the Western Mongolia Devonian Working Group conducted a field workshop in the Baruunhuurai Terrane and investigated the Middle to Late Devonian of Baruunhuurai Formation and the Late Devonian of Samnuuruul Formation, which belong to the Ulaanus and Olonbulag Subterranes, respectively.

The Baruunhuurai Formation in the studied area (GPS coordinates 45°48'36''; 90°53'10'') is characterized by mainly tuffaceous siliciclastics (total thickness; ca. 200m). We divided the formation into three units according to the dominant facies. The lower unit is composed primarily of shale, siltstone, and sandstone. The middle unit is characterized by shale deposition intercalated by thin beds of limestone. The upper unit consists of shale with intercalations of thin sandy unfossiliferous limestone lenses, silty shale to siltstone, and is overlain by a thick interval of yellowish to brown shale. Fossils are represented by rugose and tabulate corals, trilobites, bivalves, brachiopods, bryozoans, crinoids and fish dermal plates. Based on the fossils obtained and the preliminary lithofacies analysis, the Baruunhuurai Formation in this area was deposited in a shallow marine nearshore setting with regionally dispersed limestone lenses produced by locally restricted fossil communities and intermittent volcanically derived sediment.

The Samnuuruul Formation cropping out in the studied area (45°17'06''; 90°57'31'') is divided into four units. The siltstone of the lowermost unit (ca. 330 m) yields the Late Famennian cephalopods. Units 2 and 3 (an interval of approximately 74 meters) consist of dark greenish gray siltstones and shales interbedded with thin, but laterally continuous, limestones. Higher in the section are a series of vertical siltstone beds with very abundant macrofossils including brachiopods, solitary rugose corals, branching tabulate corals and phacopid trilobites. The top of the formation (= unit 4) is characterized by a series of coarsening upward sandstones and conglomerates, with interbedded siltstones and shales often containing macroscopic plant debris. This sequence grades upwards into a weathered shale culminating in a series of ?soil horizons, carbonaceous shales, and coal which likely cross the Devonian / Carboniferous boundary. Within this transition is a 0.5 meter black shale, which appears to be correlative with the Hangenberg Event.

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Wavelet Analysis of Paleomagnetic Data

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Wavelet analysis provides an automatic localization of specific behaviors such as cyclic patterns or discontinuities, both in time and frequency. Existence of periodic signals embedded into the paleointensity record and the magnetic properties are detected by the wavelet transform.

With the help of Paleomagnetic Data, we can study in-situ stress, magnetostratigraphy, paleomagnetic core orientation, sedimentology, fault studies, fracture studies, tectonic history, magnetic properties, etc. Paleomagnetic data is quite useful for hydrocarbon exploration , drilling operations and exploitation. High-sensitivity cryogenic magnetometers (SQUID Superconducting Quantum Interference Device) permits paleomagnetic applications in weakly magnetized sedimentary rocks. One of the most useful paleomagnetic applications is drill-core orientation, which is important for determining fracture orientations, for stress analysis, and for determining sediment transport directions. Weaker paleomagnetic signals, reflecting earlier thermal, diagenetic, or depositional magnetizations are also commonly preserved in sedimentary rocks and can also be used to orient core. Paleomagnetic work on subsurface cores from hydrocarbon reservoirs demonstrates the benefits of paleomagnetically oriented cores for understanding depositional trends, fracture patterns, and in situ stress, with important consequences for permeability anisotropy. In paleomagnetic core orienting, the most precise orientations are obtained from fine-grained rocks, and the method requires some prior knowledge of the region to establish the reference magnetization direction. However, paleomagnetic core-orienting requires no special downhole equipment and can selectively orient only those intervals of core that are of interest after visual inspection. The paleomagnetic core orienting technique has been successfully tested against the multishot technique. Paleomagnetic core-orientation is employed for characterizing reservoir anisotropy. Paleomagnetic core-orientation permits access to the vast resource of reservoir anisotropy data in previously unoriented cores in storage throughout the world. Paleomagnetic core-orientation is a versatile technique with proven accuracy not only in vertical wells, but also in slant holes and horizontal wells.

Magnetic Susceptibility measures the ‘magnetisability’ of a material. In the natural environment, the magnetisability tells us about the minerals that are found in soils, rocks, dusts and sediments, particularly Fe-bearing minerals. The magnetic properties of sea sediments can be used for stratigraphic correlation and as proxies for climatic and environmental change. However, to obtain a better understanding of magnetic properties and a clearer interpretation of the environmental magnetic record, it is necessary to learn more about the sources of magnetic minerals and post-depositional changes in magnetic minerals caused by diagenesis/authigenesis and by biologic processes, and to thoroughly examine the climatic response of the primary magnetic components. Grain size and magnetic susceptibility which is highly suffered by milieu and some natural agencies. Magnetic susceptibility, as we have seen, is basically a measure of how ‘magnetisable’ a material is. Magnetic susceptibility is basically measuring the total attraction of the rock’s magnetic stability. Rocks with relatively high concentrations of magnetite, like basalt, have much higher magnetic susceptibility values than rocks, such as limestone which usually have no magnetite crystals at all.

Geochemistry and Cyclostratigraphy of Magnetic Susceptibility data from the Frasnian-Famennian event interval in western Canada: Insights into the pattern and timing of a biotic crisis

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Cyclostratigraphic calibration of magnetic susceptibility data along with stable isotopic and geochemical proxy data for redox, productivity, and detrital input from western Canada provide insight into the pace and timing of the Late Devonian, Frasnian-Famennian (F-F) biotic crisis. Two organic-rich shales that, in much of the world, display geochemical anomalies indicating low oxygen conditions and carbon burial characterize the F-F event. These events, commonly referred to as the Lower and Upper Kellwasser events (LKE & UKE), have been linked to the evolutionary expansion of deeply rooted terrestrial forests and the associated changes in soil development, chemical weathering and Late Devonian climate.

Our geochemical data from both events record relatively high levels of redox sensitive trace metals (Mo, U, V), proxies for biological productivity (Ba, Cu, Ni, Zn), and detrital input (Al, Si, Ti, Zr). C stable isotopic data generated from organic matter records a 3-4‰ positive excursion during each event. Both events are recorded in lowstand and early transgressive facies. These data corroborate hypotheses about enhanced biological productivity, driven by heightened terrestrial detrital input, leading to low oxygen conditions and decreases in biotic diversity during during relatively low stands of Late Devonian sea level. This is corroborated by recent biogeographic studies that demonstrate that the biotic crisis was partly driven by interbasinal invasion of generalist species during transgressive events that affected biodiversity by reducing vicariant speciation.

Age dating of events in deep time is problematic due to insufficient biochronologic control. Each event falls within one conodont biostratigraphic zone, with durations on the order of 0.5-1.0 Ma. Time series analysis of high-resolution magnetic susceptibility data identified 16 long eccentricity cycles (405 ky) during the Frasnian and one in the earliest Famennian stage. The geochemical anomalies associated with the LKE and UKE in western Canada are recorded over 7 and 14 m of stratigraphic section respectively. These strata represent only a portion of a 405 ky long eccentricity cycle and astronomical tuning implies that the LKE likely occurred during a single short eccentricity cycle (100 ky) while the UKE was more protracted, lasting approximately two short eccentricity cycles (200 ky). The events are separated by 1.5-2 long eccentricity cycles indicating that they occurred between 600 and 800 kyr apart. This work demonstrates the utility of long time series of magnetic susceptibility data used in conjunction with other multi-proxy data to provide insight into events in geologic time. These results corroborate earlier studies that pointed out fundamental differences in the LKE and UKE wherein the LKE appears to be related to relatively rapid climate and sea level change whereas the UKE seems to be related to more protracted climatic cooling associated with the beginning of an icehouse climate.

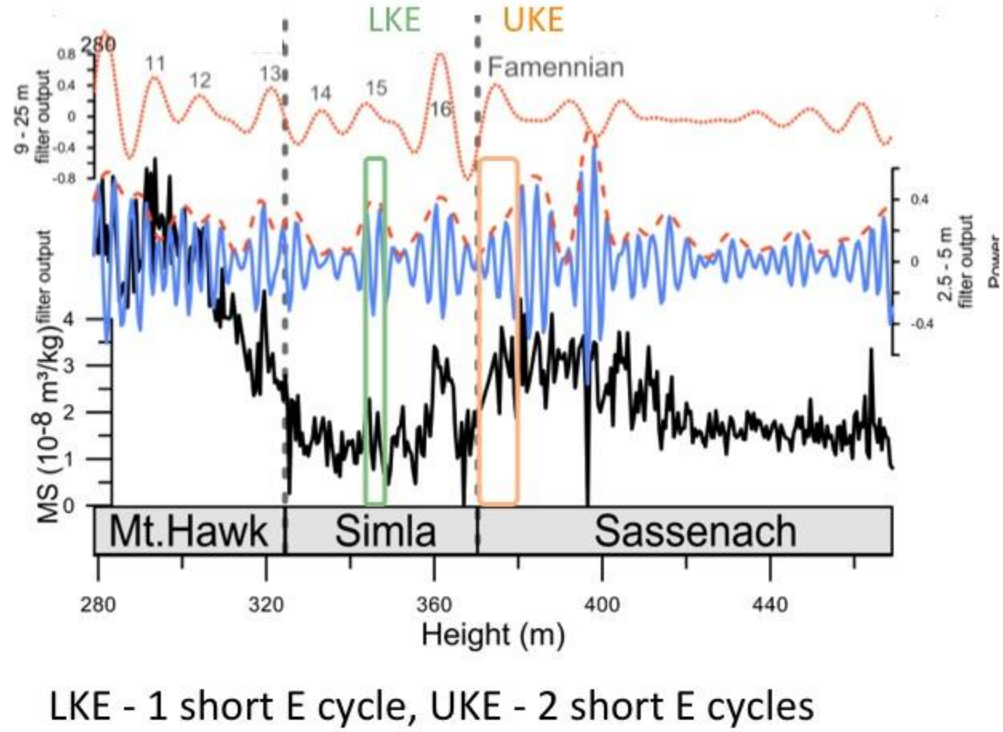

Figure 1. MS data (black) and modeled long (orange) and short (blue) eccentricity cycles. The isotopic anomalies for the LKE (green box) and UKE (orange box) are recorded over 1 and 2 short eccentricity cycles respectively. The events were thus approximately 100 and 200 ky in duration respectively, confirming earlier observations that the LKE was a shorter-term event.

Bulk geochemical expression of Late Visean - basal Serpukhovian cyclothemes of southern Moscow Basin, Russia

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Bulk XRF geochemical logs from two late Viséan – basal Serpukhovian shallow-marine cyclothemic sections of southern Moscow Basin (Novogurovsky and Polotnyanyi Zavod quarries) provide a record of changing sedimentary processes within the basin of sedimentation and in provenance areas. Geochemical proxies used in this study include: percent total Na_2O, MgO, Al_2O_3, SiO_2, P_2O_5, S, K_2O, CaO, TiO2, V, Cr, MnO, Fe_2O_3, Co, Ni, Cu, Zn, As, Rb, Sr, Ba, Pb, Hg, Zr, Mo, Sn, Cd, Ce, Cs, Ga, La, Nb, Sc, Y, Yb, and Ge. Some elements are normalized to Al and module proxies.

Our data suggest that the sedimentary archive records pulsing character of basin fill during the late Viséan transgression. Multiple subaerial exposure surfaces are clearly marked on geochemical proxies with local maximums of concentrations of Fe_2O_3, SiO_2, Al_2O_3, TiO_2, Na_2O, K_2O, sulphidophile elements and Ba.

The proportions of CaO, MgO, and SiO_2 reflect the alternation of facies in cyclothems. Geochemical data reveal dominance of calcite and essential lack of dolomite in Mikhalovian and Venevian parts as the quantity of MgO does not exceed 2%. MgO is bounded in clay minerals of weathering profiles (paleosols and paleokarsts under subaerial exposure surfaces, Alekseeva et al. 2012). Na_2O and K_2O provide maximum concentrations in limestones in Novogurovsky section and Venevian part in Polotnyanyi Zavod quarry section. Consistent increase of Na_2O and K_2O suggests increasing fixation of these elements in clay minerals in terrigenous beds in the Mikhalovian part of the Polotnyanyi Zavod section. Patterns in distribution of Na_2O+K_2O, TiO_2/Al_2O_3, and normalized to Al sulphidophile elements (Pb, Zn, Cu, ….) show similarity of the Mikhalovian in Novogurovsky and the Venevian in Polotnyanyi Zavod. Distinct peaks of Pb/Al, Zn/Al, Cu/Al, ….. elements occur in clay parts of calcareous sediments which underlie subaerial exposure surfaces in the Mikhalovian at Polotnyanyi Zavod. Peaks of Rb and Sr occur in the lower part of bed №16 in Novogurovsky and in the shale of bed 8 at Polotnyanyi Zavod.

The most informative in terms of correlation based on geochemical data are paleosols and paleokarsts under subaerial exposure surfaces, marked by distinct maximums of SiO_2, Al_2O_3, TiO_2, Fe_2O_3, MgO, Zr and sulphidophile elements. Data, provided by normalized to Al sulphidophile elements proxies, allows to educe patterns in geochemistry of calcareous facies and to give more precise variations fixation in sedimentary environments.

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Mississipian/Pennsylvanian boundary interval in Central and East Iran.

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Continental shelf deposits in Late Devonian had been extended further to Early Carboniferous in most localities of Iran. As a result of tectonic movements, related to the Hercynian epirogenetic phase, the extensive areas of Iranian platform sustained erosion, so that much thickness of lower Paleozoic rocks is missing. The variations of Carboniferous lithofacieses in Iran are considerable and Early Carboniferous platform, in Central and East Iran, covers structural blocks with different sedimentary characteristics which faults had main role in their separation. Middle Carboniferous event coinsides with a strong regression documented by terrigenous sedimentation, cross bedding facies and oolitic sandy limestones. Carboniferouis deposition in Iran reveals as a rich faunal oolitic limestone hosting conodonts together with brachiopods, gastropods, bryozoans, ostracods. Investigating the Carboniferous platform sediments and fauna in Central and East Iran a tendency of connection with the Global biological events was distinguishable.

Our interest was focused on Middle Carboniferous Event and its influence on conodonts. Besides of their connection with anoxic events, Carboniferous bio-events are more often connected with sea- level changes - transgressions and regressions than to anoxic events. Concerning bio-event characteristics of Carboniferous conodont fauna there are indicators for global changes at Mississippian/Pennsylvanian boundary.

The studied Sheshangosht, Kale-Sardar, Asadabad, Darchaleh and Howz-e-Dorah sections are examples for replacement of dominant in Early Carboniferous genera *Gnathodus* and *Lochriea* by post-event dominant genera *Declinognathus* and *Idiognathodus* in Late Carboniferous. After such global biological event as extinction, there is a demonstration of drastically increasing diversity of new conodont genera descendent of *Gnathodus*.

The Mississippian/Pennsilvanian boundary is based on indicated two conodont zones – *Rahistognathus muricatus* Zone and *Declinognathus noduliferous* Zone. *Rahistognathus muricatus* Zone is the uppermost conodont zone in Mississippian (Upper Serpukhovian), whereas *Declinognathus noduliferous* Zone is a marker of Middle Carboniferous boundary and is the lowermost conodont zone in Pennsylvanian. The Mississippian/Pennsilvanian boundary is placed at the first appearance of *Declinognathus noduliferus* (Ellison & Graves) which coincides with the global eustatic event reflected in shallowing of basins. Six conodont zones are indicated in studied sections including Mississippian/Pennsilvanian boundary.