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Joint Meeting and Field-Workshop

International Symposium in Mongolia

Ulaanbaatar, Mongolia 5-18th August 2014

ABSTRACT VOLUME

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5-18 August 2014
Ulaanbaatar

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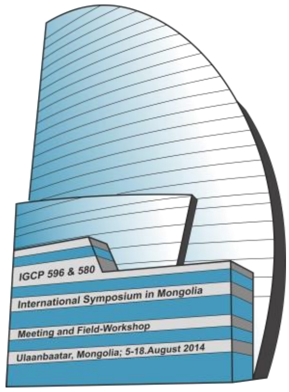

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Preface

IGCP 596 (duration: 2011-2015) focuses on Mid-Paleozoic climate and biodiversity. The Mid-Paleozoic was a time of dynamic long-term climate change accompanied by significant changes in biodiversity. The preliminary goal of this project is to increase the record of biodiversity and clarify links between specific biodiversity patterns and paleoclimate. In order to reach the goal, we would like to enhance the discussion within the project with multidisciplinary approaches such as geochemistry and geophysics as well as paleoclimate modeling. Therefore the *International Symposium* in Mongolia will take place jointly with the IGCP 580 (Application of Magnetic Susceptibility on Palaeozoic Sedimentary Rocks). We wish you fruitful discussions and hope this symposium will provide an important step towards the final project year of IGCP 596.

The Organizing Committee

CONFERENCE PROGRAMME

Mon, 4 August. Registration (16:00-18:00) & Ice-breaker (18:00-20:00)
Tue, 5 August. Opening of Conference & Scientific Session 1
Wed, 6 August. Scientific Session 2 & IGCP Joint Business Meeting
Thu, 7 August. Social day & Conference Dinner
Fri, 8-Mon, 18 August. Field-Workshop in western Mongolia

Schedule for the Field-Workshop
Fri, 8 August. Flight from Ulaanbaatar to Khovd
Sat, 9 August. Car-ride towards south to the field area (section is located directly at the Mongolian-Chinese border)
Sun, 10-Fri, 15 August. Working days
Sat, 16 August. Return to Khovd; Camping overnight
Sun, 17 August. Stay in Khovd
Mon, 18 August. Flight from Khovd to Ulaanbaatar

5. August 2014

Opening of the Conference (09:00-9:20)

KÖNIGSHOF, P., SUTTNER, T.J., BONCHEVA, I., IZOKH, N.G., TA HOA P., CHAROENTITIRAT, T., WATERS, J., KIESSLING, W. & KIDO, E. - Climate Change and Biodiversity Patterns in the mid-Palaeozoic (IGCP 596) – introduction and report.

Morning session (09:20-12:00)
S. 1.1. Devonian-Carboniferous sedimentary and bio-facies record **Chair: WATERS, J.*

1. ARIUNCHIMEG, Ya. - Devonian biostratigraphy of Mongolia **(Keynote lecture)**; 09:20-9:50
2. GATOVSKY, Y. - Devonian and Carboniferous boundary on the western slope of the Middle Urals; 09:50-10:10
3. KÖNIGSHOF, P., BAHRAMI, A., BONCHEVA, I., YAZDI, M. & EBRAHIMI KHAN-ABADI, A. - Devonian and Carboniferous shallow water sections in Central Iran; 10:10-10:30
4. ARIUNCHIMEG, Ya., NYAMSUREN, G. & ARISTOV, A.V. - Devonian/Carboniferous boundary intervals in Mongolia; 10:30-10:50

Coffee Break;10:50-11:20

5. KÖNIGSHOF, P., KOMATSU, T., KATO, S., HIRATA, K., TAKASHIMA, R., OGATA, Y., OBA, M., NARUSE, H., TA HOA, P., NGUYEN, P.D., DANG, H.T., DOAN, T.N., NGUYEN, H.H., SAKATA, S. & KAIHO, K. - Devonian-Carboniferous transition in the Paleotethys (Pho Han Formation, Vietnam); 11:20-11:40
6. STEPHENSON, C.A. - Deciphering the Origin of Plant Silica Bodies: A Novel Investigation into the Earliest Phytoliths in Earth's History; 11:40-12:00

Lunch; 12:00-14:00

Afternoon session (14:00-16:10)
S. 1.2. Multidisciplinary approach: Geochemistry & Geophysics (part1) **Chair: VALENZUELA-RÍOS, J.I.*

1. DE VLEESCHOUWER, D., DAY, J.E., WHALEN, M. & CLAEYS, P. - A high-resolution chronology for the late Frasnian constructed by integrated bio-, chemo- and cyclostratigraphy **(Keynote lecture)**; 14:00-14:30
2. SLAVÍK, L., VALENZUELA-RÍOS, J.I., CHADIMOVÁ, L., LIAO, J.-C., HUŠKOVÁ, A. & CALVO, H. - HI-Res correlation of the Lochkovian-Pragian (Lower Devonian) sections in the key regions of peri-Gondwana; 14:30-14:50

Coffee Break;14:50-15:20

3. DE VLEESCHOUWER, D., DAY, J.E., GOUWY, S., MACLEOD, K. & CLAEYS, P. - Eifelian climatic and environmental change inferred from magnetic susceptibility and stable isotope records: Grand Tower and St. Laurent Formations, southern Illinois Basin (USA); 15:20-15:40
4. PAS, D., POULAIN, G., LABBAY, C., DA SILVA, A.C., CORNET, P., DEVLEESCHOUWER, X., DE VLEESCHOUWER, D., HLADIL, J. & BOULVAIN, F. - Diversity and correlation of Givetian records in southern Belgium; 15:40-16:10

6. August 2014

Short announcement (9:10-9:20)

Morning session (9:20-12:00)

S. 2.1. Biodiversity patterns and evolution of fossils **Chair: PAS, D.*

1. KIDO, E. & SUTTNER, T. - Middle Devonian biotic crisis in the Carnic Alps: results of the Project FWF P23775-B17 **(Keynote lecture)**; 09:20-09:50
2. VALENZUELA-RÍOS, J.I. & CARLS, P. - Lower Devonian Conodont successions from Nigüella (Iberian Chains, Spain) with emphasis on evolutionary events; 09:50-10:10
3. HUNTER, A.W., RUSHTON, A.W.A. & STONE, P. - Protasterid ophiuroid from the Early Devonian of the Fox Bay Formation Falkland Islands; unravelling the missing fossil record of Upper Palaeozoic Asterozoans from Gondwana; 10:10-10:30

Coffee Break;10:30-11:00

4. LIAO, J.-C. & VALENZUELA-RÍOS, J.I. - Conodont Biofacies Evolution from the Eifelian to the Middle Frasnian (Middle and Upper Devonian) of the Spanish Central Pyrenees; 11:00-11:20
5. MOTTEQUIN, B. & POTY, E. - The uppermost Famennian Hangenberg Event in the Namur–Dinant Basin (southern Belgium); 11:20-11:40
6. WATERS, J.A., SUTTNER, T.J., KIDO, E. & CARMICHAEL, S.K. - Rebound of the Shallow Marine Ecosystem after the Frasnian – Famennian Extinction Event (Late Devonian) in the Central Asian Orogenic Belt: data from China and Mongolia; 11:40-12:00

Lunch; 12:00-14:00

Afternoon session (14:00-16:40)

S. 2.2. Multidisciplinary approach: Geochemistry & Geophysics (part2) **Chair: SERSMAA, G.*

1. CARMICHAEL, S.K., WATERS, J.A., SUTTNER, T.J., KIDO, E., BATCHELOR, C.J., DEREUIL, A.A., MOORE, L.M. & SANCHEZ, S.K. - Terrane accretion, sediment geochemistry, and ocean anoxia in the Late Devonian: the role of paleogeography and tectonic environment in black shale formation during the Kellwasser and Hangenberg Anoxia Events **(Keynote lecture)**; 14:00-14:30
2. BATCHELOR, C.J., DREW, C., CARMICHAEL, S.K. & WATERS, J.A. - Zircon Age Dating of The Late Devonian Heishantou Formation; 14:30-14:50

Announcement (14:50-15:20)
Social day, Conference Dinner and Field Workshop

Coffee Break;15:20-15:50

S. 2.3. Poster presentation (15:50-16:10)

1. YURYEVA Z.P. - Lower and overlying Devonian deposits (northern part of the Timan-Pechora Region, Russia)
2. SUTTNER, T.J. & KIDO, E. - Evidence for the Lochkov-Prag Event in the Carnic Alps
3. TAGARIEVA, R.CH. - Pathological forms of conodonts of the genus *Palmatolepis* from the Frasnian-Famennian boundary interval (Upper Devonian) in the South Urals
4. SUTTNER, T.J. & KIDO, E. - Conodont distribution across the Kačák crisis from the shallow marine Kellergrat Formation and the pelagic Valentin Formation (Carnic Alps)
5. RĂDAN, S.C. – Magnetism of Cretaceous Bauxites from Pădurea Craiului (Apuseni Mountains, Romania): Implications for Near-Surface Lens Exploration
6. RĂDAN, S.C. - A Magnetic Multi-proxy Approach of the Loess-Palaeosoil Sequences in Southern Romania, in a Chronostratigraphic - Palaeoenvironmental - Palaeoclimatic Context: An Overview and New Results

IGCP 596 and 580 Official Joint Business Meeting (16:10-16:40)

7. August 2014

Social day

Visiting the Mineralogical Museum of the MUST, followed by a guided tour through Ulaanbaatar; Conference Dinner

Abstracts

Abstracts

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Devonian biostratigraphy of Mongolia

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Devonian stratified formations are widespread throughout the territory of Mongolia and they are quite well studied (Figure 1). Significant biostratigraphic works on the Devonian have been made by ALEKSEEVA, MENDBAYAR (1981), SHARKOVA (1981), ALEKSEEVA (1993), ERLANGER (1994), OLENEVA (2000), ALEKSEEVA, AFANASIEVA & SHISHKINA (2001).

Since 1924 many species of the Devonian fauna and flora have been collected from various Mongolian localities and numerous data on Devonian biostratigraphy have accumulated. Devonian of Mongolia subdivided into following regional horizons based on the study of brachiopods: Borteeg (66), Biger (55), Chuluun (53), Tsagaanhaalga (54) and Ulgii (8) (Figures 1, 2). Bryozoans (ARIUNCHIMEG, 2000, 2010), rugosa, tabulate, heliolitids (PALEONTOLOGY…, 2003) are widespread and some of them are important reef-buiding organisms. Crinoids also are widespread but are less studied (DUBATOLOV et al., 1982; WEBSTER & ARIUNCHIMEG, 2003). Radiolarians are present in siliceous rocks formed in deeper water (KURIHARA T. et al., 2009). Tentaculites, ammonoids, ostracodes and trilobites occasionally seen in some deposits. Conodonts are the most important Devonian taxa for correlation (Nyamsuren, 1998; Wang et al., 2003, 2005, 2008, 2009).

Boundaries between series and stages unclear, except the boundary between Emsian and Eifelian which is marked by the characteristic conodont species. In Mongolian Altai (MARKOVA & SHARKOVA, 1977) and Eastern Gobi (SUETENKO et al., 1975) the upper Silurian and lower Devonian sediments were not deposited. The earliest Devonian conodont zonal fossil has been found from the “Gavuu Member” in Mandalovoo area (WANG et al., 2003), and the latest Famennian conodonts were found in several sections in Mongolia ((KURIMOTO et al., 1997; NYAMSUREN, 1998; WANG & MINJIN, 2004), but the base and top of the Devonian still cannot be precisely defined at this time.

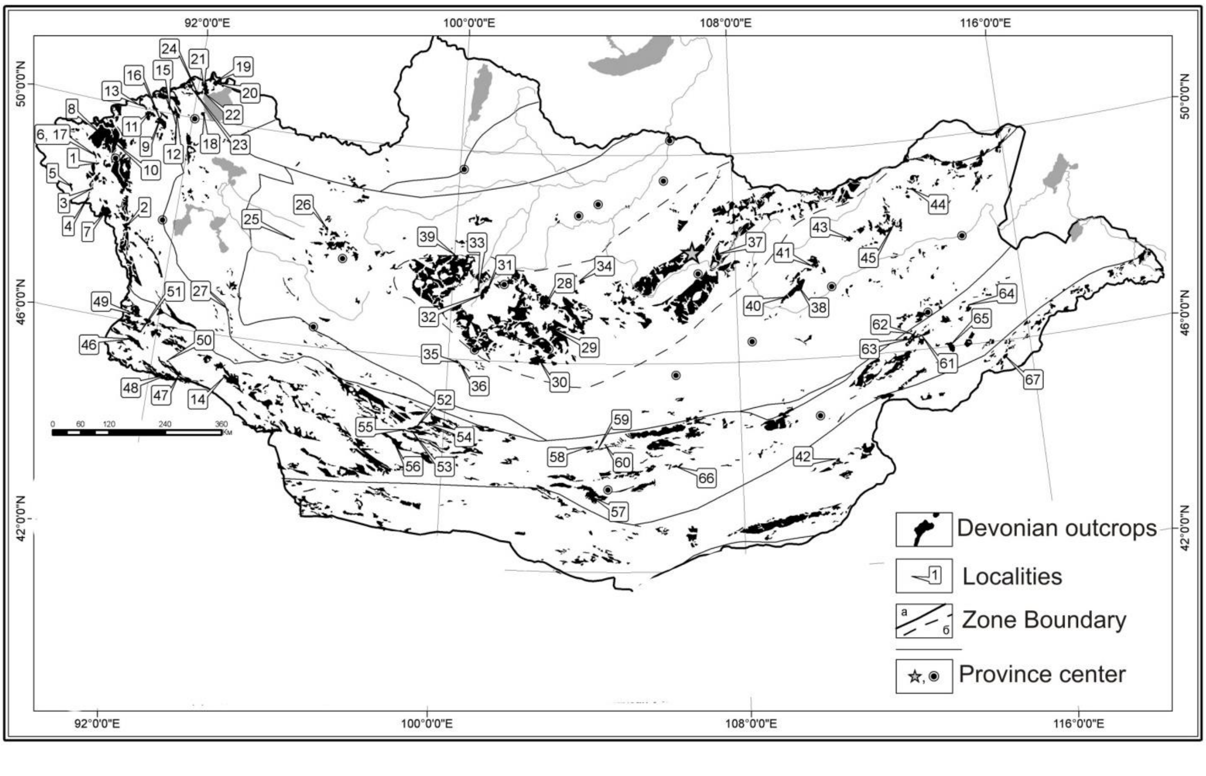

Figure 1: Map showing the distribution of Devonian outcrops and studied sections.

International chart				Regional stratigraphic units					
					zona**, lona* and beds with fauna				
System	Series	Stage	conodont zone (Nyamsuren*, 1998, Wang**, 2005)	horizon	Bryozoans (Ariunchimeg, 2010)	Brachiopods (Alekseeva et al., 2006)	Tabulate (Sharkova, 2003)	Rugosa (Ulitina, 2009)	Stromatoporoids (Bolishakova, 2003)
Devonian	Upper	Famennian	praesulcata* expansa		Intrapora lanceolata	Cyrtospirifer julii		Amplexus echinatus	
			postera trachytera marginifera rhomboidea crepida triangularis						
		Franian	linguiformis rhenana jamieae hassi punctata transitans falsiovalis	Ulgii	Sulcoretepora consona	achmet*		Aulacophyllum exignum Temnophyllum ruzhentsevi	
	Middle	Jivetian	disparilis*		Minussina maculosa	pseudocheehiel*		Cystiphylloides radugini	Stromatopora colliculata, Idiostroma cumulus
			hermanni-cristatus						
			varcus						
			ensensis						
		Eifelian	k.kockelianus	Tsagaanhaalga	Reteporina coalescens	Elymospirifer divaricatiformis*	Alveolites levis grandis**	Heliophyllum halli Pseudozonophyllum versiforme	
			k.australis						
			cost.costatus						
			cost.partitus*						
	Lower	Emsian	cost.patulus*		Mongoloclema ignota	Leptodontela zmeinogorskiana*	Emmonsia taltiensis**	Tabulophyllum major Spongophyllum massivum	
			serotinus	Chuluun		Deltospirifer amurensis*	Oculipora angulata**	Msrtiniphyllum latum, Lyrielasma aggregatum	
			inversus*		Amurodictya tsahirensis	Spinatrypa galinae*			
			gronbergi			Uncinulus tsakhirinicus*			
			excavatus						
		Pragian	kitabicus	Biger	Lioclema netshlavense	Spirigerina supramarginalis*	Favosites admirabilis-Riphaeolites zogtensis**	(Pseudomicroplasma)	
			pireneae						
			kindlei						
			sulcatus						
		Lochkovian	pesavis	Borteeg	Eridotrypa minuta	Howellella angustiplicata*	Favosites socialis**	Spongophylloides dubrovensis	Gerronostroma concentricum Stromatopora racemifera
			delta						
			eurekaensis				Favosites favositiformis**		
			woschmidti** postwoschmidti**						

Figure 2: Zonation and correlation of some important Devonian organic groups in Mongolia.

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Devonian/Carboniferous boundary intervals in Mongolia

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The study of the Devonian-Carboniferous stratigraphy and paleontology has been carried on more than 80 years and merely limited to the benthic macrofossils. Only during the past 20 years conodonts had been employed in biostratigraphic analyses.

Upper Devonian-Lower Carboniferous deposits are distinquished in several areas of Mongolia.
1. Small areas of the southern side of the Ih Dariv mountain range of Baidrag-Orhon area. They are represented by a flysh series with a thickness of about 400 m and consisted of siltstone, siliceous aleurolite and sandstone with plant fossils (BADARCH, 1990)
2. The late Paleozoic Hangai group which is widely distributed in the Bayanhongor area is subdivided into the Erdenetsogt, Tsetserleg, Jargalant and Baidrag formations. The conodont fauna from the red chert of Erdenetsogt formation is assigned to the Famennian (KURIMOTO et al., 1997).
3. Gurvan Haraat mountain, located in the western part of Gobi area. Sediments represented by Alagbayan formation, made up the sandstone, siltstone, argillite, intermediate and acidic lavas and their tuff. The Alagbayan formation reaches up to 3000 m thick and contains the remains of Late Devonian flora and Early Carboniferous brachiopods (GEOLOGY…, 1973).
4. In the Jinst subzone of Gobialtai zone the middle-upper Devonian volcanogenic-terrigenous Gobialtai formation and lower Carboniferous terrigenous-carbonate Bayansair formations were known. Ammonoids, single rugose coral and brachiopods characteristic for Wocklumeria zone were found in the upper part of Gobialtai formation. Sparse brachiopods and crinoids are known in the lower part of Bayansair formation (ALEKSEEVA,1993).
5. In the Mandalovoo subzone of Gobialtai zone Devonian-Carboniferous undivided sediments distributed along the northern margin of Mandal-Ovoo massiv. The upper Devonian is named the Orynshand formation /290m/ based on conodonts (ALEKSEEVA, 1993). Besides conodonts the crinoids and rare brachiopods and bryozoans were found.
6. In the Deliinhar subzone of Gobialtai zone near the Khabtagai mountain tuff congomerates with thin sandstone layer containing brachiopods and bryozoans known from Devonian-Carboniferous rests conformably on the terrigenous sediments with Famennian brachiopods, gastropods and bryozoans. (CARBONIFEROUS..., 1980).
7. In the Baruunhuurai zone the Late Famennian Samnuuruul formation is dominated by volcanically derived fine grained clastic deposition with sporadic limestones in the lower and middle part. The upper part consists of sandstones that grade upwards into a terrestrial coal producing early Carboniferous Olonbulag formation. Brachiopods, gastropods, cephalopods, rugose and tabulate corals, crinoids, trilobites, bivalves, small foraminifera and ostracodes were found in Samnuuruul formation (KIDO et al., 2013).

One of the crucial problems in the study of stratigraphy is the boundary between systems. It is impossible to solve this problem depending merely on the study of the benthos, so special investigations focused on the Devonian /Carboniferous boundary were done in the frame of the activity of the Russian Mongolian Paleontological joint expedition. Aristov V.A. and Nyamsuren G. /1998/ have analysed several sections in different regions of country and conodonts were studied at a bed by bed level in the shelf deposits in two subzones of Gobi Altai zone located in 400 km apart: Shine Jinst and Mandalovoo areas. As a result of this study the section Murugtsug khudag in Mandalovoo area was recommended as D-C boundary stratotype in Mongolia. The proposed level of boundary between these two systems were drawn within the thin-bedded limestones /140 m/ in the lower part of the Arynshand formation. In the upper part of this section in variously-bedded dark grey limestone with total thickness of 100 m early Tournasion conodont zones *duplicata*, *crenulata* and *isostica* were determined.

In the Mandalovoo area conodonts were discovered in the Arynshand formation from two sections: Bayan-Khoshuu ruins and Murugtsug khudag. Type section of the formation is Murugtsug khudag and Nyamsuren (ARIUNCHIMEG & NYAMSUREN, 2001) suggested the existence of praesulcata zone based on the presence of *Polygnatus symmetricus*, which are appear from the base of this zone, and the existence of the sulcata zone based on the presence of Pseudopolygnathus nodomarginatus, which appear from the base of sulcata zone. The Arynshand formation were assigned to the upper Famennian and lower Carboniferous, because the interval between horizons yielding praesulcata and sulcata is about 3 m thick and located within undivided limestone. The base of the Arynshand Formation in the type area cannot be precisely correlated with the base of this formation in the Bayan-Khoshuu ruins section. Based on conodonts Siphonodella cooperi, S.cf.crenulata and S. cf.isostica from the Bayan-Khoshuu ruins section WANG et al. (2004) concluded that Arynshand Formation is early Carboniferous rather than Devonian-Carboniferous. Also he mentioned that the global Hangenberg Event has strong incluences on sedimentation and there should be some lithologic changes within the Devonian-Carboniferous boundary beds (WANG et al., 2005).

The finding of the mixed conodont fauna of Devonian and Carboniferous suggests the reworking, which are typical for the tectonically active zones, such as “Mongolia” (Kononova and Ovnatonova, personal communication, 1998). More detailed study near the Devonian-Carboniferous bouindary is requied.

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Zircon Age Dating of The Late Devonian Heishantou Formation

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The Late Devonian Zhulumute, Hongguleleng and Heishantou Formations in northwestern Xinjiang, China, contain the Frasnian-Famennian (F-F) boundary and the Devonian-Carboniferous (D-C) boundary in a highly fossiliferous shallow marine setting. The Kellwasser ocean anoxia event below the F-F boundary is present in the Hongguleleng and underlying Zhulumute Formations, and the Hangenberg ocean anoxia event is present at the D-C boundary in the Heishantou Formation. Both the Kellwasser and Hangenberg events are evident via multiproxy geochemical evidence rather than the visible black shales commonly associated with these intervals.

The lowermost Zhulumute Formation is a poorly cemented, poorly sorted sandstone with porphyritic basalt pebbles and subhedral albite grains in an illite or illite/chlorite matrix. The cements are variable in composition and amount, and are composed of calcite, quartz, or titanite. The Hongguleleng Formation represents a deepening sequence and grades into intercalated siltstones and limestones containing storm deposits. There is no evidence for an unconformity at the Zhulumute-Hongguleleng contact or at the F-F boundary. The Heishantou Formation is primarily composed of siltstones with a base of intercalated siltstones and limestones. There is likewise no evidence for an unconformity at the D-C boundary. An ash layer is evident in the Heishantou Formation (35 meters from the base) consisting angular rock fragments and plagioclase needles, identifiable under energy-dispersive X-ray spectroscopy.

U-Pb geochronology is being conducted at the University of Chapel Hill in North Carolina to age date zircons in the Heishantou Formation using standard hydrodynamic and heavy-liquid techniques. Zircons will be analyzed with a Thermal Ionization Mass Spectrometer (TIMS). Future work includes age dating both the Hongguleleng and Zhulumute Formations to constrain complete stratigraphy of our section.

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Terrane accretion, sediment geochemistry, and ocean anoxia in the Late Devonian: the role of paleogeography and tectonic environment in black shale formation during the Kellwasser and Hangenberg Anoxia Events

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The presence of black shale is commonly associated with both the Late Devonian Kellwasser and Hangenberg ocean anoxia events in epicontinental settings across Laurussia, Gondwana, Siberia, and South China. These two ocean anoxia events are associated with two mass extinction events at the Frasnian-Famennian (F-F) and the Devonian-Carboniferous (D-C) boundaries, respectively. Black shales are not present, however, in a continuous section of sediments exposed at the Boulongour Reservoir in northwestern Xinjiang Province, China (the Zhulumute, Hongguleleng, Hebukehe, and Heishantou Formations) that spans both the F-F boundary and the D-C boundary in a highly fossiliferous shallow marine setting (SUTTNER et al., 2014). Tectonic and simple geochemical models of this region suggest that the Boulongour Reservoir section represents an isolated island arc in an accreting terrane within the Central Asian Orogenic Belt (CAOB) (CARMICHAEL et al., 2014). This location is therefore quite different from the extensively studied sections that span the F-F and D-C boundaries that are located in epicontinental basins and along continental margins.

In the absence of a visible black shale facies, a multiproxy approach must be used to detect marine anoxia, primary productivity, and changes in sea level. Whole rock geochemistry (including major, minor, trace, and rare earth element analyses), mineralogy, scanning electron microscopy and cathodoluminescence microscopy, stable isotope analyses (carbon, oxygen, and strontium), and magnetic susceptibility are all necessary tools to assess the presence and degree of anoxia, sea level fluctuations, and sediment source. In addition to standard whole rock redox proxies (V/Cr, Mo, authigenic U, Ce anomalies, etc.), the size and distribution of pyrite framboids can also be used to assess redox conditions. Proxies for enhanced productivity include excess SiO_2 (in the form of authigenic quartz silt) as well as whole rock Ba, Ag, and P. Our multiproxy geochemical and mineralogical evidence indicates that the Kellwasser Event is present in the Hongguleleng and underlying Zhulumute Formations (CARMICHAEL et al., 2014), and the Hangenberg Event is present at the D-C boundary in the Heishantou Formation.

The sediment source, continuity of sedimentation, and rate of sedimentation across these boundary intervals is herein reassessed using geochemistry in addition to field relationships. Sedimentation rates across the deepening interval (represented by the Hongguleleng and Hebukehe Formations) are relatively slow, with estimates ranging from 6-17 mm/ka, while rates rapidly increased to 50 mm/ka at the D-C boundary in the Heishantou Formation, consistent with global increases in sedimentation rates during this interval. There is no evidence for major unconformities throughout the section. Trace element concentrations associated with detrital minerals provide constraints on changes in sediment source through time (Figure 1; Figure 2); the sediments that were impacted by the Kellwasser Event all have an island arc volcanic signature (Figure 1), while the sediments at the D-C boundary that were impacted by the Hangenberg Event show evolved arc volcanism and several syncollisional magmatic signatures (Figure 2). These trace element signatures directly contrast the detrital signatures for the Late Devonian type section in the Holy Cross Mountains in Poland, which represents within-continent, cratonic sediment sources rather than island arcs or accreting juvenile crust. Our mineralogical observations and geochemical data further indicate that the sediments of this particular island arc complex record accretionary processes throughout the Late Devonian, and possibly show microcontinent or ribbon continent development by the time of the Hangenberg Event.

The Boulongour Reservoir sediments are unique in that they not only show evidence for the Kellwasser Event in a shallow, open ocean, island arc complex, but also for terrane accretion and magma evolution over the course of 16 million years. The presence of these anoxia events in an island arc environment indicates that anoxia in the Late Devonian was global in extent, and likely due to eutrophication of surface waters rather than global oceanic overturning (CARMICHAEL et al., 2014). This eutrophication model explains the presence of thick black shale units in anoxic to euxinic epicontinental basins (which act as organic carbon traps and contain abundant runoff from continental highlands), and the absence of significant black shales along steep, juvenile terranes (which do not allow the accumulation of sediment or organic carbon in restricted, anoxic environments) (CARMICHAEL et al., 2014) and in shallow reefs on continental margins that are adjacent to deep sea environments (BOND et al., 2013). Future work in the CAOB will help constrain the tectonic controls on black shale deposition and preservation during the Kellwasser and Hangenberg Events.

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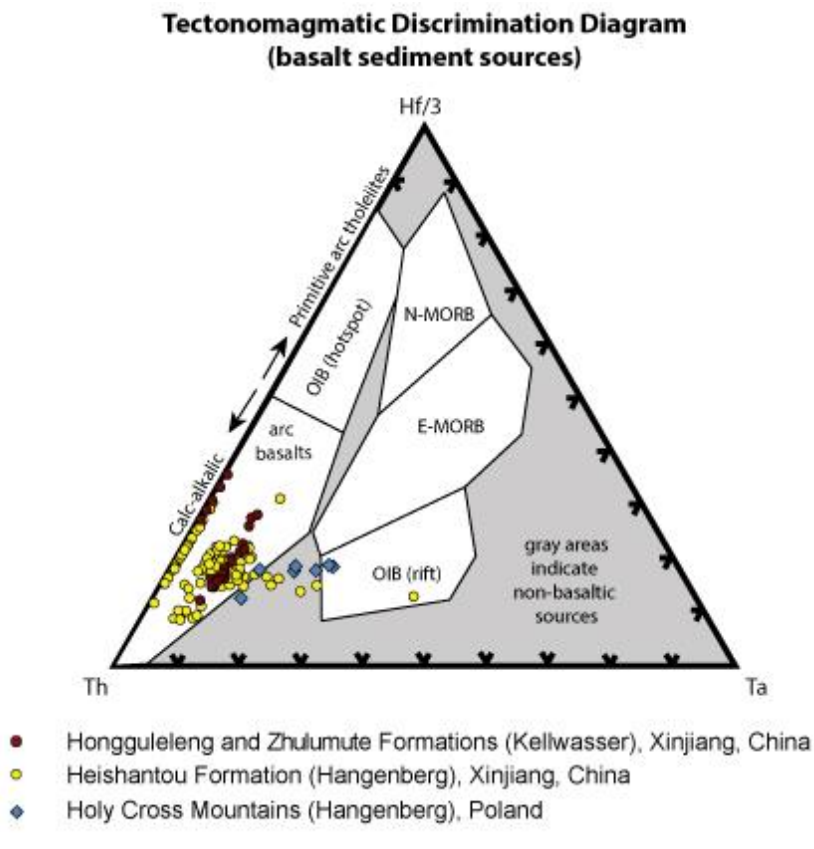
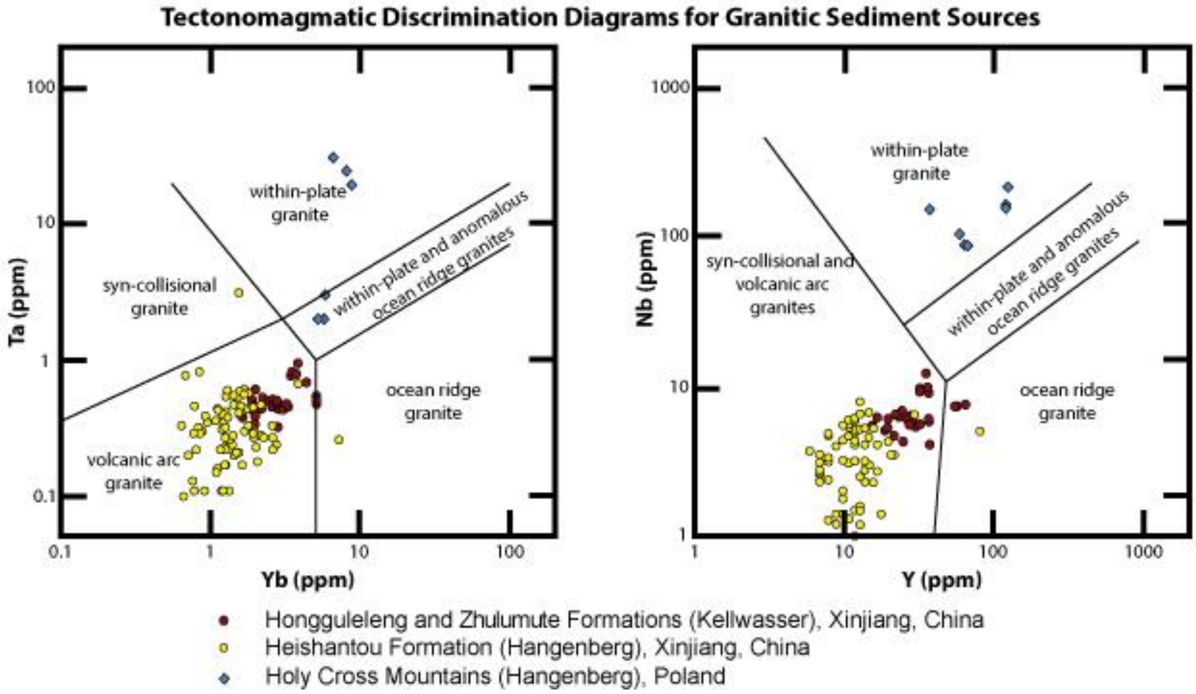


Figure 1



Tectonomagmatic Discrimination Diagrams for Granitic Sediment Sources
within-plate granite
syn-collisional granite
within-plate and anomalous ocean ridge granites
ocean ridge granite
volcanic arc granite
Ta (ppm)
Yb (ppm)
syn-collisional and volcanic arc granites
Nb (ppm)
Y (ppm)
Hongguleleng and Zhulumute Formations (Kellwasser), Xinjiang, China
Heishantou Formation (Hangenberg), Xinjiang, China
Holy Cross Mountains (Hangenberg), Poland

Figure 2

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Eifelian climatic and environmental change inferred from magnetic susceptibility and stable isotope records: Grand Tower and St. Laurent Formations, southern Illinois Basin (USA)

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Very little is known about the Earth's climate dynamics during the Middle Devonian. Discussion even exists about the general state (greenhouse versus icehouse) of the climate system during the Middle Devonian. Oxygen isotope paleothermometery of ELRICK et al. (2009) and JOACHIMSKI et al. (2009), suggests cool to intermediate tropical sea surface temperatures, whereas the extensive reef constructions of the Middle Devonian suggest a supergreenhouse climate (COPPER, 2002). In this study, we construct proxy records that cover the entire Eifelian (Middle Devonian) Stage in order to assess climatic and environmental variability during that period. In order to do so, we sampled the Grand Tower and St. Laurent Formations (southern Illinois) for magnetic susceptibility, $\delta^{13}C_{carb}$ and $\delta^{18}O_{carb}$ measurements.

The Lower and Middle Devonian strata in the southern Illinois Basin (Illinois, USA) yield diagnostic conodont faunas. The study of conodont samples of the Grand Tower and St. Laurent Formations provide good stratigraphic control on the position of the Emsian-Eifelian and Eifelian-Givetian stage boundaries in the Grand Tower type section along the Mississippi river (Jackson Co., SW Ill.) and in the Illinois State Geological Survey White County core (White Co., SE Ill.). Therefore, we are able to analyze the geophysical and geochemical proxy records against a robust biostratigraphic framework and we identify the Kačák-*otomari* positive $\delta^{13}C_{carb}$ excursion beginning in the *hemiansatus* zonal interval (lower St. Laurent Formation). Moreover, we evaluate a possible imprint of astronomical climate forcing and tentatively interpret low-frequency variations in the different proxy records as the imprint of 405-kyr eccentricity forcing.

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A high-resolution chronology for the late Frasnian constructed by integrated bio-, chemo- and cyclostratigraphy

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The Late Devonian biotic crisis is characterized by the Kellwasser extinction events near the Frasnian - Famennian boundary. This time interval includes one of the most prominent mass extinction events in Earth history, mostly affecting benthic marine organisms that lived in shallow tropical seas. Despite the severity of this crisis, no consensus exists on the cause of the mass extinction, as the evaluation of different hypotheses is hindered by the absence of a high-resolution and accurate chronology. In this study, we aim to increase the stratigraphic resolution of this interval by the application of cyclostratigraphic and astrochronologic techniques.
The late-latest Frasnian Lime Creek Formation (Fm.) in the Iowa Basin was sampled in the Cerro Gordo Project Hole #1 (CG-1) from northern Iowa and the H-32 core from southeastern Iowa. Conodont biostratigraphy (CG-1 and H-32) and $\delta^{13}C_{carb}$ provide good initial time control. For example, a pronounced shift in $\delta^{13}C_{carb}$ values from -1‰ to +2‰ in the upper Cerro Gordo Member is interpreted as an expanded record of the Lower Kellwasser $\delta^{13}C_{carb}$ excursion. For the cyclostratigraphic purposes of this study, we carried out bulk magnetic susceptibility measurements at high sampling resolution on both cores (10 cm resolution in CG-1; 4 cm resolution in H-32). The magnetic susceptibility series of both cores display the imprint of 100-kyr and 405-kyr eccentricity. The cyclostratigraphic interpretation in terms of eccentricity cycles, allows the correlation of both records and suggests that the studied interval covers the last ~2.6 million years of the Frasnian. In other words, the base of the Lime Creek Formation corresponds to the base of Frasnian Long Eccentricity Cycle 11 (Fr-LEC 11). In accordance with previous cyclostratigraphic studies in Canada (DE VLEESCHOUWER et al., 2012) and Poland (DE VLEESCHOUWER et al., 2013), the Lower Kellwasser $\delta^{13}C_{carb}$ excursion occurs within Fr-LEC 15, approximately 800 thousand years before the Frasnian-Famennian boundary. These results thus confirm that it is possible to establish global cyclostratigraphic correlations, provided that a clear astronomical imprint can be identified in the studied records and represent the first steps towards a high-resolution chronology for the Frasnian - Famennian boundary interval.

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Devonian and Carboniferous boundary on the western slope of the Middle Urals

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The Devonian–Carboniferous (D/C) boundary marks one of the major extinction events of the Phanerozoic, during which shallow- and deep-marine organisms and terrestrial ecosystems were severely affected (KAISER et al., 2006, 2011). The D/C boundary was defined in the section La Serre trench E' (Montagne Noire, France) at the base of bed 89. The criterion chosen for its definition was entry of the conodont *Siphonodella sulcata* in a supposed gradual transition from *S. praesulcata* (FLAJS & FEIST, 1988). The GSSP was accepted and ratified by the International Union of Geological Sciences (IUGS) in 1990 (PAPROTH et al., 1991). Soon after the ratification, problems arose concerning both the lithology of the La Serre section and the identification of *Siphonodella sulcata* (KAISER, 2009; CORRADINI et al., 2011; KAISER & CORRADINI, 2011). Due to these problems, the ICS decided to reconsider the GSSP. A Task Force, composed of SDS and SCS members, was established with the goal of finding a new criterion for the definition of the boundary, and a new section (CORRADINI et al., 2011).

The Urals, especially the southern and middle parts, include a range of important D/C boundary sections with different facies and faunas. Gumerovo horizon was adopted as a basal horizon of the Carboniferous system in stratigraphic schemes of the Urals and Russian Platform (STRATIGRAPHIC ..., 1993).

Typical sections of the horizon are on the western slope of the Southern Urals, stratotype - in the Zigan section and parastratotype - in the Sikaza section (KOCHETKOVA et al, 1988). The D/C boundary sections Usuyli and Ryauzyak are also well-known in this area (SULTANAEV, 1973; KOCHETKOVA et al., 1985). Currently, a number of the researchers proposed a new version of the stratigraphic Tournaisian stage cheme where gumerovo horizon is divided into two parts, of which the lower part in volume zones miospore LE and PLE with conodonts zone *S. praesulcata* related to Devonian, and the top with miospore PM - to Carboniferous. New data on the distribution of conodonts in the above sections showed close proximity of the lower zone boundaries *Siphonodella sulcata* and *pussilites* (Zigan section). Evolutionary transition from *Siphonodella praesulcata* to *S. sulcata* clearly traced in the southern Urals and the most well-fixed in the Usuyli section (PAZUKHIN, 2008).

The most comprehensive sections of the Devonian/Carboniferous boundary in the Middle Urals are the Kosaya Rechka section, located in the lower reaches of the Vizhaya River, in 1 km to the north-west of the city Gornozavodsk, and the Shirokovsky section, located on the southwestern outskirts of the village Shirokovsky on both banks of the Kosva River, Perm Administrative area. Famennian include two regional horizons: Kushelga and Lytva. The Kushelga Horizon is widespread throughout the West Uralian Folded Zone. It consists of darkgrey and grey layered limestones with brachiopod shellstones at the base. The top contains a reference bed overfilled with ammonites of the *Clymenia-Gonyoclymenia* Zone. It is connected with the Murzakaevo deposits by a gradational transition. In some sections (Sikaza) the Kushelga limestones overlie the Makarovo horizon with a gap. The thickness varies from 1–2 m to 20 m. The stratigraphic interval of the Kushelga Horizon embraces the conodont *postera* Zone and lower part of *expansa* Zone. The faunal assemblages characteristic of the Kushelga Horizon are represented by the following conodonts: *Palmatolepis gracilis gracilis* Br. et Mehl, *Pa. gracilis sigmoidalis* Zieg., *Pa. postera* Zieg., *Pa. perlobata schindewolfi* Müll., *Polygnathus experplexus* Sand. et Zieg., *Po. obliquicostatus* Zieg., *Po. extralobatus* Schäf., *Po. znepolensis* Spas., *Bispathodus stabilis* Br. et Mehl, *B. jugosus* (Br. et Mehl), *Pseudopolygnathus brevipennatus* Zieg., *Ps. controversus* Sand. et Zieg., *Mashkovia tamarae* Kon. et Paz., *Branmehla inornata* Br. et Mehl, *Mehlina strigosa* Br. et Mehl. The stratotype of the Lytva horizon is located in the Kamen Bazis section, in the upper reaches of the Lytva River on the western slope of the Middle Urals (Perm Administrative area); however it has no boundaries with both underlying and overlying deposits. In early stratigraphic schemes the Lytva Horizon was situated at the base of the Tournaisian Stage of the Carboniferous System. In 1986, the position of the Devonian/Carboniferous boundary was adopted by the Uralian Interdepartmental Stratigraphic Commission at the base of the Gumerovo Horizon, or the bottom of the conodont *sulcata* Zone, and the Lytva Horizon was included into the Famennian Stage of the Devonian System. In the West Uralian Folded Zone the Lytva Horizon includes the Abiyuskan and Zigan beds (STRATIGRAPHIC…, 1993). The Abiyuskan beds consist of dark-grey, mainly finely clotted, sometimes crinoid and finely brecciated limestone, with silica lenses and nodules. The thickness of the Abiyuskan beds is in the range of 10–15 m. In the conodont zonation scale the Abiyuskan beds correlate with the middle-upper part of *expansa* Zone. The typical conodonts are as follows: *Palmatolepis gracilis gracilis* Br. et Mehl, *Pa. gracilis expansa* Sand. et Zieg., *Pa. gracilis sigmoidalis* Zieg., *Pa. postera* Zieg., *Polygnathus communis* Br. et Mehl, *Polygnathus delicatulus* Ulr. et Bass., *Po. experplexus* Sand. et Zieg., *Po. inornatus* (Br. et Mehl), *Po. vogesi* Zieg., *Po. znepolensis* Spas., *Patrognathus donbassicus* Lipn., *Radolepis* sp. nov., *Pseudopolygnathus brevipennatus* Zieg., *Ps. controversus* Sand. et Zieg., *Ps. dentilineatus* Br., *Ps. marburgensis trigonicus* Zieg., *Mashkovia tamarae* Kon. et Paz., *Bispathodus aculeatus aculeatus* (Br. et Mehl), *B. jugosus* (Br. et Mehl), *Br. inornata* (Br. et Mehl), *Mehlina strigosa* Br. et Mehl. The Zigan beds consist of dark-grey thin slabby bioclastic limestones, which are poorly dolomitized and sometimes contain silica concretions with algal nodules. The thickness of the deposits is 0.3 m to 2.5–2.8 m. The stratigraphic interval of the Zigan beds embraces the conodont *praesulcata* Zone. The typical faunal assemblages include: *Palmatolepis gracilis gracilis* Br. et Mehl, *Pa. gracilis sigmoidalis* Zieg., *Pelekysgnathus* sp. nov., *Popolygnathus communis* (Br. et Mehl), *Po. inornatus* (Br. et Mehl), *Pseudopolygnathus primus* (Br. et Mehl), *Siphonodella praesulcata* Sand., *Bispathodus aculeatus aculeatus* (Br. et Mehl), *B. stabilis* (Br. et Mehl). The Lower Tournaisian Substage involves the Gumerovo and Kalapovo (Malevka and Upa) horizons. The Gumerovo horizon constitutes a transitional straton within the boundary Devonian/Carboniferous interval. It is characterized by the following faunal assemblages: *Siphonodella praesulcata* Sand., *S. sulcata* Hud., *Polygnathus inornatus* (Br. et Mehl), *Pseudopolygnathus nodomarginatus* Br., *Ps. conili* Bouck. et Groes., *Popolygnathus communis* Br. et Mehl, *Po. purus subplanus* Voges, *Po. purus purus* Voges, *Bispathodus aculeatus aculeatus* (Br. et Mehl), *B. aculeatus anteposicornis* (Scott). The stratigraphic interval of the Gumerovo horizon in the conodont zonation scale corresponds to the Early *sulcata* Subzone. As an independent regional stratigraphic unit the Malevka horizon was established by A. Sokolskaya (1941) in the rank of beds on the East European Platform (village of Malevka, near Moscow). In the Middle Urals it is recognized in the sections, where it is represented by grey, dark-grey, sometimes slightly dolomitized, brecciated organogenic limestones with silica lenses. The horizon is closely connected with the overlying Upa horizon and often treated together with the latter. The minimum thickness of the Malevka horizon is found in the Kosaya Rechka section, being likewise small in the other sections (1–5 m). Paleontologically the Malevka horizon is characterized by the following faunal assemblages: *Polygnathus communis* Br. et Mehl, *Po. purus purus* Voges, *Po.* aff. *corrugatus* Br., *Po. inornatus* Br. et Mehl, *Po*. aff. *parapetus* Druce, *Po. vogesi* Zieg., *Pseudopolygnathus conili* Bouck. et Groes., *Ps. fusiformis* Br. et Mehl, *Ps. primus* Br. et Mehl, *Ps. vogesi* Rhodes, Austin et Druce, *Ps. inaequalis* Voges, *Ps. dentilineatus* Br., *Ps. nodomarginatus* Br., *Siphonodella sulcata* Hud., *S. duplicata* (Br. et Mehl), *Bispathodus aculeatus aculeatus* (Br. et Mehl), *Bispathodus aculeatus anteposicornis* (Scott). The Malevka horizon corresponds to the conodont Late *sulcata* Subzone and *duplicata* Zone. The Upa horizon was first described by Struve in 1886 (STRUVE, 1886) on the Upa River in the southern Moscow Region (East European Platform). In the Middle Urals this horizon has been well studied in the sections. It consists of grey, dark-grey silicified and organogenic limestones, dolomitized in some layers. One can often observe dolomites and limestones with interbeds and lenses of cherts. The Upa deposits are connected by a gradational transition with the Malevka Horizon; the boundary between the horizons is determined by the appearance of foraminifera of the *Chernyshinella crassitheca* Zone. The boundary with the overlying Cherepet horizon is also gradational. The thickness of the Upa horizon is 7.0 m to 17.5 m. The characteristic faunal assemblages are as follows: *Polygnathus communis* Br. et Mehl, *Po.* aff. *corrugatus* Br., *Po. inornatus* Br. et Mehl, *Pseudopolygnathus conili* Bouck. et Groes., *Ps. fusiformis* Br. et Mehl, *Ps. inaequalis* Voges, *Ps. nodomarginatus* Br., *Ps. primus* Br. et Mehl, *Siphonodella sulcata* Hud., *S. duplicata* (Br. et Mehl), *S. cooperi* Hass, *S. obsoleta* Hass, *S. sandbergi* Klapp., *S. carinthiaca* Schänl. The Upa horizon terminates the Lower Tournaisian Substage. In the conodont zonation scale it corresponds to the stratigraphic interval of the *belkai* Zone.

Some of the Devonian and Carboniferous conodonts from the Shirokovsky section shown on the plate 1.

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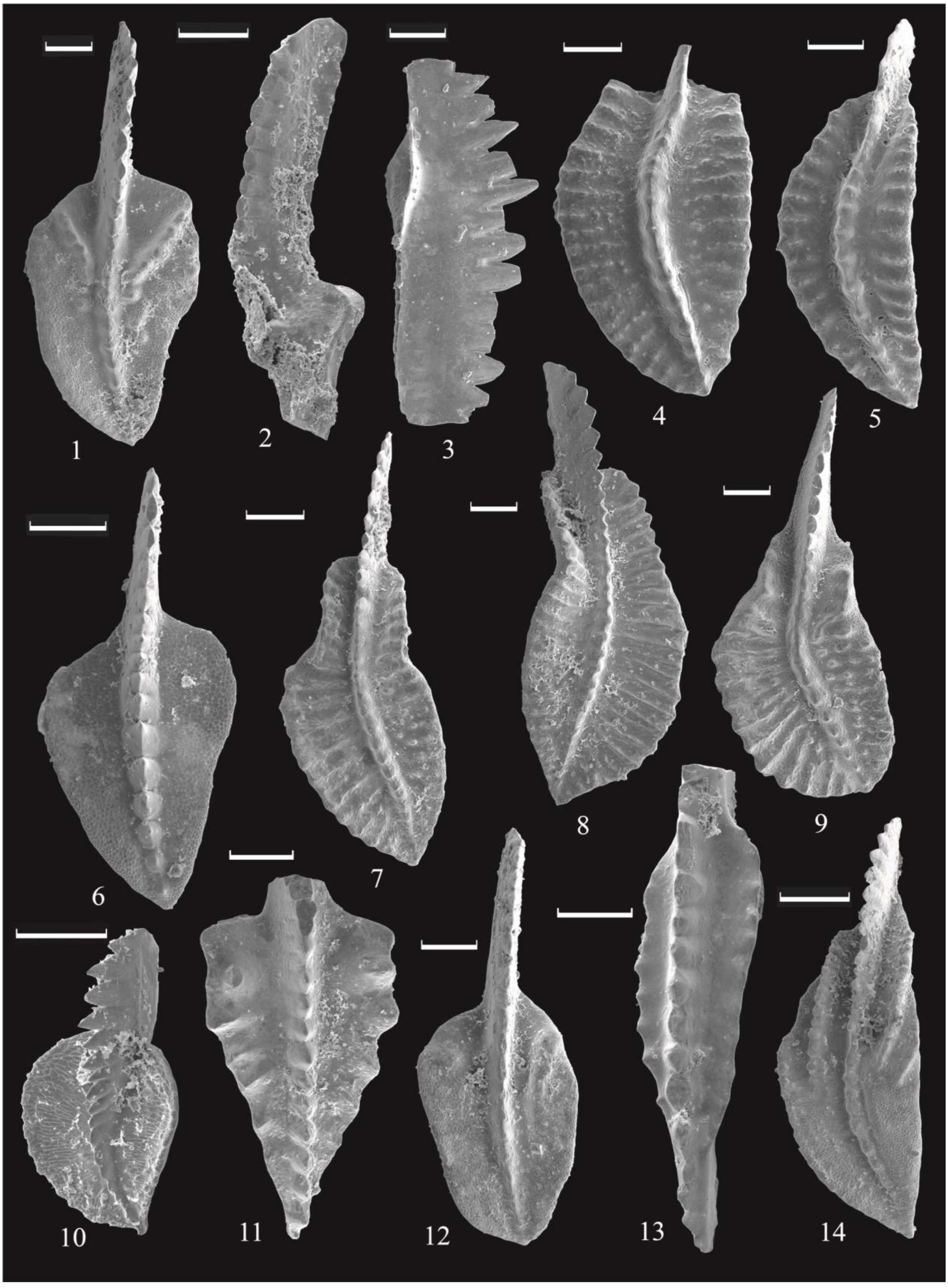
Explanation of Plate 1

Middle Urals, Shirokovsky section
Figs. 1-3 - Upper Devonian, Famennian, Lytva horizon (sample S-38)
Figs. 4-14 - Lower Carboniferous, Tournaisian, Gumerovo and Kalapovo (Malevka and Upa) horizons (samples S-15, S-27, S-28, S-31)
The length of a ruler marks 100 microns.

fig. 1. *Polygnathus vogesi* Ziegler
fig. 2. *Palmatolepis gracilis sigmoidalis* Ziegler
fig. 3. *Branmehla inornata* (Br. et Mehl)
fig. 4, 5. *Siphonodella sulcata* (Huddle)
fig. 6. *Polygnathus purus purus* Voges
fig. 7-9. *Siphonodella duplicata* (Br. et Mehl)
fig. 10. *Polygnathus* sp.
fig. 11. *Polygnathus triangulus* (Voges)
fig. 12. *Polygnathus communis carinus* Hass
fig. 13. *Pseudopolygnathus fusiformis* Br. et Mehl
fig. 14. *Siphonodella belkai* Dzik

Plate1



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Protasterid ophiuroid from the Early Devonian of the Fox Bay Formation Falkland Islands; unravelling the missing fossil record of Upper Palaeozoic Asterozoans from Gondwana

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The Late Palaeozoic is dominated by echinoderms, so much so that it is often referred to as the "Age of the Crinoid" (KAMMER & AUSICH, 2006); to date, asterozoans have tended to be interpreted as a minor component of the echinoderm biota, due to their poor preservation potential. However, examining exceptionally preserved examples from the Hunsrück Slate, Germany (GLASS & POSCHMANN, 2006) and the New York State, USA (HOTCHKISS, 1976, 1993), it is clear that a preservational bias, along with a lack study of the meso-fossil remains, has masked this diversity. Furthermore, asterozoan occurrences in Gondwana are comparatively rare compared to those in Larentia; this is especially true for those in the Devonian. In this study we look at one of the few exceptionally preserved asterozoan examples, an ophiuroid, from the South American continent and its significance for the evolution of the clade. This represents the first occurrence of a 'starfish' or asterozoan from the Falkland Islands (RUSHTON & STONE, 2011). This ophiuroid was discovered in the Lower Devonian Fox Bay Formation, first described by Charles Darwin for its rich fauna in brachiopods (DARWIN, 1846). The ophiuroid belongs to the genus Protaster (Figure 1) established from a series of Middle-Upper Ordovician taxa from The Lady Burn Starfish Beds, Girvan, Scotland, UK and Bohemia, Czech Republic (SHACKLETON, 2005). This genus persists into the Late Palaeozoic remarkably unchanged in its morphology. However we show that this is in fact a distinct genus within a much larger, distinct clade of asterozoans that retained this relatively primitive morphology into the Permian. In this study we show that this single example is in fact part of the a much wider fauna that includes the fauna from the Bokkeveld Group, Cape Province, South Africa (SHARPE & SALTER 1856, JELL & THERON, 1999) and Precordillera of Argentina (HAUDE, 1995).

Palaeobiogeographic reconstructions of these three terrains (MARSHALL, 1994) show that by studying these faunas as a distinct suite of palaeoenvironments we can track the evolution of asterozoan communities through the Devonian, recognizing the appearance of derived taxa and the persistence of archaic forms that appeared in the Ordovician/Silurian. We will explore the factors that could have been responsible for these changes in the asterozoan echinoderm bioaccumulations and meadows, and make recommendations on how this important record could be utilised further.

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Figure 1: New Protaster asterozoan from the Fox Bay Formation (Lower Devonian), East Falkland (Scale 5cm).

Middle Devonian biotic crisis in the Carnic Alps: results of the Project FWF P23775-B17

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The FWF (The Austrian Science Fund) Project P23775-B17 focuses on the Middle Devonian climate perturbation and their effects on the tropical coral communities. In order to identify intervals related to climate change, sections of three different paleoenvironmental settings (pelagic, distal slope, and shallow water platform) in the Carnic Alps (Austria-Italy) were investigated in detail. Methods used include microfacies analysis, conodont biostratigraphy and the application of geochemistry (carbon and oxygen isotopes, TOC and sulfur content, major and trace elements) and geophysics (magnetic susceptibility and gamma-ray spectrometry).

The Hoher Trieb Formation (Eifelian - Frasnian) of Zuc di Malaseit Basso section (Mt. Zermula, Lanza, Italy) consists of gray to dark gray platy limestone beds with the intercalation of black shale and chert, which are accumulated at the distal slop. Within the *kockelianus* – *hemiansatus* conodont zones, three remarkable depressions of $\delta^{13}C_{carb}$, which correspond with increasing values of TOC and sulfur are observed. The second depression of $\delta^{13}C_{carb}$ between the beds ZMB23 to ZMB20 starts with the largest negative shift of carbon isotope values in the section, ranging from 2.2 to 0.1 ‰. Within these beds, a positive spike of MS value is observed just after a minor negative shift. Such a minor negative shift is also found in the Th/U values (GRS) of the same interval. We considered that the shifts observed in the carbon isotope, TOC and sulfur content, MS and GRS in beds ZMB23 to ZMB20 are related to paleoenvironmental changes which were associated with the late Eifelian Kačák Event.

The Valentin Limestone (Eifelian - Givetian) in the Wolayer Glacier section (Central Carnic Alps, Austria) is characterized by highly condensed but rhythmically deposited sediments. Except for one thin layer (70a middle) below the E/G boundary (SCHÖNLAUB, 1985), which shows fine grained peloidal packstone with rare tentaculites, the dominant facies is composed of tentaculitid wackestone. A pronounced negative excursion of MS from 43.39 to 27.71 (10^{-9} [$m^3.kg^{-1}$]) is observed between beds 70a base and 70 top across the layer 70a middle. TOC and sulfur content show increased values within the bed 70a. Although $\delta^{13}C_{carb}$ values show only a slight negative shift across the layer 70a middle, it is suggested that the layer 70a middle is associated with the Kačák Event.

The Hoher Trieb Formation in Lanza area intercalates two thick limestone breccia beds yielding silicified corals in the Eifelian – Givetian interval, which indicate high density gravitative flow (PONDRELLI et al., 2011). These beds are traceable in the Valentin Limestone, which was accumulated in a deeper environmental setting, as the beds indicating a gravitative flow are characterized by yielding iron-coated bioclasts such as corals, crinoids and brachiopod shells. The Kačák level is observed between limestone breccia beds in the Hoher Trieb Formation and between the beds which yield iron-coated bioclasts in the Valentin Limestone. Therefore the succession across the Eifelian-Givetian boundary is more or less comparable within the pelagic units.

The corals found in the Hoher Trieb Formation and the Valentin Limestone are assigned to the re-deposited materials derived from the Eifelian or Givetian shallow water limestone. In the Carnic Alps, the Eifelian and Givetian shallow water deposits are known in the Spinotti Limestone, *Amphipora* Limestone and the Kellergrat Limestone. The succession from the Spinotti Limestone to the Kellergrat Limestone shows the change in sediments which was deposited in peritidal setting that was followed by dark bituminous limestone rich in *Amphipora* and later succeeded by a well-developed reef communities. The Spinotti and Kellergrat limestones yields diverse frame building organisms like tabulate, rugose corals and stromatoporoids, whereas the *Amphipora* Limestone yields rugose corals predominately of *Dendrostella*. The change in the sediments and in the coral community might link to the changing environmental conditions which were resulted from the Middle Devonian climate perturbations.

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Devonian and Carboniferous shallow water sections in Central Iran

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During the Palaeozoic most of Iran was part of the northern margin of Gondwana. Generally the sections in central and east Iran exhibit an evolution from a shallow carbonate-dominated shelf in the Silurian which was transformed into a siliciclastic shelf during the Early Devonian. Fully marine (mainly shallow marine) conditions occurred during the Middle Devonian to the early Frasnian and persisted into the early Late Carboniferous. A widespread uplift in the latest Carboniferous turned the entire area into a continental regime before the onset of a new marine cycle during the Early Permian (e.g., DASTANPOUR, 1996; WENDT et al., 2005).

Thick shallow marine Devonian and Carboniferous deposits have been investigated primarily for biostratigraphic purposes which is a prerequisite for further studies. The state of preservation of the conodonts is generally excellent in all sections even if they show high conodont colour alteration values (C.A.I. 5 for most Devonain conodonts). In some sections or parts within sections the abundance of conodont elements is rare and it is difficult to apply the conodont standart zonation due to shallow marine facies settings.

The studied Devonian sections (Neqeleh & Najhaf sections) are located in the Soh area, about 110 km Northwest of Isfahan. Our focus is the Givetian time interval which is characterized by transgressional – regressional episodes documented by facies differences of the sedimentary record as well as in the fossil content. The generally shallow marine sections also exhibit equivalents to several Devonian events, such as the Taghanic Event.

In Carboniferous sediments the record of conodonts related to the Mississippian/Pennsylvanian boundary interval was investigated in four sections in Central Iran from two different structural units (BAHAMI et al. submitted). Two sections from the Sanandaj – Sirjan trend zone (Asad-abad, and Darchaleh sections) and two from the East-Central Iran Microplate (Shesh-angosht and Kale-Sardar sections) exhibit a nearly complete record previously described across the Mississippian/Pennsylvanian boundary in Iran. Bio-event characteristics of the Carboniferous conodont fauna (Mississippian genera *Gnathodus* and *Lochriea* have been replaced by Pennsylvanian genera *Declinognathus* and *Idiognathodus*) as well as sedimentological changes within overall shallow water deposits which were located approximately 33° S of the paleoequator suggest sea-level changes in the frame of the Late Paleozoic Ice Age.

The talk will provide an overview on the different Devonian and Carboniferous shallow marine sections in Central Iran. Based on the stratigraphic background and the sedimentology interesting options for further studies are discussed.

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Devonian-Carboniferous transition in the Paleotethys (Pho Han Formation, Vietnam)

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During the latest Famennian, the Hangenberg Event is associated with global faunal changes and extinction events in marine and terrestrial environments (e.g., ALGEO et al.,1995). This event is named for the Hangenberg Black Shale beds in the Rhenish Massif, Germany, that are part of the *Siphonodella praesulcata* conodont Biozone (Middle *S. praesulcata* Subzone; e.g., BECKER, 1996).

The Hangenberg Event has been reported from many regions in Europe, North Africa, United States, and South China. We present equivalent sequences from the Paleotethys from Cat Ba Island, northeastern Vietnam which can be divided in three different facies settings. The three main facies of the sequence are Facies 1 (alternations of whitish gray to gray limestone and marl), Facies 2 (calcirudite, bed 115b), and Facies 3 (alternations of dark gray limestone and organic-carbon-rich black shale, beds 115c–120 and 126–129, Figure 1). The latest Famennian (*S. praesulcata* Subzone) conodont assemblage of *Siphonodella praesulcata*, *Palmatolepis gracilis*, *Palmatolepis sigmoidalis*, and *Rhodalepis polylophodontiformis* was recognized in beds 113-115c. Beds 105-112 commonly contain *Palmatolepis expansa*, *P. gracilis*, and *P. sigmoidalis*. Bed 119 yielded a basal Carboniferous index conodont *Siphonodella sulcata*. In beds 116–118, solenoporids such as *Pseudochaetetes elliotti* and *Parachaetetes* sp. were characteristic species in organic-carbon-rich dark gray limestone.

Facies 1 is characterized by bioclastic, peloidal, and intraclastic grainstone and packstone containing massive normal grading and cross-laminations, and is interpreted to represent deep ramp carbonates above storm wave base. Facies 2 is represented by typical lag deposits overlying a transgressive surface. Facies 3 comprises organic-carbon-rich black shale and minor scour-filling bioclastic, peloidal, and intraclastic packstone, and may represent a marginal basin plain environment surrounding a carbonate ramp. The alternations of organic-carbon-rich black shale and dark gray packstone (Facies 3) show no evidence of bioturbation and have high TOC contents (0.18–5.73 wt%) which is comparable with sections elsewhere, e.g. Germany and Austria. A minor succession within the transgressive lag deposits (from Bed 115b of Facies 2 to Beds 115c–120 in the lower part of Facies 3) is equivalent to the Hangenberg Black Shale (s. l.) in the middle part of *S. praesulcata* to *S. sulcata* zones, because beds 115b-120 characterized by no evidence of bioturbation and high TOC contents are interpreted to be accumulated in anoxic to dysoxic conditions.

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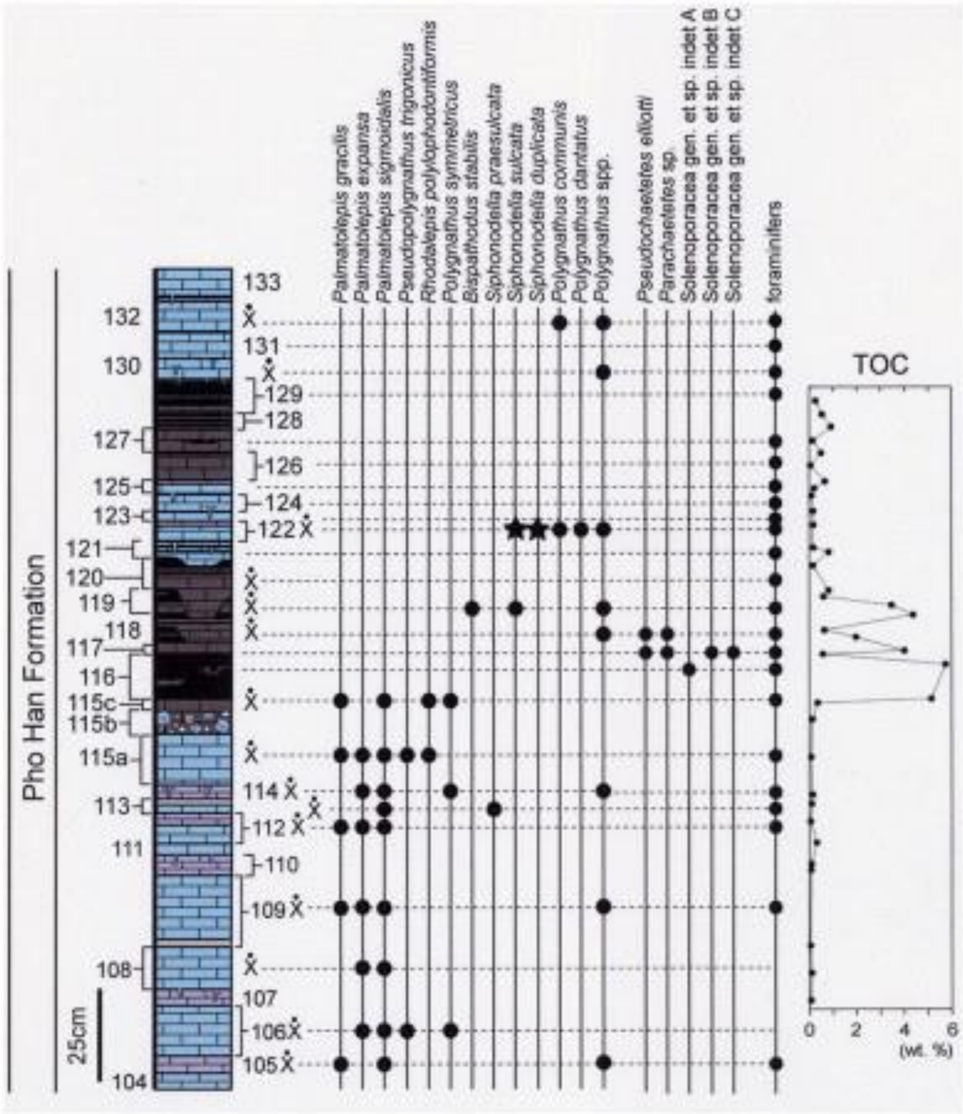

Figure 1: Detailed columnar section at Cat Ba Island (Loc. 1), stratigraphic occurrences of main conodont taxa, *Solenoporacea*, and foraminifers, and geochemical data (TOC content); after KOMATSU et al. (2014).

Climate Change and Biodiversity Patterns in the mid-Palaeozoic (IGCP 596) – introduction and report

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IGCP 596 is specifically interested in the interaction between climate change and biodiversity in the Devonian and Carboniferous Periods (416 – 299 million years ago) when the terrestrial ecosystems experienced a biodiversity boom and oceanic ecosystems suffered catastrophic extinctions.

Greenhouse climates dominated the Early and Middle Devonian (416 – 385 Ma) world, but changed to icehouse conditions in the Late Devonian (385 – 359 Ma). The Early Carboniferous world was relatively warm until cooling in the early Late Carboniferous (318 – 299 Ma) resulted in a huge polar ice shield in the southern hemisphere that covered most of Gondwana. The Mid-Paleozoic was also a time of very high plate tectonic activity that caused major paleogeographic changes which finally led to the supercontinent Pangea. As the continental landmass grew, vascular plants, arthropods, hexapods and first tetrapods spread on land. Their radiation formed the base of new terrestrial ecosystems unknown before the Devonian Period. The success of terrestrial invaders, as documented by the fossil record, culminated with the development of vast forests consisting of tree-like forms like *Calamites* (Order Equisetales), lycophyte trees (e.g. *Lepidodendron*, *Sigillaria*) and other rooted plants that covered huge areas during the Carboniferous. That unique rise among land plants and the formation of top-soil led to distinctive changes in environmental conditions. Based on proxy-data, we can show that the rapid rise of land plants was coupled with strongly decreasing atmospheric CO_2 values from 4000 ppm to nearly present day values of about 350 ppm during the latest Devonian. Increased weathering activity and soil formation by rooted plants lead to intensified run-off and changed water chemistry, which seriously affected marine communities globally.

The tectonic and climate history of the Devonian and Carboniferous as well as the novelty of soil-formation due to the explosion of life on land, and other processes, some of which are not yet fully understood, are linked with a series of ecological turnovers and extinction events primarily in the oceans. Results of this project should help to clarify whether climate change (e.g. interaction of CO_2 and temperature) from greenhouse conditions during the Early-Middle Devonian to icehouse conditions during the Late Devonian-Early Carboniferous represents a major trigger for variations in biodiversity or if a combination of multiple factors is responsible for such changes. We will give an overview of the activities of the project during the last years and what`s coming up.

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Conodont Biofacies Evolution from the Eifelian to the Middle Frasnian (Middle and Upper Devonian) of the Spanish Central Pyrenees

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The study of 441 samples from seven selected sections in the Middle and Early Upper Devonian of the Spanish Central Pyrenees has provided an enormous conodont data base that smoothes the path for further multidisciplinary studies. One of these possibilities is the analysis of conodont populations through time and space.

The precise age control in each section allows the description of faunal content bed by bed and therefore, the changes in conodont composition can be recognised and evaluated with high-precision (smaller than zonal units). Similar studies in all considered sections permits great accuracy in demonstrating the time-equivalent of rocks and, hence, the conodont faunal sequences can be precisely correlated. These kind of time and spatial analysis on the evolution of conodont faunas have led to the identification and characterisation of 14 conodont biofacies, their evolution and their distribution in the different sections.

There are five biofacies in which only one taxon (genus) counts for over 75% of the total amount of conodont elements: *Polygnathus* Biofacies, *Icriodus* Biofacies, "*Ozarkodina*" Biofacies, *Schmidtognathus Biofacies* and *Ancyrodella* Biofacies. Another eight biofacies are characterised by the presence of two dominant elements, being the first name-bearer almost double in proportion than the second: *Polygnathus-Icriodus* Biofacies, *Icriodus-Polygnathus* Biofacies, *Polygnathus-Tortodus* Biofacies, *Polygnathus*-Coniformes Biofacies, *Polygnathus-Schmidtognathus* Biofacies, *Schmidtognathus-Polygnathus* Biofacies, *Polygnathus-Klapperina* Biofacies and *Polygnathus-Ancyrodella* Biofacies. Finally, a mixed *Polygnathus-Ancyrodella-Klapperina* Biofacies is also recognised. The *Polygnathus* Biofacies prevails in many of the strata, however the richness of other genera in some levels permits the identification of the other 13 biofacies.

The studied sections come from different palaegeographical subunits within a larger unit (The southern facies-area), but this subdivision has been challenged by several authors. The distribution of Biofacies supports the initial subdivision of the Southern facies-area into four sub-facies-areas; especially demonstrates the singularity of the Renanué Subfacies.

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The uppermost Famennian Hangenberg Event in the Namur–Dinant Basin (southern Belgium)

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The uppermost Famennian succession of southern Belgium consists of a relatively thick series of shallow water siliciclastic-carbonate deposits, which locally include stromatoporoid biostromes. This thick series permits a better understanding of the Famennian and Tournaisian transition than the condensed basinal sections, which are investigated usually. However, difficulties are encountered for the precise dating of the sections on the basis of the conodonts as the current guide (*Siphonodella sulcata*) for the Devonian–Carboniferous (D–C) boundary has never been discovered in southern Belgium. Consequently, in this area, the D–C boundary was drawn on the basis of conodonts of the *praesulcata* Zone and the extinction of the so-called Devonian fauna (e.g. quasiendothyrid foraminifers and 'Strunian' rugose corals) (CONIL et al., 1986; POTY et al., 2014).

In the Namur-Dinant Basin, the Hangenberg Black Shale Event (e.g. KAISER et al., 2011) is generally not marked lithologically, as is the case in the Anseremme section, which is the neostratotype of the base of the Hastarian Substage (HANCE & POTY, 2006). This absence was interpreted by MAZIANE et al. (1999) as a stratigraphic gap on the basis of the non-recognition of the LN spore Zone but these anoxic facies, corresponding to a high sea-level event, more probably never spread or only exceptionally into the shallow-water environments of the Namur-Dinant Basin, where carbonate facies rich in benthic fossils continued to develop. Indeed, few sections (e.g. Pont de Scay) show dm to m-thick black shale horizons with impoverished marine faunas in the uppermost part of the Comblain-au-Pont Formation (Strunian) which can be considered as inputs of dysoxic–anoxic waters from deeper areas where Hangenberg Shale developed. Contrarily, the following Hangenberg Sandstone Event, which most probably reflects a strong sea-level drop, is easily recognizable and traceable from the Aachen (Germany) to the Dinant areas. In the Stolberg section near Aachen (POTY, 1986), in the proximal Vesdre-Aachen sedimentation area, a 2-m thick sandstone–siltstone bed, corresponding to the Hangenberg Sandstone Event, sharply overlies argillaceous to more or less dolomitized limestones (Dolhain Formation) which include numerous Strunian rugose corals and stromatoporoids. It is overlain by a 5-m thick massive unit of dolomitized limestone that is correlated with the Hastière Formation, a well-known lithostratigraphic unit from the Belgian Condroz (CSA) and Dinant sedimentation areas. Here, except for some bioturbations, no marine fauna was recorded in the sandstone bed and therefore the extinction event occurred between it and the underlain deposits.

In the Royseux section (CONIL et al., 1986) (CSA), a 80 cm-thick calcareous sandstone bed (bed 104) is correlated with the Hangenberg Sandstone. It includes several horizons rich in dissociated valves of brachiopods, notably the Strunian guides *Sphenospira julii* and *Araratella moresnetensis*, which are interpreted as freshly reworked material (corals are almost completely absent in the underlying Strunian part of the section).

In the Anseremme and Gendron-Celles railway sections, situated in the more distal Dinant sedimentation area, the 2 m-thick limestone bed marking the base of the Hastière Formation sharply overlies the limestone and shale alternations of the Strunian Comblain-au-Pont Formation that are rich in foraminifers (*Quasiendothyra*), rugose corals and stromatoporoids. Its base contains reworked *Quasienthothyra* and rugose corals (*Campophyllum gosseleti*).

Therefore, in the Namur-Dinant Basin, the extinction event perfectly fits the sudden sea-level drop reflected by the deposition of sandstone and more or less sandy limestone, but not the development of black shale facies as usually observed in deeper water settings and absent here. This sea-level drop and the extinction event may be related to a single short ice-age as suggested by some authors (e.g. BREZINSKI et al., 2010). The diachronic Hangenberg Black Shale (corresponding to the whole of the Middle *praesulcata* Zone or only to a thin bed of short duration) caused only local, but not definitive, extinctions, as was also the case with the diachronic development of the Upper Frasnian dysoxic–

anoxic Matagne Black Shale, whose range spans the interval of the Early *rhenana* Zone to the *linguiformis* Zone, and caused local extinctions before the end Frasnian Upper Kelwasser Event.

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Diversity and correlation of Givetian records in southern Belgium

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In a recent paper published in the frame of IGCP 580, BOULVAIN et al. (2010) compared two km-thick Eifelian-Frasnian sections from Belgium and Czech Republic using magnetic susceptibility (MS) technique. Regardless the very different background of palaeogeography, sedimentary rate, facies and local sea-level change history, a remarkable similarity in the MS long-term trends can be observed between these two sections. Publication of these results has left open questions on the nature of the long-term forcing parameters that were active at the inter-regional scale.

In order to provide more example supporting long-term MS correlations and to better constraint the factors responsible of these MS trends, we have studied two time-equivalent sections (La Thure and Fromelennes-Flohimont) covering a large stratigraphic interval into the Belgian Givetian platform (Figure 1) using a multi-disciplinary approach (sedimentology, magnetic susceptibility and geochemistry). Distance between the studied sections is ~50 km and prior Variscan deformation it might have been two times more. Field and microfacies analyses allowed us to illustrate the high diversity of environmental setting (depositional models) that occurred throughout the Givetian in Belgium and to reconstruct the long-term sedimentary evolution for both sections.

During the Middle and Upper Givetian the La Thure section is mainly characterized by internal platform environments with local occurrence of fore-reef deposit. Time-equivalent Fromelennes-Flohimont facies, located in a seaward location, are mainly corresponding to proximal reef and fore-reef deposits with local off-reef shale and marl. The mean MS values for the Belgian La Thure and Fromelennes-Flohimont sections are respectively $3.83 \times 10^{-8} m^3/kg$ and $4.67 \times 10^{-8} m^3/kg$. These averaged values of the signal measured on the rocks from Belgium are slightly lower than the $MS_{marine\ standard}$ of $5.5 \times 10^{-8} m^3/kg$ defined by ELLWOOD et al. (2011) on the basis of ~11,000 marine rocks samples. Considering the local extent of diagenetic component over the total MS signal in Devonian limestone in Belgium (DA SILVA et al., 2012, 2013) interpretation of the lower absolute MS values is perilous. Nevertheless, reasonable explanation might be the dominance of carbonated sedimentation during the Givetian, which diluted the MS carrying minerals. MS curves from these two sections show several large-scaled trends which are relatively well-correlated with evolution trends in siliciclastic input proxies such as Zr, Si, Al and Ti. Therefore, indicating an inherent link between MS and concentration in siliciclastic input. MS techniques can thus be used here as a proxy for changes in source or amount or type of weathering (RIQUIER et al., 2010). This observation also means that despite the remagnetization event characterizing Devonian limestone in Ardennes (ZEGERS et al., 2003) main trends in the MS signal still reflect some syn-sedimentary conditions (DA SILVA et al., 2013). Long-term MS trends from the La Thure and Fromelennes-Flohimont have been compared and a notable resemblance between curves can be highlighted despite distance, facies and thickness changes. Thus, our results support data from BOULVAIN et al. (2010) and support the use of MS technique as relevant tools for correlating long-term sedimentary records in carbonate platform setting.

Concerning the long-term MS controlling parameters, the question is still open and under investigation but it is clear that (1) climatically driven mechanisms, responsible for the non-carbonate clastic input basinwards (2) uplift movement which are also responsible of large siliciclastic input delivery basinwards, (3) trade winds transporting dust and (4) second order eustatic variation (T-R cycles) are all external factors that could have play a role in the long-term variation recorded in the MS signal. In the present state of the art it is still difficult to discriminate what the weight of each of those external factors is.

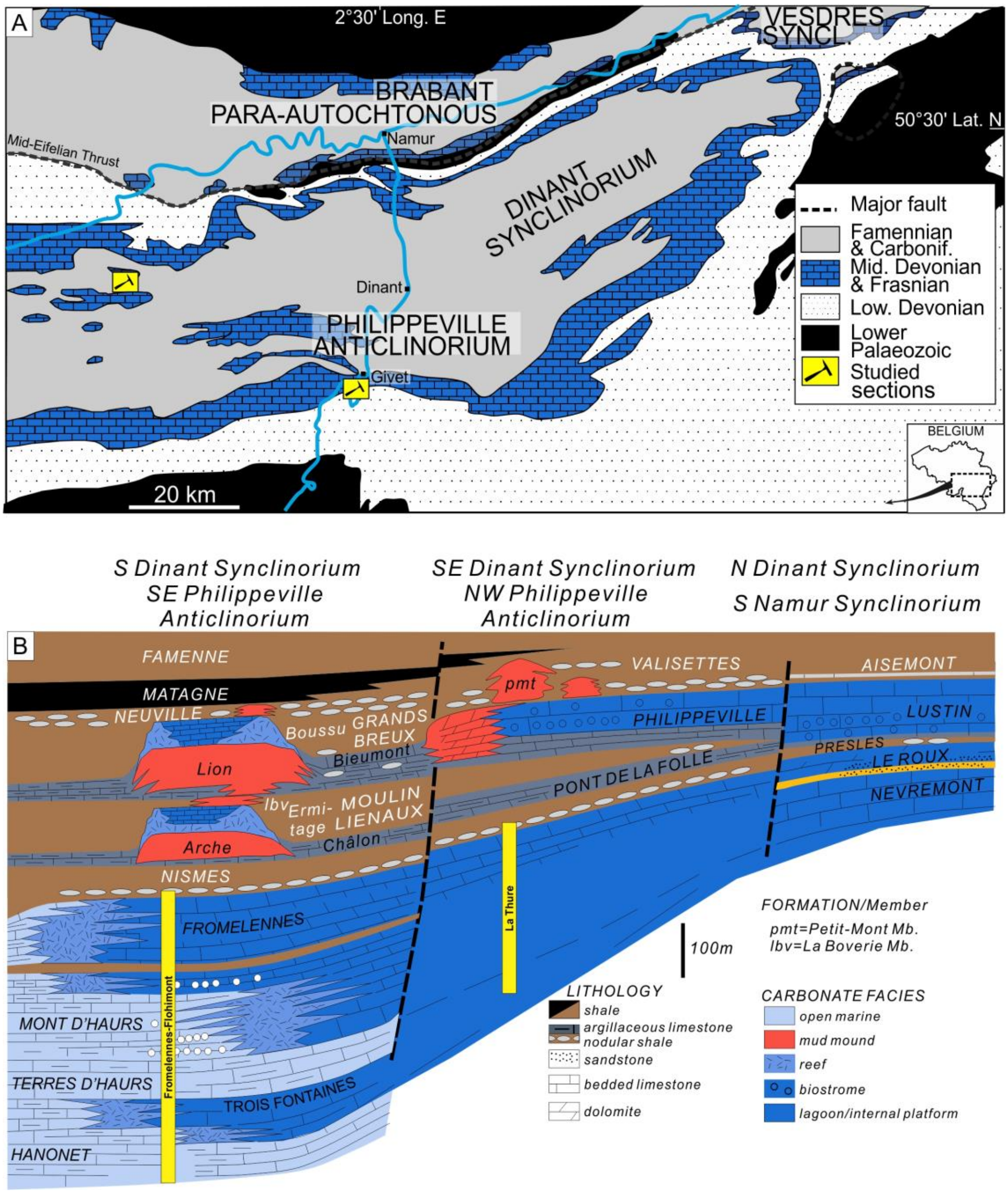

Figure 1: **A**. Simplified geological map of southern Belgium with location of the La Thure (NW of the Dinant Syncline and the Fromelennes-Flohimont (southern border of the Dinant Syncline) sections. **B**. Integrated lithostratigraphical and palaeogeographical framework for the Givetian and Frasnian of Belgium. Relative position of the reefs shows the retrogradation-progradation patterns of the carbonate platforms (modified after BOULVAIN et al., 2009)

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Magnetism of Cretaceous Bauxites from Pădurea Craiului (Apuseni Mountains, Romania): Implications for Near-Surface Lens Exploration

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The paper is concerning with the bauxitic formation (Pădurea Craiului Mountains, northwestern Apuseni Mountains), which is sandwiched between marine limestones of latest Jurassic age below and mid-Early Cretaceous above (GRIGORESCU, 1993 *in* BENTON et al., 1997). The bauxite occupies karst depressions to a depth of several meters, often filling caves and fissures (BENTON et al., 1997). In respect of the bauxite magnetic properties, in the previous published papers (e.g., AIRINEI & VELCESCU, 1970), only the magnetic susceptibility was mentioned as a measured magnetic parameter. Our rock magnetic study, carried out on a large collection of bauxite samples, integrated with micromagnetic works, led to the reconsideration of the magnetic contrast between bauxites and limestones. The main goal was to test the capability of the geomagnetic investigation to detect the bauxite lenses. Regarding the magnetic susceptibility (MS; k), the highest frequency was determined for the k values reaching $100\pi\times10^{-6}$ SI, while for the natural remanent magnetisation (NRM) intensity, the most values have reached 250 mA/m. Hence, the maximum frequence for the Koenigsberger ratio (Q) was determined for the values ranging between 7 – 8, for 96% of the bauxite samples the Q ratio being higher than 1; in most cases, the NRM prevails the induced magnetisation.

As concerns the limestones, their magnetic properties are very low: NRM intensity – lower than 7 mA/m, and MS – lower than $4\pi\times10^{-6}$ SI, with the maximum frequencies recorded for the values lower than 1 mA/m, and respectively, lower than $1\pi\times10^{-6}$ SI. As the polarity of the NRM is positive (normal), the magnetic contrast between the bauxite deposits and the limestones is strong enough to enable a successful magnetic mapping of the near-surface bauxite lenses, with the usual high resolution proton magnetometers. More than 15 bauxite lenses, with the underground location known from exploration works, were checked up for their capability to be reflected by magnetic anomalies resulting from micromagnetic surveys. The measurements were carried out in points placed in quadratic networks (5 m or 2.5 m side; Fig. 1b,d), mostly by using simultaneously two Geometrics G-826 proton magnetometers (bimodal sensitivity: 1 nT and 0.25 nT). Various methodological techniques were applied in the field (e.g., magnetic measurements related to 4 bauxite lens exploitation stages). The primary magnetic maps, revealing anomalies between ca 50 nT – 100 nT (Fig. 1a,c), were processed, and secondary images of the magnetic anomalies were obtained and analysed. On the basis of the bauxites magnetic properties (NRM and MS), and on the other side, by knowing the geometry of the bauxite lenses, several patterns were carried out, illustrating the magnetic effect of this ore body type, accumulated as lenses placed at different depths (RĂDAN et al., 1980). Moreover, based on the oriented samples collected from a few outcrops observed in the area, the anisotropy of magnetic susceptibility (ASM), as well as the palaeomagnetic characteristics of the bauxites were tested. The AMS parameters show values which do not suggest an influence on the Characteristic Remanent Magnetisation (ChRM) direction, asserting the fidelity of the geological signature printed within the bauxites.

Consequently, a palaeotectonic message could be deciphered from this rock type, among the Cretaceous bauxites investigated in the Pădurea Craiului Mountains being the "Lens with Dinosaurs" ("Bauxite of Cornet"; http://en.wikipedia.org/wiki/ Bauxite_of_Cornet; see also BENTON et al., 1997). In conclusion, the bauxite – very important as an aluminium ore – has proved various availabilities to "deliver" interesting geological and geophysical "messages". Their content was particularly deciphered by means of the (palaeo)magnetic properties of this "ore rock" which are under attention in the present paper.

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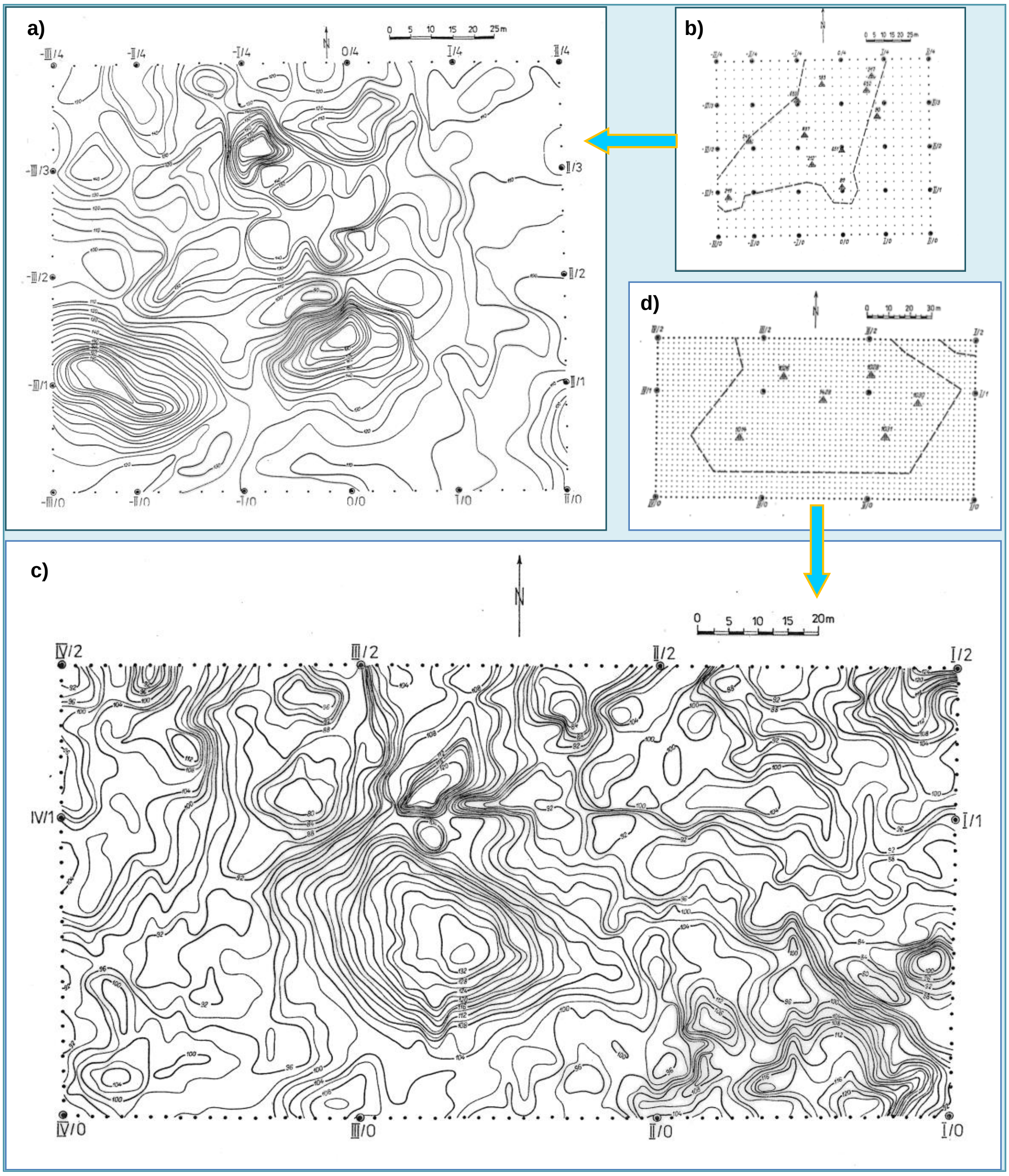

Figure 1: ∆T magnetic maps showing the anomalies recorded over two bauxite lenses from Pădurea Craiului Mountains (Apuseni Mountains, Romania). **A**. Magnetic map (5 nT contour equidistance), with 3 distinct anomalies (75 nT to 95 nT amplitudes) measured over bauxite deposits. **B**. Quadratic network (5m side) and the contour of the bauxite lens over which the micromagnetic survey with the results from [**a**] was carried out. **C**. Magnetic map (2.5 nT contour equidistance), with a distinct anomaly (54 nT amplitude) measured over the bauxite deposits. **D**. Quadratic network (2.5 m side) and the contour of the bauxite lens over which the micromagnetic survey with the results from [**c**] was carried out.

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A Magnetic Multi-proxy Approach of the Loess-Palaeosoil Sequences in Southern Romania, in a Chronostratigraphic - Palaeoenvironmental - Palaeoclimatic Context: An Overview and New Results

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The paper is dealing with a magnetic multi-proxy approach of the loess/palaeosoil sequences in the Southern Romania, in a chronostratigraphic – palaeoenvironmental – palaeoclimatic context. Firstly, it is performed a tentative synopsis which mainly focusses on the aspects of dating the Pleistocene loess – palaeosoil sequences from the Romanian Plain and Dobrogea. The first part is a short review of important achievements concerning the estimation or evaluation of the loess age, starting ca 120 years ago, with a tentative to systematising the significant contributions of the last half-century (RĂDAN, 2012). Implicitly, it is remarked the way passed through time in order to know the loess age, i.e. from the classic stratigraphy/pedostratigraphy to magnetostratigraphy, astronomically tuned ciclostratigraphy, magnetoclimatology, and up to the multi-proxy approach and optical/luminescence dating. In most of the sections, ages up to 781 ka are determined (the loess – palaeosoil horizons are assigned to the Brunhes Chron of the ATNTS-20004/ATNTS-2012 (HILGEN et al., 2012), but the synopsis includes a section from Dobrogea (analysed by the Infrared Stimulated Luminescence/IRSL dating method; BĂLESCU et al., 2003), wherefore the "estimated geological age" of 800 ka and the Marine Isotope Stage 20 are mentioned. Therefore, in this first part, the main contributions to the loess age knowledge, showing the principal steps in the evolution of the Romanian loess investigation, passed since 1961 till present, are synthetised within a comprehensive table. Its structure (related to columns) is as follows: (1) author (a long series of Romanian authors, and also several foreign ones)/year; (2) methods used to derive/confirm the chronostratigraphy/age of the loess/palaeosoil horizons; (3) location of profiles/sections (in both the Romanian Plain and Dobriogea); (4) investigated loess – palaeosoil sequences (maximum six loess horizons alternating with six palaeosoil horizons have generally been investigated within a section, by an exception in each of the two mentioned areas); (5) derived/confirmed ages of the loess/palaeosoil horizons. The table is supported by several examples concerning the multi-proxy magnetic approach undertaken by the author in the Romanian Plain and Dobrogea, during the last 30 years.

Thus, a series of magnetostratigraphic models or (palaeo)magnetic diagrams are particularly commented in the paper, illustrating the contributions to dating of the loess - palaeosoil couples or the loess only (in some cases when in the investigated sections these deposits are developed without alternating with palaeosoil horizons). In the second part of the paper, there are presented some informative data regarding the vertical distribution of several (palaeo)magnetic parameters (declination and inclination of the Characteristic Remanent Magnetisation/ChRM, NRM intensity, and initial magnetic susceptibility), recorded for some loess – palaeosoil sections from southern Dobrogea. The results are discussed in a magnetostratigraphic context. Moreover, a special attention is given to some recent data achieved for a loess – palaeosoil borehole profile (ca 30 m thick) from the Romanian Plain, resulting from a composite approach, i.e. "magnetic susceptibility (MS) stratigraphy" integrated with "magnetic polarity stratigraphy"/"magnetostratigraphy". The recent interpretation of these data points out the possible identification of the Matuyama/Brunhes boundary (MBB; 0.781 Ma) (RĂDAN, 2012, 2013a,b). The subject has generally given rise to a dispute in the scientific literature on both the Chinese and the European loess. The correlation of our results with the MS records for two loess – palaeosoil sequences from the Chinese Loess Plateau, one of them being calibrated to the "marine oxygen isotope stages" (MIS) of the benthic $\delta^{18}O$ record at ODP site 677 (SHACKLETON et al., 1990), is presented, as well. The "observed" MBB location within the loess L8, and of the "corrected" MBB within the palaeosoil S7 of the borehole profile from the Romanian Plain, as well as the calibration to *MIS* (location at the base of the MIS 19) (RĂDAN, 2012) are commented within this short overview of the case study. In conclusion, we can accept that the loess approach is a complex undertaking, and we can confirm the statement of Pécsi (1990), i.e. ”Loess is not just the accumulation of dust“. Hence, the loess - palaeosoil sequences are relevant for geosciences, they are Quaternary archives for palaeoenvironmental reconstruction.

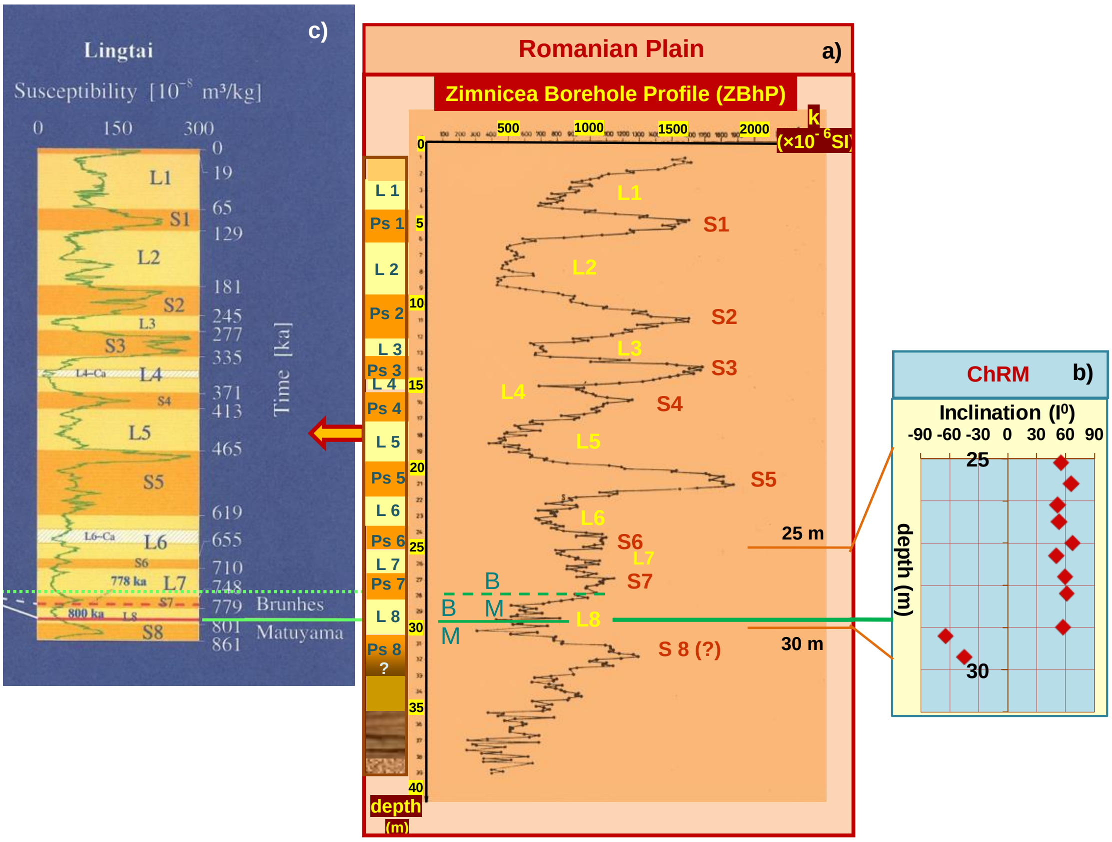

Figure 1: A composite model showing a tentative correlation of the integrated magnetic susceptibility and palaeomagnetic data obtained for the Zimnicea borehole profile (Romanian Plain) with the Lingtai section from the Chinese Loess Plateau (CLP). **A**. Variations of the magnetic susceptibility (k) with depth recorded for the loess - palaeosoil sequence traversed by the Zimnicea geological borehole. Legend: L – loess horizon; S – palaeosoil horizon. The green solid line in L8 is the "observed Matuyama (M)/Brunhes (B) boundary" (MBB), as resulted from the palaeomagnetic data, and the bright green solid line shows the correlation with the "observed MBB" in L8 of Lingtai section (CLP), according to SPASSOV (2002). The green dashed line represents the "corrected/true MBB", located in S7, taking into account the delayed remanent magnetisation. **B**. Variation with depth of the inclination of the Characteristic Remanent Magnetization (ChRM), after thermal cleaning, for a fragment of the Zimnicea borehole loess - palaeosoil profile (between 25 m - 30 m depth). **C**. Magnetic susceptibility variations with depth for the loess - palaeosoil sequence (a fragment) at Lingtai (CLP). The red solid line in L8 is the "observed MBB", whilst the dashed red line in S7 represents the "corrected MBB (figure c, reproduced from SPASSOV, 2002). Note: The MBB is located at 781 ka, according to ATNTS2004 / ATNTS2012 (HILGEN et al., 2012).

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HI-Res correlation of the Lochkovian-Pragian (Lower Devonian) sections in the key regions of peri-Gondwana

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Two key areas of European peri-Gondwana, the Prague Synform (Barrandian area, Czech Republic) and the Spanish Central Pyrenees show an excellent correlation by means of conodont biostratigraphy during Lochkovian and early Pragian times (for conodont biostratigraphy see e.g.: VALENZUELA-RÍOS, 1994a, b; MURPHY & VALENZUELA-RÍOS, 1997; SLAVÍK, 2004; SLAVÍK et al., 2007; SLAVÍK et al., 2012; VALENZUELA-RÍOS et al., 2005). The number of common guiding taxa enables a very detailed matching that in specific time-intervals (e.g. middle Lochkovian) can reach resolution of up to tens of ky, i.e. much higher than traditional application of (even refined) biozonations. The beginning of the Pragian is then characterized by an abrupt change both in benthic and pelagic communities. The early Pragian correlation between both regions based on conodont faunas have been already developed (e.g., SLAVÍK et al., 2007) and its application can be extended also to other regions of peri-Gondwana where cosmopolitan taxa are scarce. In general, the correlation from the middle Pragian onwards begins to be more complicated because of dearth of biostratigraphically significant faunal taxa. With the beginning of Emsian the global biostratigraphic correlation is easier; it is related to the radiation of early Emsian polygnathids. The Lochkovian/Pragian boundary event (in the sense of CHLUPÁČ & KUKAL, 1988) is caused by global fluctuation of sea-level (cf. JOHNSON et al., 1985). In many sections the boundary is masked by lower accumulation rate or even gaps in combination with local tectonic disturbances in some sections. Accordingly, the precise identification of the Lochkovian/Pragian boundary in many places of the world is difficult.

The aim of our Czech-Spanish project "Hi-Res correlation and dating of Mid-Palaeozoic sedimentary sequences of Peri-Gondwana using integrated biostratigraphy and chemo-physical methods" is to apply auxiliary correlation tools in intervals where the density of biostratigraphic time-marks is low. The correlation is based on application of several methods in the sections: the detailed biostratigraphical framework is supplemented by multiple chemo-physical measurements (i.e. gamma-ray spectrometry and magnetic susceptibility) in order to avoid discrepancies in correlation of the peri-gondwanan successions.

Two field campaigns have been organized: in the Prague Synform we examined classical Lower Devonian sections and did conodont samplings. In the Spanish Central Pyrenees we have sampled two early Devonian sections (Segre 2 east of Seu d'Urgell and Compte 1 north of Gerri de la Sal) for magnetic susceptibility and made gamma spetrometric logging. Especially difficult in the Segre 2 section was the precise location of the Lochkovian/Pragian boundary because of short intervals that did not provide biostratigraphic data. We have sampled and measured in total 59 m interval (328 samples) in the Compte 1 section and 62 m (356 samples) in the Segre 2 section. The laboratory magnetic susceptibility measurements were performed at the Institute of Geology AS CR, v.v.i. using a kappabridge KLY-2 device, Agico Brno. In addition, we have taken 17 samples from the Segre 2 section for lithological characterization from the thin sections (e.g., microfacies analyses) and carried out field gamma-ray spectrometry measurements using a portable natural radiation detector RS-230 BGO Super-SPEC (Georadis Ltd., Brno, Czech Republic). The GRS logging was applied with the 0.5 m step at both Compte 1 and Segre 2 sections (in total 131 measuring points at the Segre section and 127 measuring points at the Compte section).

Although evaluation of magnetic susceptibility curves and gamma-ray logs is still in progress, the preliminary matching of the magnetic susceptibility curves (expressed as mass specific magnetic susceptibility) show surprisingly very similar patterns at both sections. These two logs show similar trends and also absolute values which are positive (not negative). It means that paramagnetic and/or ferromagnetic component is present and masks the diamagnetic calcite as major constituent of the carbonates across entire sections. Low MS values in the lower parts of the sections correspond to the Lochkovian interval (according to conodont biostratigraphy, VALENZUELA-RÍOS, 1994a, 2002; VALENZUELA-RÍOS et al., 2005). The data show that the Lochkovian/Pragian boundary can be best plotted to very short (less than 1m thick) intervals at corresponding levels of both sections. Pragian interval is marked by elevated MS values at both sections (average 50.7 and 52.8 10^-9*m3.kg^-1 for the Segre and Compte sections, respectively). The similar pattern can be seen also for the Lochkovian and Pragian successions in the Prague Synform (represented by the Lochkov and Praha Fms and lowermost part of the Zlichov Fm.) In the Prague Synform (Požár 3 section, Koptíková et al. 2010), the MS values in the Praha Fm. (= original Pragian) limestones are five times higher than in the Lochkov Fm (= Lochkovian). The upper part of the studied sections show decrease in MS values; this is more prominent in the Segre section than in the Compte section. Segre section shows strong decrease in MS and average values are lower (average values of 22.8 10^-9*m3.kg^-1) than those in the Lochkovian interval whereas the Compte section shows rapid decrease and then again gradual increase.

In summary, the integration of biostratigraphic data and magnetic susceptibility logs enable more precise correlation of the Lochkovian /Pragian boundary. This study also confirmed the general increase of MS values for the Pragian time that has been recognized in the Prague Synform.

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Deciphering the Origin of Plant Silica Bodies: A Novel Investigation into the Earliest Phytoliths in Earth's History

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Phytoliths (plant silica bodies) are a result of the process by which plants deposit silica in an intracellular or extracellular location after absorbing it in a soluble state from groundwater (PIPERNO, 2006). Phytoliths are used frequently in Cenozoic studies to answer a wealth of palaeoenvironmental questions, however, research has never before been conducted to establish when, where or why these phytoliths first evolved.

Silica phytoliths in plants perform a variety of functions; they provide structural rigidity as well as helping the plant to survive numerous abiotic stresses such as salt, nutrient imbalance, drought, radiation, high temperature, freezing and ultraviolet radiation. Phytoliths are also known to reduce the impact of biotic stresses i.e. pests and fungal diseases on plants (EPSTEIN, 1994).

Phytoliths may experience a range of fates in terrestrial environments: erosion, transportation by wind or water, loss due to burning in a forest fire, or biochemical changes while passing through the digestive system of animals. However research has proven their stability and persistence within the environment even after being exposed to such hostile conditions (RAJENDIRAN et al., 2012).

During Devonian terrestrialisation one of the many advantageous features that plants developed for the first time was a penetrative root system (coinciding with the development of arborescent vegetation in the late Middle and Late Devonian). Root systems, for instance those of the Late Devonian progymnosperm *Archaeopteris*, could reach depths >100cm. Not only did these root systems have a major effect on weathering and pedogenic processes, but they had the potential to extract silica. If plants were in fact extracting silica during the Devonian, what were the reasons behind this? Did phytoliths during this time provide the benefits to vegetation they do now?

Arguably one of the most important adaptations of phytoliths is their ability to sequester carbon. Phytolith Occluded Carbon (PhytOC) is a stable inert carbon fraction which remains in soils for long periods of time. Research conducted on modern specimens show that PhytOC accounts for c. 37% of global long-term (millennial-scale) soil carbon accumulation. Placing this in a Devonian context, the 'Devonian Plant Hypothesis' (ALGEO et al., 1995) discusses the processes by which Devonian terrestrialisation resulted in the decrease of atmospheric CO_2; a potential expansion of this theory could therefore incorporate the impact of PhytOC.

Investigation into the discovery of the earliest phytoliths in Earth's history has begun with the analysis of lycopsid fossil roots (and surrounding sediment) from Spitsbergen, Norway. Using Heavy Liquid Flotation (HLF) extraction techniques, results provide evidence that phytoliths were in fact present during the Devonian. Further research is currently being conducted to expand and enhance on these preliminary findings.

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Conodont distribution across the Kačák crisis from the shallow marine Kellergrat Formation and the pelagic Valentin Formation (Carnic Alps)

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The Kellergrat Formation (KREUTZER, 1992) represents a unit consisting mainly of reef deposits (frame and rudstones). A Givetian to Frasnian age was proposed by OEKENTORP-KÜSTER & OEKENTORP (1992) based on coral assemblages from the Kellergrat area and other two localities. Conodont data from the abandoned quarry at the trail 149 to Collina (HUBMANN et al., 2003) confirm Givetian age of the coral-rich limestones. 14 samples between 0.5-3 kg are dissolved in HCOOH. All of them yield a small but determinable conodont fauna. Apart from icriodontid conodonts such as *Icriodus regularicrescens* and polygnathids of the *Polygnathus linguiformis* group, samples from the base of the section yield Pa elements of *Polygnathus ensensis*, which indicates latest Eifelian. These beds are less rich in corals but do bear stromatoporoids. A few meters higher in the section, Pa elements of *Polygnathus timorensis* and *Polygnathus varcus* are obtained, which indicate early Givetian age of already coral-rich deposits. Generally, diversity and abundance of conodonts in this section is quite low, which might be due to depositional conditions.

Moving from proximal, reef-related deposits down the slope, stratigraphically equivalent pelagic deposits are represented by the condensed limestones of the Valentin Formation. The type section of this unit is outcropping near Valentin Törl, located a few km towards NW in the Valentin Valley (previously called the Wolayer Glacier section, SCHÖNLAUB et al., 2004). Here dense conodont sampling was done bed-by-bed in the 1980's (SCHÖNLAUB, 1980). According to the strongly condensed kind of bedding, we decided to resample the late Eifelian-Givential interval with the aim of a higher resolution biostratigraphy. Therefore, we cut each bed along iron-crusts demarcating sedimentary breaks or erosional bedding plane surfaces, which are observed rhythmically nearly each cm. Finally, it turned out that bed 69 and 70 belongs to the late Eifelian, which is indicated by the occurrence of elements belonging to the *Polygnathus angusticostatus* group and the entry of *Icriodus obliquimarginatus.* Bed 71 belongs already to early Givetian indicated by the first occurrence of *Polygnathus timorensis*. This is actually nothing new and already known since Schönlaub 1980. However, new is that we achieved a higher resolution within beds 69 and 70. It turned out that both beds yield a conodont fauna typical for the *kockelianus* Biozone, but that from the base of bed 70 *Icriodus obliquimarginatus* together with strangely grown icriodontid Pa elements (transition forms between *Icriodus* and *Pelekysgnathus*) occur. That, according to BULTYNCK (2003), is a common feature of icriodontids during biotic events, which in our section indicates the onset of the late Eifelian Kačák Event.

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Evidence for the Lochkov-Prag Event in the Carnic Alps

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The Lochkov-Prag Event was defined by WALLISER (1996). Earlier sedimentological descriptions of CHLUPÁČ & KUKAL (1986) identified the nature of this event as being expressed by a lithological change from dark Lochkovian to lighter Pragian deposits. That specific sedimentological change accompanied by a change in benthic and planktonic communities is interpreted as regressive event by CHLUPÁČ & KUKAL (1986, 1988). ZIEGLER & LANE (1987) documented a conspicuous reduction in conodont diversity in the latest Lochkovian *pesavis* Biozone. TALENT et al. (1993) observed a similar sharp drop in conodont diversity in several sections from east-central New South Wales (Australia), wherefore the term end-*pesavis* Event was introduced. There, a gradual sedimentological change characterizes the event interval which was followed by a significant regional regression just before the end of the biozone. HOUSE (2002) concluded that the event did not result in a regression but in a transgression, which follows the interpretation of JOHNSON et al. (1985: T-R cycle Ia). Based on results from geophysical methods (magnetic susceptibility and gamma ray spectrometry) applied on sedimentary successions in the Czech Republic, VACEK (2011) concluded that the Lochkov-Prag Event was related to climate warming.

In the Central Carnic Alps the Early Devonian shallow marine sequence is best documented at Mount Seewarte in the Wolayer Area. There it starts with some few lithoclastic horizons and crinoidal limestones (organisms: brachiopods, gastropods, echinoderms, conodonts) followed by a short interval of dark grey nodular limestone bearing phosphatic brachiopod shells of *Opsiconidion* and some few conodonts during the Lochkovian (neritic Rauchkofel Limestone). These are overlain by well-bedded crinoidal grainstones (upper half of the neritic Rauchkofel Limestone) and a thick unit of massive bright grey frame- and rudstones (dominating skeletal components: calcareous algae, stromatoporoids, tabulate and rugose corals) of Pragian age (Hohe Warte Limestone). Lochkovian deposits continue in slope and pelagic facies towards north and east. They are named pelagic Rauchkofel Limestone and La Valute Limestone (syn. Boden Limestone) respectively. These are succeeded by the pelagic Findenig Limestone which is late Lochkovian (*pandora* beta Biozone) at La Valute in the Mount Zermula Area (CORRIGA et al. 2011) and Pragian in age at Rauchkofel Boden north of the Valentin Valley (SCHÖNLAUB, 1980).

In the shallow marine sequence of the central Carnic Alps trends in the MS-log show steadily increasing values during the *eleanore* Biozone. The above following interval of lacking measurements is due to an inaccessible section-part. At the top of the thick limestone bed (sample Se/02/07) a significant decline in values is recorded, which continues until short before the top of the *pesavis* Biozone. Minor shifting, in- and decreasing values follow which reflect a slightly increasing trend during the lowest part of the *steinachensis* Biozone. The MS-log culminates in a marking positive excursion at the top of the megaclast horizon. A short interval of decreasing values follows.

Our results confirm a “conspicuous reduction in conodont diversity in the latest Lochkovian *pesavis* Biozone” recognized by ZIEGLER & LANE (1987). According to the diversity pattern of conodont taxa observed in section 1, a certain drop as well as a change in the composition of the assemblage from an ozarkodinid to an icriodontid dominated community is recognized. However, important is that coniform taxa are more conservative and did not undergo a significant change at species level, but also show a decline in species from the *trigonicus* Biozone into the early Pragian *steinachensis* Biozone.

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Pathological forms of conodonts of the genus *Palmatolepis* from the Frasnian-Famennian boundary interval (Upper Devonian) in the South Urals

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Many researchers have noted the pathological changes in conodont elements (HASS, 1941; LINDSTRÖM, 1964; WEDDIGE, 1990; BIKBAYEV & SNIGIREVA, 2003; ZHURAVLEV, 2004; BARSKOV & NAZAROVA, 2012; NAZAROVA & KONONOVA, 2012). Karsten Weddige (1990) was the first who paid attention to the importance of this phenomenon in understanding of the conodont animal’s digestive function model. He analyzed about a hundred specimens of the conodont pathological forms of the genus *Polygnathus* from different the Lower and Middle Devonian sections and identified 13 types of pathologies. Most of them have a traumatic, rudimentary or degenerative origin.

The South Urals conodont collection (the Bol'shaya Barma, Akkyr, Ryauzyak and Kuk-Karauk sections) of the 4733 specimens of the genus *Palmatolepis* from the Frasnian - Famennian (F/F) boundary interval contains the only 7 pathological specimens (Figure 1). They were found in the *linguiformis* and *crepida* zones intervals (the Frasnian Askyn Horizon and the Famennian Makarovo Horizon). Thise time characterized by a rich quantitative and taxonomic diversity of conodonts. The *linguiformis* zone interval contains 4 modified Pa-elements: *Palmatolepis gigas* Mill. & Young. (2 specimens) from the Kuk-Karauk section, *Palmatolepis rhenana* Bisch. and *Palmatolepis hassi* Müll. & Müll. from the Akkyr section (see Figure 1). The carina and the surface ornamentation are smoothed out in *Palmatolepis gigas* Mill. & Young. – the **Abrasio** Pathology according to Karsten Weddige classification (1990). *Palmatolepis rhenana* Bisch. has an appendix on the outer posterior part of the platform – feature the **Accessio** Pathology (WEDDIGE, 1990). The *Palmatolepis hassi* Müll. & Müll. anterior carina is broken, so there is a displaced regenerated geniculate curvature – similarity the **Fractio** Pathology (WEDDIGE, 1990).

At the top of the *linguiformis* zone the conodont biodiversity become much poorer and the Frasnian taxa of *Palmatolepis* totally extinct at the F/F boundary. At the beginning of Famennian in Barma Horizon (joint Early-Middle *triangularis* zones) the conodont community was recovered with slow pace: it’s taxonomically poor and without pathological forms.

The conodont collection from *crepida* zone includes 3 pathological forms (see Figure 1). Be noted, that identified morphological changes are attributed to the posterior end of the platform. For example, species *Palmatolepis* aff. *praeterita* Schül. from the Kuk-Karauk and *Palmatolepis* sp. from the Bol’shaya Barma section have bifurcated posterior end of the platform – the **Duplicatio** Pathology (WEDDIGE, 1990). *Palmatolepis triangularis* Sann. from the Bol’shaya Barma section has crushed posterior end of the platform – the variation the **Impressio** Pathology (WEDDIGE, 1990).

There are too little pathological forms of conodonts in the F/F boundary interval deposits in the South Urals. Almost all of them (Abrasio, Duplicatio, Impressio and Fractio pathologies) have a traumatic origin. This is likely connected with the trophic relationships of the conodont animals (WEDDIGE, 1990; BIKBAYEV & SNIGIREVA, 2003; ZHURAVLEV, 2004; BARSKOV & NAZAROVA, 2012). Pathologies aren’t the result of a habitat conditions but the individual features of every organism in our case. Only Accessio Pathology (the *Palmatolepis rhenana* Bisch.) has a rudimentary origin. This one isn’t identified sign being related to variability and further development of this species as in the taxa of genus *Icriodus* (NAZAROVA & KONONOVA, 2012).

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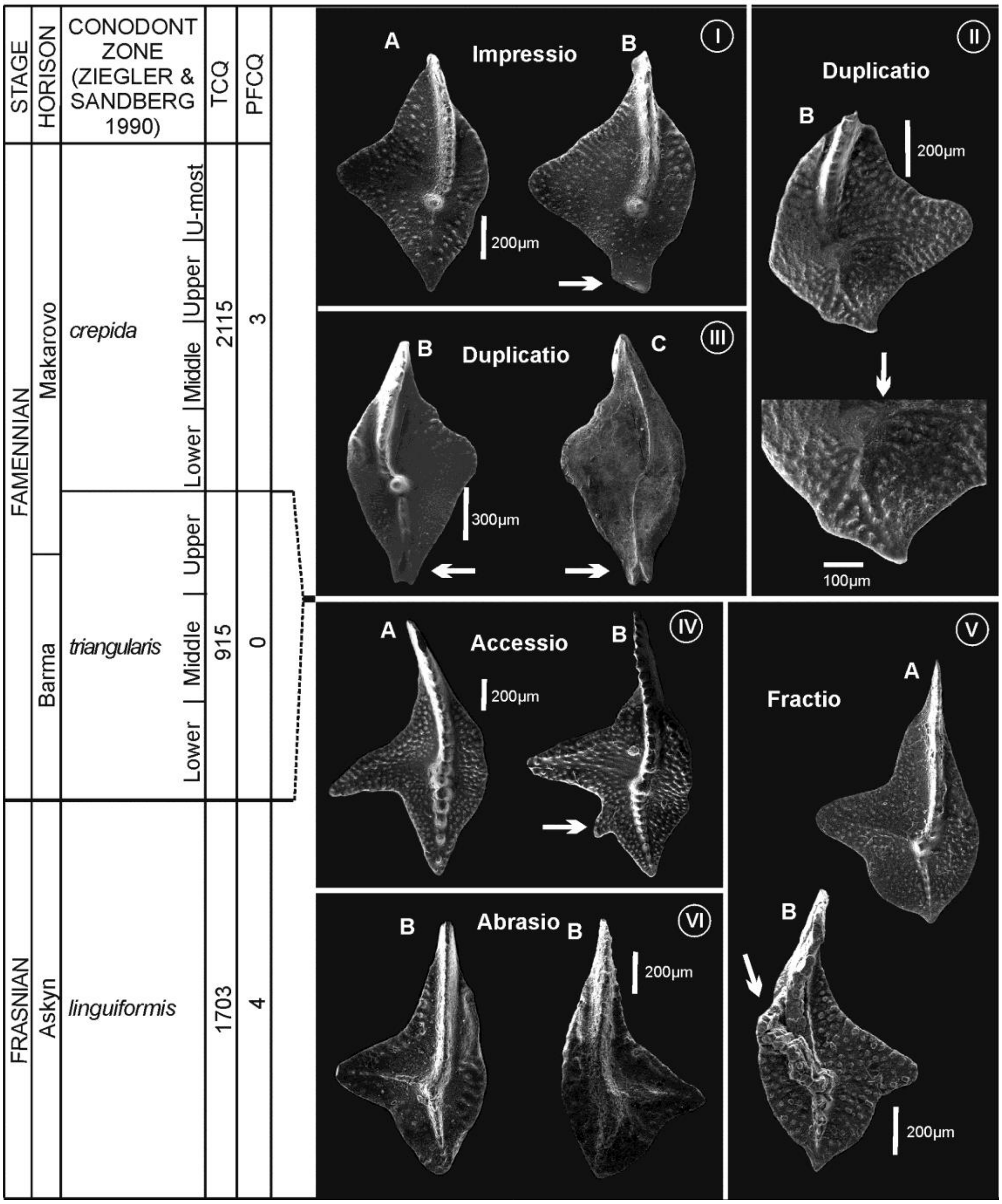

Figure 1: Pathological forms of conodonts of the genus *Palmatolepis* from the Frasnian-Famennian boundary interval in the Southern Urals. TCQ - the total conodonts quantity; PFCQ – the pathological forms of conodonts quantity; A and B – upper view, C – lower view. A – the normal Pa-element, B – Pa- element with pathology; I - *Palmatolepis triangularis* Sann., II – *Palmatolepis* aff. *praeterita* Schül., III - *Palmatolepis* sp., IV – *Palmatolepis rhenana* Bisch., V – *Palmatolepis hassi* Müll., VI - *Palmatolepis gigas* Mill. & Young.

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Lower Devonian Conodont successions from Nigüella (Iberian Chains, Spain) with emphasis on evolutionary events

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Three sections of Lower Devonian strata near Nigüella, which represents the northwesternmost outcrops of this age attributed to the Herrera Unit in the Iberian Chains, yielded a conodont sequence in shallow water (neritic) facies that supports former interpretations from the classical Axial Depression of the Río Cámaras (ADRC) regarding conodont evolution.

The lithological succession comprises parts of the Luesma Fm., the Nogueras Fm., the Santa Cruz Fm. and the lower part of the Mariposas Fm. The conodont sequence exhibit the early components of the Icriodontidae (*Icriodus* and *Pelekysgnathus*) and most of the evolutionary events of these genera.

The lowest radiation of *Icriodus* in Nigüella is recorded in the level d1cγ and is represented by numerous taxa of the group. From this level up components of the three main icriodontidae branches are present. Branch 1 is represented by *I. transiens* (Luesma Fm) and *I. vinearum* (Nogueras Fm) in the Lochkovian and by *I. curvicauda* (Santa Cruz Fm) in the upper? Pragian after an interval without icriodids representative of this branch. Branch 2 refers to the *angustoides* group; they start with *I. bidentatus* in the upper part of the Luesma Fm and continue in the Nogueras Fm with the successive records of *I. angustoides* in the Lochkovian and *I. castillianus* in the Pragian. The third Branch is represented by *I. rectangularis* and *I. lotzei* that is interpreted as its descendant. Both are recorded in Lochkovian strata of the Nogueras Fm. There is another group of forms that are not clearly related to any of these branch; they are the *I. fallax* group in the Nogueras Fm.

Besides these records, the presence of members of the *Polygnathus excavatus* group, which is the key taxon for the redefinition of the base of the Emsian, stands out in the lower part of the Mariposas Fm.

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Rebound of the Shallow Marine Ecosystem after the Frasnian – Famennian Extinction Event (Late Devonian) in the Central Asian Orogenic Belt: data from China and Mongolia

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The Frasnian-Famennian mass extinction event ranks in the top five in taxonomic and ecological severity and particularly devastated tropical marine ecosystems. Famennian strata in Xinjiang Province, China, contain both the F-F boundary, the Kellwasser and Hangenberg Anoxic Events associated with the F-F and D-C Extinctions respectively, but also a Famennian rebound fauna in a highly fossiliferous shallow marine setting associated with an oceanic island arc complex in the Central Asian Orogenic Belt (CAOB). This sequence is particularly well exposed in the Boulongour Reservoir section, although previous workers have studied faunas from additional localities. Although stratigraphic nomenclature of the Famennian strata in Xinjiang has fluctuated historically, the sequence has recently been refined by SUTTNER et al. (2014).

Total faunal diversity reported from the Hongguleleng Formation and the 'Hebukehe' Formation is 166 genera and 235 species. Diversity includes 2 genera and species of sponges, 17 genera and 22 species of corals, 1 genus and species of trilobite, 18 genera and 34 species of bryozoans, 48 genera and 57 species of brachiopods, 4 genera and species of cephalopods, 12 genera and 14 species of blastoids, 32 genera and 44 species of crinoids, and 2 genera and 2 species of vertebrates (not including the conodonts). In addition there are reports of 17 genera and 34 species of acritarchs and 13 genera and 21 species of spores. The majority of this faunal diversity is from the Hongguleleng Formation, which is predominantly a shallow marine sequence dating from the latest Frasnian to the middle Famennian (conodont biozones - *linguiformis, triangularis, crepida,* Late *rhomboidea,* and *marginifera*). The 'Hebukehe' Formation ranges in age from middle to late Famennian, is a deeper water sequence with radiolarian cherts, and has a lower diversity fauna. The 'Hebukehe' Formation does contain a unique deep-water assemblage of crinoids and blastoids that is taxonomically different from the echinoderm fauna in the Hongguleleng Formation.

The corals in the Hongguleleng Formation are dominated by cosmopolitan, long-ranging genera typically with simple solitary corallites (SOTO & LIN, 1997). They are part of the "*Cyathaxonia* Fauna" which is recognized globally as the initial rebound fauna after the devastation of corals in the F-F Extinction (DENAYER & HOSGOR, 2014). For bryozoans and echinoderms the Hongguleleng was not only a refugium, it was a center of origination. The Lower Famennian part of the Hongguleleng Formation contains 14 genera and 30 species of bryozoans (TOLOKONNIKOVA & ERNST, 2010). This assemblage shares two species with Transcaucasia and one species with Central Kazakhstan. Species endemism is 90%. About 30% of the species from the Hongguleleng occur in middle or late Famennian faunas in other regions. Therefore, the paleobiogeography of Famennian bryozoans shows migration from Xinjiang, China, to Kazakhstan and the western Tian Shan, and then to other areas. The Hongguleleng crinoid and blastoid faunas are the most diverse Famennian faunas known and have closer affinity with Mississippian faunas than with Devonian faunas, and with North American faunas than European faunas (WATERS & WEBSTER, 2009). These faunas are also morphologically advanced showing many thecal characters rare in Devonian faunas, but common in the Mississippian.

The Samnuuruul Formation outcrops in SW Mongolia in the the Olonbulag Subterrane of the Baruunhuurai Terrane is likely late Famennian in age (KIDO et al., 2013). Although fossils are abundant, the Samnuuruul Formation outcrops in an area that has been subjected to folding, faulting, and extensive fracturing from joint sets. This tectonic overprint has hampered our ability to completely characterize the stratigraphy and biota of the formation making detailed comparisons with the Hongguleleng faunas difficult at this stage. Many of bryozoans have close affinity with bryozoans reported by XIA (1997) from the Hongguleleng Formation in Xinjiang. However, only a single

identifiable crinoid specimen, a flexible, is known from the Samnuuruul Formation in contrast to the abundant and diverse echinoderm faunas from the Hongguleleng. Brachiopods and coral taxonomy is not well constrained currently. On the other hand, the highly fossiliferous intervals in the Samnuuruul Formation are Late Famennian, an interval yielding sparse faunas in the Hongguleleng.
The Hongguleleng Formation contains the most abundant, most diverse shallow marine rebound fauna known in the immediate aftermath of the Frasnian – Famennian Extinction Event. The rebound from the F-F Extinction Event was more rapid than previously thought and was concentrated in NW China, particularly for echinoderms and bryozoans.

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Lower and overlying Devonian deposits (northern part of the Timan-Pechora Region, Russia)

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The completeness of Lower Devonian sections is depended on erosion during the pre-Middle and pre-Late Devonian time (Figure 1). Sediments were accumulated under conditions of shallow marine basin with unstable sedimentation what is shown in rhythmical composition of sections in different types. On the whole, carbonate sedimentation by terrigenous one reflects regressions time in the marine basin. Thickness of deposits varies from several tens of meters to 1500 m.The Lower Devonian deposits were more eroded on the uplifts.

The Lower, Middle and Upper Devonian deposits are uncovered by holes within the Pechora Syneclise and are presented as outcrops in western part of the Pre-Ural Foredeep. In the upper part of the Lochkovian Stage mostly red nearshore marine clastic deposits (sandstones, siltstones, and argillaceous in different extent) are observed at the Denisov Depression. The Lochkovian Stage was stripped at the Kolva Megaswell. Shallow-water facies of argillaceous-carbonate and argillaceous deposits are observed in the Ovin Parma Regional Stage (RS). The upper part of the Lower Devonian (the Sotchem Kyrta RS, 0-380 m) is represented by deposits which have formed in shallow-water facies with argillaceous-carbonate and carbonate-sulphate deposits. The section is composed with marls, limestones, argillaceous dolostones, anhydrites.

The development of the Lower Devonian was defined in the eastern flank zone of the Khoreyver Depression. The reduction of the stratigraphical volume to the complete truncation takes place towards the Bol’shaya Zemlya Paleouplift arch.

The Lower Devonian deposits in the Varandey-Adzva Structural Zone (VASZ) are presented by three stages: Lochkovian, Pragian and Emsian (YUR'EVA & VALIUKEVIČIUS, 2012). Stratigraphical volume of the Lower Devonian deposits was defined by an intensity of the pre-Eifelian and pre-Timan times erosions. The Ovinparma deposits (Lower Lochkovian RS) of the VASZ and the Khoreyver Depression are characterized by conditions of shallow-water basin. The section of this RS is composed by primarily carbonates: limestones, secondary dolostones, marl and argillite. Argillaceous and argillaceous-carbonate thicks correspond to short transgression phases. The thickness of deposits is ranging from 90 to 250 m. Deposits age was dated by remains of fauna: heterostracans *Doriaspis* and *Protaspis* (YURYEVA & KARATAJUTE-TALIMAA, 2005), brachiopods *Protathiris praecursor*, *Mesodouvillina costatula*, *Lenatoechia kuliki*, *Howellella angustiplicata* (BEZNOSOVA & YURIEVA, 2001). At the Sotchem Kyrta time within VASZ area salt deposits under supratidal conditions in basin were formed. The lower part of this RS presents argillaceous-carbonate strata of 65–80 m in thickness being composed by limestones and argillaceous dolostones. The age of these deposits confirms the complex of ostracodes is represented by species of Zone *Welleriella ventriumbonata* (ABUŠIK & ŠAMSUTDINOVA, 2000). In the upper part of the Sotchem Kyra RS are occurred laminated anhydrite-dolostones strata.

The Pragian and Emsian stages are distributed within northern part of the VASZ. Their highest thickness is 350 m. Deposits in lower part of sections are represented by clastic sediments of shallow-water basin: siltstones, sandstones, argillites, dolostones. Overlying deposits were accumulated under conditions of extremely shallow-water basin with sulphate-carbonate sedimentation. This thick is composed by dolostones, marls, anhydrites. Emsian terrigenous rocks were revealed in the northern part of the Kolva Megaswell. Small forms of vertebrates *Antiarchi* in carbonate layers were determinated by V. Karatayute-Talimaa.

On anhydrite-dolostones strata cores are showing erosion. This is due to sea level drop before the Middle Devonian transgression. The thickness of karst breccias varies from several of meters to 70 m.

The Regional Stages of the Middle and Upper Devonian are overlapping the Lover Devonian deposits in the Denisov Depresion and Kolva Megaswell. Thickness of deposits are varies (to 1000 m).

Deposits of this sections were accumulated under conditions of shallow-water basin with clastic, argillaceous-clastic and argillaceous-carbonate sedimentation. Sections are represented by sandstones, siltstones, argillites, limestones. The Middle Devonian deposits were stripped within northern part of the VASZ. They are represented by the lower part of the Eifelian Stage (to 130 m). Deposits were accumulated under conditions of shallow-water basin with argillaceous-clastic and argillaceous-carbonate sedimentation. This thick is composed by sandstones, siltstones, argillites, marls, limestones. The Dzh'er and Timan sections reflect transgressions time in the marine basin. The are represented by siltstones, sandstones, argillites, limestones, marls. The Sargaj deposits are developed at the territory of the Timan-Pechora Region (to 940 m). Sediments were accumulated under conditions of shallow-water basin with argillaceous-carbonate, carbonate, sedimentation.

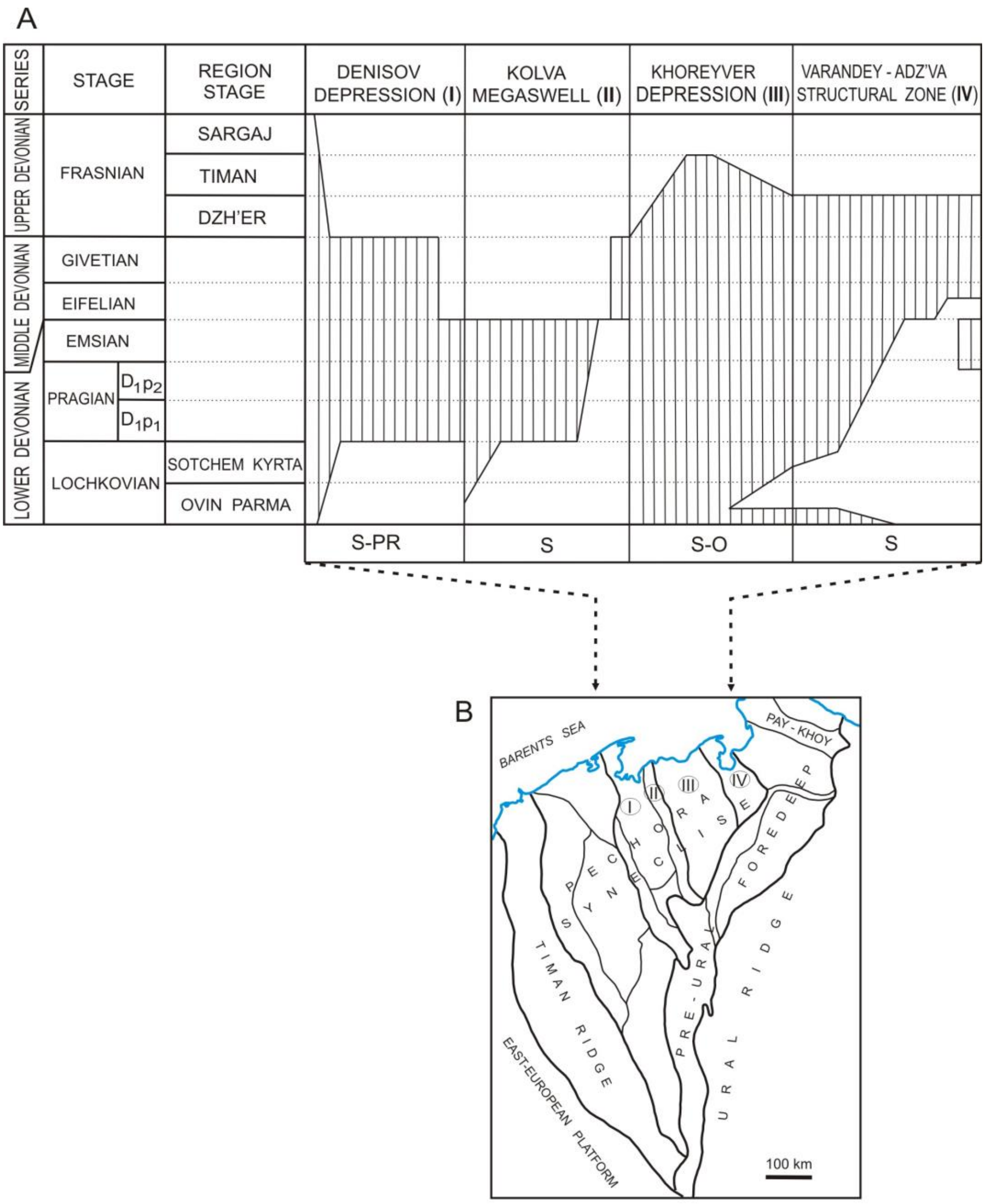

Figure 1: **A**. The chart of the dissection and correlation of the Lower and overlying Devonian deposits of northern part of Timan-Pechora Region. **B**. The tectonic chart of the Timan-Pechora Region (by MALYŠEV, 2002).

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