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Opinion: How do we sell Deep Time?

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The Palaeozoic - the era with which CIMP is primarily concerned - is Deep Time. The phrase Deep Time, meaning pre-Quaternary time, is turning up a lot recently. Within the British and American geological communities questions such as 'How do we sell Deep Time' and 'What is the point of studying Deep Time?' are continually being asked (e.g. Soreghan et al. 2003, Soreghan 2004). I am presently involved in organising a symposium at BGS on the 'Geological Survey and Climate Change', and at least two delegates have suggested privately to me that Deep Time research should not be included because its conclusions are too vague and its data cannot be used easily in climate models because it is too 'coarse'. They say that Deep Time research cannot contribute to understanding decadal or centennial climate change which is, after all, what governments are mainly interested in. Thus as Palaeozoic palynologists we ought to be 'selling' Deep Time, and thinking about the specific benefits that our period of study (which contains two major glacial events) and our science (which is arguably the only palaeontological discipline that can provide high enough resolution data in the Palaeozoic) can offer.

It's true that the Quaternary has told us a lot about the Earth's climate system. Perhaps the most significant and surprising is that climate can change quickly, within human lifetimes, and that this record can be preserved at high fidelity in ice cores for example. However, study of the Quaternary alone gives a rather myopic view of our climatic past; a view that we must look beyond, because we are now entering an atmospheric composition totally unlike that of the Quaternary, the kind of atmosphere only found in Deep Time. The ice -core record, which has enabled reconstruction of atmospheric CO2 at high resolution, shows that we are, today, at the highest level of CO2 in the last 420,000 years and likely higher than any point in the last 20,000,000 yrs (IPCC, 2001). CO2 is a particularly compelling reason to study Deep Time, owing to its relevance to climate change on all timescales (Crowley and Berner, 2001). Deep pre-Quaternary time is also more than 99% of earth time and contains most of the big events that have shaped life and this planet. According to some estimates, rates of extinction recorded in the last 50 years are higher than those at the Permian–Triassic boundary (PTB).

The Monteverde Golden toad was last seen in 1989 and is presumed extinct. 33% of toad species are endangered and 120 species have become extinct since the 1980s. For the first time fungal disease linked to global warming has been suggested as the cause (see *Nature* 439, 161-167).

So are we heading for mass extinction and is the study of Quaternary climate variability enough to understand the extremes that might be coming? These ideas alone suggest that deep time is worthy of interest. But deep time study could answer many more questions: Can 'tipping points' of climate change, e.g. from greenhouse to icehouse, be predicted? How do tectonics influence climate in affecting gateways, relief, and the ocean thermohaline circulation? (see for example Soreghan et al. 2003). Palaeozoic palynologists have been involved in posing some of these questions and could be fundamental in future research, if we build on our strengths in biostratigraphy and palaeobiogeography and work with isotope geochemists and geochronologists.

Deep time: the horizontal Permian Saiq Formation above the Precambrian Fiq Formation, Saiq Plateau, Oman.

Looking down on the Fiq Formation, Saiq Plateau, Oman. Lower Palaeozoic to the right, all capped by Permian Saiq Formation.

Most geological deep time palynological research begins with a rock section which records environmental change. We study its palynology, then we assess the value of other proxies (geochemical, isotopic) in supporting the palynological data and develop a hypothesis of change which we test most crucially by corroboration from study of correlated sections elsewhere, involving biostratigraphy and geochronology. Thus palynology is used in the reconstruction of climate change (using its value as a proxy) as well as being important in correlating sections recording change. CIMP palynologists have been involved in this kind of science with particularly strong contributions in the early Palaeozoic, though new palynological work is showing the value of study of the Carboniferous-Permian glacial period in understanding modern glaciation.

Computer climate modellers study climate by synthesising and manipulating key processes then viewing the results, whereas palynologists and stratigraphers view the results then deduce the processes. Thus there is a difference in the approach of climate modelers and the palaeontology/stratigraphy community. This historical disparity between the communities should be bridged because we can learn a lot from each other. However neither geologists nor deep time computer climate modellers can resolve questions on decadal or centennial level climate change but we can see the big events in the earth system and distinguish large and important events from small events. New projects that interest me and which might grow from work presently being done at BGS include the role of phytoplankton in controlling ρCO_2 in glacial cycles, and the value of new climate proxies such as geologically preserved lignin when studied in concert with detailed terrestrial palynology. But it's our responsibility as palynologists to ensure that the evidence of our science is heard, and that the value of the Palaeozoic in climate study is known.

References

Soreghan, G. S. 2004. Deja-vu all over again: Deep Time (climate) is here to stay. Palaois, 19, February 2004.

Soreghan, G. S., Parrish, J. T. & Maples, C. G. 2003. Geoclimate: probing the Earth's climate record at all temporal and spatial scales. Eos,Vol. 84, No. 44, 4 November 2003.

IPCC, 2001, Climate Change 2001, The Scientific Basis: Cambridge University Press, Cambridge, 881 p.

Crowley, J.C., and Berner, R.A., 2001, CO2 and climate changes: Science, v. 292, p. 870–872.

IPC Beijing 2006 abstracts

In the last issue of the Newsletter I said that the main palynological abstracts of the Internation Palaeontological Congress in Beijing 2006 would be reproduced. I have obtained permission and am in the process of trying to get the text from the IPC 2006 organizers. Sorry about the delay.

New President's message

John Marshall, jeam@noc.soton.ac.uk

Firstly I'd like to wish you all a Happy New Year and best wishes for 2007. Being elected President of CIMP for the next 4 years is both an honour and a responsibility. The outgoing President, Florentin Paris, was correct to suggest an election because it means that the position becomes a more active role rather than rotating to the next greyest palynologist. Can we thank everyone who both stood and participated? It makes our organisation stronger.

This year we have another meeting. Initially it was going to be a Spore Sub-commission meeting to follow that in Cork, Ireland in 2001. But it has now broadened out to be a joint meeting with the Acritarch Sub-commission. We have, to my knowledge, never before had a meeting in Portugal. Palaeozoic palynology is a young subject in Portugal and it has helped very significantly to understand the mineral deposits in southern Spain and Portugal. So it is a great opportunity to see what they have achieved. The details are elsewhere in this Newsletter.

I have also been giving thought to how we can better use CIMP as a way of establishing the future of Palaeozoic palynology. CIMP is quite unusual in that it has very few assets apart from the membership subscription. However, it does have a very successful record of promoting meetings, projects and publications. This year represents an opportunity. Oil prices are high and there is renewed interest in revisiting some established Palaeozoic basins. Employers are recruiting and there is a shortage of palynologists. I would hope that we can at least get some support for students at conferences. So, if you work for a company then expect a letter. I certainly intend to discuss these issues with the other CIMP officers to agree a strategy.

Palynos News

PALYNOS

CIMP members are reminded that PALYNOS, the newsletter of the "International Federation of Palynological Societies" (IFPS), is no longer distributed in hard copy. However, all issues of PALYNOS are made available in electronic format on the IFPS website http://geo.arizona.edu/palynology/ifps.html. PALYNOS is published biannually in June and December.

Meetings and conferences

AASP 40th Annual Meeting, Smithsonian Tropical Research Institute, Panama.

September 8-12, 2007.

Organizer: Carlos Jaramillo

Conference webpage: http://striweb.si.edu/aasp07

Early Registration Deadline: July 30, 2007

AASP 41st Annual Meeting, Bonn, Germany at the 12th IPC, Aug. 30 - Sept. 6, 2008

European Geosciences Union General Assembly

15–20 April, 2007, Vienna, Austria "SESSION SSP17: Environmental perturbations during the Palaeozoic-Mesozoic interval: Organic geochemical and palynological proxies" Conveners: Ulrich HEIMHOFER ulrich.heimhofer@rub.de & Annette E. GÖTZ annette.goetz@geo.uni-halle.de

Abstract Deadline 15 January 2007

non-member 400 €

Conference Web Page http://meetings.copernicus.org/egu2007/

14th Symposium, International Work Group for Palaeoethnobotany

17-23 June 2007 Krakow, Poland: Palac Larischa, Bracka 12

Prelim. Registr. deadline Sept. 15th 2006. 95 € Conference Web Page www.ib-pan.krakow.pl/iwgp/

First International Palaeobiogeography Symposium

10-13 July, 2007, Univ. Pierre et Marie Curie, Paris

Contact Monique Troy palstrat@ccr.jussieu.fr

Abstract Deadline May 10th 2007
Registration 150 € before 3/31/07, 190 € after

Conference Web Page
http://sgfr.free.fr/rencontrer/seances/s07-07paleobiogeo.html

12th International Palynological Congress

30 Aug - 6 Sept 2008, Bonn, Germany

First Flier

Contact Thomas Litt t.litt@uni-bonn.de

XVI ICCP, Nanjing China

June 21- June 24, 2007

Important dates

February 1, 2007: Second Circular available online and distribution

April 1, 2007: Deadline for pre-registration and abstract submission

May 1, 2007: Third Circular available online.

December 31, 2007: Deadline for manuscript submission to the proceedings volume

Proposed sessions:

- S1 Carboniferous and Permian Palaeobotany and Microflora
- S2 Carboniferous and Permian Macro-and microfossils
- S3 Devonian F-F Mass Extinction and Mississippian Recovery
- S4 Biotic Turnovers during the mid-Carboniferous boundary and Early
- S5 Carboniferous and Permian Reef, Biofacies, and Basin Analysis
- S6 Evolutionary Palaeogeography and Palaeoclimatology
- S7 Integrative Stratigraphy and High Resolution Biostratigraphy
- S8 Isotopic Geochemistry and Geobiology in the Permo-Carboniferous
- S9 Gondwana and Peri-Gondwana Faunas, Stratigraphy, and Geology
- S10 Bio-Diversity Patterns and Quantitative Analysis of Biotic Databases
- S11 Stratotypes, Boundaries, and Global Correlations
- S12 End-Permian Biotic Mass Extinction and Early-Triassic Recovery
- S13 Pangea formation and breakup
- S14 Cyclothemic Stratigraphy and Sequence Stratigraphy
- S15 Carboniferous and Permian Coal, Petroleum, and Economic
- S16 Computerized Palaeontology

• S17 Palaeontological Education for the Public.

Joint Meeting PTG-DGG
GEO-POMERANIA

GeoPomerania

http://www.geopomerania2007.org/

Contact:

geopomerania@fu-confirm.de

The Geological Society of Poland and Deutschen Gesellschaft für Geowissenschaften cordially invites you to visit our annual main meeting in Szczecin at the southern border of the Baltic Sea. At our conference "GeoPomerania 2007 - Geology cross-bordering the Western and Eastern European Platform" we will have presentations on new geological regional highlights as well as top themes referring to our science. Partners of our geological societies meeting will be the universities of Szczecin, Greifswald and Freiberg as well as the regional geological surveys on both sides of the river Odra/Oder.

Conference language is English. No simultaneous interpretation will be provided.

Programme

An interesting and comprehensive conference program is foreseen that offers plenary and parallel sessions, poster and industry exhibition, panel discussions, and social program.

Topics

1 Southern Permian Basin (SPB) / Central European Basin System (CEBS)

1.1 Sedimentary Basins

1.2 Regional Geology, Structures and hydrocarbon potential

1.3 Regional stratigraphy

1.4 Global Devonian, Carboniferous and Permian correlations

2 Cross-boundary groundwater management

3 Coastal dynamics

4 Geopotentials and Resources

5 Climate Change

6 Environmental Geology

7 Geoarchaeology

8 Geoheritage, geotourism and geoparks

CIMP Lisbon'07
Joint Meeting of Spores/Pollen and Acritarch Subcommissions

Lisbon CIMP Subcommissions meeting

A joint meeting of the Spores/Pollen and Acritarch CIMP Subcommissions, organized by INETI-GEOSCIENCES (Portuguese Geological Survey), will be held in Lisbon, Portugal from 24 to 28th September 2007. The conference is opened to all persons interested in any aspect of the Palaeozoic palynology. The program will include a scientific meeting consisting of contributed papers, poster sessions, workshops and courses, followed by a post-conference field trip to Southern Portugal.

Organizing Committee

Z. Pereira (INETI-GEOSCIENCES, Portuguese Geological Survey)

J. Tomas Oliveira (INETI-GEOSCIENCES, Portuguese Geological Survey)

P. Fernandes (University of Algarve, Portugal)

N. Vaz (University of Trás-os-Montes and Alto Douro, Portugal).

Scientific Committee

G. Clayton (Trinity College, Dublin)

J. Marshall (University of Southampton)

Z. Pereira (INETI-GEOSCIENCES, Portuguese Geological Survey)

P. Steemans (University of Liege)

R. Wicander (Central Michigan University)

Registration

To attend CIMP Lisbon'07, all participants must **register via the web**. Please submit the **CIMP Lisbon'07 Questionnaire** before **January 31**, 2007 and **CIMP Lisbon'07 Registration Form** before **March 30**, 2007.

Topics of the Scientific Programme

1. Palaeozoic marine microplankton
Contributions on any aspect of marine microplankton, including acritarchs, prasinophycean algae and associated forms.

2. Palaeozoic spores and pollen
Contributions on any aspect of spores, including cryptospores, microspores, megaspores and pollen, taxonomy and biostratigraphy.

3. Open presentations

Contributions on all aspects of Palaeozoic palynology, including non-marine microplankton, kerogen studies, organic palynofacies, organic geochemistry, palaeoecology, palaeoenvironments, palaeogeography, taphonomy, taxonomy and applied palynostratigraphy.

Post Meeting Field Trip

The post meeting field trip "Palynostratigraphy within the context of the Ossa Morena and Pyrite Belt geology" will start and end in Lisbon. For those who want to return via Faro, there is the possibility to stay in Beja at the end of the meeting and take a train to Faro airport. This excursion will highlight important fossiliferous mid-Palaeozoic sections:

Day 1

The Barrancos section. Barrancos region, Ossa Morena Zone. Roadcuts in the Barrancos region, near the Spanish border, exposes almost continuously Silurian black shales, Lower Devonian shales and flysch. This stratigraphic sequence is considered as a reference for the middle Palaeozoic geology of the Ossa Morena Zone in Portugal.

Departure from Lisbon, visit to the city centre of Évora (UNESCO world heritage town) and exploration of the Barrancos section.

Dinner and overnight at Barrancos.

Day 2

Pyrite Belt, South Portuguese Zone: region between Mina de S. Domingos mine, Pomarão and Mértola. The best outcrops of the Portuguese Pyrite Belt stratigraphy are exposed in this region. The stratigraphic sequence, from base to top consists on the Phyllite Quartzite Group (PQ) of late Devonian age, the Volcano-Sedimentary Complex (VSC) of Tournaisian to Late Visean age and the Mértola Formation (Mt), a flysch unit of late Visean age.

The Mina de S. Domingos mine was one of the most important copper mines in Europe during the world wars. It was actively worked from 1858 until the end of 1966, extracting 25 million tons of massive sulphides. We will visit the old mine open pit and discuss the palynostratigraphic contributions to the understanding of the local stratigraphic sequence.

The Pomarão Anticline section, well exposed along the road from Santana de Cambas to Pomarão, is a reference section within the context of the entire Iberian Pyrite Belt. It shows the Volcano-Sedimentary Complex (VSC) and the PQ Group units.

The Azenhas section situated near Mértola, in the west margin of the Guadiana River exposes the Mértola thrust that is age-controlled by spores.

Departure from Barrancos to Mina de S. Domingos Mine, crossing the Ossa Morena-South Portuguese Zone boundary and the Pulo do Lobo Anticline. Visit to the abandoned mine open pit, the Pomarão anticline and the Azenhas (Mértola) sections.

A touristic tour in Mértola, an important archaeological centre, will be arranged.

Return to Lisbon. For those who want to return via Faro, overnight at Beja.

10th International Symposium on the Ordovician System, 3rd International Symposium on the Silurian System, and IGCP 503 Annual Meeting

Nanjing, China

June 27-30, 2007

This meeting will be held together with the 10th International Symposium on the Ordovician System and the 3rd International Symposium on the Silurian System in Nanjing, China. The meeting will take place from June 27 to June 30, 2007, with pre-, mid- and post-conference field excursions.

http://www.silurian.cn/

http://www.ordovician.cn/

CIMP Prague

With kind permission of the organisers I here reproduce the full abstracts of the Prague meeting for the benefit of colleagues that could not attend.

Palynological characterization and dating of the Upper Ordovician sediment (Memouniat Formation), Northwest Sirte Basin, Libya

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This study is based on the palynological investigation of conventional core samples from wells drilled in north west Sirte Basin, Libya, penetrating the Memouniat Formation. The organic residues are dominated by diverse and well preserved marine-palynomorphs with abundant acritarchs, and chitinozoans, but only few miospores (cryptospores) of low diversity were recorded. The palynomorphs obtained provided 32 species of acritarchs belonging to 22 genera; eight species of chitinozoans belonging to seven genera and three species of cryptspores belonging to three genera. Palynological assemblage have been recognized based on microplankton taxa distribution. A number of morphologically distinctive marine taxa were recorded which prove to be stratigraphically useful, such as: *Baltisphaeridium longispinosus delicatum*, *B. aliquigranulum*, *Veryhachium irroratum* and *Villosacapsula steosapelliula*. Comparison of this assemblage with those studied by Hill and Molyneux (1988) and Grignani et al. (1991) indicates that this level of the Memoniat Formation is Ashgillian in age. The relative abundance and diversity of spores (cryptspores) to acritarchs and chitinozoans have been calculated and plotted. This shows the palaeoenvironmental deposition of the Late Ordovician sediments, related to an open marine shelf environment.

Palynological and Integrated Geological Study of the Gharif Formation, Hasirah Field, West Central Oman

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The Permian Gharif Formation is at its most basinal in the Rub Al Khali basin in the Hasirah Field in west central Oman. The formation comprises an interfingering sequence of shallow marine, clastic-carbonate, lagoonal, river, lake and paleosol deposits. The cores in Hasirah yield Sakmarian fusulinids in the Haushi Limestone, algal facies at the base of the Middle Gharif member and unusual storm deposits in the Upper Gharif member (with macroscopic plant remains) which together with ostracod and fish-bearing sediments reflect the onset of the Khuff Formation marine transgression. This study attempts to relate palynology and palynofacies to these varied sedimentary facies. A locally derived palynological sequence can be tied into the regional biostratigraphic scheme of Stephenson et al. (2003) and therefore the Hasirah sequence can be correlated regionally. It will also be related to subsurface (Angiolini et al. 2004) and surface (Angiolini et al. 2003) macropaleontological studies to allow correlation of Hasirah with surface sequences in the Huqf Outcrop area. A total of 29 samples were analysed from 3 boreholes (Hasirah-1, 10H1 and Hasirah-10H2) located in west central Oman. The taxonomy and stratigraphic distribution of over 50 palynomorph taxa are reported. Two new species are proposed. The palynostratigraphic data indicates OSPZ3b & OSPZ3c assemblages in Hasirah-1H1 (Lower Gharif), OSPZ4 assemblages in Hasirah-10H2 (Middle Gharif) and OSPZ5 assemblages in Hasirah-10H1 (Upper Gharif). Correlation with Hilwah-3 and Jufrah-1 (Saudi Arabian boreholes) proved more problematical. Thirteen palynofacies types have been identified based on visual assessment of the percentages of major categories (lath shaped inertinite, equidimensional inertinite, vitrinite, cuticle, amorphous organic matter (AOM) and palynomorphs). During Gharif times, the climate changed from temperate, to arid and then tropical.

References:

Angiolini, L., Balini, M., Garazanti, E., Nicora, A. & Tintori, A., 2003. Gondwana deglaciation and opening of Neotethys: the Al Khalata and Saiwan Formations of Interior Oman. *Palaeogeograhy, Palaeclimatology, Palaeoecology*, 196, 99-123.

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Stephenson, M.H., Osterloff, P.L. and Filatoff, J., 2003. Palynological biozonation of the Permian of Oman and Saudi Arabia: progress and challenges. *GeoArabia*, 8, 467-496.

Palynostratigraphy of the Al Khlata Formation, Oman; a study of shallow boreholes from central and south Oman

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The Al Khlata Formation is the lowest unit of the Haushi Group of interior, subsurface Oman. It is a glacigenic non-marine succession that was deposited in an intra-cratonic basin during Carboniferous-Permian time. Extensive palynological studies have allowed subdivision by PDO into three biozones; from oldest to youngest: (1) PDO biozone 2159 (Westphalian-Stephanian), AK P9, and OSPZ1; (2) PDO biozone 2165 (Stephanian-Asselian), AK P5, and OSPZ1-OSPZ2; (3) PDO biozone 2141 (Asselian-Sakmarian), AK P1, and OSPZ2. The Al Khlata was deposited in the third glaciation in the region. It occurs predominantly in the subsurface and extends from south of the Oman Mountains to south Oman and possibly beneath the Rub' Al Khali Desert. The Al Khlata Formation outcrops can be found in the Haushi-Huqf area. The formation is bounded at the top conformably by the post-glacial Gharif Formation that overlays the topmost Rahab Member of the Al Khlata Formation. The Rahab Member, however, disappears in the north central part of Oman, and palynology is the only tool allowing correlation of the beds. The Al Khlata Formation overlays Precambrian and Lower Carboniferous rocks unconformably. The thickness of the Al Khlata Formation is variable predominantly due to erosion of Precambrian salt domes, and ranges from 100m to 800m. Correlating the different production units of the Al Khlata is problematic, mainly because of the rapid horizontal and vertical changes in lithofacies, and can only be done by palynology. The Al Khlata lithofacies comprise glacio-lacustrine, glacio-fluvial, and glacio-deltaic. A recent and ongoing extensive shallow borehole palynological study offers the opportunity to relate these lithofacies with palynological assemblages. In addition, because the Carboniferous-Permian glaciation was a complete global warming cycle, this study can help in understanding current climate change and how modern biota will be affected.

Palaeoecological changes in four profiles in the Kladno-Rakovník Basin (Bolsovian), Czech Republic and the concept of palynological phases

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Four profiles (HK-1-4) of the coal seams of the Upper Radnice Seam, the Radnice Member, Bolsovian, the Kladno-Rakovník Basin were studied palynologically. Samples from the VP-29 borehole and from the Ovčín Mine from the same stratigraphic level, but from the Radnice Basin were used for the comparison.

It is possible to recognize two main characters of dispersed spore assemblages in HK-1-4 profiles, based on the changes in the prevalence of two main spore groups, lycospores and densospores. The average percentage of lycospores within all samples of the lycospore phase in HK-1-4 profiles is 55 per cent, whereas densospores make only 11 per cent on average there. Sphenophyllalean miospores are the third in frequence and make 8 per cent on average, that is comparable with the percentage of miospores of fern origin (7 per cent on average). Calamospores produced by several equisetalean plants make 5 per cent on average and cordaitalean miospores of the *Florinites*-type make only 2 per cent and their parent plant played only a minor role in plant assemblages from the HK-1-4 profiles. Several species of *Leiotriletes* are the most abundant miospores of the fern origin (3 per cent on average) and the second one is *Granulatisporites*. Other two monitored fern genera, *Raistrickia* and *Triquitrites* make less than one per cent on average (0.3 per cent severally). Miospores of sigillarian genus *Crassispora* are relatively abundant and make 2 per cent on average within all samples of the lycospore phases. Important miospore species of unknown origin, *Knoxisporites polygonalis* is relatively frequent and make 3.3 per cent on average.

The ratio of two main spore groups, lycospores and densospores is completely different within samples belonged to the densospore phase in HK-1-4 profiles than in the lycospore one. Densospores dominated (61 per cent on average) and lycospores make only 9 per cent. Surprising is, that miospores of sphenophyllalean, fern and equisetalean origin make the same percentage (8 per cent on average) comparable with that of densospores. Cordaitalean miospores are not abundant and make only 1 per cent on average from all spores. Species of *Leiotriletes* are again the most abundant from all miospores of the fern origin (2.8 per cent on average) and the second most frequent fern genus is *Granulatisporites* (1.6 per cent on average) again. The percentage of other two genera of fern affinity, i.e. *Raistrickia* and *Triquitrites* is again comparable (0.6 resp. 0.8 per cent on average) and low. Very rare are sigillarian miospores of the *Crassispora*-type (only 0.5 per cent on average). Significant species *Knoxisporites polygonalis* is relatively frequent (2.5 per cent on average), comparable to the percentage of the most abundant fern miospore genus *Leiotriletes*. Strange is, that the average number of miospores species and related estimated number of their parent plant species are the same within both phases (sixteen resp. eleven).

It is evident, that the L→D change is not the same in all profiles, but always more or less different. A special different type of the L→D change is recognised in the HK-2 Profile. It seems, that the change did not pass suddenly, but that there is the transitional-like zone. A few samples close to the L→D boundary, i.e. a few last samples of the lycospore phase are typified by a special character with decreasing percentage of sphenophyllalean miospores and increasing frequency of sigillarian miospore genus *Crassispora* and species of unknown affinity *Knoxisporites polygonalis*. It may be caused by slightly different (drier) conditions, which are still favourable for high arborescent lycopsids of genera *Lepidodendron* and/or *Lepidofloyos* but already suitable for some sigillarians and unknown *Knoxisporites polygonalis*-producing plant.

Also the D→L change is not uniform and differs in each profile.

The number of miospore species and related estimated number of their parent plant species is surprisingly the same within the lycospore and densospore phase in HK-1-4 profiles. Also the percentage of sphenophyllalean and fern miospores is the same in samples from both phases. Miospore genera *Leiotriletes* and *Granulatisporites*, produced mainly by several fern taxa are more abundant within the lycospore phase, than in assemblages with prevalence of densospores. On the other hand, other following fern genera *Raistrickia* and *Triquitrites* are more frequent in the densospore phase, than in the lycospore one. The percentage of the sigillarian miospore genus *Crassispora* and species of unknown affinity *Knoxisporites polygonalis* is bigger in spore assemblages with the dominance of lycospores than in the densospore phase, what may give the evidence, that some sigillarians and unknown *Knoxisporites polygonalis*-producing plant species preferred more wet conditions than sub-arborescent lycopsid genus *Omphalophloios*.

All comparative samples of the Upper Radnice Seam from the VP-29 borehole and the Ovčín Mine in the Radnice Basin yielded more diversed spore assemblages with 30 resp 31 miospore species on average (compared to 16 within HK-1-4 profiles!). Also related estimated number of their parent plant species is twice bigger in comparative samples (21 resp 23) than in samples from HK-1-4 profiles (only 11). All comparative samples possess palynological character typical for the lycospore phase with prominent prevalence of lycospores over densospores. Densospores occured only very rarely in the VP-29 borehole (only 1 per cent on average) and are completely absent in samples from the the Ovčín Mine. Sphenophyllalean miospores are relatively abundant in comparative samples (17 resp 18 per cent on average) and also the frequency of miospores of the fern origin is much higher (20 resp 10 per cent), than in HK-1-4 profiles (8 per cent on average). Miospores of equisetalean affinity occur comparably in HK-1-4 profiles (7 per cent on average) and in the VP-29 borehole (8 per cent) and the Ovčín Mine (2 per cent). The percentage of cordaitalean miospores of the *Florinites*-type is three times bigger in comparative samples, than in slides from HK-1-4 profiles.

It is evident, that miospore assemblages of the lycospore phase of HK-1-4 profiles are significantly different from those of the VP-29 borehole and the Ovčín Mine, which both possess similar character. Much higher percentage of sphenophyllalean, fern and cordaitalean miospores and twice bigger number of miospore species and related estimated number of their parent plant species gives the evidence about different character of plant assemblages and palaeoecological conditions in HK-1-4 profiles in the Kladno-Rakovník Basin and in the Radnice Basin (VP-29 borehole and the Ovčín Mine), although all these samples are from the same stratigraphical level, i.e. the Upper Radnice Seam.

There are differences in the composition of spore and pollen assemblages within a one of the main four palynological phases. It may be suitable to recognise some additional palynological sub-phases, because it is evident, that not all, e.g. lycospore phases and/or denospore phases are the same. The concept of four main palynological phases suggested by Smith is not functional in the stratigraphically younger coal seams especially those of the Stephanian and Autunian age, where usually the smallest monoletes (produced by several marattialeans) spores and saccate pollen dominant.

Carboniferous and Devonian *Polysporia* and its spores

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Sub-arborescent lycopsids of *Polysporia/Chaloneria*-type belong to the important fossil plants of Palaeozoic. They are ancestors of Triassic lycopsids genera *Pleuromeia* and *Annalepis* and recent *Isoetes*. Their phylogenetic lineage is documented in papers of Grauvogel-Stamm, Lugardon and Pigg. Carboniferous *Polysporia* represents compression specimens of about 2 m long unbranched plants with fertile apical zones. Micro- and megasporangia alternated. The biggest number of species of *Polysporia* is reported from the Pennsylvanian and the Czech Republic. In situ microspores belong to the dispersed spore species *Endosporites zonalis* and *E. globiformis*. In situ megaspores are correlated to the dispersed spore species *Valvisisporites auritus*, *V. westphalensis* and *Triletes bohemicus*. Phylogenetic lineage was proved from recent *Isoetes* to Carboniferous *Polysporia* via *Pleuromeia* and *Annalepis*, based mainly on the ultrastructure features of in situ spores. Devonian ancestors were considered to be plants described from

Devonian Cleveland Shale of USA (*Clevelandodendron, Arnoldia*), but we had not any direct evidence about their relationship. Now a new specimens of Devonian *Polysporia* from the Devonian of Cleveland were discovered and described. In situ microspores are the same as those of Carboniferous specimens (*Endosporites*-type) and also megaspores are of the same type (*Valvisisporites*). Microspores and most megaspores occur in dispersed form and lying of the rock surface. Only a few entire megasporangia are preserved. Devonian specimens of *Polysporia* give us a new evidence about the long phylogenetic lineage *Isoetes-Pleuromeia-Annalepis-Polysporia* which cover most of the Phanezoroic era. This lineage is documented mainly on in situ spores.

In search of the earliest seed plants

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The appearance of seed plants in the Late Devonian is a critical episode in earth history. How seeds evolved is still an open question. Recently, in *Palaeontology*, Marshall and Hemsley described *Spermasporites allenii* from a Middle Devonian lake on Ella Ø, East Greenland. *S. allenii* is a seed megaspore bearing at its apex not only three smaller aborted spores of the original tetrad, but also a cluster of microspores. This suggested a new path to seed evolution, where the seed megaspore is most likely to be fertilized by microspores from within the same sporangium but also allows for fertilization by microspores from another sporangium or individual. In order to determine the taxonomic affinity of the seed-meagaspore bearing plant, CMB, JEAM, and AH mounted a NERC-funded expedition to Ella Ø under the umbrella of CASP. Excavation of the layers in which the seed megaspores were concentrated yielded numerous partial specimens of the plant. Megaspores are snugly contained in sporangia which are inserted terminally on the end of a branching system. Association suggests that these were carried laterally on small sparsely dichotomously and trichotomously branching naked stems. This suggests morphology more similar to that of latest Devonian seed plants than to that of the contemporaneous advanced progymnosperm *Archeopteris*/*Svalbardia* found elsewhere in the same lake, which may otherwise be an obvious candidate for ancestry of seed plants.

Morphological variability of some Devonian miospores

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Human beings need to have name tags for things and classify them in different boxes, in order to deal with them. Therefore, miospore taxa are named by using Linnaean-style Latinized binomial nomenclature, formally governed by the International Code of Botanical Nomenclature (ICBN). However, Palaeozoic miospore taxonomy has currently become somewhat problematic resulting, notably, in the overlapping diagnoses of some taxa. The number of described species has been so huge that it is difficult to cope with all this information.

The fact that miospores are generally retrieved from sediments after their dispersal often imply, at least for the Palaeozoic, ignorance of their parent plants and consequently of their natural affinities, most of the time. Thus the morphology of miospores provides the unique basis for taxonomic discrimination. Therefore, miospores are commonly classified into different well-defined boxes by a simple morphological comparison. Besides, some authors urge the stratigraphic utility of subdividing miospore groupings as much as possible; but others note that gradations between taxa may be so slight that intermediaries can often be found between species or even genera, frequently regarded as separate. Many cases of such intergrading taxa are common in the fossil record. The palynomorphs often transgress the taxonomical boundaries which they have originally been defined on.

Some examples of such continuous morphological intergradation are presented here. They show that the morphological variability can be observed not only within a unique species or between several species belonging to a same genus, but also between two distinct genera. Another example of morphological variability presented here is due to a possible taphonomic problem.

This countribution highlights some problems of miospore taxonomy by showing several examples from Devonian assemblages from Libya and Saudi Arabia. These different examples of continuous intergrading morphological variation illustrate one of the major problems in miospore taxonomy: the morphological variability of each taxon, combined with the description of individual forms, which are rarely studied within large populations.

Devonian acritarch Navifusa bacilla: Morphological variability and method of opening

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Joint research activities of the Forschungsinstitut Senckenberg and the Charles University are focussed on comparison of the sedimentological development and the biostratigraphical subdivision of the commonly neritic Emsian in the type area of the Rheinisches Schiefergebirge (= Rhenish Slate Mountains) and the classical, pelagic Barrandian area. The Emsian, the third stage of the Devonian System, encompasses about 15 to 17 Ma representing one of the longest stages in the Palaeozoic. Hence, a subdivision of the Emsian into two substages, Lower and Upper Emsian is under active discussion.

Initial results of ongoing palynological studies from the Císařská rokle section in the Císařská rokle gorge are presented. Within this section the Zlíchovian-Dalejan boundary interval (corresponding roughly to the Lower / Upper Emsian boundary interval) is well developed in a continuous succession from the Zlíchov Limestone to the Daleje Shale.

Most studied samples of the Daleje Shale yielded prasinophytes, acritarchs, chitinozoans, scolecondonts and some of them also spores. Within these samples numerous specimens of the fusiform acritarch genus Navifusa have been found. All of the more than 300 observed specimens are attributed to the single species Navifusa bacilla. High number and excellent preservation of this species permit a detailed morphometrical analyse and a critical evaluation of the morphological variability within separate samples. Furthermore, it was possible to study the method of its cyst opening. Such analyse of large populations signifies a distinct differentiation of two phases in the life cycle; namely the encystment phase and the excystment phase.

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Zooplankton fecal pellets and phytoplankton particles from about 445 MA deep sea black smoker mound (Yaman-Kasy deposit, South Urals, Russia)

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The Yaman-Kasy Cu-Zn deposit represents an excellently preserved fossil black smoker mound situated in the allochthonous Sakmara Zone of the southern Uralides, near to the town of Mednogorsk. The sulphide mound formed on the Early Palaeozoic floor of the Uralian ocean that was closed by Late Palaeozoic collision between the intra-oceanic

Magnitogorsk island arc and continental margin of the East European craton. The arc-continent collision caused thrust of the considered Early Palaeozoic ocean floor segment upon the continental margin without orogenic regional metamorphism. Graptolites from hangingwall rocks of a neighbouring sulphide deposit record the Earliest Silurian *ascensus-acuminatus* zone providing a minimum age for sulphide deposition.

The Yaman-Kasy deposit is famous for preservation of the oldest known taxonomically diverse hydrothermal vent fauna comprising tube worms, inarticulate brachiopods, and monoplacophorans. Ore textures are comparable to black smoker mounds on the modern sea floor and indicate a minimum water depth of approximately 1000 m. The presence of hydrothermal vent fauna and haematite replacement of ores at top of the sulphide mound evidence aerated bottom water conditions. Sulphur isotope compositions of barite from ore are in the range of contemporaneous epicontinental evaporites suggesting a well-mixed oceanic water column.

The lateral wedge of the sulphide mound yielded sediments composed of sulphide debris and intercalations of siliceous deposits. Sedimentary textures similar to turbidites evidence episodic deposition of coarse to silt-sized sulphide and vent fauna debris sourced in the sulphide mound. Siliceous intercalations of sulphide sediments display mixed provenance comprising the pelagic background, particles from the hydrothermal plume of the black smoker mound, fine-grained volcanogenic debris, and silica likely derived from low-temperature diffuse exhalation at the foot of the sulphide mound. They record depositional processes of longer duration compared to the event-character of associated sulphide debris layers.

The siliceous intercalations contain well preserved microaggregates rich in palynomorphs and POM, abundant isolated palynomorphs (prasinophytes and acanthomorph acritarchs), as well as rare scolecodonts, radiolarians and cyanobacterial relics. The microaggregates are composed of silica matrix, display oval shape, differ in size from a few tens to hundred microns, and are devoid of significant mineral debris. Envelops of purer silica are common suggesting enhanced silica precipitation at the surface of microaggregates. Palynomorph remains within microaggregates often display a higher degree of corrosion compared to associated isolated palynomorphs. These features in context with the geological setting indicate a zooplankton fecal pellet origin of the microaggregates.

The abundance of palynomorphs in fecal pellets indicates that acritarchs and prasinophytes were significant primary producers in the bluewater pelagic environment at ca. 445 Ma.

Dating 'hot' shales using chitinozoans: a case study from northern Gondwana

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In northern Gondwana, Silurian organic-rich 'hot' shales account for 80–90% of Palaeozoic sourced hydrocarbons (Lüning et al. 2000, 2005). The depositional systems across North Africa and the Arabian Peninsula were remarkably similar around the Ordovician–Silurian boundary, with a strong eustatic sea-level rise occurring in the latest Ordovician to earliest Silurian, following the melting of the widespread glacial Ordovician ice sheets (Loydell 1998). This widespread transgression resulted in the deposition of organic-rich black shales in many areas of North Africa and the Arabian Peninsula, reaching thicknesses of over 1000 m in areas of palaeodepression (e.g. the Risha area, NE Jordan) (Lüning et al. 2005).

In Jordan, two organically enriched horizons occur in the Silurian: the lower and upper hot shales (Lüning et al. 2005). The term 'hot' refers to the high natural radioactivity of the shale units, due to an increase in authigenic uranium, and they can therefore be recognised readily in well logs due to high gamma-ray values (Lüning et al. 2005). The lower hot shale unit occurs at the base of the Mudawwara Shale, at or close to the base of the Silurian, and attains a maximum TOC of 11% in the Southern Desert area, represented in the shallow well BG-14 (Lüning et al. 2005). A recent study of the graptolites of the BG-14 core by Loydell (in Lüning et al. 2005) constrained the lower hot shale unit to the middle and upper ascensus-acuminatus and vesiculosus graptolite biozones, thus indicating an early to middle Rhuddanian age.

Due to the excellent age constraint of the BG-14 core provided by Lüning et al. (2005), it was decided to conduct a study of the chitinozoans in the same core: the chitinozoan study formed part of a recent Ph.D. thesis (Butcher 2005, unpublished). Samples were taken for palynological processing (conducted by Butcher), from the same core samples that yielded age-diagnostic graptolite species in Lüning et al. (2005), thus providing a known age for any palynomorphs recovered.

The chitinozoans recovered were extremely abundant (c. 600–4700 specimens per gram of sample) and well preserved, providing excellent data for both biostratigraphical and systematic study. The recovery of *Spinachitina fragilis*, *Belonechitina postrobusta*, *Ancyrochitina laevaensis*? and *Plectochitina nodifera* provides further data for the Rhuddanian age of the lower hot shale (Lüning et al. 2005), as these species have been found elsewhere in strata of this age (see Verniers et al. 1995).

The increasing trend of integrating biostratigraphical data from two or more fossil groups is recognised as an important tool in creating both locally and globally applicable biozonal schemes, of particular value to hydrocarbon exploration. Graptolite data have already provided a high-resolution biozonation for much of the Palaeozoic: chitinozoans, relative to graptolites, have received little study, although their value in biostratigraphy is being advanced constantly.

The chitinozoan data for this study are currently being prepared for publication, and new research is being undertaken by Butcher and Loydell for a high-resolution integrated study in North Africa.

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Early Llandovery chitinozoans from northern Gondwana and Laurentia

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A detailed study was undertaken of the chitinozoan biostratigraphy of four cores through the earliest Silurian strata of Jordan (Middle East) and Illinois (USA), representing palaeogeographical positions on northern Gondwana and Laurentia respectively.

Core BG-14, from the Southern Desert outcrop area of Jordan, is well constrained by graptolite data to the middle–upper *ascensus-acuminatus* and *vesiculosus* graptolite biozones. Core WS-6, from the eastern Wadi Sirhan area of Jordan, is constrained to the lower *ascensus-acuminatus* graptolite Biozone. Cores DH76-21 and Principia #4, from the north and west of Illinois respectively, have very poor age correlation: graptolites are rare in the lower Silurian strata of the American Midwest.

The well preserved and diverse chitinozoans recovered from core BG-14 allowed correlation of the *Spinachitina fragilis* chitinozoan Biozone with many of the biozones of *ascensus-acuminatus* graptolite Zone age proposed previously in the literature, based upon a detailed study of published chitinozoan biozonations and the data upon which they in turn were correlated. The *Belonechitina postrobusta* chitinozoan Biozone was recognised also in core BG-14, and was correlated with biozones of similar *vesiculosus* to *cyphus* graptolite Zone age, recorded from Baltica and Avalonia, and based upon the peak abundance of the species. The chitinozoans recovered from core WS-6 were abundant but poorly preserved, and provided little biostratigraphical data for the study.

Samples containing chitinozoans were rare in the DH76-21 and Principia #4 cores, although those that did contain them yielded well preserved specimens. The assemblage recovered from core DH76-21 contained *S. fragilis*, allowing correlation with the well-constrained *fragilis* chitinozoan Biozone in core BG-14 and elsewhere, constraining the strata to the *ascensus-acuminatus* graptolite Biozone. The chitinozoans from core Principia #4 represent a latest Ordovician to earliest Silurian age: the taxa recovered from the core are all long-ranging, and thus biostratigraphical constraint is less precise.

A detailed systematic study of the taxa recovered from all cores revealed difficulties in the identification of chitinozoans, due to preservational effects and considerable intraspecific variation. Such factors emphasise the need for SEM analysis of a large number of specimens of any given taxa.

A new species of the genus *Fungochitina* was erected for specimens in core Principia #4, and one new species of *Belonechitina* for specimens occurring in the BG-14 and WS-6 cores.

Permian palynostratigraphy from Northeast Bulgaria

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Late Permian salt rocks exposed near the towns Targovishte and Provadia in East Bulgaria can be found in the Hrabrovo and Vetrino members of the OR-1 Mirovo Borehole. In these paleosalt beds are sparse and comparable to those of woody and pollen gymnosperms, that known monosaccate pollen, non-taeniate bisaccate pollen, praecolpate pollen and a few spores of the ferns. Three palynological assemblage zones were established from three informal palynomorph assemblages in the succession.

Palynozone M 1. The unit (two samples for the interval 4172-3434 m contains the palynological assemblage including *Costacyclus crenatus*, *Puntatosporites rotundus*, *Converrucosisporites* sp., *Lundbladispora gigantea*, *Microfoveolatisporites* sp., *Punctatosporites rotundus*, *Latosporites* sp., *Calamospora plicata*, *C. breviradiata*, *Calamospora liquida*, *Retusostriletes* cf. *nigritellus*, *Illinites unicus*, *Limitisporites latus*, *L. rectus*, *Florinites* sp., *Wilsonites vesicatus*, *Vesicaspora* sp., *Plicatipollenites* sp., *Potonieisporites* (14%), *P. novicus*, *P. elegans*, *P. grandis* and *Cordaitina uralensis*, *Cannanoropollis* sp. This Zone occupies the Mirovo Fm. (depths 4172 m, 3434 m and 3225 m) in OR-1 Mirovo Borehole.

Palynozone M 2. The lower part of M2 Zone shows the appearing of *Limitisporites rectus* and disapearing of genera *Cordaitina* and *Cannanoropollis*. This zone contains many taxa which are common with the underlying zone, such as *Lundbladispora*, *Falcisporites* sp., *Converrucosisporites* sp.. The Zone includes the first appearance of *Vittatina subsaccata*, *V. saccata*, *V.* cf. *elegans, V. costabilis*, *Vittatina* cf. *minima*, *Limitisporites delasaucei*, *Limitisporites* sp., *Protohaploxipinus* sp., *P. samoilovichi*, *P. perfectus*, *P. amplus*, *Striatoabieites* (2730 m), *Striatomonosaccites* sp., *Hamiapollenites* sp., *Cycadopites glaber*, *Falcisporites schaubergeri*, *Vittatina elegans*, *Limitisporites latus*, *Jugasporites* sp., *Kraeuselisporites* sp., *Costapollenites* sp., *Lueckiesporites virkkiae*. Quantitatively this assemblage is distinguished by the high content of various species of *Vittatina* and *Lueckisporites*. This Zone occupies the lower part of the Hrabrovo Mb. (depth interval 2907 - 1875 m) in OR-1 Mirovo Borehole.

Palynozone M 3. The upper part of the section, from 1548 m up to the top, indicates quantitative differences in the presence of the taxa *Weylandites striatus*, *Platysaccus* sp., *P. papilionis*, *Protohaploxypinus amplus*, *P. limpidus, Marsupipollenites* sp., *Falcisporites zapfei*, *Weylandites striatus*. The lower boundary of this Zone is marked by the introduction of several pollen taxa: *Lundbladispora* sp., *Alisporites* spp., *Striatopodocarpites* sp., *Alisporites plicatus*, *Limitisporites vesiculosus*, *Striatites richteri*, *S.* spp., *Striatopinites micros*. The typical specimens in the assemblage and taxa like *Disaccites striate*, *Weylandites*, *Cycadopites*, *Nuskoisporites* and *Klausipollenites* are very common. The maximum of some species for Upper Permian sediments like the index taxon *Lueckisporites virkkiae* and Permian *Vittatina* are almost are disappearing at the top of the section. The upper boundary of the M3 Zone is manifested by common occurrence of some species of bisaccate pollen grain such as *Klausipollenites schlaubergeri*, *K. staplinii*, *Vitreisporites* sp., *Gnetaceaepollenites* sp. and *Lunatisporites* sp. Their appearance marks the base of the Triassic. The Zone is located in the upper part of the Hrabrovo Mb. (depth interval 1757 - 1007 m) in OR-1 Mirovo Borehole.

Correlation and botanical interpretation. Some stratigraphic interpretations concerning the correlations (Grigoriev, Utting, 1998) of the end of Permian transition beds from the

Central European, Boreal and Tethyan basins (Broutin et al., 1998) are inconsistent with the existing microfloristic stratigraphic data. Utting, Piasecki (1995) has made correlations between Angaran, Euroamerican and Cathaysian microfloras.

The OR-1 Mirovo assemblages, however, contain most of the elements described for the Upper Permian deposits. Typical genera of Taeniate disaccate pollen are *Protohaploxypinus*, *Hamiapollenites*, *Lunatisporites* and *Lueckisporites*. The species *Lueckisporites virkkiae* is common in the Zechstein of Western Europe (Visscher, 1971) and its earliest occurrence is Kazanian in the Russian stratotype. Important sporomorphs in Late Permian deposits are *Lueckisporites virkkiae* (Hrabrovo Mb.), *Falcisporites zapfei*, *Klausipollenites schaubergeri*, *Nuskoisporites* and *Vittatina*, which were found in the sediments from OR-1 Mirovo Borehole.

Conclusions

The Pollen is predominant (92,2% to 99,5%) and possibly had been transported over long distance. Three Assemblage palynological zones have been established for the Permian from sediments of OR-1 Mirovo Borehole. The older assemblage (Mirovo Fm.) is a part of the Lower Permian and is the first Asseblage Zone (Palynozone M 1) in Permian (Autunian) age (Broutin & Kerp, 1994). The second (Palynozone M 2) and the third (Palynozone M 3) Assemblage Zones (both in the Hrabrovo Mb.) show Upper Permian composition and similar to ones have been reported from Western Europe

Palynostratigraphic correlations are now possible with Permian assemblages in other parts of the world as those from the Zechstein (Leschik, 1956) and part of the Rothligend of Western Europe in Germany (Euroamerica) by Schaarschmidt (1963)

The fossil records are a result of the input and depositional conditions for plant remains. Their quality also depends on the taxonomic level to which the remains can be determined

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Palaeozoic phytoplankton assemblage diversity trends: a climate and palaeoenvironmental signal

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The overall diversity of Palaeozoic phytoplankton assemblages can be used to provide an indication of long term changes in climate as well as fluctuations in palaeoenvironment. The main groups of Palaeozoic phytoplankton include acritarchs with processes, acritarchs and prasinophtes with flanges, as well as acritarchs without processes or flanges.

The acritarchs with processes include many forms with complex branched processes, with the branching pattern regular or irregular. Many of these are of moderate size, and typically fall into an overall size of 15 to 50 um. These forms were apparently widespread in the open marine shelf seas of the Cambrian, Ordovician, Silurian and Devonian, as their benthonic cysts are routinely found in abundance in sedimentary sequences deposited in these areas. To a large extent these forms are comparable to the dinoflagellate cysts regularly recorded in shelf sediments from the mid Jurassic to the present day.

In addition, small acritarchs with simple processes, including *Micrhystridium*, are also associated with many shelf sediments from the Cambrian to Holocene.

The acritarchs and prasinophytes with one or more flanges as well as acritarchs without processes apparently have a widespread distribution. Though they are also common in shelf sea areas, the phycomata and cysts of some forms appear to be planktonic. They can therefore survive in areas of stratified water where the bottom waters are dysoxic to anoxic, as well as in the surface waters of deep oceans.

The diversity trends of phytoplankton assemblages from stratigraphical sequences can be directly linked to changes in palaeoenvironment and climate. Diversity values have been documented from individual samples as well as aggregate records from stratigraphical horizons. In the early Ordovician, high diversity phytoplankton assemblages are characteristic of high latitude areas. In the latest Ordovician and Silurian, fluctuations in the phytoplankton diversity in low latitude areas is apparently driven by changes in global climate.

Carboniferous seed-like megaspores of the *cystosporites*-type, their microspores and their parent plants from the Pennsylvanian of the Czech Republic

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The revision of compression specimens of lycopsid fructification from the Late Palaeozoic continental basins of the Czech Republic is based on the combination of the cone morphology and *in situ* spores revealed the presence of cones that bear *Cappasporites distortus* microspores and *Cystosporites*-type of seed-like or pre-ovule megaspores. Until now, only anatomically preserved *Cappasporites*-bearing cones have been known from coal-balls and described under the name *Achlamydocarpon,* whereas cones producing *Cystosporites* seed-like megaspores are known from petrifactions and compressions as well. However, since the correlation of petrifactions and compressions is problematic because of different nature of diagnostic features, new genera were established for the *Cappasporites*- and *Cystosporites*- bearing lycopsid cone compressions. *Cappasporites*- and *Cystosporites diabolicus*-bearing cones are assigned to the genus *Hemsleycarpon* as male and female counterparts. Parent plants probably belong to the genera *Diaphorodendron* and/or *Synchysidendron*. *Cappasporites giganteus*-producing cones are assigned to the genus *Scottocarpon* as a likely equivalent of the petrified genus *Lepidocarpon*. Its parent plants are probably *Lepidophloios*, *Lepidodendron s.s* and *Hizemodendron*. The affinity of *Lepidostrobus* cones, which produced microspores of the *Lycospora*-type as male counterparts of *Scottocarpon* is discussed.

Three *Hemsleycarpon* species, both of male and female types and one *Scottocarpon* species have been distinguished in the Late Palaeozoic continental basins of the Czech Republic. These are *Hemsleycarpon cernuus, H. lanceolatus, H. hofmanii* and *Scottocarpon majus*.

Excellent ontogenetic stages of seed-like megaspores of the *Cystosporites*-type are figured. The difference in the exine structure of both *Cystosporites* species is demonstrated.

The number of phylogenetic lineages of Palaeozoic seed-like lycopsids is discussed.

Molecular composition of Silurian/Devonian Tasmanites, Leiosphaeridia, Chitinozoa and Scolecodont as revealed by pyrolysis-gas chromatography-mass spectrometry

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The molecular composition of *Tasmanites*, *Leiosphaeridia*, chitinozoans and scolecodonts from Silurian and Devonian sediments of low thermal maturity were investigated to provide a detailed insight into their biomacromolecular structure and to improve our understanding of biomarkers of these organic-walled microfossil sources. Samples of *Tasmanites* originated from Hazro (SE Turkey), Oklahoma and Virginia (USA). For comparison, Late Carboniferous/Early Permian *Tasmanites* from Tasmania (Australia) were analysed. Chitinozoans and *Leiosphaeridia* sampled from Hazro and scolecodonts collected from Gotland (Sweden) were also analysed. Following kerogen isolation, about 300-400 individual palynomorph specimens were handpicked, cleaned by dichloromethane to remove soluble organic matter, and then analysed by Curie point pyrolysis-gas chromatography-mass spectrometry.

The pyrolysates of each of the *Tasmanites* analysed here, regardless of geographical localities were characterised by a series of *n*-C_{6-22} alkene/alkane doublets which are typical of pyrolysis products of algaenan, the microbiological resistant algal biopolymer (Hatcher and Clifford, 1997). The pyrolysates of the *Tasmanites* from Tasmania showed the typical distribution of tricyclic terpenoid compounds believed to be biomarkers of *Tasmanites* (Simoneit et al., 2005 and references therein). However, no trace of tricyclic terpenoids were detected following pyrolysis analysis of any of the *Tasmanites* from Hazro, Oklahoma and Virginia. The pyrolysates of *Leiosphaeridia* were also characterised by a series of *n*-C_{6-22} alkene/alkane doublets and several tricyclic terpenoids including monounsaturated and diunsaturated tricyclic terpenes and monoaromatic tricyclic terpanes (Dutta et al., 2006). Biomacromolecules of Chitinozoa consist of both aliphatic and aromatic moieties. Alkylbenzenes, alkylnaphthalenes, alkylphenols and alkylphenanthrenes were major aromatic pyrolysates of Chitinozoa whilst a prominent series of *n*-alkene/*n*-alkane (C_6 to C_{22}) doublets represented the aliphatic moiety. No pyrolysis products diagnostic of chitin were detected in chitinozoan samples. The pyrolysis products of scolecodonts similarly included aromatic hydrocarbons such as alkylbenzenes, alkylnaphthalenes, alkylphenols and a homologous series of *n*-alkenes and *n*-alkanes ranging from C_6 to C_{18}.

Thus, based on this study, we conclude that

- an inherent source-biomarker relationship between the *Tasmanites* and tricyclic terpenoids does not always exist and that *Leiosphaeridia* represents another biological source of these compounds.

- it is unlikely that original biomacromolecules of Chitinozoa before fossilization were made up of chitin related compounds.

- A lack of pyrolysates attributable to amino acids in scolecodonts is likely due to their facile diagenetic loss.

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Black shales microflora from the Famennian of the Kowala Quarry (Holy Cross Mountains, Central Poland).

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Four bituminous horizons are well exposed on the northern wall of the Kowala Quarry in the Famennian part of the section. Preliminary palynological research, supported by microfaunistical and geochemical investigations, reveal that two of them are equivalents of the world-wide known anoxic events. The topmost one is the Hangenberg event, which occurred just before the Devonian/Carboniferous boundary and the lowermost one is the *annulata* event from the Middle Famennian. Lithologically, the analyzed section (ca 25m of studied interval) consists of rhythmic sequence of marls, shales, tuffites and limestones with four distinct bituminous horizons. Geochemical data indicate that all the four black shale horizons are rich in organic carbon (aprox. 22%). Consequently, they contain very abundant and diversified microfloral remains (acritarchs and miospores). Preliminary palynological investigations of these horizons confirms so far the age of three of them; they are the LN (*Retispora lepidophyta-Verrucosisporites nitidus*) miospore Zone for the youngest black shale, the LV (*Retispora lepidophyta-Apiculiretusispora verrucosa*) Zone for the underlying thin horizon and the VF (*Diducites versbilis-Grandispora famenensis*) for the oldest one. The studied microfloral assemblages contain the index species *Retispora lepidophyta* and *Verrucosisporites nitidus* for the LN Zone, *L. lepidophyta* and *Apiculiretusispora verrucosa* for the LV Zone and *Diducites versbilis* and *Grandispora famenesis* for the VF Zone, and are also accompanied by other important miospore species.

Besides rich land microflora, phytoplankton is much diversified too. Abundant are prasinophytes (*Leiosphaeridia*, *Hemiruptia* and *Tasmanites*), amorphic organic matter and some acritarch species of genera *Gorgonisphaeridium*, *Lophosphaeridium* and *Dictyotidium*.

Palynostratigraphy and palaeogeography of the Lower Permian strata (Faraghan Fm. = Chal–i-Sheh Fm.) in the Zagros Basin, Southern Iran

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A clastic sequence is well developed in the Zagros Basin Southern Iran. This clastic sequence has been divided in ascending stratigraphic order into the Zakeen (Devonian) and Faraghan (Early Permian) formations. The thickness of the Faraghan Formation varies from a few meters at Kuh-e-Dinar to 500 meters in the Chal-i-Sheh area. This formation mainly consists of sandstone, siltstone, shale and a few limestone stringers. The upper contact of Faraghan Formation is gradational with the Dalan Formation of Late Permian at all surface and subsurface sections and is marked by a transition from interbedded sandstone to limestone. The lower contact is characterized by a major hiatus that its magnitude increases in a SE-NW direction of Zagros Basin. A total of 500 surface samples from the Faraghan Formation were treated and investigated for palynomorph entities in order to determine the age relationships of this rock unit. This study was also undertaken to assess the palaeogeographic relationships of the study area to Southern and Northern Hemispheres during the time interval represented by this formation. Most samples contain well-preserved palynomorph taxa which permit determination of the stratigraphic age of this formation. A detailed microscopic investigation on the samples of Faraghan Formation reveals that the lowermost part of this formation coincides with the appearance of abundant gymnospermous pollen taxa whose diversities increase toward the top of this rock unit. The relative percentage of each group of morphotype was calculated based on counts of two hundred grains per sample and the sum total resulted in, 98% pollen, 1.5% spores and 0.5% acritarchs. The high relative percentage of gymnospermous pollen taxa suggests a relatively cold condition which was in favor of gymnospermous plants at the beginning of the Early Permain. A total of 56 miospore species were identified within the Faraghan: *Vittatina costablis, V. subsaccata, V. verrucosa, Hamiapollenites ellipticus, Fusacolpites fusus, F. ovatus, Boutakoffites elongates, Mabuitasaccites ovatus, Walikalsaccites ellipticus, Corisaccites alutas, Nuskoisporites triangularis, Striomonosaccites brevis, S. triangularis, Weylandites magnus, Cycadopites cymbatus, Potonieisporites granulatus, P. neglectus, Plicatipollenites dendus, P. gondwanensis Decussatisporites circularis, Distiamonocolpites ovalis, Tiwariasporis flavatus, T. gondwanensis, Striatopodocarpites fusus, Leiotriletes virkkii, Verrucosisporites andersonii,Densosporites solidus* and *Punctatisporites gretensis*. These are diagnostic of the Early Permian and the remainder are long-ranging during the Permian. Based on the above-mentioned species an Early Permian (Sakmarian-

Artiniskian) age is suggested for the Faraghan Formation. From the point of view of lithology and age relationship, the Faraghan Formation is equivalent to the Unayzah Formation in the southern part of the Persian Gulf (Saudi Arabia). Therefore, the Upper Carboniferous age assignment to the Faraghan Formation, based on *Sigillaria persica* of Seward is rejected and the Carboniferous strata are presented by a hiatus in the Zagros Basin which possibly equates with the Hercynian Orogeny.

Likewise, the comparison was made between the miospore species of Lower Permain sediments of Zagros Basin of Iran and those of other parts of the world. The comparison reveals that from 58 miospore species of the Faraghan Formation, 40 species are common with Australia, 47 species with Africa, 30 species with India and Pakistan, 28 species with South America and three species with Turkey. Hence, based on palynological data, the Zagros Basin of Iran suggests a closer relation to those of Gondwanan Supercontinent rather than with those of Europe, North America and Turkey. The small number of acritarch taxa and scolecodonts which contribute 0.5 percent of the total assemblages are associated with miospore assemblages of the Faraghan Formation. In all samples, pollen diversity is high and masks the contributions of acritarchs, scolecodonts and spores. This phenomenon might be explained in term of close proximity of the depositional site to the parent plant source. Another interpretation would be that the Late Carboniferous Gondwana glaciation retreated and give rise to relatively cold conditions at the beginning of the Permain period. This situation favored the gymnospemous plant community and inhibited the development of spore-bearing plants as well as acritarchs and marine annelid worms in the depositional environments. In summary, the Faraghan Formation has been deposited in shallow marine environments. Therefore, based on the above, it would be reasonable to suggest that the Zagros basin, Africa, Australia and India were not distant from one another and they were at about the same latitude along the southern shore of the Tethys Ocean during the Permain period.

Thermally-induced changes in colour and δ^{15}N of *Tasmanites* and *Veryhachium*

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Palaeozoic samples containing *Tasmanites* and *Veryhachium* were heated in a tube furnace for up to three months at peak temperatures up to 250˚C. The colours of the experimentally-heated palynomorphs were determined in transmitted light in terms of RGB intensity and were correlated with colours of *Tasmanites* and *Veryhachium* from sections that have been heated by normal burial processes. The potential value of acritarch / prasinophyte colour assessment as a tool for establishing organic maturity in marine, vitrinite-deficient rocks is outlined, with reference to a Lower Palaeozoic well section in Jordan. The effect of heating was also assessed with nitrogen isotopes. The significance of the response of δ^{15}N to experimental heating of *Tasmanites* is discussed in relation to chemostratigraphy.

Stratigraphical interpretation of the new miospore data from the Carboniferous succession of the Foresudetic Homocline basement (SW Poland)

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New results of palynological studies of the Carboniferous monotonous turbidite succession from the Fore-Sudetic Homocline basement (being a part of the infill of the Variscan foreland basin) allowed a new look on their stratigraphy. Studied rocks contain macrofloristic and marine macrofaunistic fossils, mainly Late Viséan, and usually poorly preserved miospore assemblages of different age. These sediments had been considered as representing whole profile of the Carboniferous-from the Tournaisian to the Stephanian, although detailed results of the stratigraphical studies sometimes had been contradictory.

During new palynostratigraphical studies of rocks from 10 deep boreholes rich and diverse miospore assemblages were found. Over 400 miospore taxa were recorded in them. Miospore preservation is diverse and depends mainly on the organic mater thermal alteration. All recorded miospore assemblages appeared to be of mixed characteristics and consist of the Fammennian up to the Namurian or even Westphalian taxa. In part of the studied rocks Late Viséan marine macrofaunal fossils, including goniatites, had been found earlier.

Only the youngest miospore taxa could be used to the stratigraphical interpretation and all the remaining fossils were considered as reworked. In the studied sediments two rock successions of different ages were recognized. The older one represents the Lower Namurian and was documented in the Września IG 1, Katarzynin 2, Paproć 29, Czerńczyce IG 1, Siciny IG 1 and Marcinki IG 1 profiles. The younger succession, recorded in the Siciny IG 1 and Marcinki IG 1 profiles, belong to the Westphalian B? and C. The repetition of both successions in two latter profiles was observed and is probably caused by the tectonical deformation.

Stratigraphical data presented above allow to conclude on the main stages of the basin developement:

a) Turbidite sedimentation in Early Namurian and Westphalian B? and C.

b) Canibalisation of the Fammennian-Tournaisian and Upper Viséan rocks during Early Namurian and Westphalian B? and C.

c) Inversion of the basin after the Westphalian C.

A Revised Carboniferous Palynostratigraphy For Offshore Western Ireland

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A revised Carboniferous palynostratigraphy for offshore western Ireland is presented. Palynostratigraphic interpretations are based on the analysis of cuttings samples from eighteen hydrocarbon exploration wells. Previous interpretations (Robeson *et al.* 1988) incorporated the original Carboniferous miospore zonal scheme of Western Europe (Clayton *et al.* 1977). Recent zonal modifications (Clayton *et al.* 2003) have enabled a revised offshore western Ireland palynostratigraphic interpretation. The new zonal scheme approximately doubles the number of biozones and sub-biozones that can be identified, with most refinement occurring in the late Mississippian and early Pennsylvanian. Biozones are defined in terms of a single event, typically the first appearance of a taxon. Palynological data from previous interpretations are revised in terms of the new zonations and the latest SCCS ratified Carboniferous chronostratigraphic nomenclature. The resulting palynostratigraphic interpretations are of a higher resolution than previous analyses, allowing improved precision in the correlation of western Irish offshore Carboniferous strata.

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Palynological correlation of Mississippian (Carboniferous) stage boundaries in the USA and Western Europe

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A recent decision to globally recognise the Mississippian and Pennsylvanian as subsystems of the Carboniferous has highlighted difficulties in the correlation of their composite stages and stage boundaries on a global scale. A miospore zonal scheme for Western Europe has proved useful for correlation within Europe and similar spore assemblages have been recorded from localities in the USA. A continuous spore succession throughout the Mississippian of the USA is currently being assembled with plans to complete a full Mississippian zonal scheme for the Midwest/eastern USA.

A preliminary study focuses on marine and deltaic sediments from two localities; the Hannibal shale type section in Missouri, and Morehead in Kentucky. At Hannibal, dates have been constrained to a Kinderhookian age, using North American conodont biozones. An impoverished spore assemblage is found within the marine shales. The late Devonian spore, *Retispora lepidophyta*, is notably absent as is *Spelaeotriletes balteatus* which appears in the Lower Mississippian. This suggests the assemblage is representative of the recovery phase of the Late Devonian Mass extinction, comprising of a few long ranging survivor taxa. An abundant acritarch fauna is also present here, dominated by acanthomorph acritarchs from two or three genera, showing significant specific and intraspecific variation.

The age of the Morehead section has been constrained using the goniatite fauna. Palynological studies show the lower part of the section spans the Devonian/Carboniferous boundary i.e. the LN and VI biozones, while the upper part belongs to the Early Osagean (PC) biozone.

Cambrian acritarch assemblages from the Polish part of the Brunovistulicum

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The Brunovistulian Block comprises the southern part of Poland, eastern part of the Czech Republic, northern part of the Slovak Republic and partially in Austria. It forms a tectonic unit of Cadomian consolidation and consists of plutonic, metamorphic and anchimetamorphic lithologies. There is a clear zonal distribution of these different, in terms of origin, rocks. The southern and south-eastern part of Brunovistulicum consists of plutonic rocks. Towards the north and north-east, the upper parts consist of metamorphic rocks and deeper, anchimetamorphic rocks. Taking the genetic differentiation of the Brunovistulicum lithologies into account, Kotas (1985) distinguished two units, termed blocks, namely the Moravian (Brunia) and Upper Silesian. On these units similar Lower Palaeozoic sediment cover was recognized, mainly in the Polish part of the Brunovistulicum – Upper Silesian Block (USB).

The recognition of Lower Palaeozoic sediments in USB is not regular. Lower Palaeozoic sediments of USB are represented by the best investigated sediments of Lower Cambrian and also by Middle Cambrian and Ordovician, which were found in a few boreholes. The stratigraphy of Cambrian sediments is based on acritarchs in 20 borehole and trilobites in on borehole Goczałkowice IG 1 (*Holmia* age). Lower Cambrian sediments occur discordantly on anchimetamorphic or crystalline basement. They show large lateral distribution and considerable thickness reaching in the marginal zone of the block about 2500-3000 m. The Lower Cambrian sediments are represented by two lithostratigraphical units; older Borzęta Formation and younger Goczałkowice Formation. Middle Cambrian rocks form Sosnowiec Formation.

Borzęta Formation sediments form three-unit regressive sequence which consists of siltstones younging upwards into sandy mudstones with thin sandstone intercalations, and sandstones interbedded with mudstones. These sediments occur only in the marginal eastern part of the USB. Lower Cambrian organic microfossils of the sub-*Holmia* Horizon have been recognized in the Borzęta Formation. They are represented by following genera: *Leiosphaeridia*, *Tasmanites*, *Leiovalia*, *Granomarginata* and *Ceratophyton*.

The younger Lower Cambrian *Holmia* sediments of the Goczałkowice Formation were deposited over much wider area. They form 3-unit transgressive sequence which consists of: lower – *Scolithos* sandstones, middle – bioturbation sandstones, and upper – siltstones with trilobites. In USB acritarchs have so far been recognized only in samples of bioturbation sandstones and siltstones with trilobites. The bioturbation sandstones yield characteristic acritarch populations dominated by: *E. flexuosus*, *C. molliculum*, *S. ornata*, *A. tornatum, L. dubium, T. bobrowskiae.* In siltstones with trilobites acritarch assemblage includes: several species of *Skiagia*, *A. umbonulata*, *H. dissimilare*, *M. xianum*, *B. varium*, *A. baltica*, *E. minima*, *M. campanulum, Granomarginata, Pterospermella.*

Middle Cambrian sediments of the Sosnowiec Formation were only found in the borehole Sosnowiec IG1 in the central part of the block. They are represented by the complex of clastic rocks which consist of alternating layers of sandstone and clay-stone. According Moczydłowska (1998) there is a transition from Middle to Upper and even Ordovician (Tremadocian). The recent palynological study resulted in finding of the typical Middle Cambrian acritarch assemblages dominated by *A. alea*, *C. cambriense*, *H. notatum*, *E. llanisum* and *C. longispinosum*.

Heretofore Upper Cambrian sediments have not been recognized, although their presence is very likely in the northern part of the USB.

Ordovician acritarch assemblages from the Upper Silesian Block

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The recognition of Lower Palaeozoic sediments in the Upper Silesian Block is not regular. Lower Palaeozoic sediments of Upper Silesian Block are represented by the best investigated sediments of Lower Cambrian and also by Middle Cambrian and Ordovician, which were found in a few boreholes.

Ordovician sediments distinguished as Bibiela Formation were documented only in the borehole BM 152 in the northern part of the block. Under Devonian carbonate rocks, at the depth 284.6 - 375.6 m, a complex of clastic rocks differently silified with thin insertions of carbonate rocks known as "shale-sand series" was recognised (Gładysz, 1982; Gładysz et al., 1990). The Ordovician age of the recognised sediments was determined basing on conodonts (Siewniak-Madej, Jeziorowska, 1978) and acritarchs (Linczowska-Makowska, 1978; Jachowicz, 1990). Ordovician acritarchs have not been so far described from other boreholes of Upper Silesian Block. This paper presents new data concerning distribution of Ordovician acritarcha assemblages in this area.

Three boreholes (45-WB, 43-WB and 24-WB) were sampled and analysed in order to determine acritarchs. In the analysed sections of the profiles acritarchs typical for different horizons of Ordovician from Llanvirn (Darriwilian) to Caradok (Sandbyan) were recorded.

Among 8 samples taken from a 35 m thick section of the profile WB 43, only 2 contained determinable microfossils. Similarly in the borehole WB 45, among 7 samples taken from different depths, only 2 appeared positive in almost 50 m thick profile. In case of the borehole WB 24, over 80 m thick section was sampled built of the rocks which considered to be Lower Palaeozoic. Among 30 samples studied, 7 from a 9 m long section contained microfossils.

WB 43 - The obtained assemblages are poorly differentiated in terms of genus and species. Preservation state of the obtained forms is very bad, with high degree of carbonification. The specimens show many damages, which makes it impossible to determine their species in details. The most important genera determined in the material studied include: *Acanthodiacrodium*, *Baltisphaeridium, Baltisphaerosum*, *Veryhachium*, *Frankea*, *Polygonium*, *Multiplicisphaeridium*, *Micrhystridium, Timofeevia, Vulcanisphaera*.

WB 24 - In the detailed analyses of the samples studied the representatives of the following sub-groups were documented: *Diacromorphitae*, *Acanthomorphitae, Herkomorphitae*, *Polygonomorphitae* and *Sphaeromorphitae*. The most important genera and species include *Peteinosphaeridium trifurcatum*, *Stellechinatum celestum*, *Peteinosphaeridium nanofurcatum*, *Baltisphaeridium bystrentos*, *Baltisphaeridium hirsutoides*, *Acanthodiacrodium* sp., *Cymatiosphaera* sp.

WB 45 - The obtained associations are badly preserved, show many damages and high degree of carbonification. The most numerous genera in the material studied include: *Baltisphaeridium*, *Baltisphaerosum*, *Navifusa*, *Orthosphaeridium, Ordovicidium*, *Veryhachium*, *Goniosphaeridium*, *Multiplicisphaeridium*. Among them the following species were found *Baltisphaeridium longispinosum*, *B. annelieae, B. filosum, Baltisphaerosum christoferi*, *Orthospheridium bispinosum*, *Multiplicisphaeridium digitatum, M. irregulare*.

The obtained stratigraphic data confirmed the occurrence of Ordovician sediments in the succeeding profiles in the northern part of Upper Silesian Block.

Palynological investigation of Precambrian rocks on the Małopolska Block - foreland of the East - European Platform

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The area of south – eastern Poland belongs to the foreland of the eastern European Platform.

Two tectonic units are distinguished here: Upper Silesian Block and Małopolska Block. These blocks are separated from each other by a narrow, 500 m wide Kraków – Lubliniec tectonic zone. This zone is a part of the largely concealed Hamburg – Kraków tectonic zone which is parallel to the TTZ and continues SE of Kraków, where Carpathian flysh is trusted over the Palaeozoic basement.

The Upper Silesian Block together with Brno Block (situated in the Czechia and partially also in Austria) create a larger tectonic unit, which is called Brunovistulicum (Dudek, 1980).

This large tectonic unit is built of two assemblages of rocks which differ from each other in term of the degree of metamorphic transformations. The older assemblage, located in the southern, Sub-Carpathian part of Brunovistulicum is represented by crystalline schits, gneiss, magmated gneiss and olivine gabbro. These rocks represent the lower part of epi zone and mezo zone of the regional metamorphism.

The younger assemblage in the Brunovistulicum is built of phyllites, metapelites, metapsammites and metaconglomerates, which originated from flysch sediments. Anchimetamorphic rocks of Brunovistulicum occur N and NE of the outcrops of crystalline rocks on sub-Cambrian surface (alternatively, sub-Devonian, sub-Mesozoic or sub-Miocen surface). The Cambrian rocks, which represent structural cover complex of Brunovistulicum, occur discordantly on the cristalline and anchimetamorphic rocks.

Flysch character is also associated with anchimetamorphic lithologies which have been recognised in the western and southern part of the Małopolska Block (S of Kielce region of the Holy Cross Moutains). These are phyllites represented by: claystone and siltstone or sandstone and locally sandy conglomerates. This rocks are discordantly overlain by Ordovician, Silurian, Devonian or Mesozoic and Miocene sediments.

In the Małopolska Block anchimetamorphic rocks which thickness is variously estimated from 2000 m to 8000 m, have been recognized in about 250 boreholes. The microfossil assemblages of Precambrian (“Vendian“) age were documented in 7 boreholes reaching anchimetamorphic rocks. Palynological analyses provided sparse but well-preserved organic microfossils represented by tiny *Leiosphaeridia* and cyanobacteria fragments. These organic microfossils represent the first stratigraphic record.

The Cadomian age of Brunovistulicum consolidation is unquestionable, which is indicated, for example, by age of the detrital mica from Lower Cambrian clastics in the Upper Silesian Block (Bełka et al., 1997).

According to Żelaźniewicz et al. (1997), the crystalline rocks recognised in the southern, sub-Carpathian part of Brunovistulicum, represent an internal part of Cadomian orogen (Internides). The Vendian Flysch and flysch - like anchimetamorphic rocks recognised both in Brunovistulicum and Małopolska blocks would represent, therefore, the foreland of this orogen. Thus, the foreland would be located between its internal part located in the southern part of Brunovistulicum and eastern European Platform.

The first palynological results from the low metamorphosed, late Early Devonian sandstones from the Tišnov area (Moravia, Czech Republic)

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A twenty-five metre section in rhythmically bedded, matrix-supported lithic, quartz and quartz-feldspathic sandstones, with thin interbeds of argillaceous black shales, was documented in detail. This section "Lanovka" is situated near the rope tow of the ski slope Tišnov – Předklášteří (30 km NW of Brno). The rocks of this outcrop represent only one of several types of siliciclastic sedimentary sequences which were preserved in the complex fold-and-thrust structure of the sedimentary cover of the "Tišnov Brunnides" para-autochthonous unit. In this fragmentary sedimentary sequence, the sandstones and pebbly sandstones have reddish brown to green-grey colour hues. The horizontal bedding is disturbed only with few conglomerate lenses and indications of inclined bedding. In spite of different stratigraphy in the Tišnov area, there exists a weak parallel to siliciclastic deposits that border the Moravian Karst facies, particularly along with the northern edges of the Brno Massif. The six samples described in this paper originate from blackish, argillaceous-clayey slates in thin interbeds – possibly rather the layered mudstones than mudstone drapes in their original state.

The preservation of organic matter is considerably poor due to slight metamorphosis, many miospores and undeterminable organic objects are black in colour and fragmented. In spite of this bad state of preservation, less damaged spots in argillaceous parts of these rocks provided sufficiently preserved specimens of the microflora species that are significant for biostratigraphy. The presence of *Camarozonotriletes sextantii* and *Emphanisporites annulatus* indicate the *Emphanisporites annulatus-Camarozonotriletes sextantii* miospore Zone (late Emsian). Other stratigraphically significant miospores such as *Dibolisporites echinaceus* and *Acinosporites* cf. *lindlarensis* have also their first occurrences in the late Emsian. The assemblage of other miospores (*Brochotriletes foveolatus, Dibolisporites eifeliensis, D. wetteldorfensis, Retusotriletes rotundus* and *Emphanisporites* sp.) possesses broader stratigraphical ranges than indicated by the previous index species, and they occur in common in the transition interval from the Lower to Middle Devonian. In addition to miospores, there are also a few species of scolecodonts and acritarchs. Similar palynological ages from various siliciclastic rocks, i.e. Early to Middle Devonian, were described also from the southern and northeastern parts of Moravia (Měnin and Kozlovice boreholes) and also from Poland, particularly the Andrychów and Radom–Lublin areas.

Chitinozoan chemical composition: new insights from organic geochemistry and molecular biology

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Chitinozoans are enigmatic organic-walled microfossils, which occurred in the Palaeozoic oceans from Early Ordovician to latest Devonian (Miller, 1996). They are recovered from a variety of marine sediments deposited in near-shore to deep oceanic environments. Their biology and systematic affinities remain uncertain, although the soft-bodied metazoan egg hypothesis is generally regarded as the most likely (Paris and Nõlvak, 1999). Chitinozoans have proven to be very useful in several branches of the Earth Sciences, including high-resolution biostratigraphy, palaeoenvironmental reconstructions and biogeography. New fields of additional application are being explored, especially those using chitinozoans as a source of carbon for documenting high-resolution $\delta^{13}C_{org}$ curves (Lecuyer and Paris, 1997). Despite a dramatic increase in knowledge about chitinozoans, the unresolved question of their chemical composition, and especially the presence of chitin in their wall remains. In order to decipher the chemical composition of the chitinozoan wall, a variety of analytical techniques have been performed on individually isolated chitinozoan vesicles, including conventional elemental analysis, Rock Eval pyrolysis, pyrolysis GC-MS, Raman and Infrared spectroscopy and molecular biology.Selected rock samples from northern Gondwana regions yielding abundant and well-preserved chitinozoan specimens have been investigated. Total organic carbon of the most suitable rock sample is 0.47%, in agreement with total carbon deduced from elemental analysis (0.69 %) while nitrogen is 0.127 %. Low Tmax values (420°C) of this rock sample, together with Raman spectroscopy performed on single vesicles, confirm a low thermal maturity for the analysed chitinozoan specimens and potential for the samples to retain the original chemical structure. Laser micropyrolysis GC-MS performed on single chitinozoan vesicles reveals the predominance of aromatic over aliphatic compounds. Within the compounds detected, no evidence for chitin derivatives was found, unlike those confirmed in fossil insect cuticles (Flannery et al., 2001). The combined results of these techniques do not support a chitin-like structure for chitinozoans.

To further investigate chitinozoan vesicle composition, fluorescent fluorescein-labelled Wheat Germ Agglutinin was used for selective binding and fluorescence microscopy optical detection of *N*-acetylglucosamine, the main chitin monomer component. Preliminary molecular biological results are encouraging and further chemical analyses could ultimately verify the preservation of intact *N*-acetylglucosamine within chitinozoan walls.

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Upper Visean palynology of the northern margin of the Bohemian Massif (Saxony, SE-Germany) and correlations across the Rhenohercynian Basin

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Palynological studies are done in Upper Viséan strata near Chemnitz (Frankenberg Fm, Saxony, SE-Germany) at the northern margin of the Bohemian Massif, the very southeast of the Saxothuringian Zone. The mostly sandy deposits of the Frankenberg Formation are typical delta- to floodplain sediments, including some siltstone layers and even more rare thinbedded sandy shale interlayers. These dark pelitic interlayers have preserved moderately to well preserved microflora, used for palynostratigraphy just as spore assemblage analysis and palaeobotanical/palaeoecological interpretation. In opposite to all other palynological studies of the Lower Carboniferous in Germany (N-Germany, Rügen Island, Rhenohercynian Zone) preserving microflora from the northern shelf linked to Laurussia the spore assemblages in Saxony are linked to the southern shelf of the Rhenohercynian Basin derived from the Bohemiam Massif and other landmasses along the northern margin of the Gondwana Complex. Certain differences are observed in spore assemblages from Saxony compared to the ones from the northern part of Germany. Contrasting Rügen Island and the Rhenohercynian Zone spore assemblages from Saxony show high amounts of triangular spores but less cingulate and massive ornamented types of spores. Therefore these assemblages are closer comparable to the ones, known from the very north of Germany, the German North Sea and the British Isles (JÄGER & MCLEAN, in press), where sedimentary settings are very similar also. On the other side spore assemblages from Saxony are compared towards the east to Upper Visean assemblages from the sudetes, the Moravian-Silesian region to the Carpathian foredeep. Based on the spore assemblage analysis palaeobotanical and palaeoecological correlations will be done across the Rhenohercynian Basin to Northern Germany and the British Isles just as along the northern margin of the Bohemian Massif towards the Carpathian foredeep.

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Microfossil dynamics in the upper Llandovery and lower Wenlock of Estonia

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Quantitative data are essential for analysing the palaeoecology and dynamics of fossil faunas, but may also contribute to a better understanding of palaeoenvironments and depositional regime, and improve stratigraphical resolution. The purpose of the study was to elucidate the frequency and diversity dynamics of different microfossil groups, primarily chitinozoans, scolecodonts (polychaete jaws) and conodonts, in the upper Llandovery and lower Wenlock of Estonia, and to reveal possible relationships between these groups and between the data on fossils and the palaeoenvironment. This stratigraphical interval was of particular interest as it embraces the Ireviken Event, which is traceable worldwide and related to turnover in oceanic circulation as well as some regional events (“Velise transgression”). The succession of limestones and marls was studied quantitatively in the Paatsalu and Viki drill cores and semi-quantitatively in the Viirelaid drill core, western Estonia.

Altogether, nearly 60 species of chitinozoans, more than 60 apparatus-based species of jawed polychaetes and 40 species of conodonts were recovered. The absolute frequency of chitinozoans varied widely, reaching up to 170 000 vesicles per kilogram in the Wenlock. The maximum abundance of conodonts was recorded in the uppermost Llandovery — ca 4 000 elements per kilogram. Scolecodonts display the least varying pattern of abundance with a maximum of 1500 specimens per kilogram in the Wenlock (the total number of all jaws and teeth being much higher though).

All three groups display different large-scale frequency patterns, which can be explained by their different habits and environmental preferences. The only significant correlation between the three groups was recorded in the Rumba Formation reflecting changes in the deposition or compaction rate. The most significant lithological change at the boundary of the Rumba and Velise formations coincides, however, with no marked changes in the frequency or assemblage composition of chitinozoans and scolecodonts. The frequency peaks of several long-ranging taxa, for instance of the genus *Eisenackitina*, are stratigraphically restricted and have thus potential for correlation. Jawed polychaetes, on the other hand, seem to display a rather complex biofacies zonation whilst their changes in time are less conspicuous. Rapid changes in the abundance as well as relative frequency of different taxa were recorded in the Ireviken Event interval. Conodonts displayed a major turnover and diversity loss at this level whilst chitinozoans and jawed polychaetes were less affected. Chitinozoan and conodont biozones revealed also a gap in the Paatsalu section, which is partly responsible for the abrupt change at the Llandovery–Wenlock boundary.

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Biodiversity, stratigraphic and geographic distribution of Pridoli and Lochkovian acritarchs and prasinophyte algae from the Moesian Terrane, North Bulgaria

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The Upper Silurian and Lower Devonian subsurface succession of mainly dark shales and siltstones in the Moesian Platform in Bulgaria and Romania is a part of the pre-Variscan sedimentary cover of the Moesian Terrane. Two borehole sections, R-1 Dalgodeltsi in NW Bulgaria and R-119 Kardam in NE Bulgaria, yielded diverse chitinozoans, acritarchs, spores and tubular structures. A chitinozoan zonation adapted to the global Silurian and Devonian standards was proposed and tubular structures were described (Lakova, 2001) and joint chitinozoan and miospores zonations were directly calibrated (Steemans, Lakova, 2003). A chitinozoan zonation of the successive *M. elegans*, *E. bohemica*, *F. lata*, *U. simplex* and *U. simplex-C. plusquelleci* Zones suggests Přídolí and Lochkovian ages. The miospore zonation representing the *micrornatus-newportensis* Zone divided into its MN (siα), MN (siβ) and MN(G) subzones revealed some age discrepancies with the chitinozoan zonation regarding the Přídolí.

Co-occurring with the chitinozoans and miospores, 90 species of acritarchs and prasinophyte algae are identified within the Přídolí – Lochkovian section. The Přídolí assemblages are very diverse and dominated by species of *Cymatiosphaera*, *Gorgonisphaeridium*, *Micrhystridium* and *Visbysphaera*. The Lochkovian is much poorer in acritarhs. The only criterion for recognition of the Přídolí from Lochkovian is the coeval last occurrence of *Duvernaysphaera aranaides*, *Quadraditum fantasticum* and *Onondagella deunffii*. Throughout the North and West Gondwana (Libya, Tunisia, Spain, France, Argentina, Florida), these species occur within the Přídolí and persist only in the earliest Lochkovian. In the Moesian Terrane these LOs coincide with the lower part of the *E. bohemica* chitinozoan zone. Other biostratigraphic criteria for the base of

Lochkovian, the FOs of *Elektoriskos intonsus* and *Riculasphaera fissa* as proposed by Molyneux et al. (1996) are not applicable in Bulgaria as these taxa co-occur with Přídolí chitinozoans such as *Fungochitina kosovensis* and *Kalochitina lorensis*.

Even the biostratigraphic potential of the Přídolí and Lochkovian acritarchs from the Moesian Terrane is fairly low, these diverse assemblages are very useful for biogeographical purposes. Thus, the geographic distribution analysis reveales a remarkable affinities between the latest Silurian and early Devonian acritarchs in Bulgaria and those from Brittany in France and Spain (Ibero-Armorica), Algeria, Tunisia and Libya (North Gondwana) and much less similarities with Gotland in Sweden, North America, Carnic Alps in Austria, Bolivia and Podolia in Ukraine. These essentially peri-Gondwanan affinities of the Přídolí and Lochkovian acritarchs from the Moesian Terrane correspond to the affinities of the co-occurring chitinozoans (Lakova, 1995).

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Silurian graptolite, conodont and cryptospore biostratigraphy at Gülüc section in Eregli, Zonguldak Terrane, NW Anatolia

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The studied section of the Silurian Findikli Formation is situated near Gülüc village at the western (left) bank of Gülüc Creek in Eregli area, NW Anatolia, Turkey. In terms of tectonostratigraphy it occupies the eastern part of the Zonguldak Terrane. The Gülüc Section consists of 3 packets: 5-7 m thick greenish gray limy siltstones (1), followed by an irregular alternation of black shales and clayey limestones, about 15 m thick (2) and a 6-7 m thick packet at the top of mainly siltstones and sandy limestones with single sandstone and limestone beds (3).

The section has been measured and sampled for conodonts and palynomorphs. Graptolites have been collected from selected levels. As a result, a joint biostratigraphy on graptolites, conodonts and cryptospores has allowed to prove the Llandovery, Wenlock and Ludlow for the first time in the area and in the Zonguldak Terrane.

At the base of the section, within the greenish grey siltstones, acritarchs and cryptospores occur, the former being badly preserved. The cryptospore assemblage consists of 17 species of naked and enveloped monads, dyads and tetrads of the genera *Laevolancis, Dyadospora, Tetrahedraletes, Abditusdyadus, Segestrespora, Velatitetras, Imperfectotriletes*. The co-occurrence of enveloped cryptospores and *Laevolancis divellomedia* suggest a Llandovery (Aeronian-Telychian) age (Steemans and Pereira , 2002).

Upwards, within the shale-limestone alternation packet, the black shales are predominant and yielded fairly diverse graptolites. The lowermost 3 m belong to *Cyrtograptus lundgreni* Zone (Homerian, Wenlock). The following 6 m are also assigned to the Homerian based on conodonts. The graptolites at 9 m above the packet base prove *Neodiversograptus nilssoni* Zone (lower Gorstian, Ludlow). The second productive limestone bed is about 10.5 m above the base and yielded the conodonts *Ozarkodina sagitta, Oz. inclinata* and *Oz. crassa* (lower Gorstian). The uppermost 4 m of the packet 2 correspond to *Lobograptus scanicus* Zone (Gorstian). In the packet 3, within the limy sandsones graptolite finds indicate *Saetograptus leintwardinensis* Zone (Ludfordian, Ludlow).

The Findikli Formation at Gülüc section (less than 30 m thick) represents a specific relatively condensed and diverse lithological succession and differs from the thick uniform black shales of the same formation to the east, in the Camdag area (Sachanski and Goncuoglu, 2003), and to the west, at Karadere section in the Zonguldak Terrane (Dean et al., 2000).

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Tremadoc graptolites, acritarchs and cryptospores from Karadere Section, Zonguldak Terrane, NW Turkey

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Karadere section in Safranbolu area, to the S of Incigez Mahallesi, NW Anatolia, Turkey, reveals the oldest Lower Palaeozoic sedimentary rocks directly overlaying the Cadomian basement in the Zonguldak Terrane. These sediments of the Bakacak formation represent 4 m sandstones with gabbro and granite pebbles; 1.5 m grey shales with small inarticulate brachiopods; 10 m black shales with graptolites and 300 m thick succession of grey-green shales and sandstones.

During a joint Turkish-Bulgarian project in 2003 and 2004, graptolites and palynological samples have been collected from the basal 15 m of the Bakacak formation. *Rhabdinopora flabelliformis* ssp. occurs within the 1.5 m thick packet of grey shales with brachiopods and numerous finds of *Paradelograptus antiquus* are recorded from the overlaying packet of 10 m black shales. *R. flabelliformis* ssp. is characteristic for the Early and early Late Tremadoc and *P. antiquus* first occurs in the early Late Tremadoc (Cooper, 1999). Thus, the base of Bakacak formation is first assigned to lower part of the Upper Tremadoc based on graptolites.

Palynological samples have been collected from the shaly packets at the base of Bakacak formation. The sample Kar 4 at about 10 m above the unconformity contains poorly preserved acritarchs, leiospheres and cryptospores. The acritarch assemblage consisting of *Acanthodiacrodium formosum* Gorka, *Acanthodiacrodium spinum* Rasul, *Stelliferidium* sp., *Vulcanisphaera* cf. *britannica* Rasul and diverse diacrodians is characteristic of the mid-Tremadoc. Dean et al. (2000) reported Tremadoc acritarchs from the overlying grey-green shales.

Single naked cryptospore tetrads, dyads and monads also occur which could be referred to the genera *Tetrahedraletes, Dyadospora,* and *Laevolancis.* Numerous leiospheres and less common 'charophyte algae' are also components of the palynological assemblage.

Whereas the Caradoc to Llandovery cryptospores are of wide geographical distribution and diversity (Steemans, 2000), the pre-Caradoc cryptospore record is very scarce. The previous oldest documented sporomorphs of land plants were from the Llanvirnian in Saudi Arabia (Strother et al., 1996) and represent most of the cryptospore morphologies known from younger sediments.

This Tremadoc cryptospore assemblage is fairly badly preserved and of low diversity but represents the oldest cryptospore record independently dated on graptolites and acritarchs.

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Recognising the Kačák Event in the Devonian terrestrial environment and its implications for understanding land-sea interactions

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The Old Red Sandstone Basin in Scotland contains the distinctive and extensive Achanarras lacustrine horizon which is well known for its diverse fish fauna. It was been well characterized palynologically in a number of early publications by Richardson. Its presence in offshore wells can be determined by a combination of palynology, palynofacies, log character and correlation. The Achanarras lake was deep and wide and would have been filled by rainfall from a monsoon system at an insolation maximum. Faunal elements within the lake are in common with the Kernavė Member in Estonia and this level can also be conodont dated as late Eifelian *eiflius* zone. The Kernavė Member also contains a distinct palynological assemblage. The age and correlation shows that the group of lacustrine flooding events that occur at, and above, the Achanarras level can be correlated with the marine Kačák Event and that both can be regarded as having a common climatic cause and were driven by an insolation maximum. A reconstruction of the Orcadian Basin drainage system and a water balance model based on the calcium flux within the lake shows that a very significant volume of water would have been seasonally discharged to the Rheic Ocean and this would have caused an additional environmental effect.

Upper Wenlockian microphytoplankton palaeoecology in the Baltic Basin.

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Investigated material comes from three localities: Sweden, Gotland – Grötlingbo-1 drillcore, Poland – Bartoszyce IG1 drillcore and Holy Cross Mountains, Prągowiec ravine. All of them are from *lundgreni* to *praedeubeli* graptolite biozones (Silurian, Wenlock, Homerian).

Sediments of these three localities, during Late Wenlock (*lundgreni* Event) represent three different facies of the same basin. All of them are very rich in microphytoplankton, especially acritarchs and prasinophytes.

Sediments from Grötlingbo - 1 drillcore interpretated as distal platform slope environments (Calner et al, 2006 *in press*) consists of greenish-grey, slightly calcareous, variously faintly laminated or massive mudrock. 28 samples were investigated for the organic-walled microphytoplankton, which is abundant within the studied interval – acritarchs: 25 genera and 45 species; prasinophyte: 2 genera and 3 species were recognized.

The pre-extinction interval contains a quite abundant but poorly diversified acritarch assemblage that is dominated by the genus *Leiofusa*.

The frequency of acritarchs increases more than tenfold in the latest *flemingii-dubius* chron and thereafter drops. The interval lacking graptolite fauna - bizones: *dubius*, *parvus-nassa*, *dubius-nassa* (survival phase) includes a low diversity, low frequency acritarch assemblage, also dominated by *Leiofusa estrecha*.

Sediments from Bartoszyce IG1 drillcore interpreted as deep basin environments (Calner et al., 2006 *in press*) consists of light grey, sparsley bioturbated mudstones. From the *lundgreni* Event interval, 18 core samples were investigated for the stratigraphic succession of palynomorphs, for its diversity and frequency. 21 acritarch genera with 53 species and 3 prasinophyte genera with 2 species were recognized.

In the Bartoszyce section three main assemblages occur, each of them characterizing the different phases (extinction, survival, recovery phase) of the *lundgreni* Event (Porębska et al., 2004).

The first assemblage, occurring in the extinction phase (*lundgreni*, *testis* and *flemingii-dubius* biozones) and the third, documenting the graptolite recovery phase (*predeubeli* Biozone), are similar in taxonomic diversity, frequency and abundance. The second assemblage (survival phase) differs from the other two assemblages in reduced frequency, low diversity and the occurrence of a dominant species *Leiofusa parvitatis*.

Sediments from Prągowiec ravine interpreted as deep basin environments consists of yellowish- grey mudrocks (*lundgreni* and *testis* biozones) and gray silty shales with mudrocks intercalations (upper part of section).

In fact, this outcrop is not located in the East European Platform but in the southern part of Holy Cross Mts., a terrain located very close to Baltica – so it can be interpretaded as the same sedimentary basin during the Middle Silurian.

18 samples were investigated for the stratigraphic succession, diversity and frequency. 24 acritarch genera with 63 species and 2 prasinophyte genera with 6 species were recognized.

The assemblage, occurring in the extinction phase (*lundgreni* and *testis* biozones) and the assemlage documenting the graptolite recovery phase (*predeubeli* Biozone), are similar in taxonomic diversity, frequency and abundance. The second assemblage (survival phase) differs from the other two assemblages in low diversity and the occurrence of a dominant species *Oppilatala insolita*. The frequency in the survival phase is high due to the occurence of dominant species.

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Studies on the Devonian/Carboniferous Acritarch Decline

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The Devonian/Carboniferous transition experienced secular changes in the global carbon cycle that were permanent and extremely significant for evolution of life on Earth. These include shifts in the distribution of carbon in various reservoirs, including standing carbon biomass, buried carbon and atmospheric CO_2. The terminal Devonian also experienced one of the five greatest extinctions in the Phanerozoic shallow marine realm. We have begun to investigate the characteristics of the well-known acritarch decline that began in the Late Devonian. The research is based on taxon entries in the PalynoData dataset which have been progressively filtered to produce a curve that is more robust in terms of well characterized acritarch species and their temporal distribution. The results of initial binning at the stage level show a smooth decline of acritarch taxa through the Mississippian bound by significant loss at the Devonian/Mississippian (D/M) and Mississippian/Pennsylvanian (M/P) (sub)system boundaries of 24% and 32%, respectively. The decline represents a loss of approximately 80% of genera beginning at the Famennian/Tournaisian boundary with ~180 genera and continuing into the middle Bashkirian of the lower Pennsylvanian (~30 genera). This acritarch curve appears to lag behind curves of atmospheric CO_2 based on both modeling and isotopic studies and clearly postdates the Frasnian/Fammenian extinctions that characterize the shallow marine realm. Characteristics of the acritarch/prasinophyte groups that collectively go extinct during this interval will be examined to illuminate trends of the success or demise in such groups.

Progress on Constructing Acritarch Diversity Curves

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Acritarch taxon diversity over time should reflect physical and biological factors that govern the evolution of marine phytoplankton through Earth history. We are using taxon distribution data extracted from the PalynoData database to study coarse scale trends in acritarch diversity. The most striking aspect of acritarch distribution is the terminal Devonian decline, as noted and discussed by Helen Tappan quite some time ago. Because of heterogeneity in the data, we have plotted a series of progressively filtered curves, removing poorly constrained entries in the database. Initial filtering procedures include the removal of poorly constrained genera and combining synonymous taxa according to the Fensome et al. (1990) index, the removal of unnamed species and the removal of records with poor time constraints (i.e. system level first and/or last appearance ages). This has resulted in ~24% removal of genera from the raw data extraction.

Our data, when resolved to the stage level, shows that the decline of the acritarchs occurs steadily throughout the Mississippian and does not appear to be associated with Devonian extinction events in other groups. The two greatest drops in standing diversity occur at the Famennian/Tournaisian and the Serpukhovian/Bashkirian boundaries at both the genus and species levels. Progressive filtering has also been employed to construct species diversity curves based on first and last appearances within stage and at stage boundaries. With this, assumptions can be made between the diversity of monospecific genera and the long-ranging taxa that span the Late Devonian/Mississippian interval. The timing and character of these diversity curves are compatible with forced extinctions in the Carboniferous phytoplankton due to declining levels of pCO_2, perhaps in conjunction with other aspects of the redistribution of standing carbon after the advent of terrestrial forests.

Palaeozoic phytoplankton diversity patterns

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The Palaeozoic phytoplankton principally comprised the acritarchs and the phycomata of prasinophyte green algae. However, other algae are known to have occurred, including representatives of the Zygnemataceae (e.g., *Circulisporites*), Botryococcaceae (e.g., *Botryococcus*), Hydrodictyaceae (e.g., *Deflandrastrum*) and possible Scenedesmacaceae (e.g., *Morcoa*). The phytoPal project, which started in 2003 and has been funded by the Leverhulme Trust, has sought to determine the timing, extent and nature of the biodiversity fluctuations in these phytoplankton groups through the Palaeozoic.

To determine the diversity of the Palaeozoic phytoplankton we have constructed a relational database using Microsoft Access. This database holds the records of more than 1000 genera and over 6000 taxa of specific and subspecific rank. We have included both taxonomic and stratigraphical information, for example synonyms, homonyms, the age of the nomenclatural type and other reported occurrences. To obtain the stratigraphical data we have, so far, incorporated over 14,000 documented occurrences of individual taxa into the database.

Here we present our results on the diversity changes that occurred in the Palaeozoic phytoplankton. It is important to note that the modern phytoplankton are intimately linked to the Earth's ocean-atmosphere system. Thus, our analysis is designed to reveal how the phytoplankton responded to the significant changes in Earth's climate that occurred throughout the studied interval. In addition, we have also examined the relationship between the diversity of the phytoplankton, forming the base of the marine food web, and the important origination and extinction events in the Palaeozoic metazoans.

The diversity of the Palaeozoic phytoplankton increased through the Cambrian to a peak in the Middle Ordovician, Darriwilian Stage, before declining towards the end of the Ordovician. The diversity of the phytoplankton in the Silurian and Devonian was largely comparable, but a notable decline in diversity occurred at the Silurian-Devonian boundary. The most significant decline in phytoplankton diversity occurred in the latest Devonian and Early Carboniferous, and low diversity floras with mostly simple morphologies have been documented from the Late Carboniferous and Permian. The diversity fluctuations have been tested to determine whether they reflect differences in the relative amount of time sampled and no correlation was observed. However, some similarities can be discerned between Palaeozoic phytoplankton diversity and the amount of research input. The diversity curve can also be related to models of sea-level change, climatic shifts (e.g. icehouse and greenhouse conditions), variations in atmospheric CO_2 and O_2, and changes in seawater chemistry.

Mid-Namurian boundary in Amoco boreholes from the Upper Silesia Coal Basin

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The mid-Namurian boundary in the Upper Silesia Coal Basin is contained in transition of paralic deposits into continental deposits, or the boundary between Paralic Series and Upper Silesia Sandstone Series. 130 samples were collected from 9 boreholes drilled in south-central part of USCB by Amoco. Miospore assemblages from Poruba Beds, Jejkowice Beds and Zabrze Beds have been palynologically studied. Palynostratigraphy was established according to revised miospore zonation of the British Namurian (Owens et al., 2004). Palynozones *Mooreisporites trigallerus-Rotaspora knoxi* TK and *Lycospora subtriquetra-Kraeuselisporites ornatus* SO were established in deposits of Poruba Beds and Jejkowice Beds, and palynozone *Crassispora kosankei-Grumosisporites varioreticulatus* KV was established in Zabrze Beds. Miospore assemblages from this part of USCB were rather poor preserved and characterised by low taxonomical diversity, in contrast with them from the western part in Rybnik vicinity. The explanation of this difference is higher coal rank in the south-central part of USCB.

Miospore assemblages of Devonian Age from Paleozoic basement of the Carpathian Poredeep

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Results of palynological studies of Lower Devonian clastic dark deposits and Middle Devonian carbonates drilled out in Palaeozoic basement of the Carpathian Foredeep are presented. Samples were collected in four boreholes from Upper Silesia block and eight boreholes from Małopolska block. Most of collected samples yielded well preserved and diversified miospore assemblages with noticeable difference in thermal maturity between assemblages from Małopolska and Upper Silesia blocks. Clastic deposits represent palynozones *annulatus - sextantii* and *douglastownense - eurypterota* according to palynozonation of Old Red Sandstone Continent and adjacent areas (Richardson & McGregor, 1986). These palynozones indicate Emsian and Emsian/Eifelian ages of examined deposits. Overlying carbonate deposits with intercalations of mudstones and siltsones represent palynozones *velatus - langii* and *devonicus - naumovii* of Eifelian age. In some cases (samples from boreholes Kostki Małe 2, Trzebownisko 3, Zagość 2) miospore assemblages are more similar to these described from the East European Platform by Avkhimovitch *et al.*, 1993 and they represent acme zones *Diaphanospora inassueta, Periplecotriletes tortus* and *Geminospora extensa.*

Industrial palynology: stemming the tide of corporate memory loss

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In the last 20 years, palynology has suffered a decline in prestige and funding within some international oil companies. Perhaps the most grievous loss has been that of experienced palynologists either during 'restructuring' or through voluntary resignation, which has contributed to loss of 'corporate memory'. The main consequence of this is that it has become a challenge to maintain company palynological databases, skills and knowledge to a high standard. Thus very small numbers of palynologists retained within some international oil companies range over the entire stratigraphic column, and require access to potentially huge reservoirs of palynological literature to maintain high quality work. 'Inhouse' biozonation schemes, which may be based on undescribed informal taxa that have no reference specimen (the equivalent of a holotype), or are known simply by an alphanumeric code rather than a Linnaean binomial may be difficult for inexperienced staff to use. The reference slides that support or display these key specimens (if they exist) may be stored within company collections that are not curated to the standard of public palynological collections in national museums or geological surveys, and so may be difficult to find for detailed study.

In regions where Palaeozoic palynology is important there is a pressing need to rationalise the use of regional biozonal taxon names, as well as to make photographs, descriptions and reference specimens available. This talk will discuss some of the ways that databases and collections could be developed to support industrial palynology, and the pitfalls and advantages of such schemes.

Acritarch biostratigraphy from the Upper Lower Cambrian-Middle Cambrian of the northern margin of Gondwana (Ossa-morena zone, Southwest Iberia)

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A detailed cartographic revision of the post-Cadomian Cambrian of southwest Iberia (Fig. 1) allows the recognition of four lithostratigrafic units: Torrearboles, Alconera, Vallehondo and Playón formations. The last two units are the subject of this study. The continuous record of diagnostic cosmopolitan acritarchs in a thick succession bracketed between lower Cambrian levels with *Serrodiscus* (Upper Marianian *sensu* Liñán *et al*., 2002 or Upper Banian *sensu* Geyer *et al*., 2004) and Middle Cambrian levels with *Solenopleuropsis vergadiana* (Upper Caesaraugustian), allows us to establish a detailed acritarch-based chronostratigraphy (Fig. 2). Six acritarch zones are recognized, the lower Cambrian *H. dissimilare-S. ciliosa* assemblage Zone (Moczydlowska, 1991) and *Tubulosphaera perfecta* Zone and the middle Cambrian *Comasphaeridium silesiense*, *Cristallinium cambriense*, *Adara alea* (Martin & Dean, 1988) and *Timofeevia lancarae* zones. These are interval zones, with upper limit defined by the base of the successive zone. Figure 2 shows the range of these zones and proposed global correlations.

The middle part of La Hoya Member contains the cosmopolitan acritarchs Skiagia ciliosa, Dyctiotidium priscum, Asteridium tornatum, Asteridium spinosum, Comasphaeridium mackenzianum and Alliumella baltica. We include this assemblage in the H. dissimilare-S. ciliosa assemblage Zone, equivalent to the Holmia kjerulfi assemblage Zone in Baltica (Moczydlowska, 1991) and the Marianian Regional Stage in the Iberian Chains (Palacios & Moczydlowska, 1998).

***Tubulosphaera perfecta* Zone.** The lower boundary of this zone is marked by the FAD of *Heliosphaeridium notatum* and *Tubulosphaera perfecta*. This zone includes associations characterized by a great abundance and a low diversity of acritarchs, dominated by *Leiosphaeridia* spp.

Comasphaeridium silesiensis Zone. The lower limit is marked by the FAD of Comasphaeridium silesiensis, Multiplicisphaeridium martae, Comasphaeridium longispinosum and Eliasum llaniscum. In the upper part of this zone is recorded the LAD of Comasphaeridium silesiensis and Tubulosphaera perfecta. This zone is recognized for first time in this area, and globally is little represented due to the widespread regression at the end of the early Cambrian.

***Cristallinium cambriense* Zone**. The FAD of *Cristallinium cambriense* and *Adara matutina* marks the lower boundary of this zone. This Zone records an increase in the diversity of acritarchs, near the base of the Playón Formation, which include the FAD of *Celtiberium dedalinum* and *Vulcanisphaera lanugo* and a dramatic decrease of algal filaments and *Leiosphaeridia* spp., very abundant in the La Albuera Member of the Vallehondo Formation.

***Adara alea* Zone** (Martin & Dean, 1988). The FAD of *Adara alea* and *Eliasum* cf. *E. asturicum* marks the lower boundary of this zone in Newfoundland. In our material, with *A. alea* appears a great abundance of *Eliasum asturicum* and the species of the previous zone, except *V. lanugo*.

Timofeevia lancarae Zone. The FAD of Timofeevia lancarae, Solisphaeridium flexipilosum and Solisphaeridium multiflexipilosum marks the lower boundary of this zone. In the lower part of this zone is the LAD of Adara alea, Eliasum asturicum, Eliasum pisciformis and Celtiberium dedalinum. This zone, under different names (Fig. 2) has been recognized in Baltica (Volkova, 1990) and Newfoundland (Martin & Dean, 1988).

Conclusions:

We present here the first detailed chronostratigraphy of the siliciclastic and volcanosedimentary series of the uppermost Lower Cambrian-Middle Cambrian from the northern margin of Gondwana, on the basis of acritarch.

We propose the recognition of the *Comasphaeridium silesiensis* Zone as the first zone of the Middle Cambrian

Detailed correlations between Gondwana, Baltica and Avalonia is established on the basis of cosmopolitan acritarch species (Fig. 2*)*

This study reinforces the great utility of acritarchs for detailed Cambrian chronostratigraphy.

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Palynostratigraphy of the Bedford Shale and Berea Sandstone Formations of Ohio and Kentucky, USA

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A comprehensive miospore zonal scheme has been long established for the Carboniferous in Western Europe (Clayton *et al*. 1977). Surprisingly little research has been attempted on Mississippian miospores in the USA. Perhaps the most extensive investigation of Upper Devonian and Mississippian miospores in the USA was undertaken by Winslow (1962), prior to the development of the European miospore zonation. In the present study, samples collected from the Bedford Shale and Berea Sandstone Formations from localities in Ohio and Kentucky were analysed using standard techniques. Samples yielded well preserved and diverse miospore assemblages dominated by representatives of *Retispora lepidophyta* and *Vallatisporites vallatus*. Correlation with Europe will be discussed in detail and Winslow's results re-evaluated within the context of the most recent European miospore zonation (Clayton *et al*. 2003). This study forms part of an ongoing project which aims to erect a preliminary but comprehensive miospore zonation for the Mississippian of the Midwest and Eastern USA.

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Recent advances on the Upper Devonian palynostratigraphy of the Pulo do Lobo Domain, South Portuguese Zone, Portugal

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The Pulo do Lobo Domain is an antiformal structure situated at the northern edge of the South Portuguese Zone, just in contact with the Ossa Morena Zone, Iberian Variscides. In the core of the structure outcrops the Pulo do Lobo Fm. composed of phyllites, quartzites, minor felsic volcanics and amphibolites (former basalts) with MORB-type geochemical affinity at the lower part. A common feature of this unit is the widespread occurrence of exudation quartz veinlets related to the strong tectonic deformation characterized by three episodes of NW trending folds and associated cleavages.

In the north limb of the structure, the Ferreira-Ficalho Group includes from base to top the following units (Carvalho et al.; Oliveira, 1983): the Ribeira de Limas Fm. is composed of phyllites, quartzwakes and minor intercalations of tuffites with a tectonic deformation similar to that of the Pulo do Lobo Fm ; the Santa Iria Fm. is made up of greywackes, siltstones and shales, forming a flysch- like succession; the Horta da Torre Fm. is composed of dark shales, impure sandstones, siltstones and quartzitic beds with strong bioturbation. The Santa Iria and Horta da Torre Fms are affected by a main folding phase with associated cleavage. The group thickness is estimated in 500 m.

The south limb of the structure is represented by the Chança Group, which is composed also by three units: the Atalaia Fm. composed mostly of phyllites and quartzites, sharing with the Pulo do Lobo Fm. the same type of tectonic deformation; the Gafo Fm. made up of a thick pile of greywackes siltstones and shales forming a flysch succession, with intercalations and intrusions of felsic and mafic volcanics with two main episodes of NW trending folds and related cleavages; the Represa Fm. which is composed of siliceous silstones, shales, greywackes and minor intercalations of fine volcanogenic sediments. The group thickness is estimated in 1100 m

Recent palynostratigraphic research allows the following main conclusions:

1. No age determination was achieved for the Pulo do Lobo and Atalaia Fms, probably due to the high grade of metamorphism that affected these units. The unit is surely older than early Frasnian.

2. The Ribeira de Limas and Gafo Fms. revealed the presence of moderately preserved miospore assemblages assigned to the BM Biozone of early Frasnian. The assemblages include the species *Aneurospora greggsii, Chelinospora* sp., *Cristatisporites triangulatus, Cristatisporites* sp. cf. *C. inusitatus, Geminospora lemurata, Lophozonotriletes* sp., *Rugospora bricei, Verrucosisporites bulliferus, V. premnus* and *V. scurrus.*

3. The Santa Iria, Horta da Torre and Represa Fms. yielded well-preserved assemblages of miospores assigned to the VH Biozone of Late Famennian age (Cunha e Oliveira, 1989; Pereira et al, 2006). The assemblages contain *Apiculiretusispora verrucosa*, *Auroraspora macra*, *Diducites* spp., *Emphanisporites* spp., *Geminospora lemurata*, *Grandispora cornuta, G. echinata, G. famenensis*, *G. gracilis* and *Rugospora flexuosa*. All the studied samples show abundant and the same species of acritarchs and prasinophytes.

4. The ages of the units Ribeira de Limas/Gafo and Santa Iria-Horta da Torre/Represa are separated of about 14 My. This fact reinforces previous structural interpretations that suggested the existence of an unconformity

between the pair Santa Iria/Horta da Torre Fms. and the underlying Ribeira de Limas Fm.

5. The units of the Pulo do Lobo Domain have been interpreted as an accretionary prism in close relation with a northward directed (present coordinates) subduction zone. A more recent interpretation consider that only the Pulo do Lobo, Ribeira de Limas, Atalaia and Gafo Fms. were incorporated in the acretionary prism. The upper units, much less tectonically deformed were laid down in a basin superimposed over the accretionary prim (Pereira et al, 2006) and contemporaneous of the Iberian Pyrite Belt detritic substrate (Phyllite-Quartzite Group) and the overlying first volcanic episodes.

Late Precambrian - Early Cambrian 'marginata'- type acritarchs: some critical remarks

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Morphologically simple circular forms with thickened edge and smooth to spongy wall structure were documented for the first time by Naumova (1960) from the Lower Cambrian of Estonia. Although the original descriptions of *Leiomarginata simplex* Naumova, 1960 and *Garnomarginata prima* Naumova, 1960 were rather poor these species together with later described *Granomarginata squamacea* Volkova, 1968 became recognizable and most frequently cited species indicating the base of the Cambrian in the East-European Platform. Interest to these species as to biostratigraphic indexes, however, was reduced when they were found in Siberia in sediments of certain Precambrian age. Some confusion also existed in species definitions due to few diagnostic criteria.

Without reinvestigation of the original material *Leiomarginata* as a junior synonym was transferred to *Leiosphaeridia* (Cramer and Diez, 1979) and *G. squamacea* was attributed to the genus *Annulum* (Martin and Dean, 1983). Thus, morphologically similar 'marginata' species belong now to three different genera: *Annulum*, *Granomarginata* and *Leiosphaeridia* (Fensome et al., 1990).

Being very common in transitional Precambrian-Cambrian strata these acritarchs are still of high use in regional biostratigraphy. To understand interrelation between described species and to verify their taxonomic position a rich material from the type area has been reinvestigated.

Five samples from the Lontova Formation from the Narva-69 borehole, Estonia (interval 105,35 – 84,90 m) contain palynological assemblage dominated by 'marginata' acritarchs (1000 to over 5000 specimens per slide). This assemblage is qualitatively and quantitatively analyzed throughout the studied interval. Among 'marginats', specimens displaying diagnostic features of *G. squamacea* are about 2-7 %, *G. prima* – about 7-13% and *L. simplex* about 30-50%. The rest part consists of intermediate forms and forms at dividing stage. On the basis of more than 15000 specimens the following observations have been documented:

i - *Leiomarginata simplex* differs from accompanied species of *Leiosphaeridia* by its wall structure which is similar to that of other 'marginats';

ii – a continuous transition '*simplex*' – '*prima*' - '*squamacea*' shows gradual size increasing by growth of spongy extension surrounding the central body;

iii – intermediates are more abundant than certain '*prima*' and '*squamacea*';

iv – doubled forms are rare (0,5-1,3 %), but neither '*simplex*' nor '*squamacea*' is found dividing, instead, normally '*prima*' or forms intermediate between '*simplex*' and '*prima*' have double central body surrounded by thin spongy rim.

It is reasonable to assume that all studied morphological varieties of 'marginats' are different developmental stages of a single organism.

Collections from other Estonian section (the Ranna-Pungeria borehole) and from Siberia (the Chekurovka River) were studied for comparison. In addition to the reinvestigated material large published data were revised. Geographical distribution, stratigraphical range, biological and ecological aspects of 'marginats' are discussed in the present study.

Lower Devonian Cryptospores and miospores, their distribution patterns in the lower Old Red sandstone of the Anglo-

Welsh basin & the habitat of their parent plants

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Palynomorphs are abundant in some fine-grained rocks in the Lower Old Red Sandstone (L.O.R.S.) of the Anglo-Welsh Basin. In this study the distribution and relative abundance of cryptospores and miospores have been examined in a series of samples from uppermost Downton – Ditton Formation sections from Hereford in the south to Shropshire in the north. The pioneering work of John Allen on the L.O.R.S. facies of the Anglo-Welsh Basin led to a more detailed analysis than had been previously attempted. He interpreted the facies to have formed in marginal marine to fluvial environments. Muller (1959) demonstrated that the spores and pollen in Recent sediments of the Orinoco Delta were dispersed mainly by water. However, in the Late Silurian and earliest Devonian, many miospores and some cryptospores were smaller than 25µm (the upper size indicating adaptation to wind dispersal in modern bryophytes; Mogensen, 1981). The Lower Old Red Sandstone sequence in the Anglo-Welsh Basin shows offlap with the migration of medial and proximal facies (fluvial environments) to overlie the distal facies (marine influenced environments) in the south. Dispersed palynomorphs have been examined from a series of sections from the distal margins of the floodplain in the south (Hereford) to more proximal areas of the floodplain in the north (Clee Hills, Shropshire). Distribution patterns in cryptospore and miospore assemblages reflect both the lateral and stratigraphical changes, and although influenced by water transport, may be used with caution to interpret potential habitats of their parent plants. In some cases cryptospores dominated distal sediments, laid down in a marine-influenced coastal plain. In contrast, in the more proximal (upstream) sediments, miospores are usually dominant. *In situ* cryptospores and trilete spores have been isolated from the sporangia terminating tiny fragmentary plant axes (see *inter alia* Edwards & Richardson 2000 and references therein). These Lilliputian plant axes are often remarkably similar, but their variable terminal sporangia and spores, indicate increasing plant diversity possibly related to adaptation to a wider range of environments. Whilst in the lower Downton Formation (*tripapillatus-spicula* Palynozone) and in the lower and middle parts of the Ditton Formation (lower & middle subzones of *micrornatus–newportensis* (MN) Palynozone) these plants had terminal sporangia, in higher parts of the Ditton Formation, in the Clee Hills, plants with both lateral (*Zosterophyllum*) and terminal sporangia (*Salopella*) occur together (Edwards and Richardson 1974). Miospores in South Wales become increasingly larger in the upper Red Marl and lower Senni Bed Formations (upper Lochkovian, upper MN Sub-palynozone & *breconensis – zavallatus* BZ Palynozone) and trilete spores increasingly more diverse. The important macrofloras described from the Brecon Beacons by Edwards (1968, 1969, 1970, 1980) occur higher in the Senni Bed Formation, in the succeeding *polygonalis – emsiensis* Palynozone, where the greatest diversity of miospores occurs. Miospores are dominant in these spore assemblages and characteristic species have apiculate and biform or murornate sculpture.

Palynological evidence for the dating and interpretation of a late Devonian sedimentological event in northeast U.S.A.: Extraterrestrial, meteorological or glacial?

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Palynological analysis of over 120 samples from the Upper Famennian (Cattaraugus, Oswayo, and Kushequa Formations) from New York State and Pennsylvania has been used to date an unusual rock sequence in part of the latest Devonian Spechty Kopf and Rockwell Formations (Pennsylvania) overlying the Catskill and Hampshire Formations respectively. A typical sequence of these rocks includes a diamictite with sedimentary, igneous and metamorphic clasts, overlain by a pebbly mudstone, laminite and that by quartz-rich sandstone. The variable, but distinctive, sedimentary profile has a maximum thickness of c.150m to c.10m. It is known from exposures scattered across approximately 40,000 km² in a band 400 km parallel to the strike and 100 km across strike. The northernmost exposures are in northeast Pennsylvania (Scranton) and the southernmost known is in Maryland. Samples from the diamictite sequence were at first provided by Woodrow (1990's) for palynological analysis and comparison with previous palynological studies (Richardson unpublished, Richardson & Ahmed, 1988). More recently, joint fieldwork (Woodrow & Richardson) has been carried out on diamictite and other sequences in Pennsylvania (sponsored by the Pennsylvania Geological Survey). The diamictite profile varies between outcrops but it includes large boulders to granules, and sometimes rafts of material several metres across, in a silty clay matrix. The spore assemblages below, within, and at the top of the diamictite sequence are almost identical and belong to part (a subzone?) of the *Retispora lepidophyta – Indotriradites explanatus* (LE) Palynozone. Rock sequences, containing spore assemblages of the same palynological interval, traced westwards in Pennsylvania have shown no sign of the diamictite, or any other apparent disturbance although the diamictite itself is absent there. To the northwest in Pennsylvania the LE Palynozone is overlain by the *Retispora lepidophyta – Verrucosisporites nitidus* (LN) Palynozone (uppermost Famennian) and is underlain by rocks containing spore assemblages in which some key species apparently differ in their order of appearance relative to their counterparts in Western Europe and Byelorussia.

The origin of the diamictite sequence is enigmatic; many scientists working over the past 30 years have studied this unusual sequence of sedimentary rocks and failed to agree on the origin. Interpretations of the diamictite include a debris flow deposit, a subaqueous mud flow deposit formed in a marine, estuarine or lacustrine environment, a deposit formed by valley-wall collapse, a deposit related to valley glaciation, or a deposit resulting from a Bolide plunging into the Appalachian Basin, followed by a tsunami. All these hypotheses have been previously proposed, but is there another explanation for this dramatic sequence of rocks? Palynological data are discussed in relation to these hypotheses and hypotheses previously proposed for palaeoenvironments based on palynofacies data.

Early Permian palynological sequence in Indian Gondwana

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The Permian Gondwana of India is represented by elements of *Glossopteris* flora, also known as the Lower Gondwana flora. The flora survived during the entire period of Permian. The different geologic formations of the Permian Gondwana of India e.g. Talchir, Karharbari, Barakar, Barren Measures and Raniganj have provided enormous data about the plant megafossils and microfossils. Palynological investigation of the Talchir, Karharbari and Barakar formations of the Lower Permian shows the dominance of radially-symmetrical monosaccate pollen during the early phase and later shows the the proliferation of non-striate and striate disaccate pollen. The trilete spores and other forms are significantly or insignificantly associated with the flora.

Analysis and synthesis of spore-pollen assemblages have helped to identify a number of biohorizons and assemblage zones in Lower and Upper Permian sequences. The palynological composition of the biohorizons and palynological zones along with the appearance and disappearance of taxa are discussed at successive stratigraphic levels of the Lower Permian.

Megaspore Diversity in Lower Gondwana Succession of India

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Qualitatively and quantitatively rich megaspore assemblages are known from different Gondwana basins of Peninsular India e.g. Son, Mahanadi, Damodar, Satpura, Wardha and Godavari. They are described from all the formations of Lower Gondwana e.g. Talchir, Karharbari, Barakar, Barren Measures and Raniganj representing Permian Period.

Megaspores have been studied under dry and wet condition. The microscopic observation of dry megaspore shows the external morphological features of exosporium or exine such as tetrad mark, contact area, contact marking and ornamentation. At different stage of maceration individual megaspore under wet condition reveals the structural features of inner body (nexine/endosporium) indicating the thickness and sculpture of wall, presence or absence of cushions and trilete trace. The combined characters of exosporium and endosporium are useful for the classification of megaspores.

Most of the megaspores range in size from 400 to 600 µm in diameter, their shape is circular (*Bokarosporites, Jhariatriletes, Banksisporites, Ramispinatispora, Saksenasporites*), triangular (*Duosporites, Barakarella, Talchirella.).* Sometimes they are subcircular and subtriangular in shape. Exosporium besides being psilate and scabrate *(Bokarosporites)* shows verrucae (*Talchirella, Duosporites*), baculae (*Barakarella, Jhariatriletes*), coni/setae (*Biharisporites, Singhisporites*), simple spines (*Singraulispora, Lagenicula),* furcated and branched spines (*Ancorisporites, Satpuraspora).* Different types of appendages e.g. mammillate (M*ammilaespora*), long, slender, apically divided *(Sethiaspora),* rods/ribbon-like (*Manumisporites*), club shaped (*Pilatriletes*) or tubercles (*Saksenasporites)* are seen over the surface.

Presence and absence of cushions are characteristics features of inner body, wherever they occur their size and distribution are important for taxonomic deliberation. *Bokarosporites, Banksisporites, Singraulispora, Ramispinatispora, Singhisporites, Manumisporites, Biharisporites, Jhariatriletes* are devoid of cushions whereas few cushions in one row are observed in *Duosporites congoensis, Talchirella nitens,* number of trigonally arranged cushions are seen in *Barakarella pantii, Duosporites multipunctatus, Talchirella trivedii, Ancorisporites binaensis, Pilatriletes mirzapurensis* and irregularly arranged cushions are present in *Duosporites irregularis* and *Lagenicula barakarensis.*

The elevation of trilete mark and the contact area into a cone-like gula represent the gulate megaspore which are described as *Gulatrilete , Shahdolia, Lagenicula, Setosisorites* and *Satpuraspora.*

The megaspores have not yet been discovered in attachment with Lower Gondwana plant fossils in India, however, their structural features indicate their affiliation with lycopsid group of plant.

Silurian and early Lower Devonian miospores from South America

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Two new localities have been sampled for a palynological study on miospores in the Silurian and the Lochkovian. Detailed palynological study has revealed diverse assemblages, permitting to describe new species and extend the time or latitudinal range of some taxa.

The first one is located in the Urubu area, western part of the Amazonas Basin, northern Brazil, from layers belonging to the Manacapuru Formation. A previous palynological work based on chitinozoans (Grahn and Melo, 2003), had allowed dating the samples as late Ludlow, early Pridoli and early Lochkovian in age. Fourteen productive samples have been investigated. Sixty four miospore species have been identified among which two new species are described. One specimen attributed to the genus *Grandispora*, identical to unpublished specimens observed in Lochkovian layers from Saudi Arabia, has been discovered in a Lochkovian sample. They are the oldest known *Grandispora*. Among the abundant acritarchs, specimens of the genus *Schizocystia* have been observed for the first time in layers older than the Devonian.

The second locality is situated in the Quebrada Ancha area, Central Precordillera of San Juan. The La Chilca Formation, considered as late Hirnantian-Llandovery/Wenlock? in age, yield acritarchs and related marine forms, with very scarce cryptospores. Among acritarchs from the lower levels, *Tylotopalla caelamenicutis* Loeblich 1970 and *T. digitifera* Loeblich 1970 seem to be biostratigraphically useful. The overlying Los Espejos Formation considered as Wenlock to locally Pridoli in age, yield diverse, abundant and well preserved marine and terrestrial palynomorphs. The lower levels show a predominance of acritarchs and related forms, among which: *Neoveryachium carminae* Cramer 1970, *Quadraditum fantasticum* Cramer 1964, *Fibriaglomerella divisa* Loeblich & Drugg 1968, *Onondagaella asymmetrica* Playford 1977 and typical large fusiform species. Miospores increase towards the top of the unit, with more trilete spores than cryptospores. Miospores include cf. *Lophozonotriletes? poecilomorphus* Richardson & Ioannides 1973, cf. *Synorisporites verrucatus* Richardson and Lister 1969, cf. *Clivosispora verrucata* var. *convoluta* McGregor & Camfield 1986, *Chelinospora* sp. A in Richardson and Lister 1969, *C. sanpetrensis* Richardson et al. 2001, *Scylaspora vetusta* Richardson et al. 2001, *S.* cf. *scripta* Burgess and Richardson 1995 in Richardson et al. 2001, cf. *Coronaspora cromatica* Richardson et al. 2001, *Aneurospora* sp., *Coronaspora* sp. and *Amicosporites* sp. Most of these miospores are recorded for the first time in Argentina.

Although samples are relatively poor in miospore specimens, the present study displays the most diversified Silurian-earliest Lochkovian assemblage from South America.

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Upper Ordovician microphytoplankton from the western Pomerania (Miastko), NW Poland

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The Ordovician sediments in the Polish part of the Pomerania Terrane (western Pomerania, Koszalin-Chojnice Structural Zone) have been reached only by exploration drillings. Rock of Cambrian age in have not been penetrated. The oldest strata are Llanvirnian (early Darriwilian) in age and the youngest – Caradocian (early Sandbyan) in age as indicated by their graptolite fauna (Modliński, 1968, Bednarczyk 1974). The litological characteristics of the Ordovician series within the Koszalin-Chojnice area show its monotonous development and strongly disturbed tectonics. The Ordovician complex is composed of claystones, silstones and sandstones. Those deposits pass into Silurian graptolitc siltstones. The folded Ordovician and Silurian are – probably diachronously – overlined by continental clastic sediments of the Devonian (Dadlez, 1990). Detailed stratigraphy of the Ordovician has been established on graptolite, chitinozoa, conodonts and acritarchs faunas (Modliński, 1968; Bednarczyk, 1974; Szczepanik, 2000; Wrona, Bednarczyk and Stempień-Sałek, 2001).

The borehole Miastko 1, is situated east of Koszalin, in Koszalin-Chojnice Structural Zone. The Ordovician sediments have been here found at the depth 2737,0- 2745 m, directly underlies the Devonian sediments. It is represented by dark grey silstones, mudstones, fine grained sandstones and black shales occasionally with pyrite concretions.

The biostratigraphic analisys of the Ordovician from borehole Miastko 1 is based on graptolite. Modliński (1968) and Bednarczyk (1974) identified from the silstones *Pseudoclimacograptus angulatus sebyensis* Jaanusson. It is corresponded to the *Glyptograptus teretiusculus – Orthograptus acutus* Zone (Jaanusson, 1973).

Palynological assemblages from Upper Ordovician have been studied. Four palynological samples of siliceous shale were subjected to standard laboratory treatment. Three of them yielded acritarchs. The dominant palynological matter found in the samples is amorphous. Determinable palynomorphs constitute a minor admixture. There samples contained leiospheres, acanthomorphs and cryptospores. The preservation of the particular taxa is generally poor, hence many are determined to generic level only or left in open nomenclature. However, several forms can be recognised precisely. Reasonably well represented taxa are the following: *Baltisphaeridium*, *Ordovicidium* and *Orthosphaeridium* with wide and long processes which are characteristic of the Late Ordovician. They are accompanied by long-ranging taxa of simple morphology such as *Goniosphaeridium*, *Micrhystridium, Polygonium* and *Veryhachium.*

Generally the acritarch frequency is rather low being up to 40 specimens per slide. Only in a one samples is frequency higher: from 50 to 70 specimens. The dimension of acritarch are mainly in the range between 15 and 45 µm, only occasionally reaching 75 µm, the dimension of cryptospores - between 35 and 50 µm. The thermal maturity of organic matter in borehole Miastko 1 is generally low.

Palynological study agree with those of previous research on graptolites from the Ordovician in Koszalin-Chojnice Structural Zone confirm that investigated material can be attributed to the Middle - Upper Ordovician, probably Llanvirnian (Darriwilian)/Caradocian (early Sandbyan), Caradocian (Sandbyan) and correspond partially to the *Glyptograptus teretiusculus — Orthograptus acutus* Graptolite Biozone.

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Palynology and organic carbon isotopes to elucidate the millennial scale evolution of a Middle Devonian lake in response to climate change, Orcadian Basin, Scotland

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There are few palaeolimnological studies of Palaeozoic lake sediments using methodologies developed for the study of Quaternary lakes. New research described here indicates the benefits of applying multidisciplinary high-resolution sampling and analysis on the Middle Devonian lake sediments of the Orcadian Basin in order to understand lake palaeoecology and response to water chemistry change and possible climate change. In a continuously sampled 4 m thick lake cycle in two correlated boreholes in Caithness there are two distinct features. There is a broad trend in $\delta^{13}C$ of sedimentary organic matter from high values in the shallow water sediments to lower values in the deeper water sediments, attributed to changing contributions from terrestrial plant material ($\delta^{13}C$ c. -28‰) and algal material ($\delta^{13}C$ c. -33‰). This variation is consistent with palynology and is best explained by proximal-distal variation as the lake filled. A smaller but well correlated up section decreasing $d^{13}C$ trend occurs over approximately 1 m, starting at the cycle centre where the lake was at its deepest. Since the same feature is seen in two boreholes, we suggest that local effects of migrated bitumen, diagenesis or facies changes are unlikely to be the cause, and that changes in the carbon cycle of the lake are responsible. Explanations for this trend may relate to the source of carbon that algae utilise as the lake changes from a fresher to a more saline environment, and to changes in the carbon isotope composition of the lake water during periods of enhanced productivity. Change in the cycle can be scaled by reference to annual lamination, the whole period of maximum change being approximately 3000 years.

Middle Cambrian Acritarchs from the Conasauga Group, eastern Tennessee, USA

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Reports of Cambrian acritarchs from central North America are rather sparce and with the exception of a field guide report for the Reelfoot Rift area of Missouri by Gordon Wood and co-authors, are limited to scattered reports of new taxa by Wood and co-authors. An examination of the JOY-2 borehole from the Oak Ridge National Laboratories has yielded low numbers of acritarchs ranging from the Rome Formazion (uppermost Lower Cambrian) through the entire Middle Cambrian. The palynological assemblages throughout this predominantly estuarine sequence are overwhelming dominated by thick-walled sphaeromorphs and cryptospores. Thermal alteration is low and the excellent preservation has enabled detailed examination with light microscopy. Many of the acritarchs are quite small, however, which has made some taxonomic determinations difficult. The oldest samples from the Rome Fm are characterized by *Revinotesta* and *Asteridium* (*Michrystridium*) *tornatum*-like acanthomorphs. Middle Cambrian taxa include well-preserved *Retisphaeridium dichamerum* along with several forms that fall between *Celtiberium* and *Heliosphaeridium* with thin-walled, tapered processes with capitate tips. There is a new genus exhibiting short, bifurcating processes whose bases fuse to form a partial reticulum. These specimens would appear to be similar to *Dictyotidium* in light microscopic examination. Degraded specimens of *Skiagia ciliosa* occur in the *Ehmaniella* Zone; these may be reworked from Lower Cambrian sources. *Cymatiosphaera* species occur in the *Crednaria-Crepicephalus* Zone, which is considered Late Cambrian in Laurentia. There is a somewhat marked change in the assemblages in the lower Nolichucky Shale, which may mark the Middle/Upper Cambrian boundary in this part of the section. There are no diacrodiods or other indicators of later Cambrian age common in Avalonian Terrain (as described by Martin, Parsons and co-workers). Overall, the Conasauga Group assemblages are somewhat similar to acritarchs from Cambrian sections in northwest Spain described by M. Fombella, but they are extremely similar to coeval assemblages from the Canadian Rockies, including the Burgess Shale and related rocks, currently under study by Kevin Gostlin. Given the restricted depositional setting of these deposits, the construction of biozones based on these assemblages is probably unwarranted.

Relating the fossil record to deglaciation in the Early Permian of Gondwana: development of a Gondwana-wide biotic deglaciation model

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Deglaciation sequences of Early Permian age in Gondwana have until now been distinguished mainly on lithological criteria by reference to climate-sensitive lithologies such as diamictite, limestone, glacial shales (with dropstones and varves) and associated geochemistry, whereas identification on biotic criteria such as vegetational or faunal change has not been employed. Data shows that the maximum rate of deglaciation probably occurred around the *Granulatisporites confluens* palynological Biozone, at least in Australia, Antarctica, East Africa, India and Arabia, in late Asselian – early Sakmarian times.

Present palaeontological data, which is admittedly widely-scattered geographically, and of different stratigraphic scales and resolutions clearly show diversity increase from glacial conditions to post glacial conditions. Amongst the marine fauna, a cold water fauna consisting of bivalves such as *Eurydesma* and *Deltopecten*, and brachiopods such as *Lyonia* and *Trigonotreta*, were established in the earliest post glacial marine transgressions that did not affect all of Gondwana. Above this is a more diverse, increasingly warmer, temperate fauna, including brachiopods, bryozoans, bivalves, cephalopods, gastropods, conularids, fusulinids, small foraminifers, asterozoans, blastoids and crinoids like that of the Saiwan Formation/Haushi limestone of Oman.

The palynomorph succession shows some consistency across Gondwana in Asselian-Sakmarian rocks. Very broadly a change from monosaccate pollen assemblages, associated with fern spores to more diverse assemblages with common non-taeniate bisaccate pollen occurs through the deglaciation period. In Oman, where this has been studied in greatest detail, the upland saw changes from a glacial monosaccate pollen-producing flora to a warmer climate bisaccate pollen-producing flora; while in the terrestrial lowlands, a parallel change occurred from a glacial fern flora to a warmer climate colpate pollen-producing and lycopsid lowland flora. The sedimentary organic matter of the clastic rocks of the Oman sequence records a corresponding $\delta^{13}C$ trend (from approximately -21 to -24‰) believed to reflect palaeoatmospheric change due to postglacial global warming.

The advantages of developing a deglaciation model would be in understanding in detail the response of life to increasing temperatures and other climate change, and might be useful in the study of modern biotic change during global warming. However to achieve such a model more detailed bed by bed interdisciplinary palaeontological studies of measured sections demonstrably related to climate-forced deglaciation must be carried out. For these studies to be comparable across Gondwana, sections must be precisely correlateable so that like can be compared with like. Therefore a Gondwana-wide palynostratigraphy, uniting the four or five schemes presently in existence for the former continents of Gondwana, needs to be established.

Age assessment of Permian palynomorph assemblages from the Hazro Anticline (SE Turkey, Arabian Plate) and correlation with adjacent regions

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During the Permian, thick sequences of terrestrial and marine sediments were deposited at the northern edge of the Arabian Platform. Today, a more than 200 m thick succession is exposed in the Hazro Anticline. Based on lithological characteristics these sediments are referred to the Kaş and Gomaniibrik formations. In 2005, a large number of samples of clastic and coal-bearing strata of these formations were taken for palynological analyses. Palynological data may contribute towards a better understanding on the occurrence and nature of mixed floras and floral provincialism. However, reliable and precise age assessments are necessary before such aspects can be addressed. Previously published information on the age of the strata is incomplete or inconclusive. Based on palynological analyses, the same lithological units were variously dated as Early and Late Permian.

The new palynological data apparently provide much more accurate, but still not fully satisfying, age estimates of the Hazro-assemblages. Palynological biozones, established for the Permian of Saudi-Arabia and Oman, are still incompletely defined. Paleophytogeographical aspects have not yet been elaborated in detail in palynological studies. A number of recently-published studies by Turkish scientists on foraminifera, especially fusulinids typical for the Palaeotethys, and other characteristic faunal elements from the sequence in the region around Hazro have also provided new datings. Based on the combination of micropalaeontological and palynological data, it can be concluded that the sedimentary succession in the Hazro area ranges from the Guadalupian to Lopingian. This presentation focuses on the palynology of the Kaş Formation and the new stratigraphic data will be used for correlating the Hazro area with adjacent regions such as Iraq and Saudi-Arabia.

Chitinozoan biostratigraphy across the base of Darriwilian Stage from the type area in Eastern China

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In the Jiangshan-Changshan-Yushan (JCY) area, located on the borders of Jiangxi and Zhejiang provinces, eastern China, the Ordovician succession is represented in ascending orders by the Yinchufu, Ningkuo, Hulo, and Yenwashan formations. The GSSP for the Darriwilian Stage was defined by the First Appearance Datum (FAD) of *Undulograptus austrodentatus* in the Ningkuo Formation at the Huangnitang section, Zhejiang, eastern China (Mitchell et al., 1997). Three distinctive chitinozoan assemblages are recognized in the Ningkuo Formation (Fig. 1). Assemblage A consists of *Conochitina* sp. 1, *Conochitina* cf. *brevis*, ?*Lagenochitina* sp.,

?*Bursachitina* sp.. The preservation is relatively poor and the abundance is very low (<0.2 specimens/gram). Assemblage B distinguishes from Assemblage A by the presence of *Euconochitina* sp. 1 and the abundance of *Conochitina* cf. *subcylindrica* Combaz and Péniguel. The latter represents 86% of the population. The presence of *C. ordinaria* suggests links with chitinozoan microfaunas described from Canada and from Australia. Assemblage C is characterized by the appearance of *B. zhejiangensis, L. praepirum,* and *Sagenachitina* sp. 1. In addition to these species, *Belonechitina chenjiawuensis* sp. nov., *E. hengtangensis* sp. nov., *Busachitina laminaris* sp. nov. and *L. langei* are additional important elements of this assemblage.

The base of Assemblage C is very close to the base of the Darriwilian Stage where dramatic changes in chitinozoan abundance and diversity occur close to the base of the Darriwilian Stage occur in the JCY area. In the Hengtang section, new elements of specific composition represent more than 76% of this assemblage. In addition to the increasing diversity, the abundance raises sharply near the base of the Darriwilian Stage. Although the weathering processes affects the preservation of chitinozans, the fact that The FAD of *Sagenachitina* sp. 1 is close to the base of the Darriwilian Stage in the type area. This species is the oldest recorded *Sagenachitina* and therefore, the appearance of this genus, which has a wide palaeogeographical distribution, can be used for locating the base of the Darriwilian in remote regions. around the world shows its potential significance for long distance biostratigraphic correlation.

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Miospore zonation of Givetian-Fransnian deposits of the Timan-Pechora province

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In sections of the East European Platform the level of standard bottom border of Frasnian remains debatable till now. In Timan-Pechora Province this stratigraphic interval is well submitted in natural exposures and core of wells. It is characterized in details by fauna, there is detailed developed zone palynological chart.

The analysis of taxonomic structure of palynospectra from the miospore zone *Contagisporites optivus-Spelaeotriletes krestovnikovii* (Avkhimovich et al., 1993) and its comparison to spores in situ as well as the results of studying of sporoderm ultrastructure of disperse spores has allowed to establish that the most essential innovations occur on stratigraphic level *Densosporites sorokinii* palynozone (Tel'nova, Meyer-Melikyan, 1993, 2002; Tel'nova, 2005).

Archaeopteris spores Givetian-Frasnian palynospectra gradually become dominating group. In the top part of Timan horizon (Zone *Densosporites sorokinii*) appear spores of lycopsids which later in Late Frasnian form the second dominating group. The point of occurrence of these spores can be considered as the phytostratigraphic boundary corresponding to a level of Givetian-Frasnian boundary.

From the same deposits (Kuz'min, 1995) the conodont complexes was described. They can be related to Lower *asymmetricus* zone on prevalence of *Polygnatus lanei* species. Species *Ancyrodella rotundiloba*, *A. binodosa*, *A. soluta*, *A. rugosa* and *A. alata* are established in conodont complex above on a section (Ust'yarega sute). That specify on correlation of this part of a section with the top part of Lower *asymmetricus* zone. The share of "lycopsids" miospores increases up to 24 % in palynocomplexes from these deposits. The palynocomlex is of the Sargaev age and it is related to local *Cristatisporites deliqucsens* palynozone.

Thus the border of average and top Devonian in the Timan-Pechora province should be drawn in the top part of Timan horizon. This boundary is close to the international standard of Givetian-Frasnian border (Sandberg et al., 1989).

The analysis faunistic and microfloristic fossils from Middle-Upper Devonian deposits in the most full sections of the Timan-Pechora province testifies to synchronism of changes sea and continental biotas. Synchronous development of so different communities could be caused only significant changes in abiotic component and reflects the unidirectional character of biota development. The carried out analysis confirms conclusions of V.V.Menner (1962, 1973, 1982) about fast evolution of flora. It is possible to speak, at last, about comparability of rates of development in vegetative and animal communities.

The analysis of miospores distribution in palynocomplexes from boundary deposits testifies to absence of spasmodic character of change of flora and about continuity of evolutionary development in phylogenetic groups of Devonian plants.

The offered chart is based on a principle of palynozone allocation on the first occurrence of species.

Morphological variability of the acritarch genus *Eliasum* Fombella 1977

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Genus *Eliasum* Fombella 1977 (type species *Eliasum llaniscum* Fombella 1977) includes eight species ranging from the early Cambrian to early Silurian (Fensome et al., 1990). One to three species of *Eliasum* have been usually determined in several tens of papers dealing with Cambrian and Ordovician acritarch assemblages from Europe (Spain, Britain, Ireland, Czech Republic, Poland, Lithuania, Norway, Sweden, Russia), Africa (Morocco), Asia (Jordan, Turkey), Newfoundland and North America (Canada). However, evaluation of morphological variability within separate populations was never published.

Four species of *Eliasum* have been cited from Cambrian and Ordovician sediments of Czech Republic (Barrandian area):

Eliasum llaniscum Fombella 1977 has been documented from Middle Cambrian Jince Formation of the Skryje-Týřovice Basin and Příbram-Jince Basin as well as from the early Cambrian Paseky Shale of the second area (Steiner and Fatka, 1993). *Eliasum jennessii* Martin in Martin et Dean 1984 is known from Middle Cambrian of the Příbram-Jince Basin, while *Eliasum pisciforme* Fombella 1977 occurs in Middle Cambrian of both Příbram-Jince and Skryje-Týřovice basins. *Eliasum asturicum* Fombella 1977 and *E. llaniscum* were established in supposedly redeposited acritarch assemblage from the Kosov Formation of Hirnantian age (Upper Ordovician) by Vavrdová (1988).

Comparatively common occurrence combined with a good preservation of acritarchs in palynological samples from richly fossiliferous middle portion of the Jince Formation at Vinice Hill near Jince (stratotype section of the formation) provided a good chance for morphometrical analyse of several acritarch genera. More than 200 well preserved specimens were used for study of morphological variability of the genus *Eliasum*. Studied specimens come from eleven samples collected at a continual section in middle part the *Onymagnostus hybridus* Trilobite zone.

The following five parameters were evaluated:

1. central body length (CBL),

2. central body width (CBW),

3. number (N) and width of longitudinal thickenings (LTW) and

4. distance of longitudinal thickenings (DLTW).

Results:

1. Scatter diagrams of CBL against CBW show that the data of all samples are concentrated in one common cluster, with the exception of one distinctly smaller (longitudinally shorter) and two markedly larger (transversally wider) specimens in samples J-51 and J-5 respectively.

2. Very strong difference has been observed in number of longitudinal thickenings, whose

distribution is more or less regular in major part of the samples and ranges usually from three to five thickenings. Two thickenings were observed in abou 18 % of specimens comming mainly from lower portion of the section; five thickenings were ascertained in about 10 % of specimens in middle and higher levels of the section and six thickenings are known in two specimens only.

Very conspicous reduction of thickenings was uncovered in lithologically undistingushable sample J-50 where the two of the observed specimens bear three thickenings, 14 specimens display two thickenings and only one thickening was noted in two specimens.

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Organic microfossils from the Ordovician Öjlemyr Chert of Gotland, Sweden

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Ojlemyr cherts from the Isle of Gotland/Sweden are known for more than a century and have been stratigraphically determined as Upper Ordovician F1c and F2. These cherts are secondarily silicified limestone concretions which occur exclusively as glacial erratic boulders (Geschiebe). Apart from the Isle of Gotland Ojlemyr cherts have been discovered on the Isle of Sylt as well as in Niedersachsen, Germany. Regionally these cherts are weathered to a different degree and also vary concerning their faunal content, particularly with regard to presence or absence of organic microfossils. Based on these differences they have been described as Gotlandian, Braderup and Wielen type. Contrary to both Braderup and Wielen type, the Gotlandian type is completely unweathered and highly fossiliferans which can be observed already macroscopically. This chert type also contains organic microfossils of which the so-called melanosclerites have been focussed at.

Originally, this microfossil group was discovered by EISENACK in 1930. His material came from Ordovician and Silurian glacial erratics from the Baltic region. He introduced the term "Melanosclerite" to describe these problematic rod-shaped microfossils. EISENACK differentiated two groups of sclerites: the first group forms the skeleton proper, the second group represents the appendices of a skeleton. An appendix consists of two main parts, a long proximal part and the rod, ball or tine-shaped distal part. In well-preserved material the wall of the melanosclerite test is opaque and dark-brown colored. The surface of the wall is smooth. The size ranges between 60-2000µm. The sclerites can be found in marine sediments from Ordovician to Devonian age. The systematic position and natural relationship of the melanosclerites is still unknown. EISENACK 1942 first speculated upon their biological affinities and noted similarities with cnidarians. An algal origin was also assumed (GORKA 1971). DUNN (1959) suggested that melanosclerites might represent Thecamoeba. He noted that the pseudochitinous wall composition of melanosclerites resembles the shell composition of the Recent thecamoebid *Gromia oviformis* rather than true chitin. CASHMAN (1992) found similarities in shape and size between the modern cubomedusa *Carybdea alata* and the melanosclerite *Melanostylus coronifer*.

There have been two attempts to classify melanosclerites. One involves the suprageneric subdivisions first introduced by EISENACK (1942) and subsequently developed by himself (1950, 1963). This classification was adopted and improved by SCHALLREUTER (1981) who introduced new taxa on the family as well as on the generic and species level.

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Exine ultrastructure of some Givetian megaspores

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The focus of this investigation was to analyze, by means of TEM, the ultrastructure of some Middle Devonian megaspores that were described previously from Western Pomerania (NW Poland) by Fuglewicz & Prejbisz (1981).

Megaspores that are conventionally ascribed to either *Biharisporite*s or *Contagisporites* are known from megasporangia of *Archaeopteris*, with ultrastructural information available for several species. Our dispersed specimens of these genera are similar to each other and to the archaeopteridalean ultrastructural type in having a two-layered sporoderm with the outer lacunate layer and inner homogeneous layer. The proximal side of the sporoderm, in contrast to the distal one, is constituted of smaller sporopollenin units, and smaller lacunae. The outer layer of the distal wall is divisible into regions characterized by presence of larger or smaller lacunae. In *Biharisporites*, the region with larger lacunae is situated in the middle of the outer layer, and in *Contagisporites* such lacunae are situated within the inner region (of the outer layer). The inner layer of *Biharisporites* is slightly electron denser than the outer layer and easily detachable from it. At the upper region of the inner layer, there is a peculiar band of extremely small perforations, which are circular and of uniform size (about 0.015--0.02 mkm). In the region of the proximal scar, over the suture, the inner layer becomes thicker at the expense of the outer layer. Several narrow lacunae are visible in the inner layer in this region.

The difference between the dispersed *Biharisporites* and *Contagisporites* on one hand, and *in situ* archaeopteridalean megaspores on the other concerns the structure of the inner layer. It is homogenous in our material but in archaeopteridalean megaspores it is usually described as lamellate or, at least, showing locally certain lamellation. Additionally, the band of minute perforations (*Biharisporites*) has never been reported in megaspores of this affinity. Nevertheless, the sporoderm ultrastructure of the megaspores under discussion fits quite closely that of archaeopteridalean megaspores.

All four spores of the seed-megaspore tetrad of *Granditetraspora zharkovae* have a similar two-layered sporoderm with a thick lacunate outer layer and a homogeneous, often folded inner layer. The lacunae of the outer layer are small, numerous, and distributed throughout the layer, except of some homogenized lines. Distally, the outer layer presents an almost solid mass of perforated sporopollenin. The "stalk" is filled with nearly homogeneous sporopollenin mass in its axis and is margined with several bands that correspond to the meshes of the superficial net that covers this structure. *Granditetraspora zharkovae* is surprisingly different in the sporoderm ultrastructure from other Devonian seed megaspores (*Spermasporites allenii* and *S. devonicus*) and, by contrast, has much in common with the archaeopteridalean type.

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Upper Ordovician GSSP's and the British Historical Type Area: a Chitinozoan Point of View

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Recent developments in chronostratigraphic procedure and new biostratigraphical insights necessitated the ongoing revision of the Ordovician System's chronostratigraphy. A new global subdivision of the Ordovician is being established by the ICS, at the expense of the British chronostratigraphical framework, which has long been used as an informal 'global' standard. The first of this project's main objectives consisted of the study of the chitinozoan assemblages in the newly proposed, or already ratified Global Stratotype Sections and Points (GSSP's) for the Upper Ordovician Series. Chitinozoan abundances and preservation permitting, a biozonation was established and a proxy selected for each of the investigated boundary levels.

During the second phase of the project, these new Upper Ordovician GSSP's are compared to the historical type areas of the British equivalent Caradoc and Ashgill Series, from a chitinozoan perspective. Concomitantly, the first Upper Ordovician chitinozoan biozonation for British Avalonia is established. The historical Caradoc and Ashgill type sections in the Anglo-Welsh Basin yield an important chitinozoan fauna; these data are supplemented with information from other British key sections which are famous for their accurate graptolite control. As a result, the established chitinozoan biozonation for British Avalonia is nicely tied to both the British chronostratigraphical framework and the graptolite biostratigraphy. It consists of fourteen chitinozoan biozones and subzones and is of importance as Avalonia lacks a formal biozonal scheme for the Ordovician, in contrast with the well-established biozonations in the other prominent palaeocontinents of that period in time. Interestingly, the newly drawn British biozonation scheme has a predominantly Baltoscandic signature, which fits Avalonia's migrating position during the Ordovician. Highlights include:

- The chitinozoans of the Caradoc type area are re-organised into biozones which are more readily applicable than those erected by Jenkins (1967).

- The Baltoscandic *Fungochitina spinifera* Biozone brackets the base of the Ashgill Series in its type area. The base of the Ashgill therefore corresponds to a level in the Baltoscandic upper Oandu or in the Rakavere Stage; previously the base of the Ashgill was thought to fall in the overlying Vormsi Stage.

- Application of chitinozoan correlations places levels with graptolites of the *Dicellograptus morrisi* subzone (*Dicranograptus clingani* Biozone) in the Onnian and Pusgillian. Subsequently, the level of the *Pleurograptus linearis* Biozone is moved into the Cautleyan or even higher. The suggested changes result in a much better agreement with the revised graptolite biozonation of the Cautley district (Rickards, 2002) than with the previously existing ones for the area.

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New chitinozoans from the *P. linearis* graptolite biozone in Baltoscandia and Avalonia

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Rickards (2002; 2004) has recently suggested that the *P. linearis* Graptolite Biozone is of Rawtheyan age in the historical type area of the Ashgill Series (Cautley district, Cumbria, Northern England), implying that this biozone is younger than previously believed. Subsequently, Vandenbroucke *et al*. (2005) studied the rich and diverse chitinozoan assemblages from the same area and recognised several, both new as well as previously defined biozones, from bottom to top: the *Fungochitina spinifera*, *Tanuchitina bergstroemi*?, *Conochitina rugata* (three Baltoscandian biozones), *Spinachitina fossensis*, *Bursachitina umbilicata* (two Avalonian biozones), *Ancyrochitina merga* (a Northern Gondwana biozone) and the

Belonechitina postrobusta Zone (a global lower Silurian biozone). All biozones are well correlated with the graptolite (Rickards, 2002; 2004) and shelly fauna (Ingham, 1966) biozones described from the region.

However, the above dating of the *P. linearis* Graptolite Biozone is in contradiction with its age assignment in (a.o.) the classic Girvan area (Scotland), where it straddles the Caradoc-Ashgill (= Sandbyan/Katyan) boundary, as indicated by shelly fauna data. Unpublished chitinozoan data from these levels are in good agreement with chitinozoans from the Laurentian *C. pygmaeus* Graptolite Biozone, which correlates with the *P. linearis* Graptolite Biozone.

It is our intention to map graptolite-chitinozoan relations in several sections through the discussed interval, in order to contribute to the solution of the existing correlation problem. As the chitinozoan biozonation in the Cautley district has a mainly Baltoscandian signature (together with some Avalonian elements), a Baltoscandic section rich in graptolites was sought to study for chitinozoans, and to compare the graptolite-chitinozoan relations on both palaeocontinents. Such a section is found on the Bornholm Island, Denmark, where the upper main part of the Dicellograptus Shale represents the *D. clingani* and *P. linearis* zones, whereas the overlying Lindegård Mudstone contains graptolites indicative of the *D. complanatus* Zone (Bjerreskov and Stouge, 1985). The *P. linearis* Biozone interval of the Vasagård section yields a rich and diverse chitinozoan fauna, of which the first results are shown on the poster. An inter-palaeocontinental range comparison of key chitinozoan species such as *Lagenochitina baltica*, *Lagenochitina prussica*, *Angochitina communis* and *Tanuchitina bergstroemi* is presented and discussed.

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Chitinozoan biozonation and correlation of the Middle Ordovician to Llandovery succession of the Condroz Inlier (Belgium): implications for the evolution of the Condroz-Brabant Basin

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Chitinozoan studies on more than 250 samples resulted in a revised stratigraphical scheme and a biozonation for the Condroz Inlier (Belgium), contributing to the establishment of a chitinozoan biozonation for Avalonia. The obtained biozonation allowed a more detailed correlation of the Middle Ordovician to Llandovery succession of the Condroz Inlier with that of the Brabant Massif, from which a basin evolution from the Middle Ordovician to the Llandovery is inferred.

The Middle Ordovician of the Condroz Inlier succession starts with the black shales of the early Llanvirn Huy Formation, in which the *formosa* Biozone was found. Overlying are the strongly burrowed sediments of the newly defined Chevreuils Formation, for which the chitinozoans indicate a late Llanvirn to early Caradoc age. The Aurelucian to lower Onnian (lower to upper Caradoc) Vitrival-Bruyère Formation, correlated with the *stentor*, *cervicornis* and *spinifera* biozones, consists of siltstones with sometimes thick intercalated sandstone beds. The Sart-Bernard Formation is shown to be part of the Vitrival-Bruyère Formation. The calcareous siltstones and mottled mudstones of the Fosses Formation (Pusgillian – Rawtheyan), contain the *spinifera*, *bergstroemi*, *rugata*, *fossensis* and *umbilicata* biozones. Both members of the Fosses Formation display a strong diachrony, showing a deeper basin from west to east. Therefore, ?Hirnantian sandstones from the newly defined Tihange Member (Fosses Formation) and the Rhuddanian dark grey shales of the newly introduced Bonne-Espérance Formation only occur in the east. The siltstones of the Aeronian Génicot Formation, locally containing conglomeratic levels in the western Puagne Inlier, overlie these. The green-(grey) and red shales of the Dave Formation are restricted to the upper

Aeronian to Telychian. The green-grey shales of the Criptia Group in the western Puagne Inlier are tentatively correlated with this unit.

Correlation with the Brabant Basin. The lower Llanvirn Huy Formation correlates with a part of the dark grey shales of the Rigenée Formation; the upper part of the latter might correlate with the Tier d'Olne Formation of the eastern Condroz Inlier, implying a Burrellian age for it. The turbiditic sediments of the Ittre and Bornival and the slope to basin deposits of the Hospice de Rebecq formations correlate with the Burrellian - ?Actonian part of the Vitrival-Bruyère Formation. The upper shoreface deposits of the Onnian Huet Formation correspond to a stratigraphic hiatus between the Vitrival-Bruyère and the Fosses formations in the Condroz Inlier. The overlying ?outer neritic deposits of the Madot Formation record a sea-level rise, which in the Condroz Inlier corresponds to the Pusgillian to Rawtheyan interval of the Fosses Formation. In the Hirnantian, a distal turbiditic facies only occurs in the Harelbeke unit, and the equivalent in the Condroz Inlier may be the sandstones of the Tihange Member. The overlying Deerlijk and Lust formations still contain distal turbidites and are correlated with the Bonne-Espérance, Génicot and Dave formations of the Condroz Inlier.

From the upper Llanvirn on, a differentiation between the Condroz (shelf) and Brabant (deep shelf to basinal) deposits hence becomes clear. Sea-level changes consequently are more expressed in the Condroz Inlier than the Brabant Massif. These findings are in agreement with the position of the Condroz Inlier closer to the craton with respect to the Brabant Massif in Ordovician-Silurian times.

Palynomorphs from the Uhřice - 1 borehole, Middle Devonian of the Czech Republic

Vavrdová M.

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Despite numerous radiometric, petrological, mineralogical and geophysical studies, palynological analysis still appear to be a sole mean to distinguish the Early Cambrian and the Devonian clastics covering igneous and metamorphic rocks of the Precambrian Brunovistulicum. Palynomorphs contribute to elucidation of terranes assembled within the Trans-European Suture Zone. Clastic sediments from the Uhřice - 1 borehole in southern Moravia yielded dispersed miospores of ferns, sphenopsids and lycopsids (37 species) and rare marine microplankton. Genera *Acinosporites*, *Apiculiretusispora* and *Retusotriletes* dominate in the assemblage. Recovered microfossils indicate continental environment with limited marine influence such as coastal tidally influenced marshes and deltaic swamps. Miospores with prominent irregular verrucate scupture such as *Verrucosisporites flexuosus, V. premnus* and *V. scurrus* suggest the Middle Devonian, most probably early Givetian age. A composition of palynospectrum reflects a presumed Middle Devonian homogeneity of miospore assemblages from paleo-tropical to paleo-subpolar regions. Close connection can be noted with miospores from the Orcadian Basin, Scotland. Cell wall of the organic-walled microfossils is more affected by the irreversible colour changes than Early Cambrian microfossils from the neighbouring boreholes in southern Moravia.

A case study using spore biochemistry as a proxy for past UV-B levels: the rise and fall of atmospheric oxygen during the Carboniferous-Permian

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Recently reported experiments demonstrate that angiosperms increase their investment in pollen exine UV-B screening pigments when exposed to elevated levels of UV-B radiation. We have confirmed that a similar response occurs in extant homosporous (*Lycopodium*) and heterosporous (*Selaginella*) lycopsids, based on experiments in the Abisko research station in arctic Sweden. The experiments utilize *Lycopodium* and *Selaginella* grown in outdoor plots subjected to either background or enhanced UV-B radiation. Furthermore, we have analysed levels of exospore UV-B screening pigments in historical records of

Lycopodium spores from herbaria collections of plants from Ecuador and South Georgia. The spores from Ecuador have been exposed to constant UV-B radiation levels and show no change in pigment levels. The spores from South Georgia have been exposed to a progressive increase in UV-B radiation (related to thinning of the stratospheric ozone layer) and clearly exhibit an increase in pigment levels. Our data records a strong three fold linear increase in the concentration of UV-B protecting pigments in response to a 14% thinning of the ozone column. This newly identified response offers a potential tool for investigating natural changes in UV-B flux over geological time (potentially related to changes in atmospheric oxygen levels and concomitant changes in the thickness of the stratospheric ozone layer). In order to test if spore wall biochemistry can be utilized as a proxy for past UV-B levels we have analysed fossil lycopsid spores from throughout the Carboniferous-Permian interval. This interval is of interest because it is considered to have witnessed a huge rise and subsequent fall in atmospheric oxygen levels, that presumably affected thickness of the stratospheric ozone layer, and thus UV-B radiation levels.

Late Silurian to Earliest Devonian organic-walled phytoplankton biodiversity changes

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Environmental factors including light, temperature, salinity, nutrients, water depth, circulation patterns, and latitude contribute to the distribution, abundance, and diversity of present-day marine phytoplankton. These same factors are most likely to have also affected the Palaeozoic marine phytoplankton, which was dominated by organic-walled acritarchs and prasinophytes.

The late Silurian (Ludlow and Přídolí) through the earliest Devonian (early Lochkovian) was a time, not only of major compositional change in the marine organic-walled phytoplankton, but also important changes in the palaeogeography, palaeooceanography, and geochemistry of the world as well. Innovative morphologies appeared in high latitude assemblages during the late Silurian, although overall diversity decreased elsewhere, and marine transgressions along the margin of Gondwana apparently led to the emergence of new taxa during the early Devonian.

Observed changes in biodiversity during the nine-million year period of the Ludlow through earliest Lochkovian were based on organic-walled microphytoplankton data derived from published and unpublished stratigraphic sections where independent age control was firmly established. Regional biodiversity changes for the organic-walled microphytoplankton were then determined for low latitude warm water areas (Avalonia, Baltica, and Laurentia) and the middle to higher latitude temperate to cool water regions of northern Gondwana.

The late Silurian-earliest Devonian organic-walled phytoplankton was divided into three major categories to facilitate comparison between geographical areas and to determine compositional changes. The three categories are: marine chlorophytes and prasinophytes, marine acritarchs, and nonmarine types, including coenobial forms. This tripartite grouping is based on overall morphology, and within each category is detailed enough to mark critical changes in the paleoenvironment as well as the phytoplankton assemblage.

The only meaningful data for the late Silurian of Laurentia indicates a phytoplankton assemblage dominated by prasinophytes similar in composition to that reported from Podolia. This is followed by an initial radiation of new taxa as indicated by the diverse assemblage of acritarchs and prasinophytes present in the Lochkovian Haragan Formation of Oklahoma, U.S.A. The highest phytoplankton diversity in the Welsh Basin of Wales and the Welsh Borderland, a part of Avalonia, occurred during the late Homerian to early Gorstian and late Gorstian, with a decline in diversity in the Ludfordian. Data from Gotland, Sweden, mirrors that from the Welsh area. In Podolia, phytoplankton diversity declined during the Wenlock and Ludlow. The significantly lower values in the late Ludfordian, however, may be reflective of very shallow marine conditions.

Data from northwest Libya and northern Spain along the northern Gondwanan margin, indicate phytoplankton diversity increased from the Gorstian to the late Ludfordian and early Přídolí, and then declined in the late Přídolí. A significant new diversification began in the early Lochkovian, coincident with that in North America, resulting in a noticeable reduction in phytoplankton provincialism.

An Upper Devonian palynomorph assemblage from Bolivia

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A well-preserved and diverse assemblage of palynomorphs was recovered from a river section and nearby roadside outcrop at Bermejo, Santa Cruz Province, Bolivia, approximately 80 km southwest of Santa Cruz. Six productive samples were taken from sandstones and shales assigned to the uppermost few metres of the Upper Devonian Iquiri Formation. Eighteen productive samples were recovered from the lower 17 m of the overlying diamictites. This approximately 38 m thick unit constitutes the Itacua Formation, which has been described in the past as “Early Carboniferous” and as “Devono-Carboniferous” in age. Regionally, the Itacua Formation unconformably overlies the Iquiri Formation, but in the Bermejo section, the contact is sheared. Spot samples from basal sandstones of the Tupambi Formation, which overlies the Itacua Formation, all proved barren.

The assemblage is dominated by acritarchs and prasinophytes, all of which show the same degree of thermal maturity and are typically well preserved. The miospore assemblage is less diverse than the acritarchs and prasinophytes, but is equally well preserved. The miospore assemblage includes stratigraphically restricted taxa such as *Retispora lepidophyta*, *Rugospora famenensis* and *Vallatisporites pusillites*, all of which are definitive of a latest Devonian (late Famennian) age. Reworked earlier Devonian taxa are also present, together with long-ranging forms. The acritarch and prasinophyte assemblage is very diverse and consists of the following characteristic Middle and Upper Devonian species: *Duvernaysphaera angelae*, *D. radiata*, *Evittia someri*, *Exochoderma irregulare*, *Horologinella horologia*, *Maranhites mosesii*, *M. brasiliensis*, *Pterospermella pernambucensis*, *Umbellasphaeridium deflandrei*, *U. saharicum*, and *Veryhachium trispinosum*. Other taxa recovered include *Ammonidium* sp., *Cymatiosphaera* sp., *Dictyotidum* sp., *Gorgonisphaeridium* sp., *Hapsidopalla* sp., *Leiosphaeridia* sp., *Lophosphaeridium* sp., *Micrhystridium* sp., and *Veryhachium* sp. The taxa recovered are consistent with a Late Devonian age, although none are restricted to the latest Devonian.

Although the Itacua Formation has been reported as “Early Carboniferous” and “Devono-Carboniferous,” there are no definitive Carboniferous miospore or marine phytoplankton species present in the preserved assemblage. Based on the spore and acritarch/prasinophyte taxa recorded, the oldest that this section could be is latest Famennian. However, total reworking of Devonian palynomorphs into barren Carboniferous sediments cannot be totally ruled out as a possible, if somewhat unlikely, scenario. Based on the miospore/acritarch ratio, the low abundance of phytoclasts, and the composition of the acritarch assemblage, these sediments are interpreted as having been deposited in an offshore, shelf environment.

Electron-microscopical studies for Permian palynology

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The aim of this talk is to show why broader application of electron-microscopical studies of fossil exines is important for Paleozoic palynology (using the example of Permian pollen). SEM and TEM not only allow one to observe minute morphological characteristics of the exine, indiscernible in transmitted light, but also to differentiate between surface and inner elements of the exine. The consecutive application of LM, SEM, and TEM to one and the same specimen (that is particularly pertinent dealing with dispersed material, because similar palynotypes, which may occur even in the same assemblage, might have been produced by evolutionary distant plant groups) provides complete information about each specimen and prevents merging the morphological characteristics of different plant groups.

A list of Permian pollen genera has been studied in terms of their exine ultrastructure. For example, ultrastructural characteristics made it possible to differentiate between the Permian and Triassic members of *Cordaitina* Samoilovich, 1953 and to show that the latest members of this dispersed genus most probably were produced by a different plant group than its Permian members. The functionality of the trilete scar was supposed. An intermediate type between protosaccus and eusaccus was revealed (Zavialova et al., 2001, 2004).

Electron-microscopical data provide better substantiation to the morphological basis on which conclusions of palynologists are based, concerning the affinity of parent plants of dispersed pollen and spores, plant evolution, and distribution of plant groups on different continents. The last problem is especially topical for the Permian, which is characterized, on the one hand, by high degree of provincialism, and, on the other, by the striking similarity between pollen morphotypes occurring in different continents. Meyen (1987) believed that ultrastructural data would clarify the apparent similarity between several Gondwana and Angaraland palynotypes. Recently, the exine ultrastructure of *Plicatipollenites* Lele, 1964 from the Permian of Oman was studied (Zavialova and Stephenson, 2006). The comparison with its Angaraland analogue *Cordaitina*, surprisingly show much more similarities between these dispersed genera that we have been expecting keeping in mind their distant occurrence and most probable different origin as well as the high variability earlier revealed within *Cordaitina*. The comparative analysis of other genera would be extremely interesting.

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***Goldenbergites* gen. nov. a new genus of herbaceous lycophytes and its spores from the Radnice Member (Bolsovian) of the Radnice Basin (Czech Republic)**

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Three shoots of herbaceous lycophytes from the Radnice Member (Bolsovian) of the Radnice Basin were studied, together with their insitu spores. These fossils are preserved as compressions in whitish tuff lying at the base of the Whetstone volcanic horizon directly overlying the Lower radnice Coal and comes from Ovčín (Pokrok), opencast Mine, near Radnice. The sterile laafy shoot appear to be isophyllous with their leaves configurational to four rowes on the shot bearing strobile are leaves relatively closelly adpressed to the axis. Serrated monosporangite sporophylls create narrow apical strobiles. Each sporophyl bores one big cordate sporngium. Simple sporophylls are arranged in alternating verticils, two per whorl. The strobiles yelded megaspores closely comparable with dispersed species *Bentzisporites tricollinus*. Simillar specimens were described and figured by Goldenberg (1855) as *Lycopodites elongatus* and transfered to *Sellaginellites* by Halle(1907). Megaspores isolated from *Sellaginellites elongatus* by Haslle (1907) and Sen (1958) are closelly comparable with dispersed species *Bentzisporites bentzii*. Cingulate megaspores of the genus *Bentzisporites* are different from zonate megaspores of the genus *Triangulatisporites* isolated from carboniferous herbaceous lycophytes of the genus *Selaginella*. A new genus *Goldenbergites* gen. nov. is proposed, most especially on the bases of the presence different megaspores. Two species consist genus *Goldenbergites* gen. nov. in present: *Goldenbergites elongatus* and *Goldenbergites serratus sp. n.*

References:

Goldenberg, H. R., 1855: Flore Saraepontana fossils. *Die Flora der Vorwel.* Saarbrücken. 1: 1-38.

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Palaeogeography and palaeoclimatology as main controlling factors for the Ordovician chitinozoan diversification

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Chitinozoans originated in the early Tremadocian and disappeared in the latest Devonian. These enigmatic tiny organic-walled vesicles are recorded in marine sediments ranging from nearshore to deep oceanic environments. They were an important component of the Ordovician palaeoplankton. They are generally interpreted as reproduction stages of cryptic, soft-bodied "chitinozoan" animals.

The chitinozoan group diversified progressively from the Tremadocian to the late Darriwilian, when it reached its acme in Baltica and northern Gondwana. At that time, a first peak of diversity is registered in Laurentia and the global chitinozoan diversity represented approximately the sum of the regional diversities. This is consistent with the important endemism documented for the Early and Mid Ordovician chitinozoans. The limited faunal exchanges in the group were partly due to the scattering of the main palaeoplates and to green house conditions that favoured sluggish oceanic circulation.

From the early Late Ordovician onward, the biodiversification slowed down progressively in Baltica and northern Gondwana while in Laurentia, after a marked decrease during the Sandbian, the diversification continued to develop, reaching its maximum in the early Katian. The global chitinozoan diversity followed the same pattern with the magnitude of the late Katian peak comparable to the Darriwilian one. This Katian global diversity, however, was not much higher than the Laurentian one, suggesting important faunal exchanges. During Late Ordovician, a major paleogeographic reorganisation of the southern hemisphere resulted from northward drift of Avalonia, its docking to Baltica, and the concomitant widening of the Rheic Ocean. In the meantime important tectonic events (Taconic orogeny) related to the closing of the Iapetus Ocean developed along the Laurentian margin. All these geotectonic events induced global changes in climate, sea level, seawater composition, nutrient input, and oceanic circulation. These changes deeply influenced the chitinozoans through a lowering of their previous endemism and an inversion of their biodiversification trend in Baltica and Gondwana. In Laurentia, however, as the result of the Taconic orogeny and modifications of the oceanic circulation patterns, a diversity decrease is observed in the early Late Ordovician followed by a diversity increase attributed to the development of turbid nutrient rich waters.

Globally an important decrease in chitinozoan diversity is observed in Late Ordovician. It started in early Sandbian in northern Gondwana and Baltica and in middle Katian in Laurentia. This trend seems concomitant with the onset of an icehouse environment culminating with the Hirnantian glaciation. The triggering factors of this icehouse episode are not fully understood, but they could be linked to the major paleogeographic and paleoceanologic changes of the Late Ordovician. Temporary and periodic global perturbations of the carbon cycle are also documented during this period.

The dramatic fall of the chitinozoan diversity during the Hirnantian resulted from a combination of climatic and environmental changes on populations already weakened. However, as for other fossil groups the chitinozoan extinction event was not selective. Only a few genera really disappeared just before the top of the Ordovician and the chitinozoan assemblages recorded during the Silurian recovery exhibited the same morphologic features and the same ecology as their pre-Hirnantian predecessors.

This is a contribution to IGCP n° 503.

CIMP General Meeting minutes

Mike Stephenson

Date of meeting 5-10-06, Time 1500hrs

Treasurer's presentation

P. Steemans (Treasurer) presented the financial accounts for CIMP (reproduced at the back of this Newsletter).

The treasurer made the following points:

A google spreadsheet showing the details of each CIMP member including their membership and payment status is at http://spreadsheets.google.com/pub?key=pPFD_Y0BN_lB_fzVxd-kYSg&output=html&gid=0&single=true

If you would like to access your information you can obtain a password from P. Steemans at p.steemans@ulg.ac.be

There will be a general amnesty for members that have not paid up until 2006, but after this year (2006) all members are expected to pay the correct amount (Euros 10 or $10) per annum. Students and retired professionals have free membership.

P. Steemans said that not enough people pay their subscriptions at present. He also asked that council members and officials of CIMP should pay their fees more often.

M. Stephenson (Secretary) said that without a guaranteed and predictable income it is difficult to commit to an annual spend. A few members however countered by saying that members don't feel that CIMP spends any money and that the level of subscription payment would be improved if CIMP were to be seen to be spending some money. M. Stephenson agreed that two 'grants –in-aid' might be offered to deserving CIMP members to help them attend the International Palynological Congress in Bonn in 2008. P. Steemans agreed that there are funds to allow modest support. It was also suggested that additional funds might be sought from industrial sources.

Some members mentioned that it is sometimes difficult to organise payment of subscriptions and that the cost of bank transfers is too high. Methods of alternative payment e.g. the Paypal system (https://www.paypal.com/) were discussed. The Secretary and Treasurer agreed to look into the use of Paypal for CIMP subscription.

Newsletter

The Newsletter Editor (M. Stephenson) said that very few people send articles for inclusion in the biannual CIMP Newsletter. G. Clayton suggested that one Newsletter could be produced per year instead of two. Another member said that perhaps there should not be Subcommission Newsletters. M. Stephenson said (1) there was a danger that CIMP might become rather moribund if there were only one Newsletter per year, and (2) that the purpose of the biannual CIMP Newsletter is primarily to discuss non-specialist topics of interest to all Palaeozoic palynologists and thus is more general than the Subcommission Newsletters.

Subcommission reports

Reports were given by the respective Secretaries. New personnel were voted into office (see next section).

Publications for Prague CIMP papers

Oldřich Fatka said that papers could be published in the Czech Bulletin of Geoscience (http://nts1.cgu.cz/bulletin/contents/2006/vol81no1). Colour plates would be possible but papers would be restricted to 12 printed pages and 4 diagram pages. For more details fatka@natur.cuni.cz.

CIMP role in curating type specimens

M. Stephenson mentioned that some of the most important holotypes and paratypes (particularly in Carboniferous and Permian palynology) are either lost or not curated professionally. Similarly specimens that are exemplars of key informal species in industrial contexts are sometimes not curated at all. He asked if CIMP could have a role in storing or arranging for the storage of important type specimens. He mentioned such initiatives as Taxonomy Online at the British Geological Survey (http://www.bgs.ac.uk/taxonomy/spores/home.html.) and PalyWeb (http://www.palyweb.ulg.ac.be/wiki/index.php?title=Main_Page) and suggested that 'virtual museums' may be a solution.

New President of CIMP

The election of a new President was discussed. Alternatives were presented: (1) an immediate vote in the chamber, or (2) a vote by email. A vote was carried out to decide which option was best. An email vote was decided upon. The result of the vote is given in a later section.

Future CIMP activities

It was agreed the the CIMP IFPS councillors would enquire about CIMP representation at the IPC in Bonn 2008.

It was suggested that proposals be made to the Secretary regarding the venue for the next CIMP Conference. See later section.

Election of President of CIMP

I am sorry that it has taken so long to reply over the election of our new President, but I was overseas much of the time after September 2006. However I am pleased to say that the election went smoothly and the results for the two candidates were:

John Marshall - 31 votes

Jacques Verniers - 23 votes

Thus John Marshall is elected President of CIMP! Congratulations John!

New subcommission positions in CIMP

Spore-Pollen Subcommission

Secretary and Newsletter Editor: Marco Vecoli., who replaces Duncan McLean

President: Zelia Pereira, who replaces Ken Higgs

Acritarch Subcommission

Secretary and Newsletter Editor: Catherine Duggan who replaces Marco Vecoli.

President: Reed Wicander was re-elected.

Chitinozoan Subcommission

Secretary and Newsletter Editor: Thijs Vandenbrouke who replaces Gary Mullins

President: Ken Dorning was re-elected..

Next CIMP Conference: Cracow 2010?

Monika Masiak (mmasiak@twarda.pan.pl) and colleagues have volunteered to host the CIMP 2010 conference in Cracow, Poland, including a fieldtrip to the Holy Cross Mountains.

Gallery of Prague photos

Left to right: Issam Al-Barram, PhD student at Sheffield, Charles Wellman, Bader Ali Al Belushi, palynologist at Petroleum Development Oman

Reading through abstracts before the talk begins

Jiri Bek preparing to speak

The CIMP Gala dinner

Something amusing.

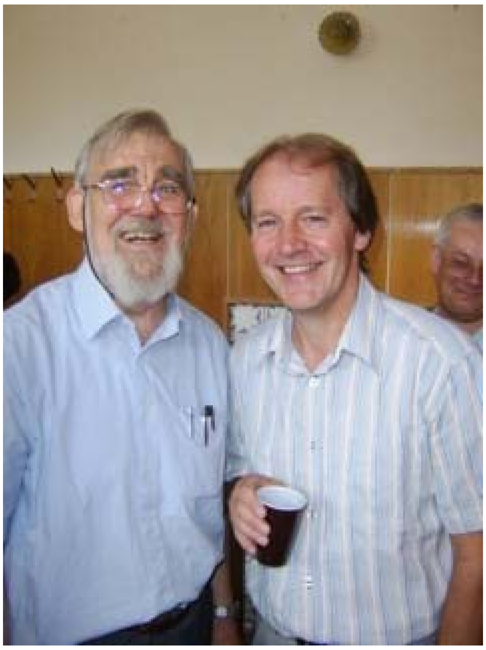
The PDO dinner

Randall Penney and Bader Ali Al Belushi at the PDO dinner

The CIMP Gala dinner

Deep discussion at the excellent lunches

Drinks at breaktimes



John Richardson and Ken Higgs

Natalia Zaviolova and Maria Tekleva

Post CIMP Field trip

Mike Stephenson

I attended the fieldtrip 'Lower Palaeozoic of the Barrandian area' which was a very nice short tour of the geology of an area to the west of Prague, as well as a superb introduction to some important GSSPs in the Barrandian area. The trip included visits to the Upper Ordovician of Levín and the Lower Silurian of Klučice. In addition we also visited the Silurian/Devonian GSSP at Budňany Rock , Karlštejn.

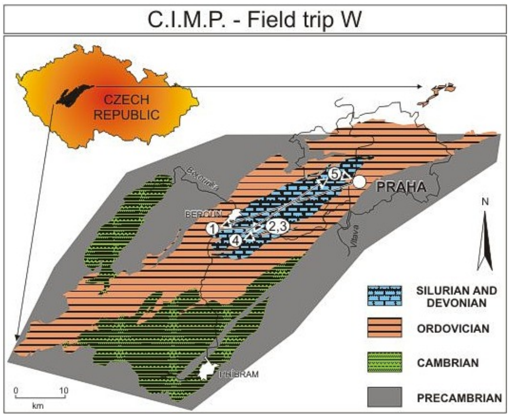


Fig. 1 the Barrandian area

Budňany Rock , Karlštejn

Also the beautiful section at the Silurian-Devonian GSSP at Klonk near Suchomasty was a fine stop in the sunshine, before setting off back to Prague.

Silurian-Devonian GSSP at Klonk

Finally the Ludlow/Přídolí GSSP at Požáry Quarry was a fascinating end to the trip.

Ludlow/Přídolí GSSP at Požáry Quarry

The stratigraphic positions of the localities visited are shown in Fig. 2.

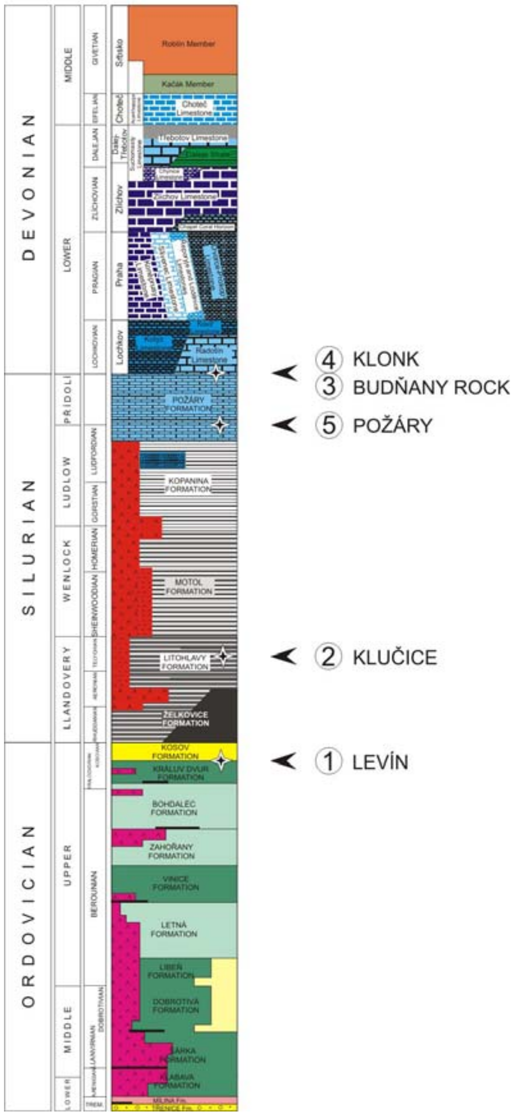


Fig. 2 Stratigraphic positions of the localities

Letter from Jiri Bek

Dear CIMP Members,

I should like to present some of my impressions and feelings concerning CIMP General Meeting Prague 2006 with a special attention to the closing CIMP Council.

First of all, thank you very much to all participants for their contributions, presentations and official and unofficial discussions. I hope, that the meeting 'upgraded' and enriched all of us.

Secondly, it was suprising, that so many of us do not pay their CIMP fee regularly. CIMP, as a member of IFPS, possesses two councillors (representatives of CIMP on the highest world-wide palynological level) because it has more than 200 members. I understand that CIMP pays only for 40-50 members (if I understood Phillipe Steemans correctly) although it has two councillors. It is not dangerous for today, because I am IFPS Secretary and Treasurer, but it may be a dangerous thing in the future. I am sure, that it is good that CIMP has two councillors on the highest palynological level because only a few other palynological societies possess two councillors (AASP, Russian palynologists, APLF and Chinese palynologists). It may be good, if it is a constant feature also for the future. So, please pay your fees. It will be good for all of us.

Thirdly, CIMP has a small chance to be active in some ways if people cannot rely on the finance of the organization. There are several ways how to spend or use fee money. For example, we could (1) support the best PhD students; (2) support selected projects (e.g. CIMP working groups); (3) support participations of students and people from not so rich countries ; (4) support selected senior palynologists on international meetings and conferences organised by CIMP ; or (5) support publications of CIMP members. But if there is no money of activities must be very limited.

If the situation continues, I think that the organizers of the next CIMP General Meeting will have to compromise the financial situation of the conference, like ourselves in Prague. It is not a real problem to organise a 'budget' conference. At such a conference nothing would be free, except the book of abstracts and you would have to pay for coffee or tea during cofee breaks, lunches, the opening ice breaker party. There would be no support for students or senior palynologists. The fee of such a conference could be very low, perhaps 20-30 Euros. But I think, nobody wants a 'budget' conference.

The second type would be the organisation of a "more comfortable" conference with support of several colleagues, free lunches, free opening party, bags with abstracts book, photos, pencils, notebooks and related things etc. The problem is that the fee for such a conference cannot be low without financial help. Organizers of Prague meeting were able to support EVERYBODY who asked for support within the published deadline. We even supported people who made application after the deadline, for example a few weeks before the meeting. The main problem was that the level of the fee did not correspond with our previous ideas. We had to fix the fee for 160 Euros due to all these factors. Maybe the level of the fee was not ideal for all, but we had no other chance because Palaeozoic palynology is not so attractive for sponsors. In fact I hoped that CIMP will be able to help us and will cover some costs. The best should be, if organizers will be able to manage all these things together with relatively low fee. If CIMP could help us, I think, that the fee might be less than 100 Euros including full service, supports of people etc. It is my suggestion for organizers of the next CIMP General Meeting.

I heard complaints that the two parallel sessions was not ideal, and that this was the first time, a CIMP conference has had two parallel sessions. In fact everybody who was at Lille in 2000 knows that two parallel sessions were organisied there as well. I think that there were only a few people who were interested in both sessions – marine microplankton and chitinozoans as well as spore and pollen session. Few people are working on Ordovician-Devonian microplankton and Devonian-Permian spores together.

In fact, if we had had one session there would have been two problems for the organizers. The first, you do not need another room but on the other hand you have to pay for longer time for all other previous rooms (you need one room for the session, one for cofee breaks and one for organisers, internet, registration etc). The second problem - the whole conference must be longer. In Prague only one session should mean not three days but almost five days. It represents additional costs for organizers (costs of all rooms) as well as for participants (hotels, table money) and additional time for all of us. We prefered two parallel sessions due to all these factors.

I am sure, that a good and predictable financial situation for CIMP will greatly help our next President – John Marshall or Jacques Vernier - with his effort to make CIMP a well organised and research organisation.

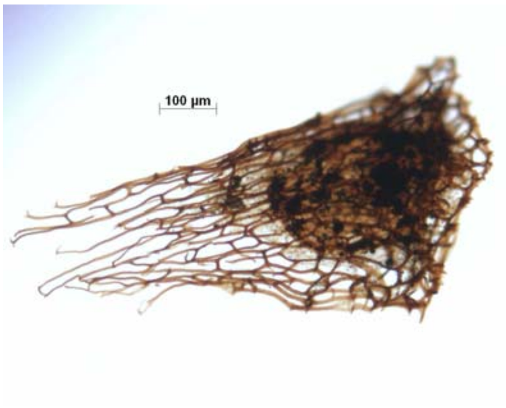
At the end of the General Meeting, I noticed, that nobody said thank you to our former President Florentin Paris - no applause and no thanks. This is not a good exit from the scene after four years. So, Florentin thank you very much for your service to CIMP!

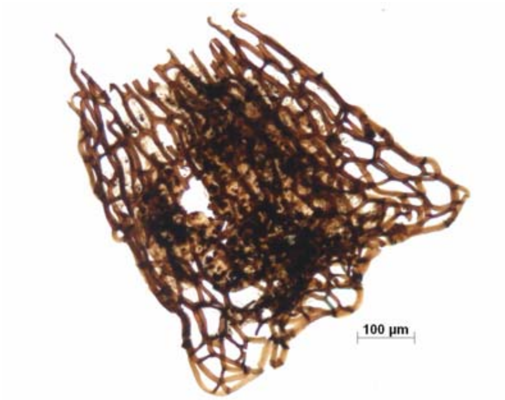
Jiří Bek, Laboratory of Palaeobiology and Palaeoecology, Institute of Geology, Academy of Science, Prague, Czech Republic

Enigmatic Givetian palynomorphs

P. Steemans (p.steemans@ulg.ac.be)

Have you seen anything like this (below)? Large enigmatic palynomorphs have been observed in Givetian samples from Libya





I have found nothing similar in the literature. They are associated with rare chitinozoans and acritarchs, and with numerous well preserved miospores and megaspores. There are also abundant cuticles and tracheids. Because of this, the palynofacies corresponds to a near shore environment with a strong continental input. The strange palynomorphs are composed of two distinct parts: a central body and a sheath in which it is enclosed (see above). The central body is spherical, or ovoid, with a diameter ranging from 260 to 450 µm. It is composed of an indistinct very thin pale brown membrane supported by a network of interweaved fibres. The external sheath has is vase-shaped and looks like a net closed at its largest part and open at its narrowest extremity. The general appearance is of a fisherman’s keepnet. The meshes are rounded at the largest extremity and strongly elongated at the opposite one. The mesh diameter size ranges from around 40 µm to 60 µm at the base and from around 16x90 µm to 20x160 µm at the top. The “threads” of the mesh are around 10 µm in diameter. Some specimens have spines on the mesh, 20 to 50 µm long and 10 µm large at their base. A very thin membrane, 5 to 20 µm high, runs all along the “threads” on their internal and external faces (figs 4-5). When spines are present, they subtended the membrane (fig. 6). In one case, two palynomorphs are brought together, one above the other one. Dimensions: Length: 564 (940) 1617 µm (lowest dimensions are underestimated as several specimens are broken). Base width: 401 (500) 603 µm. Top width: 186 (260) 341 µm (largest dimensions are probably overestimated as several specimens are broken).

As a reward for all suitable information, I will offer a good drink of your choice during the next CIMP meeting (If it is at Lisbon, then I suggest an excellent Port!).

Thank you in advance

Taxonomy online

Mike Stephenson

A new online searchable pictorial database of the 'Bernard Owens Collection' of single grain mount palynological slides, curated at the British Geological Survey (BGS), is at http://www.bgs.ac.uk/taxonomy/spores/home.html. This is part of the BGS ‘Taxonomy Online’ project.

Gallery of database

The aim of ‘Taxonomy Online’ is to use the internet as a forum to illustrate fossil specimens held in the collections of the BGS, and to outline their taxonomic and biostratigraphical importance. As such, these web-based publications supplement but do not replace traditional hardcopy palaeontological publications but allow easy access to illustrations of specimens, descriptions, and to information about stratigraphic distribution.

For convenience, data are presented as web-based packages so that amateur, student and professional palaeontologists will have easy access to the information. However, web sites do not have publication status and for this reason a formal publication is produced in .pdf format in the Research Report series of the British Geological Survey. They are available as a free download from the website. These reports have been assigned ISBN numbers and are deposited with the copyright libraries. It is to the Research Report that bibliographical reference should be made in formal taxonomic research.

The collection of single grain mount slides which is partly illustrated in the database, is one of the most important collections of single grain Late Palaeozoic palynomorphs in the world with over 145 taxa represented by many specimens (up to 25 specimens per taxon), showing a wide range of preservation and natural variation. The specimens were collected from localities worldwide but are most closely associated with the UK and north-west Europe. Many of the taxa illustrated and described are integral to the biozonation of the Carboniferous of north-west Europe published by Clayton et al. (1977) and to earlier regional biozonations of smaller stratigraphical intervals within the UK (Smith and Butterworth, 1967; Neves et al., 1972, 1973; Owens and Burgess, 1965; Owens et al., 1977).

Each single grain mount slide is associated with a unique BGS collections number prefixed with MPK. All slides are held in the BGS Palaeontology Collections at Keyworth, Nottingham. For information on the collection and on slide loans please contact Dr Mike Howe, Chief Curator, BGS, Keyworth, mhowe@bgs.ac.uk.

In short this initiative is an attempt to broaden access to BGS' collections and I hope, if you have time, you will look at the work and comment on it. We would like to include new information on the taxa illustrated in future versions of the database.

PalyWeb

Phil Steemans P.[1,2] & Pierre Breuer[1]

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[2] NFSR Research Associate

PalyWeb is a project of a web based free-content palynological databank in open access. Its conception is similar to the well known Wikipedia encyclopaedia. It is a wiki website type. This means that it is allowed to visitors of the site to very quickly and easily add, remove, or edit all content for rectification. This ease of interaction and operation makes such website an effective tool for collaborative scientific writing. PalyWeb is a databank filled collaboratively by volunteers, allowing most articles to be changed by anyone with access to a computer, web browser and Internet connection. However, users need to be logged to avoid external vandalism, and inconsistency. The PalyWeb site is housed on the web server of the University of Liège. A daily backup is carried out in order to safeguard all information in the event of system failure.

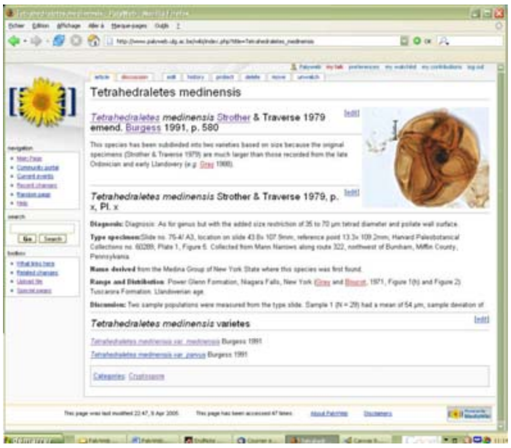

Fig. 1 Example of a PalyWeb page containing the description of the *Tetrahedraletes* genus. Blue words inside the descriptive text are links to other pages (bibliographic references or genus description pages).

Its internet address is:

http://www.palyweb.ulg.ac.be/wiki/index.php?title=Main_Page

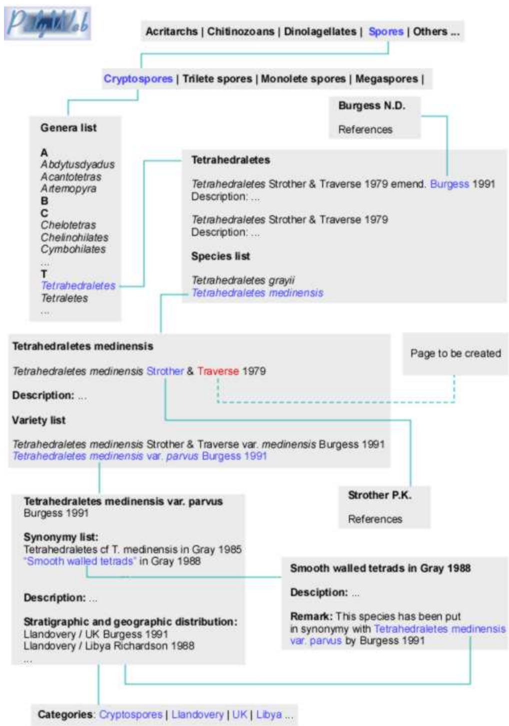

Fig. 2 General architecture of PalyWeb based on the example of the *Tetrahedraletes* cryptospore genus.

PalyWeb is destined to contain the description of a maximum of available palynomorph taxa published in scientific reviews in accordance with the Botanical and Zoological Nomenclature Codes. There is no limitation in number of pages or in their length. Text, figures and pictures may be up- and down-loaded. The navigation through pages may be done in clicking on the case sensitive links or in typing keywords in search engine (e.g. in typing a species name etc.). The databank contains three sections: the main one contains the descriptions of the taxa previously published in scientific reviews, the second one contains unpublished taxa left in open nomenclature for which information from the PalyWeb community is requested, and the third one is devoted to enigmatic palynomorphs. Of course, this structure is a suggestion, and can be subject to debate and easily modified. Each page (article) is articulated around four main components. The first one is the "page" itself which is named with a title located in the top of the screen. The second one is obtained by selecting the heading "to modify" (edit page), to change immediately the page content, without restrictions. A third component is the heading "discussion", where PalyWeb users, can exchange their ideas on the contents. The last component is the "history" of pages. All former versions of the pages are stored with the user name, authors of modifications. Every previous version can be restored (a very useful tool to prevent mistakes). Bibliographic pages associated to the main body of the databank may be added. Pages may be put in one or more categories, creating automatically alphabetic list of pages related to them (listing of species by stratigraphic level, by countries, etc.)

In the expectation that this project meets with success, such databank would have numerous advantages. The whole palynological community has a free access to the website and everybody is allowed to improve it without leaving his/her own computer. The free distribution, constant updates, diverse and detailed coverage, by numerous palynologists would guaranty the high quality of data brought in the website. Only free internet browser software is needed. There is no limitation in size and contents. It is the place where taxa described in other languages than the English, which is the usual way of communication for scientists, can be translated. The building of the website is not function of the pugnacity of the databank creator or of a small group of persons. It does not need to organize meetings which are usually limited to people who have funds to travel … and numerous otheradvantages.

New address

Duncan McLean and David Bodman, formerly of Sheffield University, have moved to MB Stratigraphy Ltd., 11 Clement St., Sheffield, S9 5EA, UK.

More contributions

Please contribute articles to the *Newsletter*. Items on new techniques, research, book reviews and ideas are all welcome.

Treasurer's Report CIMP Finances

Delivered by P. Steemans (Treasurer) at CIMP General Meeting, 5-10-06

- Expenses: ………………………..……………………0.00
- Entries:
  - 2005
    - Fees: Fess payment of 3 members for 2 to 10 years ……………………………………………………….. 94.00
    - Interests 2005: ………………………………… 29.58
  - 2006
    - Fees: Fess payment of 8 members for 1 to 5 years …………………………………………………..…..190.00
- Balance:
  - 1836.22 +94 +29.58 +190= …………………..**2149.80**
  - Difference Dec. 2004 – July 2006= …………..293.58

Participants at Prague.