Newsletter Winter 2007 No. 72

Sintra, Lisbon

Commission Internationale de Microflore du Paléozoïque

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Message from the President

Firstly let's look at the year that is finishing. Those of you who were able to attend the CIMP spore and acritarch meeting in Lisbon this September were treated to an excellent meeting and fieldtrip. It's certainly the first time I (with everybody else I must add) was sent for a compulsory siesta on a fieldtrip. The organisation team was led by Zélia Pereira from INETI in Porto whom we must thank for all their hard work. The meeting certainly set new standards in design co-ordination from logo to shoulder bag to abstracts.

This year also saw a considerable effort by the Treasurer Philippe Steemans from Liège both with the website and in trying to get the organisation onto a more professional basis. Philippe has mastered the intricacies of PayPal so we can all now regularly pay our extremely modest CIMP subscriptions online. Please support his endeavours which translated from polite English means 'pay the money'. We must also again thank Mike Stephenson for his efforts with this newsletter. Again please support it by writing articles rather than leaving him to compile most of it himself.

And so to the future and 2008. Happy New Year to those CIMP members on this particular calender and belated or advance greetings to those who live on differently calibrated time scales. This year is an IPC year and as I am sure you know we are meeting in early September in Bonn, Germany. The organisers have boldly organised the IPC in parallel with the IOPC palaeobotanical meeting and are to be congratulated for this. So, please support what we hope will be an excellent and integrative meeting. At the time of writing we are unsure which CIMP sponsored sessions or combinations thereof have been approved. But we submitted three, one on the Arabian Plate, one on palynostratigraphy and one on Palaeozoic oceans and climates. Hopefully you will all make efforts to attend and support CIMP with your presentations and posters. One thing we may attempt to organise, in addition to the business meetings, is a CIMP members' reception where we can informally meet in what will otherwise be a big meeting.

So here's to Palaeozoic palynology and 2008!

John Marshall

Meetings and conferences

12th International Palynological Congress

30 Aug - 6 Sept 2008, Bonn, Germany

First Flier

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

International Geoscience Programme (IGCP) Project 503
Ordovician Palaeogeography and Palaeoclimate

International Congress "Palaeozoic Climates"

August 23-31, 2008, Lille, France

The Second Circular is available for download

August 23-24: Pre-conference excursion : Lower Palaeozoic of Belgium and northern France (Brabant, Condroz, Ardennes)

August 25-26: Lower Palaeozoic Climates, Sea-Levels and Biodiversity (Closing Session IGCP 503)

August 27: Plenary Session : Palaeozoic Climates, with invited keynote speakers

August 28-29: Upper Palaeozoic Climates, Sea-Levels and Biodiversity

August 30-31: Post-conference excursion : Upper Palaeozoic of Belgium and northern France (Avesnois, Meuse Valley, Ardennes)

AASP 42nd Annual Meeting,

Meadowview Convention Center, Tennessee.

September 27-30, 2009.

Organizer: Michael Zavada

Convention Center webpage: http://www.marriott.com

See announcement in AASP Newsletter

European Geosciences Union General Assembly

Vienna, Austria, April 13 – 18 2008

SSP11 - New applications and challenges in stratigraphic palynology

The EGU (http://www.copernicus.org/EGU/) General Assembly 2008 will be held at the Austria Center Vienna (ACV) in Vienna on April 13-18 2008.

Austria Center Vienna

The Assembly is the major scientific venue for Earth Science specialists in Europe, covering all aspects of Earth Science. The meeting provides the possibility of interdisciplinary interactions among scientists working on distinct fields, which often prove to be closely related than generally considered.

Placing precise chronostratigraphic constraints on biotic or physical events is fundamental for any geological and palaeobiological model, and palynostratigraphy is certainly one of the most suitable and powerful tools for high-resolution biostratigraphy and correlation.

The SSP11 Session - "New applications and challenges in stratigraphic palynology" is intended to present a broad overview of current developments in stratigraphic palynology and their impact in pure and applied research. Submission of papers dealing with all aspects of palynostratigraphy of the entire stratigraphic column is strongly encouraged.

Visit the SSP11 webpage (http://www.cosis.net/members/meetings/programme/view.php?m_id=49&p_id=315&day=1&view=schedule)

For more information on this session and instructions on how to submit an abstract email or write to Marco Vecoli (marco.vecoli@univ-lille1.fr).

News from Argentina

Compiled by Mercedes di Pasquo
medipa@gl.fcen.uba.ar

Palynostratigraphy and Paleobotany Laboratory (PPL) website (http://palino.gl.fcen.uba.ar)

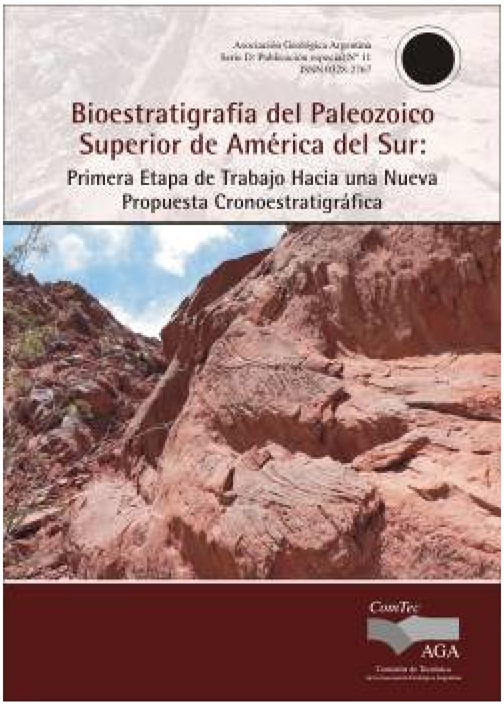
We invite you to visit this website where you can find information about different activities of the staff such as current research projects (in both English and Spanish), teaching courses, a gallery of photographs of different events, links of interest including a map with the location of different Argentinean Palynological Groups. A list of contributions, some of them with pdf files (please contact M.M. di Pasquo to obtain them), is included in the section called "TRABAJOS DE INVESTIGACIÓN" and the section called "NEW" has updated the information since 2005. Another new section is called "TAXONOMÍA" and includes the illustration of holotype and paratypes of new taxa defined by the members of the group. On the other hand, we want to acknowledge all the colleagues that have sent to us their reprints either by postmail or pdf versions!! We know that the reprint version is better than the pdf file, but it is very difficult for us to send reprints by postmail to everybody (long distances, huge prices and not enough funds for this issue!). Additionally, sometimes we do not have reprints of all contributions. So, this is the best way we find to share our information with all of you and we hope it will be useful as well. We are grateful if everybody can send to us either pdf files or reprints if it is possible of course. We are interested in palynology in general (all periods and issues) and other paleontological researches are welcome as well.

Most recent contributions have been presented in the 4th European Meeting on Paleontology and Stratigraphy of Latin America, held in Madrid (September 12-14th) and they can be downloaded from the website http://www.igme.es/4empsla.

New books and special publications

Biostratigraphy of the Upper Palaeozoic of South America: first step to a new chronostratigraphic proposal (Bioestratigrafia del Paleozoico Superior de América del Sur: Primera Etapa de Trabajo Hacia una Nueva Propuesta Cronoestratigráfica)

Carlos Azcuy, Angeles Beri, Mary E.C. Bernardes-de-Oliveira, Hugo A. Carrizo, Mercedes di Pasquo, Pamela Díaz Saravia, Carlos González, Roberto Iannuzzi,Valesca B. Lemos, José Henrique G. Melo, Alejandra Pagani, Rosemarie Rohn, Cecilia Rodríguez Amenábar, Nora Sabattini, Paulo A. Souza, Arturo Taboada, Maria del Milagro Vergel (Authors in alphabetical order).



An important achievement of the Working Group on Upper Palaeozoic Chronostratigraphy of South America that will be published soon (Azcuy et al., 2007), is the first result of the following meetings: The 1st Meeting of the Upper Palaeozoic Chronostratigraphy Committee of South America, held within the framework of the *XI Reunião de Paleobotânicos e Palinólogos* (Gramado, Brazil, 2004), included researchers from Argentina, Brazil and Uruguay and was coordinated by Carlos Azcuy. The meeting constituted the first step to discuss and establish a regional chronostratigraphic scheme of the Upper Paleozoic of South America. The current scheme established in Western Europe, Russia and North America has been defined using fossil associations that are not common to the region of Gondwana. All of the participants agreed that the best way to establish a regional chronostratigraphy would be by synthesizing all systematical, palaeontological, and radiometrical works of Upper Palaeozoic basins from South America. It was agreed to divide the task among the participants with Dr. Carlos Azcuy, as Lead Coordinator. The first results of the project were discussed in the framework of the *XIII Simposio Argentino de Paleobotánica y Palinología* (Bahía Blanca, Argentina, 2006). The biostratigraphical units established for the different basins of South America as well as other data (more isolated and new information) are updated and discussed and a correlation chart is supported by a list of selected references.

A summary of this work was presented in the 4th European Meeting on Paleontology and Stratigraphy of Latin America, held in Madrid in September 2007 (see above Azcuy et al., 2007).

CIMP 2010, Poland

Monika Masiak, mmasiak@twarda.pan.pl

Dear Palynologists,

We kindly invite you to a CIMP 2010 General Meeting in Poland, in September 2010. The Institute of Geological Sciences of the Polish Academy of Sciences with the cooperation of the other geological institutions are pleased to host this meeting and to showcase a long (since the beginning of the XIX century) and ongoing tradition of Polish palynological research.

We propose the capital city of Poland, Warsaw, as the location for the meeting. We plan three days of presentations (lectures and posters) and a two-day field trip in the Holy Cross Mountains where we can visit many outcrops of Palaeozoic deposits.

We are also considering a one-day workshop before the field trip, to present microscope equipment and to allow comparative studies of palynological slides collections of CIMP 2010 participants. The conference language will be English.

The CIMP 2010 General Meeting will offer an opportunity to meet nearly all Polish palynologists and foreign guests working on Palaeozoic strata, to discuss problems and solutions, to identify new issues, and to shape directions and joint projects for future research.

First Circular

Details on registration fees, accommodation, and meeting schedule will be given in the First Circular, which will be sent later.

ORGANIZING COMMITTEE

Monika Masiak – mmasiak@twarda.pan.pl

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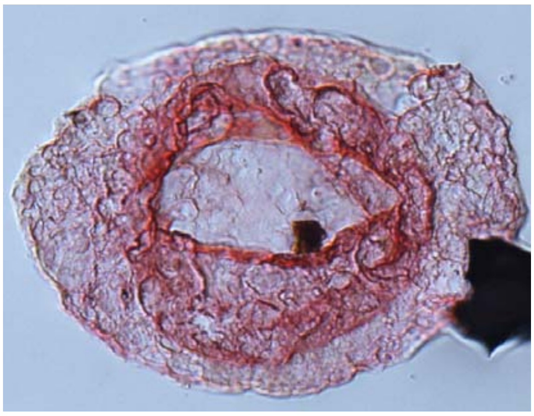
Palynology of the proposed basal Artinskian GSSP

Mike Stephenson, mhste@bgs.ac.uk

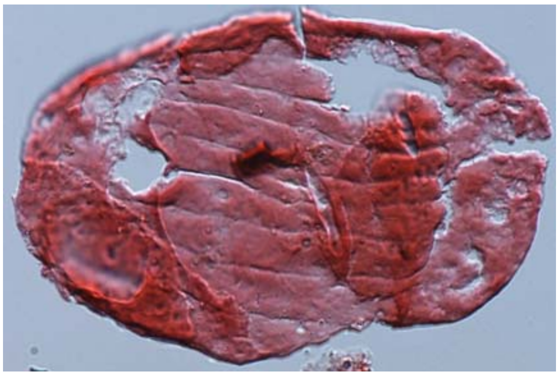
The Dal'ny Tulkas section in southern Urals is the proposed basal Artinskian (Early Permian) GSSP. Samples were collected from the marls, siltstones and thin limestones of the section. The eleven samples yielded large amounts of organic residue including palynomorphs, sheet cellular material, woody material and amorphous organic matter. Palynomorphs were common in several samples but were generally poorly preserved.

The samples are dominated by indeterminate non-taeniate and taeniate bisaccate pollen, *Cycadopites* (mainly *C. ?glaber* (Luber & Valts) Hart) and *Vittatina* spp. (mainly *V. minima* Jansonius, *V. vittifera* (Luber & Valts) Samoilovich and *V. subsaccata* Samoilovich). Other taxa recorded include ?*Complexisporites* sp., *Alisporites indarraensis* Segroves, *Cordaitina* spp. (including *C. uralensis* (Luber & Valts) Samoilovich), *Crucisaccites ornatus* (Samoilovich) Dibner, *Florinites luberae* Samoilovich, *Hamiapollenites bullaeformis* (Samoilovich) Jansonius, indeterminate monosaccate pollen, *Knoxisporites* sp. *Limitsporites elongatus* Lele & Karim, *L. monstruosus* Luber & Valts, *Maculatasporites* sp., *Potonieisporites grandis* Tshudy & Kosanke, *Protohaploxypinus* spp., *Punctatisporites* sp. and *Sulcatisporites* spp. (see below for a selection).

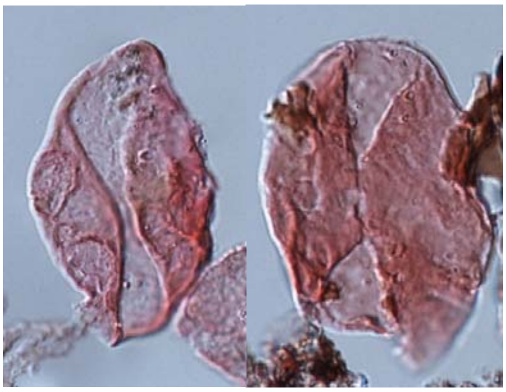


Potonieisporites grandis

Hamiapollenites bullaeformis



Protohaploxypinus sp.



Cycadopites ?glaber

For full details of the study see the forthcoming issue of Permophiles, the SPS Newsletter, http://www.nigpas.ac.cn/permian/web/permo.asp

PhD News

Thesis of Pierre Breuer, Université de Liège

Paléobotanique-Paléopalynologie-Micropaléontologie (PPM)

Allée du 6 Août, Bât. B-18, parking 40

Université de Liège, Campus du Sart Tilman

B-4000 Liège 1, Belgique

Pierre Breuer will defend his PhD on 25 January 2008. His thesis is entitled: 'Devonian miospore palynology in western Gondwana: an application to oil exploration'

The abstract of his thesis is reproduced below.

Devonian miospore assemblages from 16 sections in Saudi Arabia and North Africa are studied in order to characterize the palynostratigraphy of the northern margin of western Gondwana which remains poorly known in Saudi Arabia. The preliminary taxonomic work identifies more than 200 miospore species, including a lot of new species endemic to western Gondwana. Numerous species have still to be more precisely circumscribed because of their large morphological variability. Others show continuous intergrading morphological variation. The morphological variability of each taxon is one of the main problems in any palynological study. It is due to phylogenetic evolution, ontogeny (maturation of sporangia) and taphonomic factors.

Although the standard Devonian miospore zonations established in Euramerica (Richardson & McGregor, 1986; Streel et al., 1987) are commonly used in most of the palynological studies, they are not always easily recognizable in western Gondwanan localities because of the endemic nature of the assemblages. Therefore, a new local/regional biozonation based on the characteristics of the miospore assemblages described here was needed for a more accurate correlation. The new established biozonation consists of 9 assemblage zones, 8 interval zones and 2 acme zones, extending from the late Pragian to the late Givetian and possibly the early Frasnian. The new defined biozones are compared to other coeval biozones defined in the literature. Thanks to this new local/regional biozonation,

reliable correlations are established between sections.

Numerous oilfields occur in the Devonian from western Gondwana. A biozonation based on the first down-hole occurrence of species is developed for oil exploration. Thanks to this type of biozonation, only the top of a biozone has to be reached in order to be identified. The use of this biozonation is facilitated by the choice of easily recognizable and common index species. This provisional downward biozonation consists of 8 interval zones. Although it seems relatively reliable by comparison with the previously defined upward biozonation, it needs to be further tested on other drilled sections.

The review of the Emsian-Givetian miospore assemblages from the literature allows to evaluate the provincialism of assemblages on a worldwide scale during this interval. Coefficient of similarity is calculated between palynofloras from northern Euramerica, southern Euramerica, eastern Gondwana, southwestern Gondwana and northwestern Gondwana. The resulting low values correspond to low to moderate similarity of miospore assemblages between the considered regions in the Emsian-Givetian interval. The provincialism may be explained by a latitudinal climatic gradient as no palaeogeographic barrier is known during this time interval. Indeed, both Euramerican and Gondwanan land masses were very close as soon as the earliest Devonian. Despite a certain degree of provincialism, floristic interchanges existed. Northwestern Gondwana constituted an intermediate warm temperate region with shared taxa mainly from more arid Euramerican localities in the North, and cooler southwestern Gondwanan localities in higher latitudes. However, it seems that a progressive homogenization of the vegetation took place in Middle Devonian as the standard Euramerican biozones are more easily recognized in Givetian than in Eifelian and Emsian. This transition from provincialism to cosmopolitanism during the Devonian is not only shown by palynofloras but also by the palaeogeographic distribution of many other fossil groups. It is likely due to a decrease of the latitudinal climatic gradient in Middle Devonian.

Late Devonian acritarchs and their relation to the development of oceanic anoxic events and black shales

Sarah de la Rue, University of Idaho

I recently transferred to the University of Idaho where I will be continuing my Ph.D research, under the supervision of Peter Isaacson. My project is on Late Devonian acritarchs and their relation to the development of oceanic anoxic events and black shales. Please note my new email and mailing addresses:

Sarah de la Rue, University of Idaho Geological Sciences, Moscow, ID 83844 USA,
sarah.delarue@vandals.uidaho.edu

Please note also advance news of a special edition of the journal *Palaeogeography, Palaeoclimatology, Palaeoecology*, which will contain papers based on talks presented at the Devonian-Mississippian session during the 2006 Geological Society of America meeting in Philadelphia, USA. It is scheduled to be published late 2008.

CIMP Lisbon 2007

Mike Stephenson

During the Prague CIMP meeting, delegates suggested that a future meeting should be organized in Iberia. A group of Portuguese stratigraphers working in the Palaeozoic accepted this challenge and the meeting was planned for September 2007.

The meeting was organized by the Geosciences Area of the Instituto Nacional de Engenharia, Tecnologia e Inovação (INETI) in Lisbon, Portugal. The conference was open to everyone interested in Palaeozoic palynology, and the program consisted of three days of technical and scientific sessions, a poster session, workshops, a cryptospore short course and an acritarch short course, and web presentations, all followed by a post-conference field trip to southern Portugal.

The Geosciences Area of INETI corresponds to the former Instituto Geológico e Mineiro, a 150 year-old state organisation. Nowadays the Geosciences Area works in systematic mapping, geology, hydrogeology, geophysics, economic geology, marine geology and has several associated laboratories. A Geological Museum and a Library are also integrated in Geosciences Area.

INETI-Geosciences provided all the facilities for the meeting and a field guide. PARTEX Oil Services and Fundação para a Ciência e Tecnologia also kindly made available financial support.

The meeting was an excellent showcase for the interesting and innovative research being carried out in palynology. Particularly interesting for me were talks on melanosclerites and the relationship between volcanism and palynology, as well as the fundamental work being done in Portugal by Gil Machado and Zélia Pereira, amongst others. Approximately half of the abstracts for the meeting are reproduced here with kind permission of the organisers of Lisbon 2007. The other half will appear in the next newsletter. I apologise for the small size of some of the diagrams included in abstracts, and I realise that some of these will be difficult to read, especially in PDF form. If there is a diagram you'd like to read in more detail, you can contact me (mhste@bgs.ac.uk) and I will send it to you by email.

CIMP Lisbon 2007 Gallery

Excellent facilities at INETI

Jiří Bek gives an interesting talk

People listening to Jiří!

Oscar Abbink and John Utting

CIMP Lisbon 2007 Conference Fieldtrip

Kin Higgs, K.Higgs@ucc.ie

A two day post conference fieldtrip visited the Ossa Morena and South Portuguese Zones in southeast Portugal to examine sections through the Silurian, Devonian and Carboniferous. The fieldtrip was expertly led by Tomas Oliveira, Zelia Pereira, Paulo Fernandes, Joao Matos and Manuel Picarra. The first morning the group of twenty travelled westwards across the sun drenched cork tree plains of central Portugal. After two scenic stops at the world heritage town of Evora and the picturesque hilltop village of Monsaraz we reached our first geological locality at Barrancos. However, the heat of the midday sun necessitated a leisurely lunch followed by an afternoon siesta before we could venture out to the rocks. Several road side exposures south of Barrancos provided sections through the Silurian and Lower Devonian of the Ossa Morena Zone. The sediments are demonstrably deep marine and in the lower part contain an impressive condensed succession of 17 graptolites zones in some 35m of strata. Miospore data indicate the upper part of the succession is close to the Pragian- Emsian boundary. The second day took us southwards into the South Portuguese Zone. After crossing the terrane boundary at Santia Iria we examined roadside sections of the Upper Devonian in the Pulo do Lubo Antiform. The palynological data has confirmed the presence of a significant unconformity between the early Frasnian and late Famennian in this region. We continued southwards to the Sao Domingos Mine area in the northern part of the Pyrite Belt. This old mine was once one of the largest and most important massive sulphide deposits in Portugal. The mine closed in the 1960's and is now being developed for geo-tourism. The geological succession in the mine area ranges from late Famennian to late Visean in age and palynostratgraphy has proved to the only means of dating and correlating the structurally complex sections. Despite the presences of tectonism and mineralisation these rocks have yielded remarkably well preserved spore and acritarch assemblages. The final stop of the fieldtrip took us to the outskirts of the historic town of Mertola, where we posed for the official group photo before we descended the western slopes of the Guadiana River. Here we examined a well exposed and continuous section of the overthrusted sequence of the Mertola Formation (late Visean), Volcano Sedimentary Complex (early Visean) and Phyllite Quartzite Formation (late Famennian). Again, it was demonstrated how the detailed palynological work carried out by the Portuguese Geological Survey (Zelia Pereira) has played a crucial role in dating the thrusted sequences and therefore allowing the complex geology to be better understood. This was a wonderful fieldtrip with excellent geology and palynology, lots of local culture, superb weather and very good company.

CIMP Lisbon 2007 Abstracts

BIOSTRATIGRAPHIC STUDY OF UPPER SILURIAN AND LOWER DEVONIAN MIOSPORES OF THE IN SALAH AND OUED SAOURA AREAS, CENTRAL ALGERIAN SAHARA

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SUMMARY

A thick, laterally extensive sequene of Upper Silurian and Lower Devonian sediments in the central Algerian Sahara is investigated. The five well sections at In Salah and five outcrop sections in the Oued Saoura region yield a total of 67 miospore taxa which permit the establishment of a sequence of eight miospore assemblage zones. Comparisons with data from Libya and Saudi Arabia suggests positive correlations are possible across the North Gondwana region. Differences are highlighted with contemporary Euro-American biozones

The study is based on the palynological investigation of core samples from five petroleum wells of In Salah and closely spaced samples from five outcrop sections representing five formations at Oued Saoura. It describes for the first time moderate to highly mature miospore assemblages from the uppermost Silurian to latest Lower Devonian sediments of Oued Saoura. The Upper Silurian and Lower Devonian deposits of the In Salah and Oued Saoura areas are of significant thickness and laterally widespread and display similarities between the two areas. These lithostratigraphic similarities are confirmed by evidence from the sporomorph assemblages and sequence stratigraphic correlations between the two provinces. The most striking uniformity between In Salah (Kowalski et al. 2003, Hassan Kermandji et al. 2003a, b, c and Hassan Kermandji 2007) and Oued Saoura (Legrand, 1983, and Nedjari et al. 2003) sequences is that the upper part of Oued Ali Formation and the upper part of In Salah succession are composed of shales and marls, thin layers of siltstone and sandstone and rare horizons of calcareous sediments, partially representing cycle 1 of Kowalski et al. 2003 (Upper Přídoli- lowermost Lochkovian of Hassan Kermandji 2007). The Zeimlet Formation and the equivalent strata of the In Salah area, consists of alternations of sandstone/siltstone beds and shale/muddy horizons with rare calcareous bands containing coelenterates, gastropods and bivalves, representing cycles 2, 3 and 4 of Kowalski et al. 2003 (Lower and Middle Lochkovian of Hassan Kermandji et al 2003a). The Saheb el Dijr Formation and the corresponding successions of the In Salah area embrace very thick claystone, sandstone bands and thin calcareous beds with *Orthoceras* and trilobite debris, representing cycles 5 and 6 of Kowalski et al. 2003 (Upper Lochkovian). The lower member of Dekhissa Sandstone Formation and the comparable sequence of the In Salah area consists of an alternation of mudstone and siltstone/sandstone layers representing prodeltaic sediments. The middle member corresponding sequence in the In Salah succession consist of layers of siltstone and sandstone representing delta front sediments whilst the upper member of Dekhissa Formation which has no equivalent strata in the In Salah sequence consists of limestone beds and mudstone layers, both with *Orthoceras* relics, indicating shallow marine conditions. The lower and middle members of Dekhissa Formation and the equivalent strata of In Salah typify the 3 cycles of Hassan Kermandji et al. 2003b (Pragian age). The lower member of Teferguenit Formation and the equivalent sequences in the In Salah area consist of silty limestone to mudstone layers with rare chert nodules. They represent a transgressive sequence which is followed by an erosional event, probably representing the uncompleted cycle of Hassan Kermandji et al. 2003c (Emsian age). The organic residues are dominated by mature to very mature fluvial miospores and marine acritarchs through Oued Souera and less mature through the In Salah sequence. The miospore assemblages indicate that the lowermost strata studied in both regions are of similar latest Přídolian to lowermost Lochkovian age, also suggest that the upper deposits are also of comparable Lochkovian to Emsian age. Critical unproductive palynological samples from the upper part of the Oued Ali Formation and equivalent strata from the In Salah sequences might span the boundary between the Přídoli and Lochkovian stages. Miospore assemblages of Oued Saoura are more mature compared with those from In Salah, and there are also some differences in terms of the quality of preservation and the qualitative/ quantitative composition. It is possible to identify 67 characteristic miospore taxa and to establish eight miospore assemblage biozones. The miospore assemblages contain several diagnostic components of the Algerian Silurian - Devonian succession which are also common with contemporaneous miospore assemblages from Libya, Saudi Arabia implying reasonably reliable correlation across the northern Gondwanan region. Comparison with Euro-American miospore biozones suggests apparent differences during the Přídoli to Early and early Late Lochkovian interval but in the Pragian and the subsequent sequences, these differences are less distinct. The phytogeographic implications of the results are discussed.

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Nedjari, A., Ait Ouali, R.,Chikhi-Aouimeur,F., and Bitam, L.,2003. Le bassin de l' Ougarta au Paléozoque : une mobilité permanente (Livret guide du field trip),103pp.

MELANOSCLERITES – AN OVERVIEW OF THIS FOSSIL GROUP

Trampisch, Claudia

University of Greifswald, Institute of Geography and Geology, Dept. of Paleontology and Historical Geology, F.-L. - Jahnstr. 17a, 17487 Greifswald Germany. Email: claudia.trampiach@uni-greifswald.de

SUMMARY

Melanoclerites are rod-shaped, organic microfossils of uncertain affinity, and were first identified by Eisenack (1942). They are only known from palynological residues, and their stratigraphic range is Cambrian to Devonian. They have not yet been widely studied, and are apparently facies-controlled. Thus, they may be potentially useful for paleoenvironmental and paleogeographical studies.

Melanosclerites, the name introduced by Eisenack (1942) is an artificial group of "black rodlets of uncertain origin." It includes any small (most are between 50-1500 µm across), organic-walled microfossils, that cannot be assigned to a natural group. Melanosclerite morphology is the basis for their classification and therefore, requires detailed analysis. The sclerites are brown to black in color and have a smooth outer surface. Their overall body shape ranges from large and short to long and small cylindrical rods commonly with distal differentiation, and composing a sometimes branched skeleton with axial symmetry. The skeleton are assumed to have formed an axial structure for support of a body or sclerite-like elements in benthic animals that might belong to the Cnidaria. An algal origin has also been postulated (Gorka, 1971). Dunn (1959) suggested that melanosclerites might be members of the 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*.

The earliest palynomorphs that we now classify as melanosclerites are probably those reported by Eisenack (1932) from the Silurian Baltic sediments. In the early 1930s, Eisenack, working on material from the Baltic, re-assigned many species to the melanosclerite group and came to regard them as being derived from Octocorallia. The oldest known melanosclerites are recorded by Winchester-Seeto (2001) from the Lower Cambrian Lontova Clay of Estonia. From the Devonian onwards, melanosklerite abundance appears to have declined. Whether this is a reflection their true abundance and diversity, or the amount of scientific research is unclear.

Although the biologic affinities of the melanosclerites remains unclear, Eisenack (1942, 1950, 1963) and Schallreuter (1981) have provided a usable classification system. However, attempts at constructing a natural classification of melanosclerites have not yet led to satisfactory results. The artificial classification introduced by Eisenack and Schallreuter has been widely accepted and serves the purposes of most palynologists, such that there is little incentive for change. Under the artificial classification of Eisenack and Schallreuter, melanosclerites are divided into the following three morphologic groups: Melanoporellidae, Mirachitinidae, and Melanoskleritoitidae.

Melanosclerites are frequently the only microfossils preserved, and thus are extremely useful for stratigraphic correlation of rocks from the Proterozoic and Palaeozoic. They are not only important for Palaeozoic biostratigraphy, but they are also helpful in palaeoenvironmental interpretations.

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SPORE ASSEMBLAGE OF THE RADNICE BASIN, BOLSOVIAN OF THE CZECH REPUBLIC

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SUMMARY

Palynological research of spore assemblages of the Radnice Basin, Pennsylvanian of the Czech Republic confirmed lower Bolsovian age of coal-bearing strata. Older assemblage represents plant assemblage before the volcanic eruption and is preserved in situ. Assemblage after the period of volcanic activity belongs to the same palynological phase, but differs in the percentage spores produced by herbaceous and sub-arborescent lycopsids and some sphenophylls.

Palynological samples from the Radnice Basin are from VP-29 borehole, Ovčín Quarry and excavations close to the Ovčín Quarry. Stratigraphical position of all samples in the Radnice Basin is the Lower and Upper Radnice seams, lower Bolsovian. Diferences between spore assemblages of the Lower and Upper Radnice seams possess palaeoecological and not stratigraphical character. Vegetation of the Upper Radnice seams has grown after a short period of volcanic activity, that is represented by two types of volcanic layers, tuff and tufit between these two seams.

Palaeoecological conditions were basically similar before and after the eruption. Spore assemblages of the Lower and Upper Radnice seams can belong to the Lycospore phase *sensu* Smith. Both assemblages are characterizied by high percentage of miospores of arborescent lycopsids, sphenophylls and ferns and fern-like plants (excluded marattialean ones). Percentage of miospores of arborescent lycopsids and calamites is the same before and after the eruption. Sphenophylls was not a group of plants with the same ecological needs, because some sphenophyllalean miospores were more abundant before the eruption and some others after the period of volcanic activity. Palaeoecological results are based on the study of miospore and megaspore assemblages. Interpretation of coal-forming vegetation is suggested based on our knowledge of in situ micro- and megaspores.

Dispersed spore taxa are compared with macrofloristic record from excavations at the Ovčín locality. We know parent plants of most of spore taxa and only about eleven per cent of spores are of unknown origin. The comparsion of macrofloristic and palynological records confirmed much greater potencial of palynology for the reconstruction and interpretation of plant fossil vegetation.

PALYNOSTRATIGRAPHY OF THE CARBONIFEROUS BARACHOIS GROUP, SOUTHWESTERN NEWFOUNDLAND, CANADA

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SUMMARY

In southwestern Newfoundland continental predominantly red-beds of the Searston Formation, Barachois Group, contain a miospore assemblage of late Pendleian to Arnsbergian age (early Serpukhovian). The assemblage enables palynostratigraphic correlations to be made with rocks elsewhere in Atlantic Canada, with the UK, and with the North Sea. The Searston assemblage predates a major floral change comparable to that which occurs in western Europe at the top-Arnsbergian.

In southwestern Newfoundland a miospore assemblage of late Pendleian to Arnsbergian age (early Serpukhovian/Namurian A), has been recognised in continental red-beds of the Searston Formation of the Barachois Group, and in unnamed coal bearing strata in the upper parts of the group. Characteristic taxa include *Reticulatisporites carnosus* (consistently present, but not common), *Crassispora maculosa*, *Cribrosporites cribellatus*, *Grandispora spinosa, Grumosisporites rufus*, and *Microreticulatisporites concavus* are rare. Common to abundant in some samples are *Anapiculatisporites bacccatus*, *Crassispora kosankei, Granulatisporites microgranifer, Lycospora. pusilla, L. noctuina and Waltzispora planiangulata*. Monosaccate pollen *Florinites* spp. and *Potonieisporites elegans* are rare and sporadic. Common in one sample from the coal bearing strata, is *Schulzospora rara*.

The assemblage predates a major floral change, comparable to the Gothan Floral Crisis at the top-Arnsbergian in western Europe (Menning et al., 2000). The precise position of which in Atlantic Canada is obscured by a significant Late Arnsbergian to Yeadonian hiatus representing the Mississippian - Pennsylvanian boundary. The Barachois Group assemblage can be compared with that from the red-bed dominated Pomquet Formation of the upper Mabou Group, Nova Scotia. Also comparisons can be made with other parts of the Euramerican floral province in western Europe, where the climate was semi-humid. For example, it resembles that described by Turner and Owens (1993) from the Cornbrook Sandstone Formation (Pendleian-Arnsbergian) of Shropshire, England, which consists of a variable succession of conglomerates and coarse grained sandstone, with thin mudstone and coal intercalations. In addition comparisons can be made with the assemblages from the North Sea (McLean et al., 2005).

The only other known post-Arnsbergian Carboniferous sediments in southwestern Newfoundland, which post-date those of Pendleian-Arnsbergian, are the Bolsovian (early Moscovian/Westphalian C) coal measures in a small outlier to the north, near Stephenville. Thus a major hiatus is present between the coal bearing strata of Serpukhovian age and those of Bolsovian age, and it would appear that the thick coal measures of Yeadonian(?) to Duckmantian age, found in other parts of Atlantic Canada, are absent in southwestern Newfoundland, thus indicating a significant reduction in Newfoundland's coal potential.

The thermal maturity, as determined from spore colouration, varies considerably throughout the area, although it lies generally within the "oil window". The main exceptions are some coastal sections in the vicinity of the Searston type section where it is within the thermally generated gas zone. The occurrence of thin coal seams and rare oil shales at the top of the Searston Formation, and in overlying unnamed beds of the undivided upper Barachois Group, and the variations in thermal maturity, indicate a limited potential for the generation of thermally derived gas and liquid hydrocarbons.

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ORDOVICIAN (FLOIAN-DARRIWILIAN) ACRITARCHS FROM SOUTH CHINA

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SUMMARY

Six biostratigraphic acritarch zones are established using first appearance datum (FAD) data based on the Floian-Darriwilian acritarchs from several sections of the Yangtze Platform of South China. In addition to the six acritarch biozones established, twelve acritarch assemblages are recognized by cluster analysis. Acritarch diversity changes occurring in the four sections are related to sea level changes.

Floian-Darriwilian acritarchs from several sections of the Yangtze Platform of South China have been investigated Yan, 2007 . Based on the recovered taxa, six biostratigraphic acritarch zones are established using first appearance datum (FAD) data. The six zones in ascending stratigraphic order are:

Assemblage Zone A corresponds to the *T. approximatus* graptolite biozone and is characterized by the FAD of *Acanthodiacrodium burmanniae*, *Acanthodiacrodium tasselii*, *Aureotesta clathrata* var. *A. simplex*, *Cristallinium dentatum*, *Leprotolypa evexa*, *Pachysphaeridium rhabdocladium*, *Petaloferidium bulliferum*, *Petaloferidium florigerum*, *Picostella turgida*, *Rhopaliophora palmata*, *Rhopaliophora pilata*, *Stelliferidium striatulum*, *Striatotheca pricipalis parva*, *Veryhachium lairdii*, *Veryhachium symmetricum*, and *Veryhachium trispinosum*.

Assemblage Zone B corresponds to the *A. filiformis* graptolite biozone and is characterized by the FAD of *Coryphidium* *bohemicum*, *Peteinosphaeridium tenuifilosum*, *P. robustriramosum*, *Sacculidium inornatum*, and *S. macropylum*.

Assemblage Zone C corresponds to the *D. eobifidus* graptolite biozone and is characterized by the FAD of *Arbusculidium filamentosum*, *Dasydorus cirritus*, *Liliosphaeridium kaljoi*, *Pachysphaeridium pachyconcha*, *Peteinosphaeridium angustilaminae*, *P. armatum*, *P. coronula*, *P. dissimile*, *Pirea sinensis*, *Rhopaliophora florida*, *R. membrane*, *R. mamilliformis*, *Sacculidium peteinoides*, *Stelomorpha crassula*, *S. erchunensis*, *S. princeps*, *Tongzia meitana*, and *Tranvikium polygonale*.

Assemblage Zone D corresponds to the *C. deflexus* graptolite biozone and is characterized by the FAD of *Arkonia tenuata*, *Barakella rara*, *Liliosphaeridium intermedium*, *Loeblichia heterorhabda*, *Stelomorpha composta*, *Striatotheca monorugulata*, *S. transformata*, and *Vavrdovella arenigai*.

Assemblage Zone E corresponds to the *A. suecicus-U. intersitus* graptolite biozone and is characterized by the FAD of *Baltisphaeridium coolibahense*, *B. klabavense*, *Coryphidium elegans*, *Dasydorus microcephalus*, *Dicrodiacrodium ancoriforme*, *Multiplicisphaeridium rayii*, *Ordovicidium elegantulum*, *Pachysphaeridium kjellstromii*, *P. striatum*, *Peteinosphaeridium exornatum*, and *Pirea ornata*.

Assemblage Zone F corresponds to the *G. linnarssoni* graptolite biozone and *N. gracilis* graptolite biozone and is characterized by the FAD of *Baltisphaeridium* sp. cf. *B. dasos*, *B. dispar*, *B.* sp. cf. *B. oligopsakium*, *B. onniense*, *Gyalorhethium chondrodes*, *Leiosphaeridia caradocensis*, *Lophosphaeridium edenense*, and *Navifusa ancepsipuncta*.

Four of the six acritarch biostratigrapic zones appear in the Floian, due to the rapid evolution of acritarchs during the Early Ordovician.

In addition to the six acritarch biozones established, twelve acritarch assemblages are recognized by cluster analysis. The *Baltisphaeridium* and *Leiosphaeridia-Polygonium* assemblages are present in the shale basin environment. The *Baltisphaeridium-Leiosphaeridia-Polygonium-Micrystridium* assemblage, the *Polygonium-Baltisphaeridium-Leiosphaeridia-Peteinosphaeridium* assemblage, and the *Polygonium-Rhopaliophora* assemblage are present in the outer shelf or shale basin environment. The *Polygonium* assemblage is present in the shelf to shale basin environment. The *Cymatiogalea-Leiosphaeridia-Baltisphaeridium* assemblage is present in the outer portion of the outer shelf or shale basin environment. The *Baltisphaeridium-Peteinosphaeridium* assemblage, the *Stelliferidium-Baltisphaeridium* assemblage, and the *Polygonium-Dactylofusa* assemblage are present in the outer shelf environment. The *Stelliferidium* assemblage is present in the inner shelf or shelf environment, and the *Baltisphaeridium-Leiosphaeridia* assemblage is present in the shelf environment.

Acritarch diversity changes occurring in the four sections are related to sea level changes. The three peaks of the acritarch diversity curve of South China appear in the *C. deflexus-A. suecicus*, *U. austrodentatus,* and *G. linnarssoni-N. gracilis* graptolite biozones that correspond to transgressions in the early Floian, early Darriwilan, and early Sandbian respectively. With rising sea level, spreading of continental masses, and increasing habitat space, the diversity of acritarchs increased rapidly during the Early-Middle Ordovician.

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NEOPROTEROZOIC AND CAMBRIAN PHYTOPLANKTON AND CYANOBACTERIA: PALAEOBIOLOGY AND EVOLUTION.

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SUMMARY

The Neoproterozoic and Cambrian phytoplankton records several radiations and declines in diversity. The acritarch radiations are directly linked to, and were probably one of the causes of, the emergence of new metazoan clades by forcing changes in trophic strategy and expansion into a pelagic mode of life. The records of cyanobacteria pre- and post-date the global Neoproterozoic glaciations, proving the survival of the Snowball Earth conditions, and thus preservation of their habitats.

The Neoproterozoic and Cambrian phytoplankton, mostly described under the informal name of acritarchs but representing predominantly green microalgae, is a group of spheroidal and ornamented morphotypes of organic-walled microfossils, recorded approximately between 1000-488 Ma (million years ago). The microfossils are taxonomically diverse and record several radiations and declines in diversity of the marine phytoplankton. The most conspicuous radiations are those in the Ediacaran, at ca. 580-570 Ma, and at the beginning of the Cambrian, ca. 542 Ma. Records extend across various palaeocontinents, but the best known for the Neoproterozoic Era are from the Siberian Platform, China, Svalbard, and Australia, and for the Cambrian Period, the East European Platform, Greenland, Scandinavia, and Scotland (Downie, 1982; Volkova et al., 1983; Moczydlowska, 1991, 1998, 2005; Rudavskaya and Vasileva, 1989; Moczydlowska et al., 1993; Zhang et al., 1998; Zang, 1992; Zang and Walter, 1992a, b; Grey, 2005).

Phytoplanktic species, predating the appearance of Ediacara-type bilaterian metazoans, originated and spread rapidly throughout the world, became extinct before the end of Neoproterozoic, and radiated again at the onset of the Cambrian. The causes of their diversifications and extinctions are not easy to explain, but the events coincide within short time intervals of major global climatic and environmental changes. The radiation of Ediacaran acritarchs followed, with a time lapse of ca. 10-20 Myr, the Varangerian/Marinoan glaciation, which was the final global stage of the Snowball Earth conditions. The Varangerian/Marinoan glaciation was not, however, the last of the ice-ages during the Neoproterozoic, with some younger diamictites in China and elsewhere interpreted as glaciogenic, but it was a major episode (Knoll et al., 2004). The following, such as perhaps the Hankalchough glaciation in North China, was probably more restricted and had less devastating effect on the biosphere.

The Ediacaran acritarch radiation was coeval with the ensuing warming and establishment of green house conditions, oxygenation of the oceans, and recovery of the global gyres and surface current circulation.The sequence of these changes is interrupted, probably with a profound environmental effect, as due to the Acraman bolide impact ca. 580 Ma (Grey, 2005). A terminal Neoproterozoic extinction eliminated most of the photosynthetic marine biota, including cyanobacteria and unicellular and thallophytic algae that are well known from earlier Neoproterozoic fossil records, as well as soft-bodied Ediacara-type metazoans and some other enigmatic multicellular organisms. This is, however, even less clearly understood because there are no evident and directly-related environmental changes at the time that may have triggered the biotic extinction. The anoxic event related to the Precambrian-Cambrian transgression in some parts of the world, along with the extension of the water masses with low oxygen content onto the shelves and platforms surrounding the palaeocontinents, which are the most inhabitable of the marine ecosystem, may have contributed to the extinction at this time, but it might be only one of several factors.

The Ediacaran acritarchs are, in general, characterized by complex morphology and large size, being two to three times the order of magnitude of Phanerozoic specimens. Based on the accounts of morphologic form-taxa (Vidal and Moczydlowska-Vidal, 1997; Grey, 2005), their diversity ranged from approximately 65 up to perhaps 100 species. However, their diversity may vary significantly, depending on the taxonomic approach and concepts of the identification of species. Inevitably, their number may be under- or over-estimated, in relation to the fossil record. A consistent taxonomy is needed to assess more realistically (within feasible palaeontological reliability) the biodiversity of the Ediacaran phytoplankton and to depict their morphologic innovations and adaptations to changing ecological conditions and interactions with the evolving metazoan consumers. From the viewpoint of establishing evolutionary trends among the global biota and relationships between primary producers and heterotrophic consumers, the Ediacaran acritarch diversity has a basic value for further interpretation. The application of acritarchs to biostratigraphy is also of great value for the recently accepted terminal Neoproterozoic system, the Ediacaran System (Knoll et al., 2004; Grey, 2005).

In summary, the chronologic sequence of environmental and biotic events during the Neoproterozoic, deduced from data compiled from various sources and arranged biochronologically in part by acritarch-based correlation, is as it follows.

The Marinoan glaciation at ca. 635-600 Ma, which was the final and truly global stage of the Snowball Earth, was followed by warming and recovery of the environments.

In the interval between 600 and 580 Ma, simple, spheroidal acritarchs persisted worldwide (Vidal and Moczydlowska-Vidal, 1997; Grey, 2005) and low-grade, yet undetermined, metazoans producing embryos evolved, as is recorded in the lower Doushantuo Formation (Zhang et al., 1998; Xiao and Knoll, 2000).

At ca. 580 Ma, a post-Marinoan and geographically more limited glaciation occurred, as evidenced by the Gaskiers Formation in Newfoundland and some other diamictites, including the Hankalchough Formation in North China (Xiao et al., 2004).

Subsequently, the Ediacaran phytoplankton, assigned to the Ediacaran Complex Acanthomorpic Palynoflora (ECAP), radiated and diversified soon after ca. 580-570 Ma (Grey, 2005). This major acritarch radiation is marked by the appearance of some 50 or so new species and is well constrained in Australia. The latter age is determined by the isotopic dating of the Acraman impact ejecta layer, whose stratigraphic position is evidently post-Marinoan and pre-dates the phytoplankton radiation, because both events are convincingly documented in the same sedimentary successions and in several localities. The acritarch radiation has been considered to be global and is supported by the worldwide distribution of certain taxa. The ECAP radiation post-dates the Acraman bolide impact, but it may be contemporaneous with the appearance of the earliest macroscopic Ediacaran biota, which are rangeomorphs of the Mistaken Point assemblage in Newfoundland, at 575 Ma.

The frondose Ediacara-type metazoans evolved and persisted between 575 and 543 Ma, and bilaterians emerged sometime around 555 Ma. The phytoplankton characterized by the ECAP became extinct before the end of the Ediacaran Period, and the minimum age of its duration is around 550 Ma. This time limit is provided by the age of the Ediacaran metazoans in Australia, which are preserved in the same sedimentary successions as acritarchs in the Amadeus Basin (Zang and Walter, 1992b; Grey, 2005) when the palynoflora vanished.

The records of filamentous and coccoid cyanobacteria are fragmentary and stratigraphically discontinuous in Neoproterozoic and Cambrian strata, yet certain diagnostic taxa occur in successions pre- and post-dating the global glaciations. Cyanobacteria are preserved as solitary cells and sheaths, in clusters and in colonies. Filamentous cyanobacteria are most often preserved as empty sheaths, but entire trichomes with cells inside are the most diagnostic for inferring the affinities with modern clades. The biological affinities are established to the family level for many commonly occurring taxa. Because cyanobacteria are versatile in their metabolism and some may survive extreme conditions of temperature range, oxygen content, acidity, and UV radiation, they are less affected by environmental changes. Many taxa were long-lived and showed very slow rates of evolution, which are characteristic of prokaryotes. They are not, however, very useful for detailed biostratigraphy, although they are significant in proving the survival of the global glaciations, and thus preservation of their habitats. The implication of this is to test the Earth System model that should be adequate to life requirements of the surviving biota.

The Cambrian acritarchs appear to be taxonomically diverse, innovative in their morphology, and much smaller in size, including some morphotypes that subsequently persisted throughout the Phanerozoic. The pattern of phytoplankton diversity trends, established in a global compendium, is consistent with the radiations of metazoans and reflects the major environmental changes seen in the rock record. The observed regional and global taxonomic turnovers of phytoplankton correlate well and precede slightly, the major diversification events of metazoans. These events are the first appearance of diverse shelly metazoans (the *Platysolenites* biochron), the first appearance of non-mineralized arthropods and trilobites (the *Schmidtiellus* biochron), followed by the higher taxonomic diversification of trilobites and metazoans during the Cambrian. All of these events are synchronous in time and tightly coupled, revealing the relationships between the evolving primary producers (phytoplankton) and consumers (metazoans).

The acritarch radiations and their increase in both diversity and abundance are directly linked to, and were probably one of the causes of, the emergence of new metazoan clades by forcing changes in trophic strategy and expansion into a pelagic mode of life.

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PALYNOSTRATIGRAPHY OF DEVONIAN DEPOSITS IN HERMANOWA-1 BOREHOLE (SOUTHERN PART OF THE CARPATHIAN FOREDEEP, POLAND)

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SUMMARY

Clastic Devonian deposits in Hermanowa-1 borehole yielded miospores assemblages characteristic for two Assemblage Zones of Richardson & McGregor (1986): Grandispora douglastownense – Ancyrospora eurypterota and Emphanisporites annulatus – Camarozonotriletes sextantii. Carbonate deposits of the Middle and Upper Devonian were palynostratigraphically mute, only one sample yielded amorphous organic matter.

The oldest appearance of coenobial algae Musivum gradzinskii was recorded from Late Emsian strata.

INTRODUCTION

Deep borehole Hermanowa-1 was drilled 15 km south from Rzeszów within the Skole Nappe of the Outer Carpathians. Paleozoic deposits were drilled below strata of Carpathian Nappes, Stebnice Unit, autochtonous Miocene and Triassic, and contain Lower Carboniferous, Devonian, Silurian and Ordovician. Palaeozoic deposits occurring in the basement of the southern and eastern part of Carpathian Foredeep belong to the Małopolska Terrane. Devonian deposits occur in the depth interval 4640-4529 m. Seven samples for palynological studies were collected: five samples from carbonate deposits of the Middle and Upper Devonian and two samples from clastic Lower Devonian deposits. Only the samples from mudstones contained well preserved and taxonomically diversified palynomorphs; one sample from Upper Devonian limestone yielded only amorphous organic matter.

PALYNOSTRATIGRAPHY

Sample from the black mudstone (depth 4542.8m) yielded numerous and very well preserved miospore assemblage, with such important stratigraphically species like: *Emphanisporites annulatus, Camptozonotriletes caperatus, Camptozonotriletes* cf. *aliquantus, Dibolisporites eifeliensis, Dibolisporites wetteldorfensis, Brochotriletes foveolatus, Kraeuselisporites gaspesiensis, Apiculiretusispora brandtii, Apiculiretusispora plicata, Rhabdosporites minutus, Rhabdosporites* cf. *parvulus, Hystricosporites microancyreus.*The occurrence of the last mentioned species and high frequency of *Rhabdosporites* specimens allowed to distinguish Assemblage Zone *Grandispora douglastownense – Ancyrospora eurypterota* (Richardson & McGregor, 1986) of the Late Emsian – earliest Eifelian age.

Sample from dark-grey mudstone (depth 4585.1 m) yielded less numerous and worse preserved miospore assemblage. This assemblage contained following species: *Emphanisporites cf. epicautus, Emphanisporites erraticus, Emphanisporites annulatus, Apiculiretusispora brandtii, Apiculiretusispora plicata, Camptozonotriletes caperatus, Tetrahedraletes medinensis, Ambitisporites dilutus, Tholisporites chulus, Brochotriletes foveatus, Dictyotriletes subgranifer, Camarozonotriletes sextantii.* Such composition of miospore assemblage indicates slightly older age of examined deposits – they represent Assemblage Zone *Emphanisporites annulatus – Camarozonotriletes sextantii* (Richardson & McGregor, 1986) of the Early Emsian – early Late Emsian age.

OTHER PALYNOMORPHS

Sample from the black mudstone (depth 4542.8m) contained also acritarchs *Baltisphaeridium* sp. and coenobial algae *Musivum gradzinskii.*This algae species was described by Wood & Turnau (1998, 2001) from Givetian deposits in the Holy Cross Mountains. The occurrence of *Musivum gradzinskii* in Hermanowa-1 borehole is an evidence for the longer stratigraphical range of this species – at least since Late Emsian.

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PALYNOSTRATIGRAPHY OF ORDOVICIAN SEDIMENTS IN SOUTHEASTERN CASPIAN, NORTHERN IRAN

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SUMMARY

An undated lower Palaeozoic sequence is well exposed, near Kholin-Darreh village at Fazelabad area, 46km southeastern Gorgan city. The sequence has in ascending stratigraphic order divided into the Lalun (Early Cambrian) Formation and Abastu and Abarsaj formations (Ordovician). Both Ordovician rock units were measured and sampled, treating for palynomorph entities. All samples contain well–preserved palynomorphs (acritarchs, chitinozoans, scolecodonts and cryptospores).Twenty–one acritarch species were identified. Based on

stratigraphic potential of acritarch taxa a Late Ordovician is assigned to Ordovician rock units of Kholin -Darreb village, in the Fazelabad area, in North Alborz Mountain Ranges.

A lower Paleozoic succession is well-developed in the Kholin-Darreh area, which is located approximately 46km southeastern the city of Gorgan. A total of 37 surface samples were treated and investigated in the Palynological Laboratory of Exploration Directorate of National Iranian Oil Company. The Lower Paleozoic strata in ascending stratigraphic order have divided into Lalun (Cambrian), Abastu (Ordovician), Abarsaj (Ordovician) and Soltan Maidan (Silurian) formations. All samples of Ordovician strata contain acritarchs, chitinozoans and scolecodonts.

In this article, the acritarch group was considered and the important encountered species are: *Baltisphaeridium perclarum, Baltisphaeridium oligopsakium, Multiplicisphaeridium irregulare, Multiplicisphaeridium bifurcatum, Orthosphaeridium insculptum, Orthosphaeridium ternum, Orthosphaeridium inflatum,Orthosphaeridium bispinosum,Navifusa ancepsipuncta,Ordovicidium elegantulum ,Evittia denticulata, Actinotodissus crassus, Villosacapsola setosapellicula, Veryhachium oklahomense, Frankea hamulata, Veryhachium hamii, Tunispheridium eisenackii, Dactylofusa spinata,Eupoikilofusa cabottii, Polygonium gracile and Peteinosphaeridium accinctulum.*

Based on stratigraphic potential of the above -mentioned acritarch taxa, a Late Ordovician age is suggested for the Abastu and Abarsaj formations in the studied area. The known acritarch taxa from the late Ordovician sediments of southeastern Caspian Sea were compared with those of the same age elsewere, indicating the cosmopolitan distribution of acritarch taxa during the Late Ordovician time

On the other hand, the presence of acritarchs, chitinozoans and scolecodonts in the Late Ordovician sediments of Kholin-Darreh area suggests a marine environment for these sediments and it is consistant with those of other parts of Alborz, Zagros and Central Iranian basin.

A PALYNOLOGICAL INVESTIGATION OF THE EARLY MISSISSIPPIAN PRICE FORMATION OF WEST VIRGINIA, USA

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SUMMARY

The results of a palynological investigation focusing on the early Mississippian Price Formation of West Virginia, USA are presented. Two rock sections were selected for palynological analysis. Samples from Morgantown yield diverse and well preserved miospore assemblages assigned to the Verrucosisporites nitidus (LN) Biozone. In contrast, samples collected from the Price Formation from the vicinity of Caldwell yield poorly preserved miospore assemblages of low diversity which are tentatively assigned to the LN, BP and PC biozones.

MAIN FEATURES – INTRODUCTION

The Appalachian Basin is one of the most distinctive geological features on the North American Craton. Extending from Alabama to New York and trending SW-NE, the basin is approximately 1,075 miles long and covers an area of roughly 185,500 sq. miles. It contains rocks ranging in age from early Cambrian to early Permian. This study focuses on the Upper Devonian and Lower Mississippian strata within the basin. Rocks of this age in the Appalachian Basin can be divided into two distinct lithofacies; terrestrial clastics deposited along the eastern margin of the basin and marine shales and sandstones in the west.

Two rock sections in West Virginia within the terrestrial facies ‘belt’ were selected for palynological analysis; a road cut along Interstate Highway 64 near the town of Caldwell, Greenbrier County, and a borehole core drilled near Morgantown, Monongalia County (Figure 1). Over 70 samples were collected and processed using standard palynological techniques.

Various authors (including Molyneux *et al.* 1984, Clayton *et al.* 1998 and Streel & Traverse, 1978) have conducted palynological studies on Upper Devonian and Lower Mississippian strata in adjacent states. However, this is the first palynological investigation within the state of West Virginia at this stratigraphic level. West Virginia is known to contain some of the most complete and lithologically varied Mississippian sections within the Appalachian Basin (Arkle *et al.* 1979), but complex facies relationships, time transgressive boundaries and a plethora of synonyms for laterally equivalent rock units currently impede elucidation of the lithostratigraphy. Biostratigraphic dating and correlation of the sections have previously been limited by the poor resolution of the megafloral zonation of Read & Mamay (1964) and the scarcity of marine fossils in a succession dominated by terrestrial clastics .

Most of the samples used in this study were collected from a borehole core drilled in Mylan Park, Morgantown, close to the West Virginia – Pennsylvania state line. In total, 57 samples were collected from the core. The borehole penetrated the Meramecian (Viséan) Greenbrier Limestone and four members of the underlying Price Formation. In descending stratigraphic order, these are the Big Injun, Squaw, Weir and Murrysville sandstone members. These sandstones act as convenient marker horizons that permit tentative lithostratigraphic correlation. However, their use for this purpose is limited since they thin southwards towards the West Virginia Dome, an active syndepositional tectonic high. South of the West Virginia Dome, these sandstone members cannot be recognized and a tripartite division of the Price Formation is used; the lower part being divided into the Cloyd Conglomerate and Sunbury Shale members, while the upper portion remains unnamed, since its heterolithic character precludes ready subdivision into members (Carter and Kammer, 1990). A further fifteen samples were collected in this region from a large road cut through the Price Formation on Interstate Highway 64 near the town of Caldwell, WV.

PRELIMINARY RESULTS

Diverse and well preserved miospore assemblages were recovered from the Mylan Park core samples. Assemblages typical of the European *Retispora lepidophyta - Verrucosisporites nitidus* (LN) Biozone were recovered from strata below the Murrysville Sandstone Member. These assemblages include *Emphanisporites rotatus, Knoxisporites* cf. *triradiatus, Retispora lepidophyta*, *Retusotriletes crassus, Rugospora radiata, Vallatisporites pusillites*, *Vallatisporites verrucosus*, *and Verrucosisporites nitidus*.

Traditionally, the Devonian/ Carboniferous boundary has been placed at the top of the Murrysville Sandstone Member. Carter & Kammer (1990) reported Kinderhookian brachiopod taxa *Schuchertella macensis* and *Verkhotomia nascens* from the overlying Riddlesburg Shale at Keysers Ridge, Maryland. However, it has been noted in the present study that five miospore taxa (*R. lepidophyta, V. pusillites, Rugospora radiata, Hystricosporites spp.* and *Ancyrospora* spp.) which become extinct at the base of the Carboniferous occur above the level of the Riddlesburg Shale and are present throughout the core. This may represent extended ranges for these taxa in this region. However, it is far more likely that this represents reworking. Thus, in an attempt to locate the position of the Devonian/ Mississippian boundary, the relative abundances of these five taxa known to have range tops at this boundary were established. In the strata underlying the Murrysville Sandstone Member these species comprise between 7-20% of assemblages (mean 13%). Directly above the Murrysville, the same species comprise between 2-5 % (mean 4%) of the assemblage (Figure 2). This suggests that the Devonian/ Mississippian boundary lies within the Murraysville; an assertion supported by macrofossil evidence presented by Carter and Kammer (1990) who reported the late Famennian brachiopod taxa *Schuchertella bowdenensis*, *Syringothyris angulata* and *Cyrtospirifer* spp. from this unit in the vicinity of Morgantown. The presence of Upper Devonian miospore taxa such as *R. lepidophyta* throughout the section above the Murrysville, albeit in reduced numbers, suggests extensive reworking. Megaspores belonging to the Devonian genera *Ancyrospora* and *Hystricosporites* are typical components of the sub-Murrysville assemblages. Rare specimens of these taxa are also present above the postulated position of the Devonian/ Mississippian boundary; typically in the form of poorly preserved specimens and isolated processes with bifurcate tips. The poor preservation of these specimens further supports the notion of reworking.

In contrast to the assemblages described from the Mylan Park core, the Caldwell samples have yielded poorly preserved miospore assemblages of low diversity. Sample 1 from the Cloyd Conglomerate Formation contains a miospore assemblage which is tentatively assigned to the LN Biozone based on the presence of *Ancyrospora* spp., *R. lepidophyta, R. radiata, V. pusillites V. verrucosus* and *V. nitidus*. This is consistent with records of brachiopods belonging to the Late Famennian genus *Cyrtospirifer* sp. from the Cloyd Conglomerate at this locality (Carter & Kammer, 1990).

Samples 3 & 4 from the Sunbury Shale and 6 to 10 contain from the un-named upper part of the Price Formation contain assemblages dominated by *Spelaeotriletes balteatus* and *Vallatisporites* spp. These compare very closely to assemblages described by Clayton *et al.* (1998) from the Logan Formation in Ohio and are tentatively assigned to the *Spelaeotriletes balteatus* (BP) Biozone. Sample 11 contains an identical assemblage with the addition of *Spelaeotriletes pretiosus* and is thus assigned to the *S. pretiosus* (PC) Biozone. These results suggest that Allo-units B and C of Matchen & Kammer (1994) are Kinderhookian/Osagean in age rather than mid to late Kinderhookian as has been inferred based on previously available macrofossil and sequence stratigraphic evidence (Kammer personal communication 2007) The occurrence of selected miospore taxa present in the Caldwell samples is illustrated by Figure 3.

CONCLUSIONS

In northern West Virginia, assemblages from strata underlying the Murrysville Sandstone Member are assigned to the LN Biozone. The Devonian/ Carboniferous boundary is placed within or at the top of the Murrysville Sandstone Member. On the basis of the miospore evidence, the Murrysville correlates with the Bedford Shale and Berea Sandstone formations of Ohio. At Caldwell in south West Virginia, a miospore assemblage from the Cloyd Conglomerate Member is tentatively assigned to the LN Biozone and the Devonian/ Carboniferous boundary is placed at the top of this unit. The Sunbury Shale and the lower un-named portion of the Price are assigned to the BP Biozone, while assemblages from the upper un-named Price are assigned to the PC Biozone. The absence of the VI and HD biozones may suggest the presence of previously unrecognized unconformity, or a very condensed interval. Alternatively, the absence of the parent plants of the index species of these zones may have been due to local ecological conditions.

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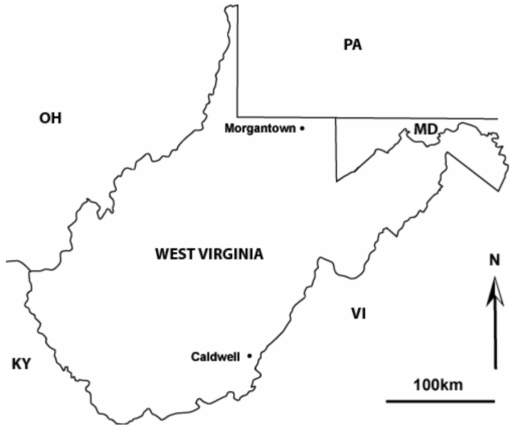

Figure 1. The location of sample localities in West Virginia, USA.

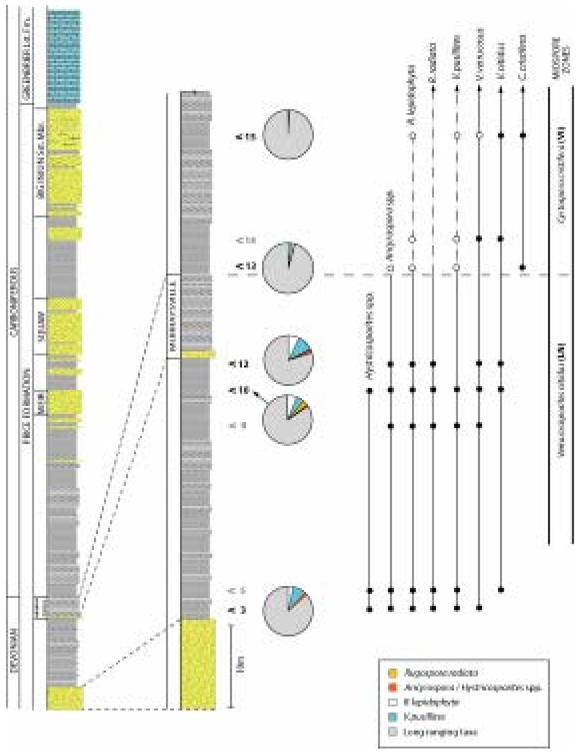

Figure 2. The relative abundance of selected miospore taxa from the interval below and

above the Murrysville Sandstone Member in the Mylan Park borehole core, Morgantown, West Virginia. The range and occurrence of stratigraphically important miospore taxa, inferred reworking and miospore biozones are also shown.

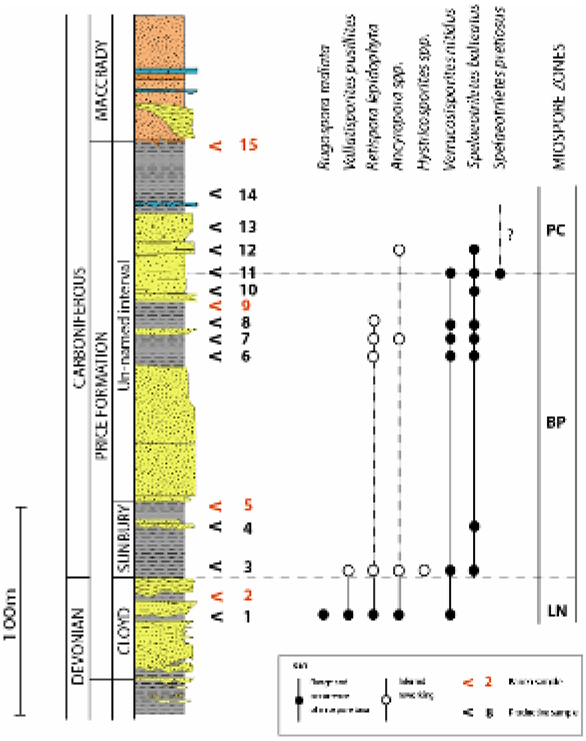

Figure 3. The range and occurrence of selected miospore taxa at the road cut on Interstate Highway 64 near Caldwell, Greenbrier County, West Virginia, USA.

GIVETIAN MEGASPORES FROM LIBYA AND BELGIUM

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SUMMARY

Two Middle Devonian localities have been investigated for megaspores. The first one is located in Belgium, in the Ronquières locality, well-known thanks to the recent discovery of the proto-ovule “*Runcaria*”. The second is in Libya, in the Ghadamis Basin. Samples have been collected from the A1-69 borehole. The assemblage observed in Belgium is similar to others from Poland and Canada. On the other hand, the Libyan assemblage is the richest known on the Gondwana. New species are observed. Palaeogeographic implications are mentioned.

Two Middle Devonian localities belonging to two different palaeoplates have been investigated for miospores and megaspores. The first locality is in Belgium, at Ronquières, around 40 kilometres south of Brussels and the second locality is the A1-69 borehole, in Ghadamis Basin, western Libya. An extended abstract has already been published on both localities (Ville de Goyet et al. 2007). After revision of the material, we can bring now more precisions on the composition of the megaspore assemblages.

1 - RONQUIÈRES (BELGIUM):

The outcrop is situated along a water channel linking Charleroi to Brussels, at the level of the “Plan incliné de Ronquières”. The siliciclastic Silurian layers of the Brabant Massif are overlaid unconformably by Middle Devonian layers of the northern flank of the Namur Synclinorium. The Middle Devonian layers belong to the Bois de Bordeaux Formation (Bultynck & Dejonghe, 2002). This formation is subdivided in three members, called in the stratigraphic order, Mautiennes, Bois de Planti and Mazy. The Mautiennes Member is mainly constituted by conglomerates, sandstones and, of less thickness importance, by sandy shales. The layers are mainly red and also sometimes green and grey in colour. The Bois de Planti Member is mainly formed by grey or dark grey shales and sandstones. Sandstones can incorporate levels with pebbles but never become real conglomerates. Many levels contain abundant remains of megaflora. Layers are lenticular. Fertile palynological samples mainly come from this member. The Mazy Member is similar to the Mautiennes Member. All those sediments are fluvial to near-shore. They are overlain by sediments becoming progressively more and more carbonaceous upwards, demonstrating the general transgression of the Middle Devonian sea on the Brabant Massif. This locality became famous recently since the discovery in a rock sample coming from this outcrop and hosted in the collections of the NIRSB of Brussels, of the proto-ovule “*Runcaria*” (Gerrienne et al., 2004).

Fourteen palynological samples contain miospores. Three of them are poor, and all others are rich in species (more than 45 species have been observed). Miospores are moderately well preserved, brown to dark brown in colour and sometimes strongly damaged by pyrite. Some of the species are important for the biostratigraphy. Among others, they are the following important species: *Chelinospora concinna*, *Geminospora lemurata*, *Grandispora velata*, and *Samarisporites triangulatus. G. lemurata, S. triangulatus* together with the *Ancyrospora ancyrea* megaspore characterise the TA Oppel Zone of Streel et al. (1987) and are observed from the lower part of the outcrop (respectively in the samples 23 and 24). *C. concinna* is observed in the single sample 37, in the upper part of the outcrop, and characterises with *S. triangulatus* the TCo Oppel Zone. Those biostratigraphic results demonstrate a Givetian age. All those species had also been observed in the rock fragment containing *Runcaria*, except *C. concinna* (Gerrienne et al., 2004). Seven samples from the outcrop and the "*Runcaria*" sample contain megaspores, all in the Givetian TA Biozone. They are abundant in some levels but usually moderately well preserved.

The assemblage is composed by: *Ancyrospora ancyrea* var. *ancyrea*, *A. ancyrea* var. *brevispinosa*, *Biharisporites articus* var *articus*, *Biharisporites capillatus*, *Biharisporites* spp., *Contagisporites optivus*, *?Cirratriradites grandis*, *Trichodosporites delicatus*, *Trichodosporites minor*, *Laevigatisporites* spp., and an unknown reticulate form. The assemblage is largely dominated by the *Biharisporites* specimens. This assemblage is similar, but poorer than assemblages from the Middle Devonian from Canada (Chi and Hills, 1976) and Poland (Fuglewicz & Prejbisz, 1981; Turnau & Karczewska, 1987)

2 - A1-69 (LIBYA):

During the revision of Devonian palynological samples from North Africa, large megaspores have been discovered from Givetian sediments sampled from the A1-69 borehole from the Ghadamis Basin, western Libya. This borehole has been drilled by SHELL in 1959 and samples have been provided during the eighties to the palynological laboratory of the Liège University thanks to the courtesy of D. Massa. Previous palynological results on this borehole have been published (Loboziak et al., 1992; Loboziak and Streel, 1989; Streel et al., 1990). However during those previous studies all samples had not been processed. Twenty nine samples, from 2109.5 ft up to 971 ft, have been studied or restudied for a PhD research work on miospores (PB) and for a master degree on megaspores (FdVdG). All samples contain miospores and, besides them, nine samples contain megaspores.

The deepest sample in the borehole containing megaspores is situated at 1496 ft. It belongs to the AD Oppel Zone (Loboziak & Streel, 1989). The first appearance of *Geminospora lemurata* characterising the Lem Interval Zone (Melo & Loboziak, 2003) is located a few feet above, at 1483 ft. The 1496 ft. sample is considered to belong to the upper part of the pre-Lem Biozone, latest Eifelian or earliest Givetian. The first appearance of *Samarisporites triangulatus*, at 1277 ft., characterises the base of the TA Oppel Zone of Givetian age. *Chelinospora concinna* characterising the TCo Oppel Zone has been observed in the upper part of the borehole. The base of this biozone is late Givetian in age. In summary all samples are Givetian in age, except the oldest one, 1496 ft. which could be latest Eifelian in age.

The megaspore assemblage is composed by: *Auroraspora macromanifestus*, *Biharisporites jubahensis*, a new species of *Biharisporites*, two others undetermined *Biharisporites* sp., *Contagisporites optivus* var *optivus*, *Contagisporites optivus* var *vorobjevensis*, a variety of *Contagisporites optivus* in open nomenclature, *Grandispora libyensis*, *Lagenicula* cf. *Lagenicula devonica* var. *reticulatus* Chi & Hills 1976, a new species of *Lagenicula*, and *Verrucosispora* cf. *Verrucosispora primus*. A new morphon has been created on the base of the species: *Heliotriletes longispinosus*. The morphon contains four new varieties of this species. This assemblage is the richest observed in the Devonian from Gondwana. It contains also the largest megaspores observed in the Middle Devonian with specimens reaching 1800 µm in diameter.

3 - PALAEOGEOGRAPHIC IMPLICATIONS

Clearly, heterosporous plants have less potentiality to be dispersed on long distances because, notably, of the large size of their propagules (megaspores). In addition microspore and megaspore of the same species need to be dispersed at the same moment and close each other to allow fertilization to produce a new plant. It is interesting to note that among those 20 taxa, 4 are known on the Old Red Sandstone Continent. Therefore, differences in the megaspore assemblages are probably mainly due to latitudinal differences and not to a palaeogeographic barrier. The Rheic Ocean was probably narrow and terrestrial paths between the Gondwana and the Euramerica plates existed. This palaeogeography existed at least since the Lochkovian (Steemans et al. 2007). The hypothesis of absence of a palaeogeographic barrier has been also argued recently by Marshall et al. (2007) on the presence of quite similar Givetian megaspore species of *Verrucisporites* in Arctic Canada (Chi and Hills, 1976) and in Saudi Arabia. Now, thanks to our results from Libya, the arguments are stronger as based on identical species from both palaeoplates.

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PALYNOLOGICAL CORRELATION OF SOME MISSISSIPPIAN (CARBONIFEROUS) STAGE BOUNDARIES

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SUMMARY

Early Mississippian miospore assemblages from the Midwest USA are described and compared with those from Europe. Assemblages from Kentucky can be tentatively assigned to latest Devonian and early Mississippian biozones from Europe. However, assemblages of similar age from the Mississippi Valley further to the West differ significantly from their European equivalents.

The introduction of the Mississippian and Pennsylvanian as subsystems of the Carboniferous has highlighted difficulties in the correlation of their constituent stages and stage boundaries (Fig. 1). A miospore zonal scheme for Western Europe has existed for a considerable time (Clayton *et al.* 1977) but no comparable zonation has been established for the USA.

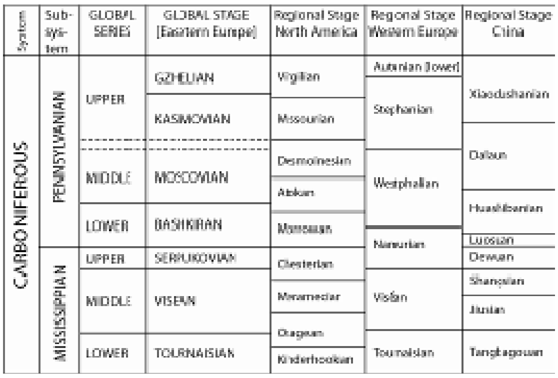

Fig. 1 Carboniferous global and regional stage correlation (Heckel and Clayton 2006)

This study focuses on marine sections at Morehead in Kentucky, and sections in the Mississippi Valley (Missouri and Illinois) (Fig. 2). Latest Devonian/Carboniferous miospore assemblages from Morehead closely resemble assemblages typical of the LN, VI, BP and PC biozones in Western Europe. Miospore assemblages typical of the BP and HD zones are not generally recognised in the USA. However, Richardson (2006) noted the occurrence of *Spelaeotriletes balteatus* (Playford) Higgs, *Vallatisporites vallatus* Hacquebard and *V. verrucosus* (Ibrahim) Ibrahim from the Michigan Basin suggesting this interval be assigned to the BP Biozone of Western Europe.

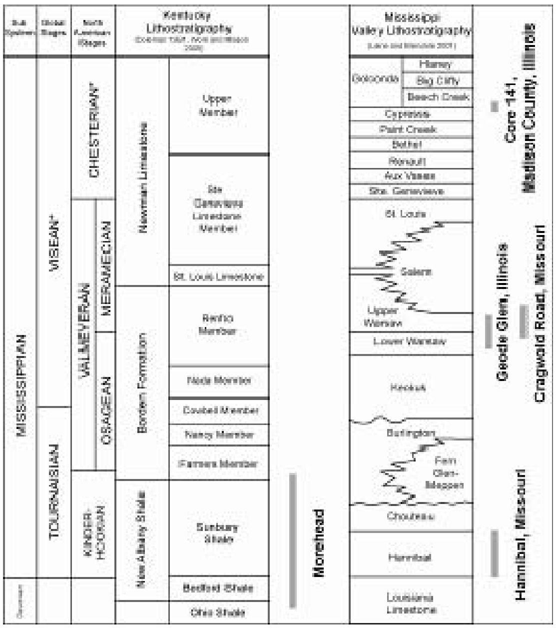

Fig. 2 Stratigraphic ranges of the studied sections. * in part.

Further west, within the classic Mississippian area, assemblages differ in composition to their European equivalents. An assemblage from the Kinderhookian Hannibal Shale at Hannibal, Missouri is assigned to the VI Biozone, though a relatively low diversity is noted in comparison to Europe. At Geode Glen, Illinois, and Cragwold Road, Missouri, the Osagean Warsaw Formation yields an assemblage comprising long ranging miospore taxa. However, Viséan zonal taxa commonly recognised at this stratigraphic level in Europe are notably absent. These include *Lycospora* spp., small densospores such as *Densosporities brevispinosus* Hoffmeister, Staplin and Malloy and *D. intermedius* Butterworth and Williams, *Knoxisporites stephanophorus* Love, *K. triradiatus* Hoffmeister, Staplin and Malloy and *Tricidorisporites* spp.

Assemblages obtained from core samples from the Cypress Formation of Madison County, Illinois include taxa such as *Schulzospora* and C*onvolutispora*, typical of the mid Viséan of Western Europe. Significantly, *Lycospora* is absent.

This preliminary research suggests that the Western European miospore zonation may be applicable in the Mississippi Valley up to and including the PC Biozone but a separate scheme will be required for the upper part of the Mississippian.

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AN ASSESSMENT OF THE GAS GENERATION POTENTIAL OF THE ORDOVICIAN KHABOUR FORMATION, WESTERN IRAQ

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A well-preserved acritarch and chitinozoan assemblage was recovered from 106 core and cutting samples from the Ordovician Khabour Formation in the Akkas-1 and Khleisya-1 boreholes of Western Iraq. The acritarch assemblage consists of 18 genera and 50 species. Common taxa include *Baltisphaeridium contrictum, Multiplicisphaeridium irregulare, Orthosphaeridium rectangulare,* and *Veryhachium trispinosum*. The chitinozoan assemblage is comprised of six genera and 22 species, including *Conochitina intermedia, C. campanuliformis, Desmochitina minor,* and *Rhabdochitina magna*. Based on the acritarch and chitinozoan taxa recovered, five palynozones are erected. Amorphogen dominates the kerogen component of the palynofacies in the lower part of the Khabour Formation, changing to mainly melanogen upwards in the boreholes.

Interpretation of gas generation potential is based on maturation assessment according to the Thermal Alteration Indices (TAI) of *Baltisphaeridium constrictum, Orthosphaeridium ternatus,* and *Diexallophasis* sp. which have a TAI of 3.8 as indicated by their dark brown color. Maturation levels indicate source potential for wet gas and condensates from Caradocian-age strata at depths between 2750-3000 m, and dry gas from Llanvirnian-age strata at depths between 3570-3600 m for borehole Akkas-1 only. These gas-potential source rocks have a TOC range between 0.5-1.0% by weight, highly biodegraded amorphous organic matter of 70-75%, and gas-prone type B kerogen. Therefore, this organic matter is capable of generating wet gas and condensates that could be trapped in stratigraphic facies within the same formation. It could also migrate upward to be trapped, along with the oil generated from the overlying Lower Silurian formations, at the stratigraphic unconformity with the Upper Silurian Akkas Formation along the flanks of the Gaara Uplift. Such a scenario could also extend into Syria and Jordan.

Based on paleontologic and palynologic analysis, deposition of the Khabour Formation in the Akkas-1 borehole ranged from an inner to outer neritic marine environment. Deposition of the Khabour Formation for the Khleisya-1 borehole, was seemingly restricted to the outer neritic marine realm.

NEW PALYNOLOGICAL AGES IMPROVING THE GEOLOGICAL BACKGROUND OF THE RÍO TINTO MINE AREA (SPANISH PART OF THE IBERIAN PYRITE BELT)

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SUMMARY

Recent palynostratigraphic studies developed in the Río Tinto mine, the largest and historically most representative mining district of the Iberian Pyrite Belt, allow the identification of the following ages, for the first time, a Tournaisian age (CM miospore biozone) were found in intra-VSC slates and conglomerates and an upper Visean (NM and VF miospore biozones) age was constrained for the CG. A comparative study of the data obtained in these investigations with other palynological and radiometric data in close areas were established. These ages reinforced the structural interpretation of the Rio Tinto mine region.

Despite Río Tinto is a world size mining district, its geological setting is not completely understood. In the last years palynological studies have revealed to be a helpful tool for the stratigraphic and structural knowledge of the whole Iberian Pyrite Belt -IPB- (Cunha et Oliveira, 1989; Pereira et al., 1996; Rodríguez et al., 2002; Oliveira et al., 2004; Pereira et al., 2004, González, 2005; Oliveira et al., 2006). During a structural field survey, 38 samples were collected inside the mine area and processed following standard palynological laboratory procedures (Wood et al., 1996). The slides were examined with transmitted light, with a BX40 Olympus microscope equipped with an Olympus C5050 digital camera. All samples, residues and slides are stored at INETI, Department of Geology, S. Mamede Infesta, Portugal. The miospore biozonal scheme used follows the standard Western Europe Miospore Zonation (Clayton *et al*, 1977; Clayton, 1996; Higgs *et al*, 1988; Streel *et al*, 1987). The results were compared to palynological and radiometric studies in nearby areas (see C on figure 1 and figure 2); including a very complete study of the Neves-Corvo mine, in the Portuguese part of the IPB (Oliveira et al., 2004; Pereira et al., 2004).

The mine sector studied is situated in the IPB, the most internal part of the South Portuguese Zone -SPZ- (see A and B on figure 1). The latter is considered a palaeozoic exotic terrane accreted to the Gondwanan margin during Variscan times by the consumption of the Rheic Ocean (Munhá et al., 1986; Crespo & Orozco, 1988; Silva et al., 1990; Quesada, 1991; Martínez Catalán et al., 1997; de la Rosa *et al.*, 2002). The three main sequences of the SPZ cropping out in the IPB (Schermerhorn, 1971; Oliveira, 1983) are, from older to younger:

a) Phillyte and Quartzite Group (PQG); b) Volcanic-Sedimentary Complex (VSC); and c) the Variscan synorogenic Culm Group (CG). The Variscan Orogeny generates a south verging, thin-skinned fold and thrust belt which propagates southwards (Silva et al., 1990; González-Clavijo et al., 1994; Quesada, 1998).

Two samples collected in the VSC yielded miospores assigned to the CM biozone of late Tournaisian age. Assemblages contain moderately to well preserved miospores, that include *Auroraspora macra, Crassispora trychera, Densosporites spitsbergensis, Granulatisporites microgranifer, Knoxisporites* cf. *triradiatusSchopfites cf. claviger, Spelaeotriletes sp., Vallatisporites microspinosu,. V. pusillites* and *Verrucosisporites* sp. Present are also the species, *Cristatisporites* sp., *Knoxisporites concentricus, Retispora lepidophyta*, *Verrucosisporites bulliferus* and *V. premnus* that are interpreted as reworked miospores, of late Famennian and late Strunnian age.

The CG, in the region provided several samples containing moderately preserved assemblages of miospores, assigned to the NM Biozone of mid late Viséan. In general, assemblages contain the key specie *Raistrickia nigra* along with *Densosporites brevispinosus*, *Dictyotriletes castaneaeformis, Granulatisporites microgranifer, Knoxisporites stephanephorus, Knoxisporites triradiatus, Leiotriletes sp., Leiotriletes tumidus* and *Microreticulatisporites concavus.*

Three main conclusions arose from a comparative study of these results with other palynological and radiometric investigations in close areas (figure 2).

The top of the PQG is not visible in the mine, but in the surrounding area it is coincident with the Famennian-Tournaisian limit (Rodríguez *et al.*, 2002). PQG in the Neves-Corvo mine is dated late Famennian (VH miospore biozone in Oliveira et al., 2004).

Tournaisian miospores (CM miospore biozone) were only just found in intra-VSC slates and conglomerates. This matches the radiometric ages of volcanic rocks inside the VSC and intrusive rocks of the Sierra Norte Batholilth (Barrie *et al.*, 2002; Dunning *et al.*, 2002), but it is not consistent to the upper Strunian age (LN miospore biozone) of the black slates bearing the stratabound massive sulphide mineralization in both, Río Tinto and Neves-Corvo. The stratigraphic sequence considers the ore body layer situated on the top of the VSC, whose age can reach the mid late Visean (Oliveira et al., 2004).

CG age is well constrained at the upper Visean (NM and VF miospore biozones, figure 1) for all the area with the exclusion of the Peña de Hierro data (TS and TC miospore biozones, figure 1). The northern orogenically internal position of this late group of samples with respect to the southern external location of the Río Tinto and Jarrama Section, displaying younger CG samples, perfectly fits in to a structural stacking of thrust sheets, arranging slightly older synorogenic materials on the top of the synorogenic sequence. This supports the thin-skinned tectonic style for the region and predicts a more complex structure for the formerly considered a simple syncline with CG in the core (Río Tinto synform in figure 1-C).

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REGIONAL CORRELATION ON THE BASIS ON PERMIAN PALYNOMORPHS: SOUTHEAST TURKEY – NORTH IRAQ

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ABSTRACT

In the last decades the Permian deposits of Southeast Turkey were difficult to date solely on the basis on palynology. Age assessments for same strata yielded Early as well as Late Permian ages and could not be assigned reliably to stages. Similar problems are known from adjacent countries like Iraq and Jordan. However, on the basis on fusulinid biozonations there are age assignments from Wordian to Changxingian for the Permian deposits of Southeast Turkey, and therefore also the palynological assemblages from this

region can be related to the time scale now. In correlation with the standard biozones for Oman and Saudi Arabia the palynomorphs of Southeast Turkey belong to the OSPZ6 biozone, at their base also fixed in time with a probable Wordian age. With some key taxa of OSPZ6 like ?*Florinites balmei* Stephenson and Filatoff 2000 and *Camptotriletes warchianus* Balme 1970, together with significant taxa of the Southeast Turkish assemblages, parts of borehole sections from North Iraq can be correlated with the standard stages.

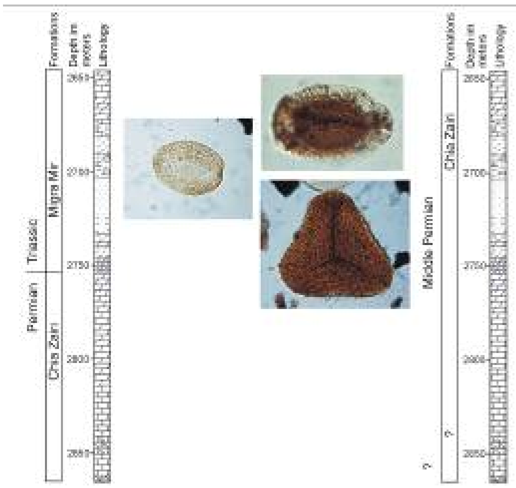

Fig. 1 Borehole Mityaha-1, Southwest Mosul City, Iraq. Former consideration (left column), reinterpretation (right column) and significant palynomorphs (?*Florinites balmei*, ?*Vallatisporites* sp., *Camptotriletes warchianus*) of the Wordian and Capitanian of Southeast Turkey and North Iraq.

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UPPER DEVONIAN PALYNOMORPHS FROM THE GEIRUD FORMATION, SOUTHWEST OF DAMGHAN, CENTRAL ALBORZ MOUNTAINS, NORTHERN IRAN

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SUMMARY

Moderately diverse and reasonably well-preserved palynofloras, dominated by miospores and acritarchs (*sensu lato*), occur in surface samples of the Geirud Formation, southwest of Damghan, Iran. Scolecodonts also occur as subordinate components of the studied palynofloras. The microphytoplankton and miospores combined indicate a Late Devonian (Frasnian-Fammenian) age for the Geirud Formation at the study section. The associated marine microphytoplankton, scolecodonts, along with miospores implies a nearshore depositional setting.

Keywords: Upper Devonian, miospores, microphytoplankton, Geirud Formation, Alborz Mountains, Iran

INTRODUCTION

Marginal marine Middle-Upper Devonian sediments from north and central Iran generally yield reasonably diverse and variably preserved faunas (summarized in Stöcklin, 1972) applicable to relative age determination. However, this potentiality has not been utilized for detailed age determination and stratigraphic correlation of the Iranian Middle-Upper Devonian strata in either regional or international contexts.

Additionally, yields of moderately diverse palynomorphs of both land-derived and marine origin occurring in the Iranian Middle-Upper Devonian sequences (Hashemi and Playford, 1998) provide independent evidence on the age of the host strata, supplementing the available faunal evidence. Furthermore, comparison of the results of palynological investigation on the Iranian Devonian strata with those obtained from coeval sediments of adjacent areas (e.g., Clayton et al., 2000; Loboziak, 2000; Higgs et al., 2002) could shed light on the palaeogeography and phytogeographic history of this area during the Devonian time.

GEOLOGICAL SETTING AND STRATIGRAPHY

Stöcklin (1968) divided Iranian geology into various tectono-stratigraphic units including the almost west-east trending spectacular Alborz Mountains of northern Iran. A varied and thick (up to several thousand meters) sequence spanning, admittedly with some interruptions, the Precambrian-Quaternary interval exposed in the Alborz Mountains. The stratigraphic framework of the Devonian sediments in the Alborz Mountains was established by Assereto (1963), Bozorgnia (1973) and Alavi and Bolourchi (1973).

The Geirud Formation (Assereto, 1963) was initially introduced to denote Devonian sediments in the central Alborz Mountains. At the study section, 35 km southwest of Damghan, central Alborz Mountains (Figure 1), the Geirud Formation rests with a distinct unconformity upon the Lashkarak Formation and is conformably succeeded by the Mobarak Formation. The sequence commences with thick-bedded red conglomerate, quartzite, and sandstone intercalated with minor yellow to red, palynologically non-productive shale. Few poorly preserved plant megafossils, identifiable only at the supra-generic level as Lepidodendrales, are the only fossils sporadically occurring therein. Upward, the sequence continues with alternation of limestone, sandstone, dolostone, and shale. Earlier palynological investigations (e.g., Kimyai, 1972, 1979, Hashemi and Fahimi, 2006) have already indicated the presence of variably diverse palynofloras in the Geirud Formation.

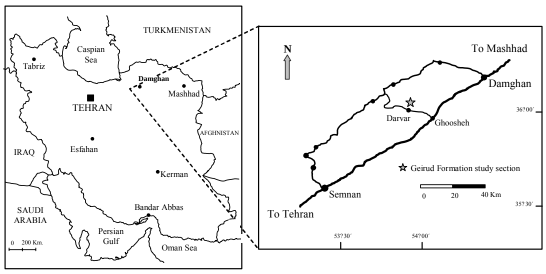

Figure 1: Sketch map showing the location of the Geirud Formation study section, 35 km southwest of Damghan, northeastern Iran.

PALYNOLOGY

The majority of the study samples contain variably diverse and reasonably well-preserved palynofloras dominated by miospore and microphytoplankton floras; some representatives of which are illustrated in Plate 1. Most of the miospores are trilete; only one species of monolete and hilate categories was encountered. Scolecodonts also occur as a subordinate component of the studied palynofloras.

The combined microphytoplankton and miospore data indicates a Late Devonian (Frasnian-Fammenian) age for the Geirud Formation at the study section; this dating generally corroborates the faunal evidence. Of the miospore assemblages, *Retispora lepidophyta* is particularly useful in palynologically locating the global Devonian-Carboniferous boundary. *Geminospora lemurata*, *Retispora lepidophyta, Grandispora cornuta, Grandispora* sp. cf. *G. gracilis,* eponymous index species of the *lemurata-magnificus*, *pusillites-lepidophyta, radiate-cornuta, torquata-gracilis* Assemblage Zones of Richardson and McGregor's (1986) zonation scheme, respectively, are identifiable in the Geirud Formation's palynofloras.

The occurrence of marine microphytoplankton (acritarchs and prasinophyte phycomata) as well as scolecodonts with numerous miospores indicates a nearshore depositional setting for the Geirud Formation.

The co-occurrence of *Geminospora lemurata* and a meager, poorly diversified and indifferently preserved megaflora (identifiable only at the supra-generic level as Lepidodendrales) collectively attests to the presence of archaeopterid progymnosperms among the contemporaneous coastal vegetation. In addition, the presence of miospores widely assigned to Rhyniopsida, Cycadopsida, Zosterophyllopsida, Equisetopsida, Ginkgopsida, Lycopsida, Filicopsida, and Barinophytopsida refers to the probable source of the dispersed spores.

The Geirud palynofloras share some key elements with coeval assemblages reported elsewhere in northern and central Iran. Beyond Iran, the alliance with ±co-eval Australian palynofloras is prominent.

CONCLUSIONS

Palynofloras, dominated by variably diverse and reasonably well-preserved miospore and microphytoplankton floras, occur in the majority of the studied samples. Scolecodonts also occur sporadically.

The majority of miospores are trilete; few bilaterally symmetrical and hilate forms are also represented.

A Late Devonian (Frasnian-Fammenian) age is inferred for the Geirud Formation at the study section, and this is in general accord with the known faunal evidence.

Eponymous index species of the *lemurata-magnificus*, *pusillites-lepidophyta, radiate-cornuta, torquata-gracilis* Assemblage Zones are identifiable in the studied palynofloras.

Co-occurrence of acritarchs and prasinophyte phycomata as well as scolecodonts with numerous terrestrial palynomorphs indicates a nearshore depositional setting for the Geirud Formation.

Association of *Geminospora lemurata* with a sparse, poorly diversified and indifferently preserved megaflora together indicates the presence of archaeopterid progymnosperms among the contemporaneous coastal vegetation. In addition, the presence of miospores widely assigned to Rhyniopsida, Cycadopsida, Zosterophyllopsida, Equisetopsida, Ginkgopsida, Lycopsida, Filicopsida, and Barinophytopsida refers to the probable source of the dispersed spores.

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Plate 1

Explanation of Plate 1

Figs. 1, 2. *Dictyotidium araiomegaronium* Hashemi and Playford, 1998. Figs. 3, 4. *Dictyotidium senticogremium* Hashemi and Fahimi, 2006. Fig. 5. *Papulogabata annulata* Playford in Playford and Dring, 1981. Figs. 6, 7. *Leiosphaeridia* spp. Fig. 8. *Deltotosoma intonsum* Playford in Playford and Dring, 1981. Fig. 9. *Dictyotidium* sp. A. Fig. 10. *Dictyotidium craticulum* (Wicander and Loeblich) Wicander and Playford, 1985. Fig. 11. *Cymatiosphaera spicigera* Playford in Playford and Dring, 1981. Fig. 12. *Cymatiosphaera perimembrana* Staplin, 1961. Fig. 13. *Gorgonisphaeridium telum* Wicander and Playford, 1985. Fig. 14.

Gorgonisphaeridium plerispinosum Wicander, 1974. Fig. 15. *Elektoriskos tenuis* Playford in Playford and Dring, 1981. Fig. 16. *Unellium piriforme* Rauscher, 1969. Fig. 17. *Unellium lunatum* (Stockmans and Willière) Eisenack et al., 1979. Fig. 18. *Micrhystridium* sp. cf. *M. pentagonale* Stockmans and Willière, 1963. Fig. 19. *Micrhystridium stellatum* Deflandre, 1945. Fig. 20. *Tornacia sarjeantii* Stockmans and Willière, 1966. Fig. 21. *Saharidia lusca* Playford in Playford and Dring, 1981. Fig. 22. *Lophosphaeridium granulosum* (Staplin) Playford, 1976. Fig. 23. *Lophosphaeridium* sp. cf. *L. umbonatum* Hashemi and Playford, 1998. Fig. 24. *Gorgonisphaeridium asperum* Hashemi and Playford, 1998. Fig. 25. *Gorgonisphaeridium tabasense* Hashemi and Playford, 1998. Fig. 26. *Chomotriletes vedugensis* Naumova, 1953. Fig. 27. *Maranhites perplexus* Wicander and Playford, 1985. Figs. 28, 29. Scolecodonts. Fig. 30. *Veryhachium downiei* Stockmans and Willière, 1962.

THOUGHTS ON SPOROMORPH DATA AND THE ORIGIN AND EVOLUTION OF THE EARLIEST LAND PLANTS: AN UPDATE.

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SUMMARY

Early records of cryptospores, miospores and in situ sporomorph are reviewed in an attempt to establish the timing of the first appearance of early land plants, and their subsequent evolutionl. Cryptospores appear first and dominate Lower Palaeozoic microfloras but their parent plants are poorly known. The earliest trilete spores occur in the Aeronian and are equatorially crassitate (Ambitisporites); proximally retusoid miospores (Retusotriletes) appear later in the upper Ludfordian. Both spore types have been found in situ and their parent plants may represent the early divergence of two separate plant groups but anatomical data from their parent plants is often sketchy.

With regard to the origin of the land flora ….

"The primary source of evidence has been the study of living Archegoniatae [higher plants]; but the reasoning based on these has been checked by reference to palaeontological facts. This mode of enquiry should lead to more valuable results in the organographic study of Land-Plants at large than any mere search for phyletic schemes." (Bower 1935, p.635).

Since Bower's famous book was published a great deal of relevant new *in situ* (Edwards and Richardson, 2004) and dispersed spore data has been published. Dispersed spore data is reviewed using the two most important principles proposed by Banks for plant fossils (*inter alia* 1968) that palaeobotanical data should be carefully scrutinised to accurately ascertain a) the nature of the fossil remains and b) to assess any independent dating so that their relative appearance in the geological sequence can be established. Often one or both of these objectives cannot be satisfied. Publications in which the palaeontological remains are not accurately identified are common, and frequently the remains are in continental deposits where, unless there is interdigitation with marine deposits, independent dating by marine invertebrate zonal fossils is not possible. However, more constructively, there has been an explosion of Late Prídolí and Early Lochkovian data on *in situ* spores (mainly trilete) and dispersed cryptospores. Cryptospores occur earlier but have been described less frequently from sporangia though spore masses of dyad "cryptospores" were described by Lang as early as 1937 (see also Shute *et al.* 1996). More recently a wealth of data a wealth of data has been accumulated on permanent tetrads, pseudodyads, loose dyads, hilate and alete monads (Gray 1985, Richardson 1985, 1988 1996; Strother and Traverse, 1979, Wellman 1996). Dispersed miospores are common in many areas from the Mid-Palaeozoic (Burgess 1991, Burgess and Richardson 1991, Burgess and Richardson 1995, Richardson and Lister 1969). New work on the petrifactions and associated sediments from the Rhynie Chert flora (Edwards 2003, Wellman 2007) has revealed tantalising new palaeobotanical and palynological insights. Nevertheless challenges remain including accurate description, assessment and dating of fossil plant data in relation to the evolution and dispersal of the land flora.

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PALAEOECOLOGICAL AND POSSIBLE EVOLUTIONARY EFFECTS OF EARLY NAMURIAN GLACIOEUSTATIC CYCLICITY REVEALED BY PALYNOLOGY, ISOTOPES AND ORGANIC GEOCHEMISTRY

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SUMMARY

Early Namurian sedimentary cycles in the Throckley and Rowlands Gill boreholes, near Newcastle-upon-Tyne, UK, consist of fossiliferous limestones followed by (usually unfossiliferous) black mudstone, followed by sandstones and then often by thin coal seams. Sedimentological and regional geological evidence suggests that the largest are high amplitude cycles, most likely of glacioeustatic origin. $\delta^{13}C$ (of bulk organic matter) delineates marine and non marine conditions due to the large difference between $\delta^{13}C$ marine organic matter (c.–30‰) and $\delta^{13}C$ terrestrial (c.–23‰), and indicates only intermittent full marine salinity resulting from glacioeustatic marine transgression superimposed on a background of constant inundation by freshwater from the north by large rivers, which killed off the marine biota. Palynology suggests that terrestrial plant groups, including ferns, putative pteridosperms and forest mire plants were affected by changing sea level, and that there may be a connection between cyclicity

and the appearance of monosaccate pollen such as *Potonieisporites*. Phytoclasts, common in the palynofacies preparations, contain some of the earliest molecular chemical evidence of lignin. Long term terrestrial and marine increasing $\delta^{13}C$ (organic) may reflect the onset of major glaciation in Gondwana, since there is some evidence to suggest that the two are coeval, but no specific mechanism can be suggested to link the trends.

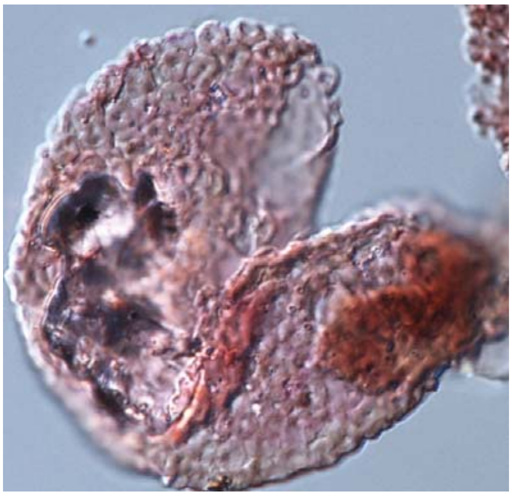
More contributions

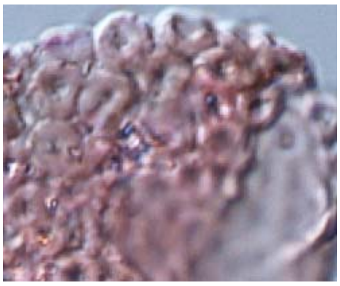
Please contribute articles to the *Newsletter*. Items on new techniques, research, book reviews and ideas are all welcome

Anyone seen this before?

Mike Stephenson

As part of palaeontological study of the proposed basal Artinskian (Lower Permian) GSSP, palynological samples were taken from the Dal'ny Tulkas section in southern Urals, Russia in July 2007 (see Davydov, V. & Henderson, C. 2007, Permophiles 49, 4-6). In a few samples a curious palynomorph was recovered (see below)





Algal palynomorph sp. A from Dal'ny Tulkas, diameter of specimen 60 µm

Algal palynomorph sp. A appears to be non-haptotypic, and has ring-like ornament elements.

Algal palynomorph sp. A from Dal'ny Tulkas, diameter of specimen 60 µm

Has anyone seen anything like this before? I would be pleased to hear from anyone who has (mhste@bgs.ac.uk)

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