(SS39) Precambrian to Palaeozoic Palynology: the state of the art (CIMP-sponsored Symposium)

Date: August 25
Place: Room 5333 (oral), Room 6318 (poster)
Organizers: Marco Vecoli & Charles Wellman
Contact email address: marco.vecoli@aramco.com
Purpose: Recent Precambrian to Palaeozoic research have witnessed the application of organic-walled microfossils (acritarchs, miospores, chitinozoans) for the solving of fundamental palaeobiological problems and for a deeper understanding of global functioning of complex ecosystems and biosphere-geosphere interactions. The use of new analytical techniques on single either in situ or isolated specimens is now providing new insights into the nature of the enigmatic Palaeozoic palynomorphs. On the whole, these new developments have had an impact also on the fundamental use of palynomorphs in the classic field of biostratigraphy, greatly expanding the potential for refinement of existing biozonations.
This Symposium invites contributions on cutting-edge Precambrian and Palaeozoic palynomorph research and application to palaeoclimatic and palaeoenvironmental reconstructions, evolution of oceanic microphytoplankton, early terrestrial ecosystems, high-resolution palynostratigraphy in application to oil exploration.

Oral Presentation

Aug. 25 [AM1] Room: 5333

Chair: Charles Wellman

9:00-9:40 **[Keynote] The incomplete story of the Palaeozoic phytoplankton** SS39-O01 (463)

Thomas Servais

9:40-10:00 **Acritarch biostratigraphy of the Lower-Middle Ordovician in South China** SS39-O02 (280)

Jun Li, Kui Yan, Thomas Servais

10:00-10:20 **Palynostratigraphy of Ordovician-Silurian transition in Southeastern Anatolia, Turkey** SS39-O03 (448)

Recep Hayrettin Sancay, Aksel Tugba Dinc

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Chair: Charles Wellman

10:50-11:10 **Palynostratigraphy of the Frasnian-Famennian boundary deposits in the Lower Volga region, Russia** SS39-O04 (307)

Valentina Mantsurova

11:10-11:30 **Palynology of the Upper Palaeozoic strata, southeastern Nodeh, northeastern Iran** SS39-O05 (173)

Hossein Hashemi

11:30-11:50 **Pennsylvanian (mid- Bolsovian-Cantabrian; Moscovian) vegetation change in the Bristol Coalfield, UK** SS39-O06 (402)

Janine L. Pendleton, Charles H. Wellman, Christopher J. Cleal

11:50-12:10 **The Late Palaeozoic palyno-biostratigraphy in Northern Ordos Basin and its palaeogeographical significance** SS39-O07 (288)

Feng Liu, Huaicheng Zhu

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14:30-15:10 **[Keynote] Evolutionary stasis of sporopollenin biochemistry revealed by unaltered Carboniferous spores** SS39-O08 (296)

Barry Lomax, Wesley Fraser, Andrew Scott, Anne Forbes, Ian Glasspool, Roy Plotnick, Fabien Kenig

15:10-15:30 **Palyno-petrographical facet and depositional account of Gondwana sediments from East Bokaro coalfield, Jharkhand, India** SS39-O09 (359)

Srikanta Murthy, Mahesh.S

15:30-15:50 **Permian phytoplankton diversity: a big surprise** SS39-O10 (270)

Yong Lei, Thomas Servais, Qinglai Feng

Poster Presentation

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13:30-14:30 **The Ordovician acritarch genus *Barakella*** SS39-P01 (586)

Kui Yan, Jun Li, Thomas Servais

Lopingian palynomorphs in the Linxi Formation, Inner Mongolia, China SS39-P02 (504)

Yuewu Sun, Shuqin Zhang, Chuanbiao Wan, Dejun Zhang, Mingsong Li

Palynology, palynofacies and organic geochemistry from the latest Permian of the Yangtze Block, South China SS39-P03 (269)

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Palynology: A good tool of resolving stratigraphic problem of the Karoo strata in Tanzania SS39-P04 (356)

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SS39-O01 (463)

The incomplete story of the Palaeozoic phytoplankton

Thomas Servais

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The modern oceans display three major groups of marine phytoplankton: the calcareous (coccolithophores, etc.), siliceous (diatoms, etc.) and organic-walled (dinoflagellates, etc.) phytoplankton. The fossil record indicates that elements of the organic-walled microphytoplankton were most probably present in the oceans since the Precambrian. However, the presence of calcareous and siliceous phytoplankton in the Precambrian and Palaeozoic is not clearly established, coccolithophorids and diatoms only appear in the fossil record in the early Mesozoic. In the Palaeozoic the fossil record of the acritarchs can be used as a proxy for the larger marine organic-walled microplankton (> 20 µm), the smaller fractions of the phytoplankton, the picoplankton and the bacterioplankton having usually not been documented. Although the artificial group of the acritarchs is, by definition, polyphyletic, many of the Palaeozoic acritarchs most probably represent the cysts of phytoplanktonic organisms, similar to modern organic-walled dinoflagellates. The diversity changes of the Palaeozoic acritarchs at the species and genus level indicate some major palaeoecological trends and allow us to redraw partly the evolution of the marine phytoplankton from the Cambrian to the Permian. Here we present a summary of the evolution of the Palaeozoic organic-walled phytoplankton in major steps: a long-term Cambrian-Ordovician radiation, most probably triggering the ‘Ordovician plankton revolution’ (Servais et al., 2008), possibly following a ‘pulse of atmospheric oxygen’ in the Late Cambrian (Saltzmann et al., 2011); fluctuating diversities in the Silurian and Early Devonian, leading to the ‘Devonian nekton revolution’ (Klug et al., 2010); a dramatic decrease during the Late Devonian-Early Carboniferous interval; a period with apparently low diversities during the ‘Late Palaeozoic phytoplankton blackout’ (Riegel, 2008). Similarly to Mesozoic-Cenozoic phytoplankton diversities, the acritarch diversity in the Lower and Middle Palaeozoic can roughly be correlated with sea levels. Moreover, the Palaeozoic diversity curve can also partly be compared with the evolution of the atmospheric pCO_2 (Strother et al., 2010). However, the fossil record of the Palaeozoic phytoplankton is far from being complete and most interpretations remain highly speculative.

Keywords: phytoplankton, acritarchs, Palaeozoic, Ordovician plankton revolution, Devonian nekton revolution.

SS39-O02 (280)

Acritarch biostratigraphy of the Lower-Middle Ordovician in South China

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As the Global Stratotype Section and Points (GSSPs) for the base of three stages of Ordovician have been defined in South China (base of the Dapingian, Darriwilian and Hirnantian), the biostratigraphical implications of acritarch are reconsidered. Based on the acritarch assemblages from Huanghuachang section (GSSP for the base of the Dapingian) and the nearby section at Daping in the Yichang area, from Huangnitang section (GSSP for the base of the Darriwillian) in the Changshan area, from Honghuayuan section in the Tongzi area, from Guanyinqiao section in the Qijiang area and from Houping section in the Chengkou area, several biostratigraphically significant acritarch taxa are recognized. *Aureotesta*, *Striatotheca* and the *Veryhachium lairdii* - *V. trispinosum* groups appear in the basal part of the Floian in South China, while *Ampullula*, *Arbusculidium filamentosum*, *Coryphidium bohemicum*, *Sacculidium* and *Tongzia* first appear slightly higher. The FADs of *Barakella* and *Liliosphaeridium* indicate the base of the Dapingian, and *Orthosphaeridium* and *Dicrodiacrodium* first appear higher in the Dapingian. Most of these acritarch taxa can be

correlated within sedimentary basins from other peri-Gondwana regions, some of them can also be correlated with those in Baltica. According to stratigraphical studies on graptolites and conodonts, a precise Ordovician biostratigraphical framework has been built up in South China and can be correlated with other palaeocontinents. From the above-mentioned six Lower - Middle Ordovician sections and from four sections in the Miaopo Formation from the Yichang area, and based on the First Appearance Data of several index acritarch taxa, six acritarch assemblage zones are recognized, in ascending order: the *Veryhachium trispinosum* - *V. lairdii* - *Striatotheca* Zone, the *Coryphidium* - *Sacculidium* Zone, the *Ampullula* - *Arbusculidium* Zone, the *Barakella* - *Arkonia* Zone, the *Dicrodiacrodium ancoriforme* Zone and the *Navifusa* - *Gyalorhethium* Zone. These acritarch assemblage zones are well correlated with the graptolite biozones in South China and can be integrated in a global scheme of acritarch biozonation.

Keywords: acritarchs, South China, Ordovician, biostratigraphy.

SS39-O03 (448)

Palynostratigraphy of Ordovician-Silurian transition in Southeastern Anatolia, Turkey

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Early Paleozoic sediments of Northern Gondwana has taken so much attention in terms of oil exploration since Early Silurian sediments have good to excellent source rock potential while Late Ordovician sediments are mainly evaluated as reservoir rocks. This play concept has also been tested in several wells in southeastern Turkey similar to many localities in Northern part of Gondwana (e.g. Libya, Saudi Arabia, Oman). Paleogeographically, southeast of Turkey is such a unique location to study Ordovician and Silurian successions as being the northern margin of Gondwana. Silisiclastic dominant deposition represented by Bedinan and Dadas formations comprise the Ordovician-Silurian transition and yield very well preserved and abundant acritarch and chitinozoan assemblages and rich in organic matter. Two conventional cores have been taken from Lower Silurian (Llandoverian) and Upper Ordovician (Ashgilian) sediments from the well drilled in northwestern part of Diyarbakir, Turkey. Cores and cuttings collected from above, between and below the cores have been studied semi-quantitatively and the distribution of acritarch and chitinozoan assemblages documented. Common occurrences of *Domasia bispinosa*, *Cymbosphaeridium pilaris, Diexallophasis denticulatum*, *Oppillatala eoplanktonica*, *Sphaerochitina lepta*, *Conochitina edjelensis*, *Angochitina papillata* and *Ancyrochitina fragilis* dominate the Lower Silurian (Llandoverian) sediments whereas Upper Ordovician (Ashgilian) sucsessions have been represented by *Vilosacapsule setosapellicula*, *Baltisphaeridium hirsutoides*, *Baltisphaeridium longspinosum*, *Baltisphaeridium latiradiatum, Veryhachium subglobosum*, *Veryhachium trisulcum*, *Multiplicisphaeridium bifurcatum, Eupoikilofusa striatifera*, *Calpichitina lenticularis*, *Ancyrochitina merga*, *Plectochitina sylvanica* and *Orthosphaeridium* sp. Palynofacies analyses reveal that Lower Silurian sediments have dominated by amorphous type of organic matter (up to 90 %) with some acritarchs and chitinozoan fragments. Upper Ordovician sediments, on the other hand, have more acritarchs and chitinozoan fragments and less amorphous content. Deposition took place in marine depositional conditions. Pyritization seen on amorphous type of organic matter reflects anoxic depositional settings.

Keywords: palynology, acritarch, chitinozoan, Northern Gondwana.

SS39-O04 (307)

Palynostratigraphy of the Frasnian-Famennian boundary deposits in the Lower Volga region, Russia

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Frasnian-Famennian boundary deposits are stripped by boreholes in the 2400-5200 m depth interval. These deposits include Livny, Volgograd and Zadonsk horizons and are characterized by brachiopods, ostracods, miospores, rarely conodonts. A generalization of the results of palynological research of Livny, Volgograd and Zadonsk horizons has been carried out. Chelinospora lepida-Grandispora subsuta (LS) zone corresponds to the Livny horizon (0-142 m in thick) of Frasnian Stage. In shallow-marine facies this horizon is represented by limestones, marls and argillites. It is characterized by conodonts Palmatolepis linquiformis zone (Galushin, Kononova, 2004). The basic characteristic spore species of LS zone have been determined: *Grandispora subsuta* (the first appearance), *Chelinospora lepida* (maximum), *Cristatisporites deliquescens*, *C.imperpetuus*, *C.eximius*, *Auroraspora speciosa*, *Diducites hopericus*, *Membrabaculisporis radiatus*, *Verrucosisporites evlanensis*. LS zone conforms to the upper part of Cristatisporites deliquescens-Verrucosisporites evlanensis zone (Avkhimovich et al., 1993). The upper boundary of the LS zone is fixed of almost complete disappearance of the Frasnian typical species with broad membranous area, including *C.deliquescens* species, disappearing at the same level in Western and Eastern Europe (Loboziak et al., 1983; Streel et al., 1987; Avkhimovich et al., 1993; Stempien-Salek, 2002; Filipiak et Zbukova, 2006). In the deep-shelf facies LS zone overlaps deposits of Corbulispora viminea-Geminospora vasjamica zone (VV), which corresponds to Volgograd horizon (0-320 m in thick) of Famennian Stage. It is composed of argillites, marls with clayey limestone interlayers. It is characterized by conodonts Middle triangularis zone (after V.G.Khalymbadzha). On the base of Famennian Stage a significant update of the miospore taxonomic composition is observed. Here new species *Geminospora vasjamica, G.notata var. microspinosus, Corbulispora viminea, C.semireticulata, Cymbosporites boafeticus, Lophotriletes multiformis, Punctatisporites famenensis* appear. Unfortunately, for palynostratigraphy the palynofacies of most eastern sections of the studied territory contain predominantly prasinophytes Leiosphaeridia and amorphous organic matter with an insignificant amount of miospores. Cyrtospora cristifera-Diaphanospora zadonica (CZ) zone corresponds to the Zadonsk horizon (0-240 m in thick), represented by limestones and marls with argillite interlayers. It is characterized by conodonts Palmatolepis crepida zone (Galushin, Kononova, 2004). In the deep-shelf facies CZ zone overlaps deposits of VV zone. In coastal and shallow-marine shelf facies Zadonsk horizon with stratigraphic unconformity and sedimentological break overlies Livny one. *C.cristifera*, *D.zadonica, Convolutispora zadonica, Kedoesporis angulosus, Punctatisporites famenensis,* etc. species are characteristic of the Zadonsk horizon.

Keywords: miospores, conodonts, Frasnian-Famennian boundary, zone.

SS39-O05 (173)

Palynology of the Upper Palaeozoic strata, southeastern Nodeh, northeastern Iran

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Relatively thick, marginal marine Upper Paleozoic sequences are widely distributed in the eastern Alborz Mountains of northern Iran. Diverse and well-preserved palynofloras, dominated by spore assemblages and acritarchs (*sensu lato*), occur in surface samples of the Khoshyeilagh and Mobarak formations, southeast of Nodeh, eastern Alborz Mountains, northeastern Iran. Scolecodonts and chitinozoans also occur as minor components of the palynofloras examined; though with significant palaeonvironmental implications. The spore assemblages are entirely composed of trilete forms; no monolete or hilate taxa encountered. Based on the vertical distribution of certain spore species and on the introduction of particular spore-morphological traits, two successive spore floras, informally termed "assemblages", are identified within the succession investigated. The microphytoplankton and spore data combined suggest a Late Devonian-Early Carboniferous age for the Khoshyeilagh and Mobarak formations at the section studied; this age designation generally corroborates that based on faunal evidence. Of the spore assemblages, absence in the material studied of *Retispora lepidophyta*, useful in locating Devonian-Carboniferous Boundary globally, is particularly notable. *Geminospora lemurata* and *Vallatisporites vallatus,* eponymous index species, respectively, of *lemurata-magnificus* Assemblage Zone and *Retispora lepidophyta-Vallatisporites vallatus* Interval Zone are identifiable in the palynofloras examined. The co-occurrence of marine microphytoplankton (acritarchs and prasinophyte phycomata), scolecodonts, and chitinozoans collectively indicates an open marine, nearshore depositional setting for the Khoshyeilagh Formation. The presence of *Geminospora lemurata* attests to the presence of archaeopterid progymnosperms among the contemporaneous coastal vegetation. In addition, the occurrence of spores assigned to Rhyniopsida, Zosterophyllopsida, Equisetopsida, Lycopsida, Filicopsida, and Barinophytopsida refers to probable source of the *sporae dispersae*. The Khoshyeilagh palynofloras share some index microphytoplankton taxa with coeval assemblages specifically with those of northeastern and central Iran; beyond Iran broad alliance with Australia is noteworthy.

Keywords: palynomorphs, Khoshyeilagh and Mobarak formations, Alborz Ranges, Iran.

SS39-O06 (402)

Pennsylvanian (mid- Bolsovian-Cantabrian; Moscovian) vegetation change in the Bristol Coalfield, UK

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The Bristol Coalfield of southwest Britain, although intensively studied in the early history of palaeobotany (1820s to 1940s), has received little attention for 75 years. Here we present the results of an on-going multidisciplinary re-investigation the Warwickshire Group of this neglected coalfield; which comprises, from base to top, the Winterbourne, Pennant Sandstone and Grovesend formations. This integrated study considers both palaeobotanical (permineralisations, adpression and sandstone-cast) and palynological (miospore and megaspore) data sets in a facies context, allowing recognition of a diverse patchwork of plant communities closely related to a variety of depositional settings, including: coastal plain, alluvial plain, peat mire, clastic swamp, riparian communities and interfluve/hinterland areas. The Bolsovian-Cantabrian Warwickshire Group allows us to track vegetation changes in these tropical Euramerican forests over this critical period of pan-equatorial floral turnover; when humid Westphalian lycopsid-dominated mires contracted and were replaced by a drier substrates dominated by tree ferns and ferns in the Cantabrian. The causes of this turnover probably relate to substrates drying out due to tectonic uplift, that possibly also coincided with a period of global climate change. Palynomorph relative abundance data indicates that the demise of

the lycopsid-dominated mires may have been gradual; starting in the mid-Bolsovian, ~3 million years before the Asturian-Cantabrian boundary. Pronounced cyclicity in palynoassemblages are identifiable in clastic environments, which likely reflect changes in vegetation driven by fluctuations in moisture levels related to pulses of uplift in front of the rising Central Pangean Mountains to the south. Based on an investigation of all available data, we also develop a new system of biostratigraphical zonation for the Bristol Coalfield. The palaeobotanical biozonation identifies a stratigraphical gap encompassing the early to mid-Asturian, occurring between the mid- to late Bolsovian Pennant Sandstone (*Laveineopteris rarinervis* Subzone) and the late Asturian Grovesend formations (*Dicksonites plukenetii* Subzone). This tectonic-induced stratigraphical gap most likely relates to the Leonian Phase of the Variscan uplift and can be correlated with contemporaneous hiatuses in the South Wales and other European coalfields. However, palynological biozonation indicates the presence of Asturian aged rocks at the top of the Pennant Sandstone Formation; slightly diminishing the duration of this stratigraphical gap.

Keywords: Leonian phase, palaeoecology, palynology, palaeobotany, biostratigraphy.

SS39-O07 (288)

The Late Palaeozoic palyno-biostratigraphy in Northern Ordos Basin and its palaeogeographical significance

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The Late Palaeozoic strata cropping out in the northern Ordos Basin, China contain a continuous and varied fossil record, making this succession a classical locality for palynological study during that interval in North China. Abundant, diverse and well-preserved miospores are recorded and illustrated from the Penchi Formation to the Sunjiagou Formation, comprising 167 species assigned to 67 genera, as well as some scolecodonts. According to the first appearance of a few selected species and their abundance changes through succession, eight miospore assemblage zones have been recognized in ascending order, viz., the *Torispora securis-Torispora laevigata* (SL) Assemblage Zone (Moscovian), the *Reticulatisporites polygonalis-Endosporites globiformis* (PG) Assemblage Zone (Kasimovian), the *Torispora verrucosa-Pachetisporites kaipingensis* (VK) Assemblage Zone (Gzhelian), the *Thymospora thiessenii-Striatosporites heyleri* (TH) Assemblage Zone (Asselian-Sakmarian), the *Radiizonates solaris-Platysaccus minus* (SM) Assemblage Zone (Artinskian), the *Indospora cingulata-Sinulatisporites shansiensis* (CS) Assemblage Zone (Kungurian-Roadian), the *Playfordiaspora crenulata-Schopfites convolutus* (CC) Assemblage Zone (Wordian), and the *Patellisporites meishanensis-Brialatisporites iucundus* (MI) Assemblage Zone (Capitanian-Wuchiapingian).With evidence from microfossils (mainly fusulinids and conodonts), the age of these assemblage zones can be determined approximately. Compared with the Wuchiapingian palynofloras from the north-west and north-east of North China which are generally dominated by typical mixed Angaran-Cathaysian forms, Angaran forms are scarce in the northern Ordos Basin. Meanwhile, compared with the Late Permian palynofloras from the southern North China which are generally dominated by pteridophytic spores (including a few pteridospermous spores), gymnospermous pollen are more abundant in the present palynology assemblages. These comparisons indicate that the north-west and north-east part of North China Plate firstly collided with the Siberian Plate at the beginning Wuchiapingian, but there still was a wide trench between Inner Mongolia and Siberia. More abundant gymnospermous pollen in the northern Ordos Basin

from the Wordian to Wuchiapingian may have resulted from arid climate brought by continental drift during collision between North China and Siberian Plates.

Keywords: Late Palaeozoic, palynology, biostratigraphy, palaeogeogragphy, Ordos Basin.

SS39-O08 (296)

Evolutionary stasis of sporopollenin biochemistry revealed by unaltered Carboniferous spores

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The biopolymer sporopollenin is prevalent throughout the Phanerozoic preserved in the outer wall of palynomorphs, and is regarded as one of the most recalcitrant biomacromolecules. Sporopollenin chemistry affords insights into the long-term stability of biopolymers, the preservation of biogeochemical signals, and the evolutionary state of sporopollenin through time. This study presents chemical analyses of Pennsylvanian age megaspores that show a strong chemical resemblance to extant relatives. Comparison with published literature demonstrates that extant sporopollenin structure may be similar across widely spaced phylogenetic groups. Our study demonstrates the first evidence for evolutionary stasis in lycopsid sporopollenin for the past ~310 million years, and suggests sporopollenin structure has remained stable since embryophytes invaded the land.

SS39-O09 (359)

Palyno-petrographical facet and depositional account of Gondwana sediments from East Bokaro coalfield, Jharkhand, India

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Palynological and petrological studies have been undertaken on the Gondwana coal and associated lithology encountered in borehole EBM-2 of East Bokaro coalfield of Damodar Basin, India. The palynological study is undertaken resulting in the formation of Assemblage-I, Assemblage-II and Assemblage-III which were used to demarcate the formations by palynodating. The palynodating was done by studying the biomarkers of the assemblages. Lithofacies study was also done for better understanding of the preservation and abundance/paucity of the spores and pollen in different lithology as the current borehole has significant thickness of mudstones, shales and siltstone and a correlatory trend of corresponding palynoassemblages from adjoining coalfields and other gondwana coalfields of India was deduced using the derived dataset. Palynofacies study and petrographical studies of coal samples encountered in the borehole was also studied to determine the depositional environment of the coal precursor peat swamp. Using the petrographical as well as palynological

data from the present study site an attempt has been made to reconstruct the terrestrial flora vis-à-vis the botanical affinity of the derived spores and pollen and prevailing geomorphic setup.

Keywords: Permian coal petrography, Permian palynology, depositional environment, palynofacies, Damodar Basin.

SS39-O10 (270)

Permian phytoplankton diversity: a big surprise

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The Palaeozoic fossil record of organic-walled microphytoplankton is represented by the acritarchs, organic-walled microfossils considered mostly as the resting cysts of phytoplanktonic organisms, although the biological affinities of the acritarchs are, by definition, unknown. Acritarchs appear in the Precambrian and reach their highest diversity in the Lower and Middle Palaeozoic (Cambrian to Devonian). After a drastic diversity drop in the Late Devonian, they are considered to be of very low diversity in the Upper Palaeozoic (Carboniferous to Permian), where some authors claim the presence of a 'phytoplankton blackout' due to nutrient depletion in the oceans. Here we present a synthesis of the Permian fossil record of acritarchs. The revision shows that Permian acritarch descriptions have largely been neglected, compared to other palynomorph groups, such as spores and pollen grains. While larger organic-walled cysts, as known from the Lower and Middle Palaeozoic, are usually absent, many smaller acritarchs are commonly found in Permian palynological assemblages. In addition, several organic-walled microfossils interpreted as fungal spores have been described, but also possible green algae, including chlorophycean, prasinophycean or zygnematophyceaen algae. During most of the Permian stages, the organic-walled microphytoplankton shows diversities with about 10 to 20 genera described. Some genera, such as *Micrhystridium* and *Veryhachium*, have been reported in over 50 publications. The Permian phytoplankton diversity is thus much higher than previously thought, and the currently available diversity curves need to be redrawn. Nevertheless, many Permian acritarchs still need to be documented in detail, and additional systematical studies, in particular of the very small taxa, are needed to fully understand the diversity and significance of the Permian phytoplankton and its different components.

Keywords: Acritarchs, latest Permian, phytoplankton, distribution, Yangtze Block.

SS39-P01 (586)

The Ordovician acritarch genus *Barakella*

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The acritarch genus *Barakella* Cramer and Díez 1977 was first described from Morocco, and is characterized by 'a hemimorphic process topography.' After the original description of *Barakella*, three species, *Barakella fortunate*, *Barakella felix* and *Barakella rara*, have been attributed to this genus. Based on new material from South China, *Barakella rara* is herein considered as a synonym of *Barakella felix*. On the other hand, *Barakella fortunate* differs from *Barakella felix* because the former displays a rectangular outline and processes at each corner whereas the latter has a prismatic outline. Most records of *Barakella* are from the peri-Gondwanan acritarch palaeoprovince. *Barakella fortunate* has been described from Morocco, Iran, Saudi Arabia, Turkey, Algeria, Tunisia and North Wales, while *Barakella felix* is found in Saudi Arabia, Tunisia, South China and Argentina. In addition, some questionable *Barakella* specimens are found in Öland, Sweden and northern England. *Barakella* is a useful taxon in biostratigraphy and can be considered as an indicator for the base of the Dapingian stage (the base of Middle Ordovician). *Barakella felix* (as *Barakella rara*) are described from several sections in South China in the upper *suecicus* graptolite Biozone. *Barakella felix* is also found in the 'lower Arenig' of Argentina, the 'Llanvirn' of Tunisia and Saudi Arabia. Vecoli and Le Hérissé (2004) indicated a first occurrence of *Barakella fortunata* at the base of the *ornensis* chitinozoan Biozone in North Africa. *Barakella fortunate* is also found in the 'Arenig' of Iran, the 'late Llanvirn' of Saudi Arabia and the 'Llanvirn' of North Wales.

Keywords: *Barakella*, acritarchs, Ordovician, taxonomy, palaeogeography.

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Lopingian palynomorphs in the Linxi Formation, Inner Mongolia, China

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The Linxi Formation distributed widely in northeastern China is composed of lacustrine dark grey mudstone, siltstone and sandstone in huge thickness, and is considered as an important potential horizon of source rock for oil and gas in recent years. The formation named by Teilhard Chardin in 1924 contains the famous *Palaeanodonta* – *Palaeomutela* fauna (Lamellibranch) and the *Callipteris* - *Noeggerathiopsis* Angara-type flora, and is regarded as late Permian in age. The palynomorphs found for the first time in the tye section of the Linxi Formation in the Guandi, Linxi County, Inner Mongolia of northeastern China are dominated by *Leiotriletes*, *Verrucosisporites*, *Cyclogranisporites*, *Calamospora*, *Kraeuselisporites*, *Convolutispora*, *Raistrickia*, *Limitisporites*, *Platysaccus*, *Alisporites*, *Vitreisporites*, *Protohaploxypinus*, *Hamiapollenites*, *Falcisporites*, etc. These pollen and spores are also documented in the Upper Permian strata (the Wutonggou and Guodikeng formations) in Xinjiang, northwestern China. The palynomorphs in the Linxi Formation can be divided into two assemblages according to their vertical distribution in the section. The *Kraeuselisporites spinulosus* - *Falcisporites sublevis* asemblage distributed in the lower member of the Linxi Formation is characterised by fern spores (12 species of 9 genera) and gymnospermae pollen (10 species of 9 genera). The fern spores are dominated by *Kraeuselisporites spinulosus*, *Leiotriletes levis*, *Cyclogranisporites micaceus*, *C. orbicularis*, *Verrucosisporites microtuberosus* and *Calamospora pedata*. The gymnosperm pollen contain *Falcisporites sublevis*, *Alisporites communis*, *Protohaploxypinus parviextensisaccus*, *Vesicaspora wilsonii*, *Platysaccus papilionis*, *Cycadopites caperatus*, etc. On the contrast, the *Cyclogranisporites staplinii* - *Sulcatisporites ovatus* asemblage

in the upper member of the Linxi Formation is less diverse than those in the lower member, and is composed of gymnosperm pollen (9 species of 6 genera) which are dominated by *Sulcatisporites ovatus, S. rectangulus, S.* sp., *Falcisporites sublevis, F.* cf. *zapfei* and fern spores (6 species of 5 genera) such as *Cyclogranisporites staplinii, Laevigatosporites perminutus, Leiotriletes adnatus* and *Calamospora breviradiata*. The difference between these two assemblages reflects the vegetation changes with the climate becoming more and more dryer during the late Permian.

Keywords: palynological assemblages, vegetation, climate, late Permian.

SS39-P03 (269)

Palynology, palynofacies and organic geochemistry from the latest Permian of the Yangtze Block, South China

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Here we described diverse and well-preserved latest Permian phytoplankton from five sections of the Yangtze Block, South China, including Zhongzhai section in Guizhou Province, Meishan section in Zhejiang Province, Shangsi section in Sichuan Province, Xiakou section in Hubei Province and Dongpan section in Guangxi Province. Most of these species are reported previously. The phytoplankton are generally very small in size, usually around the diameter of 20 µm, like *Micrhystridium*, *Veryhachium* and *Leiosphaeridia*. However, the *Dictyotidium* with big shell (over 80µm in diameter) occur in Shangsi section abundantly. In Shansi section, three palynological assemblage zones have been recognized, in ascending order the *Dictyotidium* (Wuqiapingian), the *Leiosphaeridia–Michrystridium–Veryhachium* (Changxingian) and the *Pteruchipollenites–Leiotriletes* (Induan) assemblage zones. Five palynofacies types were recognized and are related to different depositional environments. A first interval (bed 15 to bed 22) is clearly dominated by AOM (Amorphous Organic Matter) and acritarchs, with moderate or high TOC (Total Organic Carbon) values, indicating offshore and shallow–deep marine, dysoxic –anoxic depositional environments. A second interval (bed 23 to bed 29) are dominated by terrestrial components with low TOC values, clearly indicating deltaic–nearshore and shallow marine, oxic depositional environments. The first interval has a good petroleum potential, but the latter not. In zhongzhai section and Xiakou section, only a few species occur in several samples with low abundance. And only two species of *Leiosphaeridia* occur in Dongpan section, however, they are abundantly in many samples. In addition, a nearshore-offshore distributional trend is presented in our investigated. The nearshore environments with shallow water (Zhongzhai section) or with deep water (Dongpan section) show low diversity with only 2 to 4 species, whereas the offshore shelf environments with shallow to deep water (Meishan section and Shangsi section) reflect the higher diversity with over 13 species. However, only 3species occurred in the distal shelf of Xiakou section.

Keywords: acritarchs, phytoplankton, Shangsi section, depositional environments, nearshore-offshore distributional trend.

SS39-P04 (356)

Palynology: A good tool of resolving stratigraphic problem of the Karoo strata in Tanzania

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In Tanzania, the Karoo sediments, which are mainly non-marine, occur in isolated basin. The strata are poorly exposed, scanty in megafossils and mineral-walled microfossils; dating and correlation is problematic. Palynology, the science of palynofloras was first applied in the dating of Karoo strata in Tanzania in 1960, in Ketewaka-Mchuchuma coalfield, in the Ruhuhu Basin. Based on palynological data, the Ketewaka-Mchuchuma Karoo strata were dated as Early Permian. Hitherto, there are several palynological studies in relation to the Karoo strata of various Karoo basins in Tanzania. These studies have revealed diverse index palynomorphs including: *Plicatipollenites gondwanensis* (Late Carboniferous-Early Permian, Karoo strata at Msonge Village, Mvuha Basin), *Cannoropollis* spp., *Plicatipollenites* spp. (Early Permian-Idusi Formation, Ruhuhu Basin), *Welwitchia simplex* (Late Carboniferous-Early Permian, Lower Tanga Beds, Tanga Basin), *Cirratriadites splenders* (Early Permian-Ketewaka-Mchuchuma Formation, Ruhuhu Basin), *Playfordiaspora* spp. [Latest Permian-Early Triassic, younger Karoo (K5-K6), Stigo Series, Selous Basin], *Weylandites Lucifer* (Permian-Ruhuhu Beds of Ivuna-1 well, Ruhuhu Basin) and *Cardagasporites reticulatus* (Early Jurassic-Ngerengere Beds of Kizimbani-1 well, Mandawa Basin). From palynological support, the age of the Karoo strata in Tanzania ranges from Late Carboniferous (Pennsylvanian through Early Jurassic). Accordingly, on the basis of palynofacies, it is possible to correlate Karoo successions of different Karoo basins in Tanzania.

Keywords: palynology, Karoo rocks, Tanzania, Late Carboniferous-Early Jurassic.