The Golden Anniversary Meeting of AASP - The Palynological Society

Nottingham
3–7 September 2017

Organized jointly with

CIMP - Commission Internationale de la Microflore du Paléozoïque
TMS - The Micropalaeontological Society (Palynology Group)

A joint meeting of AASP – CIMP – TMS (Palynology Group)

50th Annual Meeting of AASP – The Palynological Society

CIMP – Commission Internationale de la Microflore du Paléozoique

TMS – The Micropalaeontological Society (Palynology Group)

At The British Geological Survey, Keyworth, Nottingham, United Kingdom

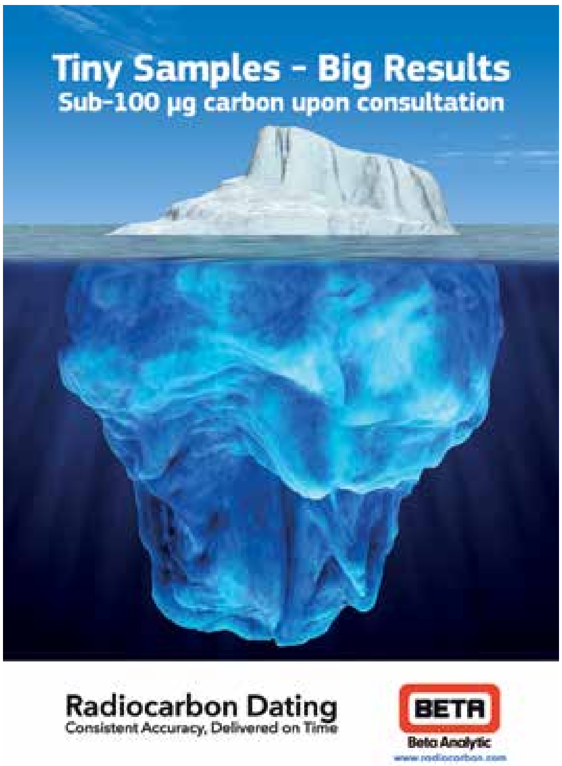
Organising Committee:

James Riding, Jan Hennissen, Maria Wilson, Stewart Molyneux, Reed Wicander, Matthew Pound, Barry Lomax

Many Thanks to Our Workshop and Fieldtrip organisers:

Duncan McLean (MB Stratigraphy), David Bodman (MB Stratigraphy), John Athersuch (StrataData), Paul Britton (StrataData), Peter Norton (StrataData), Katrin Ruckwied (Shell) and Iain Prince (Shell)

Special Thanks to our sponsors:



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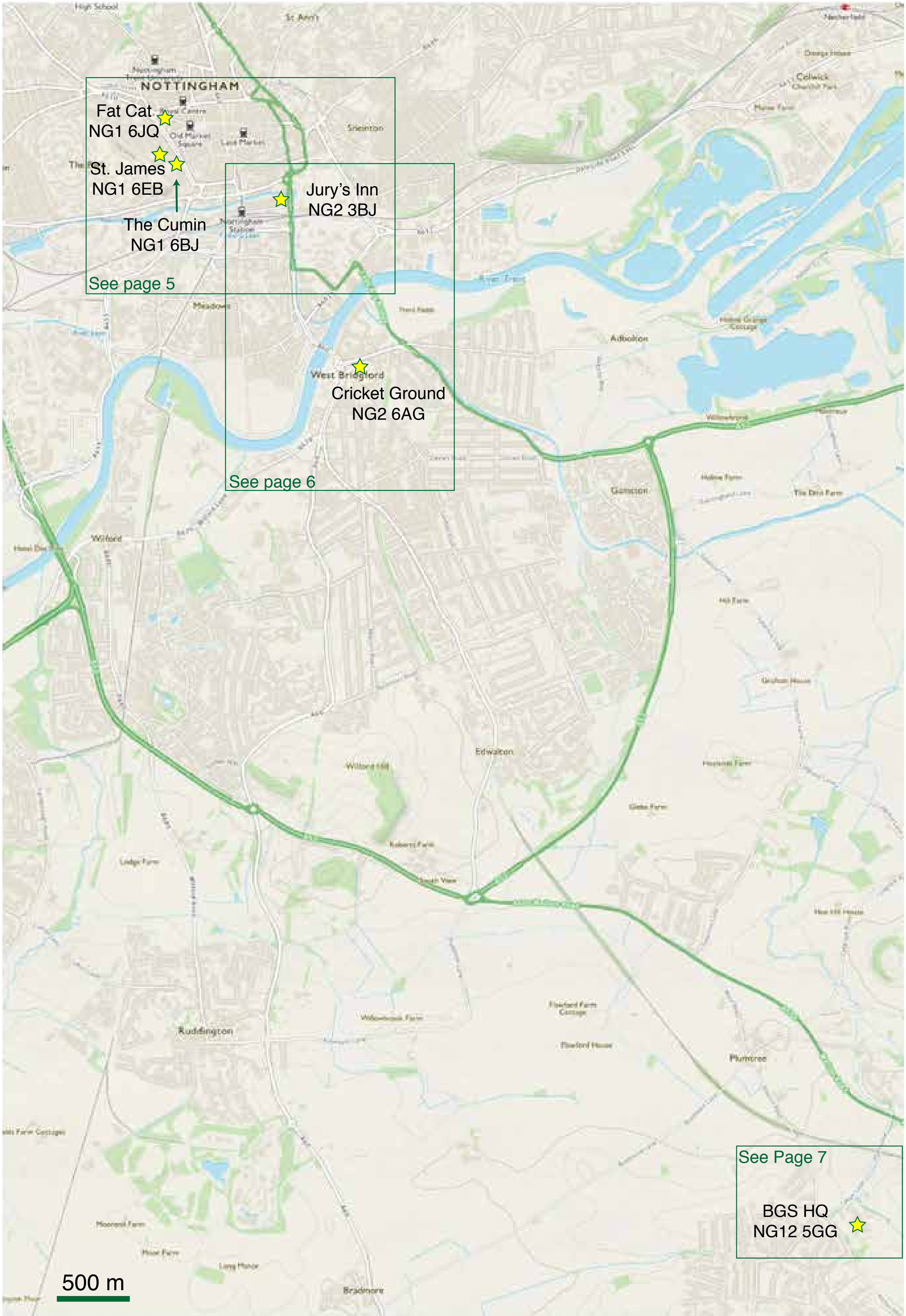
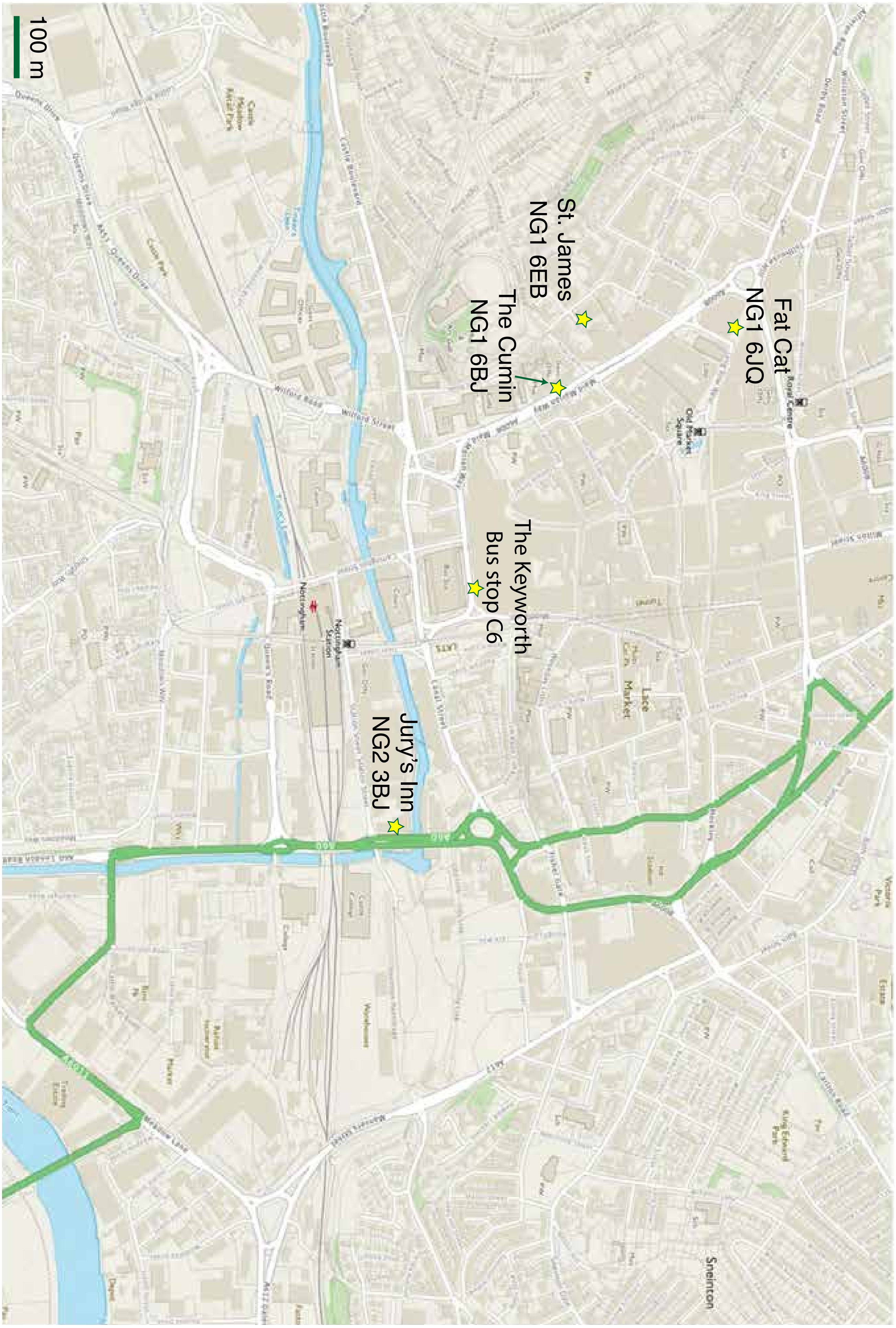
Map of Nottingham and Keyworth




100 m
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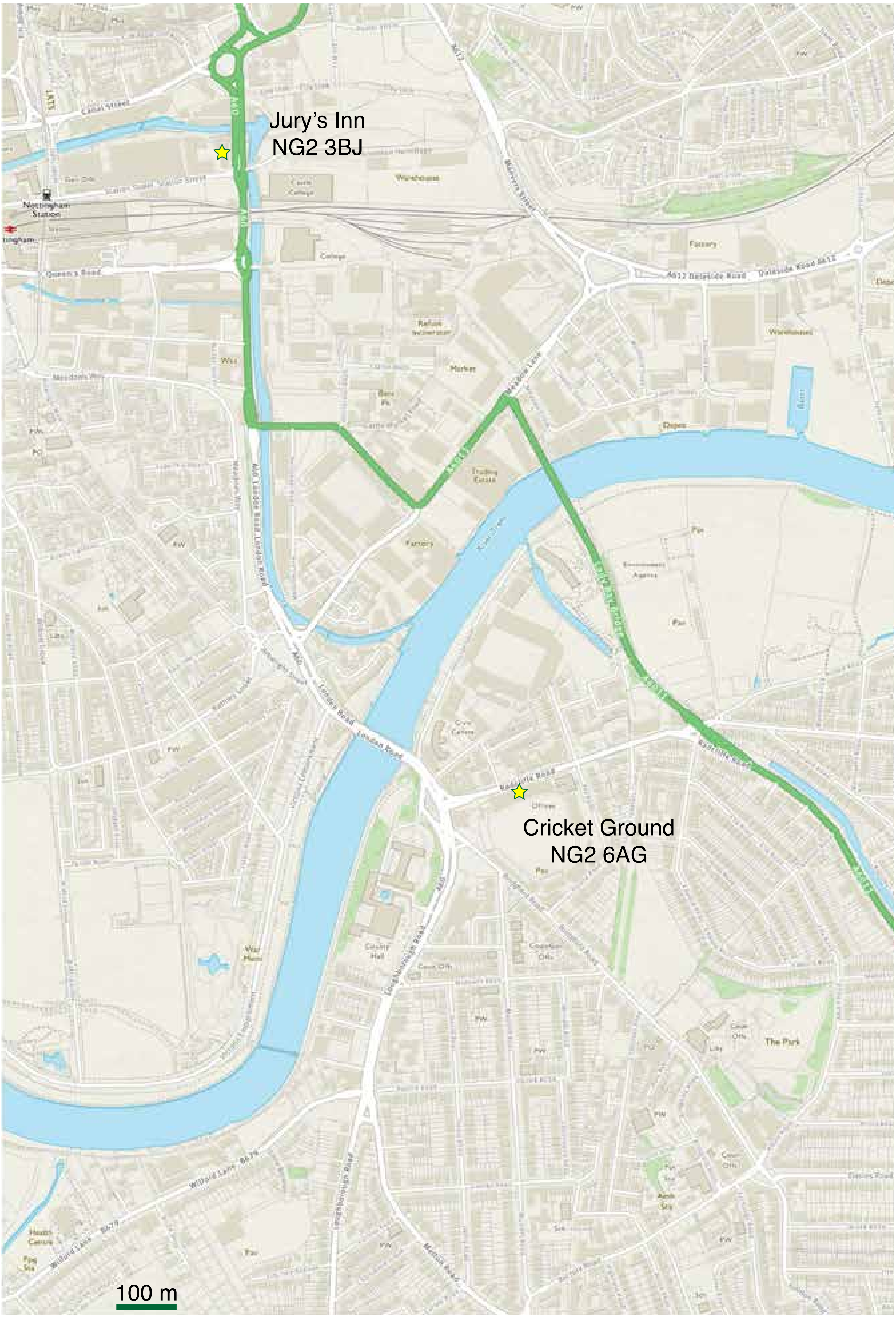
NG1 6EB
The Cumin
NG1 6BJ
Fat Cat
NG1 6JQ
The Keyworth
Bus stop C6
Jury's Inn
NG2 3BJ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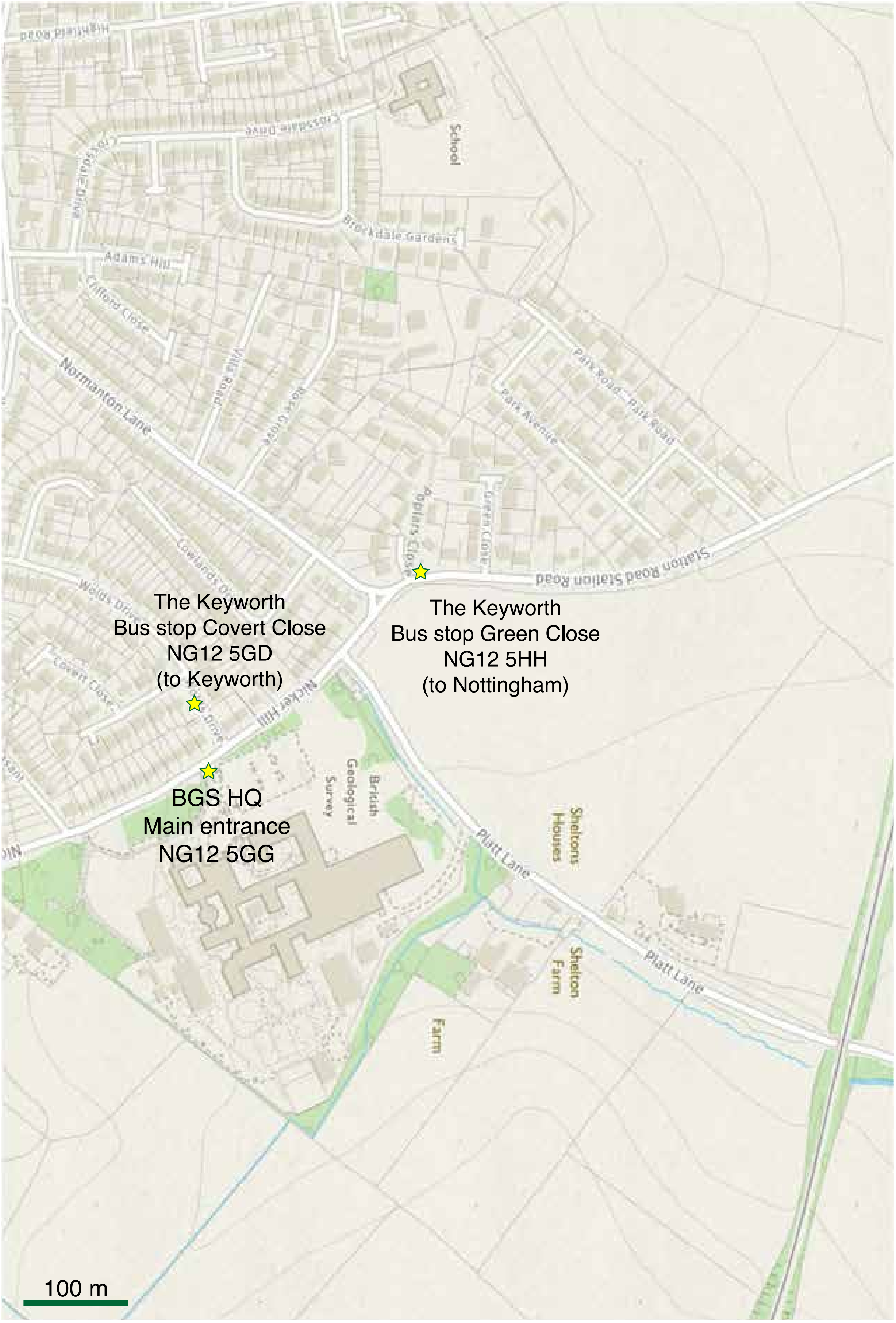
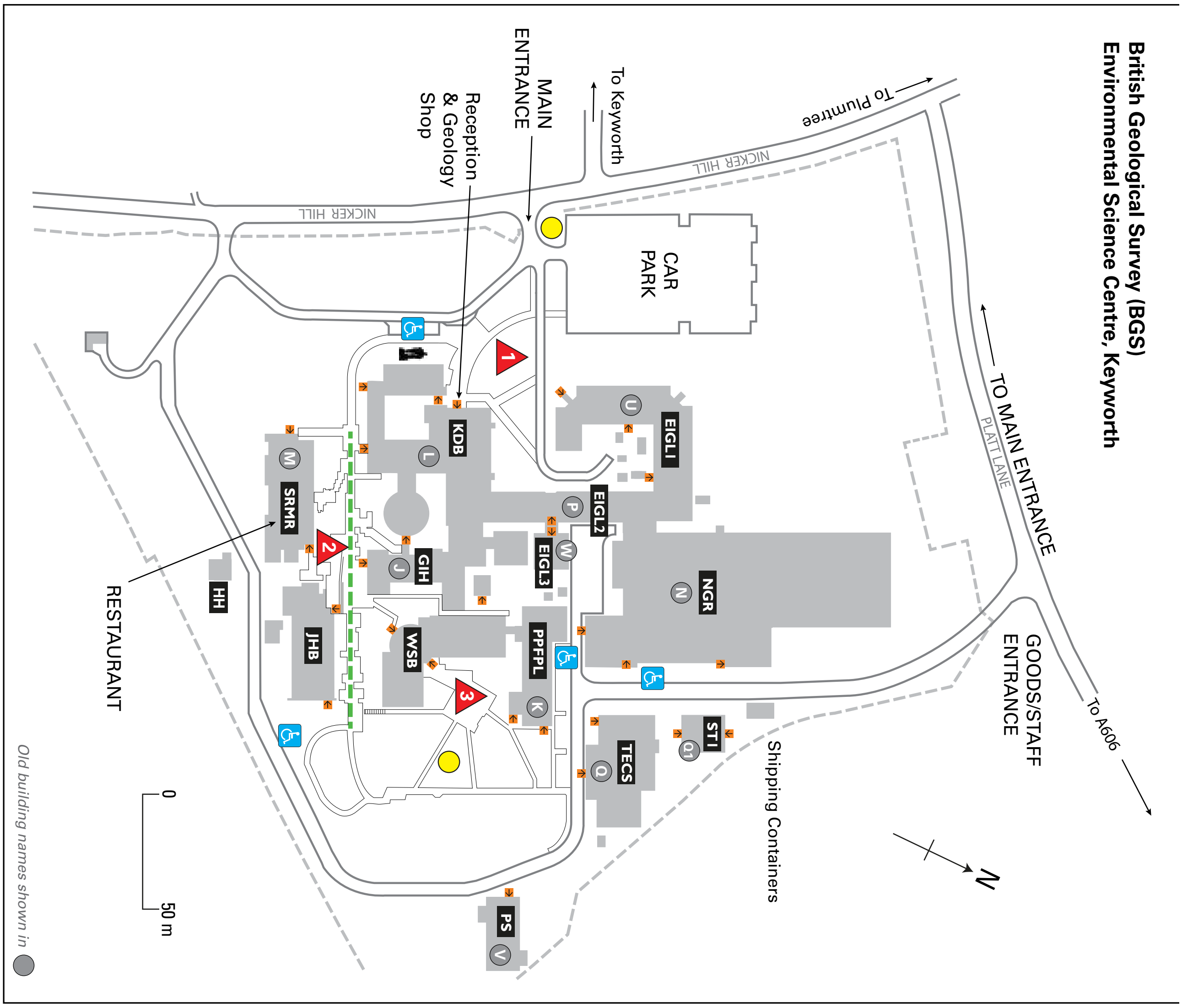

Highfield Road
Crossdale Drive
School
Brockdale Gardens
Adams Hill
Clifford Close
Normanton Lane
Villa Road
Ross Grove
Park Road
Park Avenue
Poplars Close
Green Close
Station Road
Lowlands Drive
Wolds Drive
Covert Close
Nicker Hill
The Keyworth
Bus stop Covert Close
NG12 5GD
(to Keyworth)
The Keyworth
Bus stop Green Close
NG12 5HH
(to Nottingham)
BGS HQ
Main entrance
NG12 5GG
British Geological Survey
Platt Lane
Sheltons Houses
Shelton Farm
Farm
100 m



BUILDINGS

EIGLI Environmental & Isotope Geotechnical Laboratories 1
NERC Isotope Geoscience Laboratory

EIGL2 Environmental & Isotope Geotechnical Laboratories 2

EIGL3 Environmental & Isotope Geotechnical Laboratories 3

GIH Geoscience Innovation Hub - also includes;
- IGS (International Geoscience Services Ltd)
- HSE
- ACAS

HH Hanlon House

JHB James Hutton Building

KDB Kingsley Dunham Building - also includes;
- De La Beche Lecture Theatre
- De La Beche Library
- Exhibition Area
- **Main Reception**

NGR National Geological Repository

PS Publication Store

PPFPL Physical Properties & Fluid Processes Laboratory

SRMR Staff Restaurant & Meeting Rooms 1 to 4

STI Store 1

TECS Technical Engineering

WSB William Smith Building

Building entrance

Disabled parking

Fire Assembly Point

Hercules statue

Smoking shelter

Geological Walk

BGS site boundary

Road

Footpath

	Year	Date	Location	Country	Reference	Registrants
1	1968		Louisiana State University campus, Baton Rouge	USA	Newsletter V2/1	83
2	1969	October 19–22	Pennsylvania State University, University Park	USA	Newsletter V2/1	
3	1970	October 14–17	Park Plaza Hotel, Toronto	Canada	Newsletter V4/1	104
4	1971	October 13–16	Hilton Inn, Tucson, Arizona	USA	Newsletter V4/2	
5	1972	October 25–28	Sheraton Islander Inn, Newport, Rhode Island	USA	Newsletter V6/1	109
6	1973	October 16–20	Grand Hotel, Anaheim, California	USA	Newsletter V7/1	123
7	1974	October 16–19	Palliser Hotel, Calgary, Alberta	Canada	Geoscience and Man, 7	
8	1975	September	Houston, Texas	USA		178
9	1976	October 12–16	Chateau Halifax, Halifax, Nova Scotia	Canada	Newsletter V9/4	125
10	1977	October 18–21	Fairmont Mayo Hotel, Tulsa, Oklahoma	USA	Newsletter V11/1	152
11	1978	October 24–28	Del Webb's Townehouse Hotel Phoenix, Arizona	USA	Newsletter V12/1	
12	1979	October 29 – November 3	Dunfey's Inn, Dallas, Texas	USA	Newsletter V13/1	225
13	1980	October 14–18	Keystone lodge, Keystone, Colorado	USA	Newsletter V14/1	
14	1981	October 7–14	New Orleans, Louisiana	USA	Newsletter V14/4	159
15	1982	September 13–15	Joint AASP CIMP meeting, Trinity College, Dublin	Ireland	Newsletter V15/4	± 120
16	1983	October 25–29	San Francisco, California	USA	Newsletter V17/1	
17	1984	October 17–20	Hyatt Regency, Crystal City, Arlington, Virginia	USA	Newsletter V18/1	150
18	1985	October 16–19	El Paso, Texas	USA	Newsletter V18/4	115
19	1986	October 29 – November 1	Milford Plaza Hotel, New York City, New York	USA	Newsletter V19/4	151
20	1987	October 7–9	Chateau Halifax, Halifax, Nova Scotia	Canada	Newsletter V20/4	123
21	1988	November 10–12	Houston, Texas	USA		
22	1989	October 18–21	Sheraton Kensington Hotel, Tulsa, Oklahoma	USA		
23	1990	October 10–13	Banff Springs Hotel, Banff, Alberta	Canada	Newsletter V23/4	
24	1991	October 21–23	Holiday Inn On-the Bay, San Diego, California	USA		
25	1992	September 6–12	Joint IPC and AASP meeting Aix-en-Provence	France	Newsletter V25/4	230

Overview of 50 years of AASP annual meetings (1992–2017)

	Year	Date	Location	Country	Reference	Registrants
26	1993	October 23–28	Louisiana State University, Baton Rouge, Louisiana	USA	Newsletter V26/4	'over 120'
27	1994	November 2–4	Texas A&M University, College Station, Texas	USA	Newsletter V27/4	69
28	1995	October 10–14	Chateau Laurier, Ottawa	Canada	Newsletter V29/1	'fewer than 100'
29	1996	June 23–28	IPC, AASP sponsored, Houston, Texas	USA	Newsletter V29/3	400
30	1997	September 14–19	MBL Swope Conference Centre, Woods Hole, Massachusetts	USA	Newsletter V31/3	59
31	1998	October 27–31	Ensenada, Baja California	Mexico	Newsletter V31/1	84
32	1999	October 26–29	Georgia Southern University	USA	Newsletter V32/4	62
33	2000	November 13–16	In conjunction with GSA, Reno, Nevada	USA	Newsletter V33/4	'60(?)'
34	2001	October 21–24	Menger Hotel, San Antonio, Texas	USA	Newsletter V34/4	65
35	2002	September 11–13	Joint AASP-TMS-NAMS meeting, University College London, London	UK	Newsletter V35/3	185
36	2003	October 5–8	Joint AASP- CAP-NAMS meeting, Brock University, St. Catharines, Ontario	Canada	Newsletter V36/4	98
37	2004	July 4–9	Joint AASP-IPC, Grenada	Spain		
38	2005	September 18–21	Radisson Hotel, St. Louis, Missouri	USA	Newsletter V38/3	66
39	2006	October 22–26	In conjunction with GSA, Philadelphia, Pennsylvania	USA	Newsletter V39/4	45–200
40	2007	September 9–12	Smithsonian Tropical Research Institute, Panama City	Panama	Newsletter V39/4	82
41	2008	August 30–September 6	Bonn University, Bonn	Germany		
42	2009	September 27-30	Meadowview Resort and Conference Center, Kingsport, Tennessee	USA		
43	2010	September 29-October 1	Joint AASP-CAP-CPC, Harbourview Holiday Inn, Halifax, Nova Scotia	Canada		
44	2011	September 4– 7	Joint AASP-TMS, National Oceanographic Centre, Southampton	UK		
45	2012	July 21–25	University of Kentucky, Lexington, Kentucky	USA	Newsletter V45/3	
46	2013	October 20–24	Joint Dino 10-CAP-CIMP-NAMS, Hotel Whitcomb, San Francisco, California	USA	Newsletter V46/4	183
47	2014	September 28– October 3	Joint AASP-TSP meeting, Mendoza	Argentina		
48	2015	October 31– November 5	In conjunction with GSA, Baltimore, Maryland	USA	Newsletter V48/4	107
49	2016	September 16–24	Joint TSOP-ICCP-AASP meeting, Magnolia Hotel, Houston, Texas	USA	Newsletter V49/4	>170
50	2017	September 3–7	Joint AASP-CIMP-TMS, British Geological Survey, Nottingham	UK		108

Year	President	President-Elect*	Past-President	Managing Editor	Secretary-Treasurer	Director	Director	Director	Director
1968	Paul Nygreen	Colin McGregor		Lewis Stover	Alfred Traverse	George Fournier	Robert Tabbert	Charlie Upshaw	
1969	Charlie Upshaw	George Fournier	Paul Nygreen (3)	Lewis Stover/ Robert Clarke (1)	Alfred Traverse	Marcia Winslow	Richard Hedlund	3) Paul Nygreen	
1970	George Fournier	Geoff Norris		Richard Hedlund (2)	Alfred Traverse	Charlie Upshaw	Daniel Habib	John W. Hall	
1971	Alfred Traverse	Don Engelhardt		Richard Hedlund	Robert Clarke	George Fournier	David Wall	Paul Martin	
1972	Geoff Norris	John W. Hall		Richard Hedlund	Robert Clarke	William Evitt	Colin McGregor	Alfred Traverse	
1973	Don Engelhardt	Harry Leffingwell		Richard Hedlund	Robert Clarke	Wayne Brideaux	Warren Drugg	Geoff Norris	
1974	Robert Clarke	Wayne Brideaux		Richard Pierce	Herbert Sullivan	Graham Williams	Glenn Rouse	Don Engelhardt	
1975	Richard Hedlund	William Elsik		Richard Pierce	Herbert Sullivan	Jack Burgess	William Fairchild	Robert Clarke	
1976	Ken Piel	Sedley Barss		Richard Pierce	Jack Burgess	John Clendening	Colin McGregor	Richard Hedlund	
1977	Richard Pierce	John Clendening		Vaughn Bryant Jr.	Jack Burgess	G.K. Guennel	Raymond Malloy	Ken Piel	
1978	William Elsik	Warren Drugg		Vaughn Bryant Jr.	Jack Burgess	Richard Pierce	Evan Kidson	Norman Frederiksen	
1979	Jack Burgess	Evan Kidson		Vaughn Bryant Jr.	John Clendening	Jocelyne Legault	John Bennett	William Elsik	
1980	James Canright	John Bennett		Vaughn Bryant Jr.	John Clendening	Jonathan Bujak	Jack Burgess	Sarah Damassa	Charles Felix
1981	John Bennett	Lewis Stover		Vaughn Bryant Jr.	John Clendening	Sarah Damassa	Charles Felix	Carol Chmura	David McIntyre
1982	Lewis Stover	Doug Nichols		Vaughn Bryant Jr.	Ken Piel	Carol Chmura	David McIntyre	Ray Christopher	Rex Harland
1983	Doug Nichols	John Clendening		Vaughn Bryant Jr.	Ken Piel	Ray Christopher	Rex Harland	James Canright	Jocelyne Legault
1984	John Clendening	Vaughn Bryant Jr.		Doug Nichols	Ken Piel	James Canright	Jocelyne Legault	Lucy Edwards	Virgil Wiggins
1985	Vaughn Bryant Jr.	Ray Christopher		Doug Nichols	Ken Piel	Lucy Edwards	Virgil Wiggins	Judith Lentin	Reed Wicander
1986	Ray Christopher	Don Benson Jr.		Doug Nichols	Ken Piel	Judith Lentin	Reed Wicander	Barb Whitney	William Cornell
1987	Don Benson Jr.	Norm Frederiksen		Doug Nichols	Gordon Wood	Barb Whitney	William Cornell	David Goodman	Patricia Gensel
1988	Norm Frederiksen	Harry Leffingwell		David Goodman	Gordon Wood	Patricia Gensel	Harold Kaska	Rob Ravn	Loretta Satchell
1989	Harry Leffingwell	Judith Lentin		David Goodman	Gordon Wood	Stephen Hall	Loretta Satchell	Owen Davis	George Hart
1990	Judith Lentin	Barb Whitney		David Goodman	Gordon Wood	Owen Davis	George Hart	Leonard Eames	Eleanora Robbins
1991	Barb Whitney	John Wrenn		David Goodman	Gordon Wood	Leonard Eames	Eleanora Robbins	Eileen Williams	Nairn Albert
1992	John Wrenn	Rob Ravn	Barb Whitney	David Goodman	Gordon Wood	Eileen Williams	Nairn Albert	Sarah Damassa	Art Sweet

* Pre1980, this position was termed Vice-President and did not succeed to President
1) Robert Clarke was appointed AASP Editor in mid-1969 when Lew Stover was transfered to Australia
2) Richard Hedlund was elected Editor and started serving on October 21, 1969
3) Nygreen was called “Past President” in the 1968 Board meeting after the “formal” business meeting. He is also refered to as “Past President” in the March 27, 1969 mid-year meeting. However, in the Exec. Committee meeting on October 18, 1969 (before the change in command).

Year	President	President-Elect	Past-President	Managing Editor	Secretary-Treasurer	Director	Director	Director	Director
1993	Rob Ravn	Lucy Edwards	John Wrenn	David Goodman	Gordon Wood	Sarah Damassa	Art Sweet	Martin Farley	Martin Head
1994	Lucy Edwards	Reed Wicander	Rob Ravn	David Goodman	David Pocknall	Martin Farley	Martin Head	Joyce Lucas-Clark	Farley Fleming
1995	Reed Wicander	Jan Jansonius	Lucy Edwards	David Goodman	David Pocknall	Joyce Lucas-Clark	Farley Fleming	Rosemary Askin	Thomas Demchuk
1996	Jan Jansonius	Gordon Wood	Reed Wicander	David Goodman	David Pocknall	Rosemary Askin	Thomas Demchuk	Don Engelhardt	Jocelyne Legault
1997	Gordon Wood	Rolf Mathewes	Jan Jansonius	David Goodman	David Pocknall	Jocelyn Legault	Don Engelhardt	Javier Helenes-Escamilla	Gretchen Jones
1998	Rolf Mathewes	Chris Denison	Gordon Wood	David Goodman	David Pocknall	Javier Helenes-Escamilla	Gretchen Jones	Joyce Lucas-Clark	Pierre Zippi
1999	Chris Denison	Fred Rich	Rolf Mathewes	David Goodman	Thomas Demchuk	Joyce Lucas-Clark	Pierre Zippi	Bob Cushman	Paul Strother
2000	Fred Rich	David Pocknall	Chris Denison	David Goodman	Thomas Demchuk	Bob Cushman	Paul Strother	Sharma Gaponoff	Jim Riding
2001	David Pocknall	David Jarzen	Fred Rich	Owen Davis	Thomas Demchuk	Sharma Gaponoff	Jim Riding	Merrel Miller	Thomas Davies
2002	David Pocknall	Jim Riding	Fred Rich	Owen Davis	Thomas Demchuk	Merrell Miller	Thomas Davies	Carlos Jaramillo	Peta Mudie
2003	Jim Riding	Sharma Gaponoff	David Pocknall	Owen Davis	Thomas Demchuk	Carlos Jaramillo	Peta Mudie	Daniel Michoux	Eddie Robertston
2004	Sharma Gaponoff	Martin Head	Jim Riding	Owen Davis	Thomas Demchuk	Daniel Michoux	Eddie Robertson	Francine McCarthy	Enrique Martin-ez-Hernandez
2005	Martin Head	Robert Cushman Jr.	Sharma Gaponoff	Jim Riding	Thomas Demchuk	Francine McCarthy	Enrique Martin-ez-Hernandez	Peter McLaughlin	Jorg Pross
2006	Robert Cushman Jr.	Carlos Jaramillo	Martin Head	Jim Riding	Thomas Demchuk	Peter McLaughlin	Jorg Pross	Sophie Warny	Thomas Davies
2007	Carlos Jaramillo	Francine McCarthy	Robert Cushman Jr.	Jim Riding	Thomas Demchuk	Sophie Warny	Thomas Davies	Sarah de la Rue	Joyce Lucas-Clark
2008	Francine McCarthy	Fredrick Rich	Carlos Jaramillo	Jim Riding	Thomas Demchuk	Sarah de la Rue	Joyce Lu-cas-Clark	Barrie Dale	Yow-Yuh Chen
2009	Fredrick Rich	Joyce Lucas-Clark	Francine McCarthy	Jim Riding	Thomas Demchuk	Barrie Dale	Yow-Yuh Chen	Stephen Louwye	James White
2010	Joyce Lucas-Clark	Paul Strother	Fredrick Rich	Jim Riding	Thomas Demchuk	Stephen Louwye	James White	Ian Harding	Jennifer O'Keefe
2011	Paul Strother	Franca Oboh-Ikue-nobe	Joyce Lucas-Clark	Jim Riding	Thomas Demchuk	Ian Harding	Jennifer O'Keefe	Susanne Feist-Bur-khardt	Lanny Fisk
2012	Franca Oboh-Ikue-nobe	Ian Harding	Paul Strother	Jim Riding	Thomas Demchuk	Susanne Feist-Bur-khardt	Lanny Fisk	Rebecca Tedford	Debra Willard
2013	Ian Harding	Lanny Fisk	Franca Oboh-Ikue-nobe	Jim Riding	Thomas Demchuk	Rebecca Tedford	Debra Willard	Pi Suhr-Willumsen	Guy Harrington
2014	Lanny Fisk	Jen O'Keefe	Ian Harding	Jim Riding	Thomas Demchuk	Pi Suhr-Willumsen	Guy Harrington	Iain Prince	Fabienne Marrett
2015	Jen O'Keefe	Guy Harrington	Lanny Fisk	Jim Riding	Stephen Stukins/ Thomas Demchuk	Iain Prince	Fabienne Marrett	Kara Bogus	Kimberley Bell (Student)
2016	Guy Harrington	Iain Prince	Jen O'Keefe	Jim Riding	Stephen Stukins/ Rebecca Hackworth	Kara Bogus	Kimberley Bell (Student)	Katrin Ruckweid	

How to get around

As part of the registration package, delegates will be transported from downtown Nottingham to BGS HQ, which is located about 9 km south of the city centre in Keyworth. This bus service will leave from the St. James Hotel (NG1 6EB) at 08:00 am to arrive at BGS around 08:20 am on Monday, Tuesday and Wednesday.

Bus

The Keyworth Connection (operated by TrentBarton) is a bus service between Nottingham and Keyworth and runs each 15 minutes from the Broadmarsh Center. Timetables can be found on https://www.trentbarton.co.uk/services/keyworth/timetable. This service leaves from Collin Street Stop C6 (Map p. 5) and runs approximately every 15 minutes. The bus stop closest to the BGS main entrance is 'Covert Close' (NG12 5GD; map p. 7). The closest bus stop for the return journey to Nottingham is 'Green Close' (NG12 5HH; map p. 7).

A single fare costs £2.80, a two trip ticket is £5.50.

Taxis

The taxi service routinely used by personnel of The British Geological Survey is DG Taxis which can be reached at: 01159500500 or on http://www.dgcars.co.uk/. The rate for a single fare from Nottingham Station to Keyworth is about £17.

Parking

Parking is available at the BGS Site. Please enter via the main entrance, Nicker Hill, and pass by the security hut where you will be granted access to the car park (Maps p.7 and 8).

BGS Site Information

Wi-Fi information

For your convenience Wi-Fi is available at the BGS site:

- Network: BGS Visitor
- Username: BGS Visitor
- Password: bgsvisitoraccess

The Eduroam network is also available at the BGS site.

No smoking policy

Smoking is prohibited in all buildings of the Environmental Science Centre. A smoking shelter is located behind the Security Hut at the Nicker Hill Gate (see site map on p. 8). Please dispose of cigarette ends in the bin provided and keep the area tidy.

Safety and Security information

Badge Reminder

Badges must be worn at all times while attending the conference on BGS premises. Please also bring your badges to the various off-site events as they contain your registration information.

Fire alarms

- Continuous siren: Fire Alarm activated in this building. All persons should evacuate the conference suite immediately and make their way to the ground floor and outside.
- Intermittent alarm (repeating double beep): Fire Alarm elsewhere on site. You do not need to evacuate immediately but should be prepared to do so if requested or if the alarm changes.

In case of an emergency evacuation:

- Two staircases are present to evacuate the Lecture theatre; the main staircase from reception and the emergency stairs to the left of the stage. Once outside go to ASSEMBLY POINT 1 (site map on p. 8) on the path in front of reception, near the large boulders.
- Stay at the assembly point until you are told by your meeting host, a member of the BGS Estates team or the Site Security Officer that it is safe to leave.
- All persons with mobility issues should leave the conference room by the main door. **Do not use the lift in the event of a fire**. A member of the Estates team or Library team will be able to help evacuation using the evac chair located on the wall near the Library Desk.

Scheduled fire alarm testing:

- **The Fire Alarm is tested Thursday morning (7 September) at around 10:30 am**. There will be three activations of the alarm lasting roughly 5–10 seconds each. The first sounding will always be the continuous alarm. The second two sounding will be either the continuous alarm or intermittent alarm depending on whether the engineers are testing the alarm in this building or elsewhere on site. As long as the individual alarm soundings do not last for more than approx. 10 seconds you do not have to evacuate the buildings. If the alarm continues to sound then you should evacuate as normal.

If you discover a fire, please alert a member of the organizing committee and press the red break glass point to activate the fire alarm. Then evacuate as above.

First Aid

A trained first aider is on call at all times at:

- External: 07976721260
- Internal phone: 5555

Oral Presentations

Presenters should preferably send their presentations to Jim Riding (jbri@bgs.ac.uk) or Jan Hennissen (janh@bgs.ac.uk) prior to the meeting so the talk can be preloaded. If this for any reason is not possible, please bring your presentation on a data stick. Be aware that **all data sticks will have to be scanned** prior to uploading the talks on the BGS conference centre PC. For this process to run as smoothly as possible, **please put the presentation on a data stick containing very few other files**. The acceptable file formats are .ppt(x) and .pdf. Someone from our IT department will be available to perform the security scans during every break. Please make sure your talk is uploaded at least 15 minutes prior to the start of the assigned session.

Oral presentations are 20 minutes in length, except for keynote presentations which will be 40 minutes. When you have 5 minutes remaining, the session chair will signal the time. A second signal will be given at two minutes time remaining. You will be summarily cut off at the end of you allotted time. If fewer than two minutes remain at the end of your presentation, audience members will be instructed to save their questions for the next break.

Poster Presentations

The poster format is A0 Portrait. Posters are to be hung Monday morning (08:20–08:50 during registration or 10:25–10:55 during the Morning Coffee Break). Poster boards and Velcro stickers will be provided and we ask that you hang your poster on the assigned poster board. We kindly ask to remove posters after the last session on Wednesday 6 September.

A poster session is taking place on Monday September 4 from 17:20h to 19:15h and we ask that poster presenters are available during that period to present their work.

Applause & Questions

Save your applause and questions for the end of talks unless instructed otherwise by the speaker.

Photography and Filming

Flash photography is forbidden during oral presentations. Photography or filming of presentations, slides or posters is strongly discouraged and is prohibited without the permission of the author. Please be aware that many presentations contain preliminary data that may not be shared via social media. It is requested that delegates respect authors' wishes and do not share contentscontaining these symbols:

AGI Guidelines for Ethical Professional Conduct

Note that AASP – The Palynological Society is a member society of the American Geosciences Institute (AGI) and therefore we ask delegates abide by the AGI Guidelines for Ethical Professional Conduct (see below). Delegates violating this code of conduct may be asked to leave the meeting.

Geoscientists play a critical role in ethical decision making about stewardship of the Earth, the use of its resources, and the interactions between humankind and the planet on which we live. Geoscientists must earn the public's trust and maintain confidence in the work of individual geoscientists and the geosciences as a profession. The American Geosciences Institute (AGI) expects those in the profession to adhere to the highest ethical standards in all professional activities. Geoscientists should engage responsibly in the conduct and reporting of their work, acknowledging the uncertainties and limits of current understanding inherent in studies of natural systems. Geoscientists should respect the work of colleagues and those who use and rely upon the products of their work.

In day-to-day activities geoscientists should:

- Be honest.
- Act responsibly and with integrity, acknowledge limitations to knowledge and understanding, and be accountable for their errors.
- Present professional work and reports without falsification or fabrication of data, misleading statements, or omission of relevant facts.
- Distinguish facts and observations from interpretations.
- Accurately cite authorship, acknowledge the contributions of others, and not plagiarize.
- Disclose and act appropriately on real or perceived conflicts of interest.
- Continue professional development and growth.
- Encourage and assist in the development of a safe, diverse, and inclusive workforce.
- Treat colleagues, students, employees, and the public with respect.
- Keep privileged information confidential, except when doing so constitutes a threat to public health, safety, or welfare.

As members of a professional and scientific community, geoscientists should:

- Promote greater understanding of the geosciences by other technical groups, students, the general public, news media, and policy makers through effective communication and education.
- Conduct their work recognizing the complexities and uncertainties of the Earth system.
- Sample responsibly so that materials and sites are preserved for future study.
- Document and archive data and data products using best practices in data management, and share data promptly for use by the geoscience community.
- Use their technical knowledge and skills to protect public health, safety, and welfare, and enhance the sustainability of society.
- Responsibly inform the public about natural resources, hazards, and other geoscience phenomena with clarity and accuracy.
- Support responsible stewardship through an improved understanding and interpretation of the Earth, and by communicating known and potential impacts of human activities and natural processes.

Saturday 2 September

14:00h–18:00h	Outgoing Board of Directors Meeting AASP–TPS	Jury's Inn Station St., Nottingham NG2 3BJ

Sunday 3 September

07:30h–18:30h	Pre-Meeting Field Trip: 'Carboniferous Stage Stratotypes in the Peak District of Staffordshire. Led by: Dr. Duncan McLean and Dr. David Bodman (MB Stratigraphy)	Minibuses depart from St. James Hotel Rutland Street, Nottingham, NG1 6EB
19:30h–21:30h	Icebreaker Event	The Fat Cat Café Bar 11 Chapel Bar, NG1 6JQ

Monday 4 September

08:00h	Buses leave for BGS HQ in Keyworth	St. James Hotel Rutland Street, Nottingham, NG1 6EB
08:20h–08:50h	Arrival at BGS; Registration open; Opening remarks	BGS Reception, NG12 5GG
08:50h–09:05h	Welcome and opening remarks	De La Beche Conference Suite
09:05h–10:25h	Session 1: 50th Anniversary of AASP	De La Beche Conference Suite
10:55h–12:35h	Session 2: Saudi Aramco Session	De La Beche Conference Suite
13:30h–15:10h	Session 3: Silurian to Devonian Palynology	De La Beche Conference Suite
15:40h–17:20h	Session 4: Neogene Palynology	De La Beche Conference Suite
17:20h–19:15h	Reception + Poster Session	Exhibition area
19:30h	Buses return to St. James Hotel	

Tuesday 5 September

08:00h	Buses leave for BGS HQ in Keyworth	St. James Hotel Rutland Street, Nottingham, NG1 6EB
08:20h–08:30h	Arrival at BGS; Registration open	
08:30h–08:50h	Opening remarks - Intro Dave Batten Session	BGS Reception
08:50h–10:30h	Session 5: Dave Batten Session	De La Beche Conference Suite
11:00h–13:20h	Session 6: Triassic Palynology	De La Beche Conference Suite
14:10h–15:50h	Session 7: Cenozoic Palynology	De La Beche Conference Suite
16:20h–18:00h	Session 8: Carboniferous Palynology	De La Beche Conference Suite
18:10h	Buses Leave for Trent Bridge and St James Hotel	
19:00h for 19:30h	Conference dinner	The Boundary Edge Nottinghamshire County Cricket Club Trent Bridge, West Bridgford, Nottinghamshire, NG2 6AG

Wednesday 6 September

08:00h	Buses leave for BGS HQ in Keyworth	St. James Hotel Rutland Street, Nottingham, NG1 6EB
08:20h–08:30h	Arrival at BGS; Registration open	
08:30h–08:50h	Opening remarks Gordon Wood Session	De La Beche Conference Suite
08:50h–10:30h	Session 9: Gordon Wood Session	De La Beche Conference Suite
11:00h–13:00h	Session 10: Palaeozoic Palynology	De La Beche Conference Suite
14:00h–15:40h	Session 11: Mesozoic Palynology, Geochemistry and Nomenclature	De La Beche Conference Suite
16:10h–17:50h	Session 12: Cenozoic Palynology and methodology	De La Beche Conference Suite
17:50h–18:00h	Closing of the meeting	Exhibition area
18:10h	Buses Leave for St James Hotel	
19:30h for 20:00h	AASP and CIMP Luncheon	The Cumin 62–64 Maid Marian Way, Nottingham NG1 6BJ

Thursday 7 September

08:30h	Post-meeting fieldtrip: Buses leave for Charnwood Forest: Precambrian, Triassic, Quaternary	St. James Hotel Rutland Street, Nottingham, NG1 6EB
18:00h	Return to Nottingham	St. James Hotel Rutland Street, Nottingham, NG1 6EB

09:00h–12:30h	StrataBugs workshop led by Paul Britton and John Athersuch (StrataData Ltd.)	BGS HQ, Meeting Room 3 Nicker Hill, Keyworth, NG12 5GG

09:00h–17:30h	Workshop Biostratigraphy: applications to petroleum exploration and production. Led by Iain Prince and Katrin Ruckwied (Shell)	BGS HQ, Meeting Room 1 Nicker Hill, Keyworth, NG12 5GG

Start	End	Session	Chair		Abstract Number
08:00	08:20			Bus leaves St. James Hotel at 8:00; Arrival at BGS around 8:20	
08:20	08:50			Registration + Poster Setup	
08:50	09:05			Welcome and opening remarks - M. Stephenson	
09:05	09:25	Session 1 50th Anniversary of AASP	Chair: Jim Riding	Keynote - Fifty years of AASP-The palynological society: where we have been, where we are, and where we are going - *T. Demchuk*	9
09:25	09:45				
09:45	10:05			Permian palynostratigraphy: a global review - *M. Stephenson*	47
10:05	10:25			Why cryptospores are acritarchs (and why not) - *T. Servais*	45
10:25	10:55			Morning Coffee Break + Poster setup	
10:55	11:15	Session 2 Palaeozoic Palynostratigraphy of Saudi Arabia - Saudi Aramco Session	Chair: Marco Vecoli	Keynote -Lower Paleozoic Palynology of the Arabian Plate: a synopsis and historical perspective - *M. Vecoli*	54
11:15	11:35				
11:35	11:55			Chitinozoan biostratigraphy of the Sharawra Member (Qalibah Formation, Silurian) in the 802-5 shallow borehole, Saudi Arabia - *A. Butcher*	6
11:55	12:15			Permo-Carboniferous Palynostratigraphy and Paleoenvironments of Central and Eastern Saudi Arabia - *H. Boukhamsin*	4
12:15	12:35			Marine palynomorphs from the Permian-Triassic transition in Well QIBA-1, Northern Saudi Arabia- *M. Vecoli*	23
12:35	13:30			Lunch + Posters	
13:30	13:50	Session 3 Silurian to Devonian Palynology	Chair: Stewart Molyneux	Integration of acritarch morphological analyses with organic carbon isotope chemostratigraphy in the Kallholn section (early Silurian, central Sweden): complementary evidence for sequence stratigraphy- *N. Walasek*	55
13:50	14:10			Kirusillas Formation: new Silurian insights from high palaeolatitudes - *I. Troth*	53
14:10	14:30			Miospore assemblage associated with plant, fungal and animal fossils from the Lower Devonian alluvial deposits from the Bukowa Góra Quarry, Holy Cross Mountains, Poland - *P. Filipiak*	12
14:30	14:50			Irregular depositional dynamics in Northern Spain during the Middle Devonian: evidence from a detailed palynological analysis - *A. Askew*	1
14:50	15:10			Middle Devonian miospore assemblage biozones of the Sahara, Algeria Synclines: Geological implication and Evidence for Stages Boundaries - *O. Kermandji*	20
15:10	15:40			Afternoon Coffee Break + Posters	
15:40	16:00	Session 4 Neogene Palynology	Chair: Ulrich Salzmann	An attempt to date the Utsira Formation used for CO_2 storage in the North Sea, using dinoflagellates - *G. Mangerud*	8
16:00	16:20			The value of integrated palynological, lithological, wire-line and seismic studies in providing new insights into the regional geological development of the Dutch Neogene - *D. Munsterman*	32
16:20	16:40			Oceanic environments, vegetation and climate from the Middle to Late Miocene Brassington Formation, UK - *M. Pound*	38
16:40	17:00			Palynology and paleoecology of Haida Gwaii (former Queen Charlotte Islands), British Columbia, and implications for glacial refugia - *R. Mathewes*	30
17:00	17:20			The mid-Piacenzian warm period in the Asian interior: Assessing palaeoclimate variability with high-resolution pollen records from the Qaidam Basin and Chinese Loess Plateau - *F. Schwarz*	43
17:20	19:15			Poster Session + Reception in the BGS Exhibition area	

Scientific Program Tuesday 5 September

Start	End	Session	Title	Abstract Number
08:00	08:20		Bus leaves St. James Hotel at 8:00; Arrival at BGS around 8:20	
08:20	08:30		Registration	
08:30	08:50		Opening remarks - Martin Head (Intro Dave Batten Session)	
08:50	09:10	Session 5 Session dedicated to Dave Batten's career in Palynology Chair: Martin Head	Sporoderm ultrastructure of species of the water-fern megaspore genus Molaspora from a Cenomanian deposit in western France - *D. Batten*	3
09:10	09:30		Upper Jurassic-Lower Cretaceous Palynostratigraphy of the Husky Formation in the Canadian Arctic - *A. Nguyen*	33
09:30	09:50		Early Cretaceous deltaic deposits of the Main Pay Reservoir, Zubair Formation, SE Iraq: integrated palynostratigraphy - *D. Finucane*	13
09:50	10:10		Re-examination of the palynological content of the Lower Cretaceous deposits of Angeac (Charente, south-west France) - *F. Polette*	37
10:10	10:30		Arctic Cretaceous to Neogene palyno-biostratigraphy from Greenland, Canada, Faroe Islands and Norway - *H. Nøhr-Hansen*	34
10:30	11:00		Morning Coffee Break + Posters	
11:00	11:20	Session 6 Triassic Palynology Chair: Gunn Mangerud	Diversity patterns of land plants across the Permian–Triassic boundary - *H. Nowak*	35
11:20	11:40		Timing is everything – a new correlation of Triassic–Jurassic boundary successions and the Central Atlantic Magmatic Province - *S. Lindström*	24
11:40	12:00		Palynological record of changing environments across the Triassic-Jurassic boundary interval in Northern Ireland - *R. Walley*	56
12:00	12:20		Megaspores and associated palynofloras of the Late Triassic (late Carnian – Rhaetian) Kapp Toscana Group on Hopen, Arctic Norway - *N. Paterson*	36
12:20	12:40		Continental record of the Carnian Pluvial Episode (CPE) from the British Keuper (Mercia Mudstone Group, southwestern United Kingdom) - *V. Baranyi*	2
12:40	13:00		Mid-Triassic palynology in the Cheshire Basin (NW England) – a mine, a cemetery, a 'dungeon', and boreholes - *G. Warrington*	58
13:00	13:20		Biostratigraphy and Paleo environmental Reconstruction of the Triassic of the Central North Sea - *R. Burgess*	5
13:20	14:10		Lunch + Posters	
14:10	14:30	Session 7 Cenozoic Palynology I Chair: Matthew Pound	Cenozoic terrestrial climate change and the demise of forests on Wilkes Land, East Antarctica - *U. Salzmann*	42
14:30	14:50		A Cenozoic Southern Hemisphere Rainforest Record of climate, floral evolution, and fire - *V. Korasidis*	21
14:50	15:10		*Cerodinium* and related cavate peridiniod cysts - *J. Lucas-Clark*	17
15:10	15:30		Palaeovegetation responses to Oligocene glacial events and orbital eccentricity in NW Spain - *M. Gallego*	14
15:30	15:50		Cenozoic biogeography of *Striatopollis catatumbus* (Fabaceae – Detariae) - *I. Romero*	40
15:50	16:20		Afternoon Coffee Break + Posters	
16:20	16:40	Session 8 Carboniferous Palynology Chair: Jan Hennissen	Post-extinction recovery of terrestrial vegetation following the End Devonian Mass Extinction: palynological evidence from the Tournaisian (early Carboniferous) of the UK - *E. Reeves*	39
16:40	17:00		Palynostratigraphic analysis of the Mississippian Birger Johnsonfjellet Section, Spitsbergen, Svalbard - *G. Lopes*	26
17:00	17:20		New data on the biostratigraphy of Upper Visean (Mikhailovian) deposits from the Mstikhino Quarry (Kaluga Region) based on the miospores and foraminifers - *D. Mamontov*	28
17:20	17:40		The bearing of the stratigraphy and palynology of the Pennsylvanian Buçaco Basin on the geodynamic evolution of NW Iberia - *G. Machado*	27
17:40	18:00		A Comparative Palynofacies Study of Two Methods Used for Source Rock Validation - *T. Hansen*	15
18:10			Buses leave for Trent Bridge and St. James at 18:10	
19:30			Conference Dinner - Trent Bridge	

Start	End	Session	Chair	Title	Abstract Number
08:00	08:20			Bus leaves St. James Hotel at 8:00; Arrival at BGS around 8:20	
08:20	08:30			Registration	
08:30	08:50			Opening Remarks - Reed Wicander (Intro Gordon Wood Session)	
08:50	09:10	Session 9 Session dedicated to Gordon Wood's career in Palynology	Co-Chairs: Reed Wicander & Merrell Miller	New fossil protists from the basal Neoproterozoic Nonesuch Shale - *P. Strother*	48
09:10	09:30			Are laminae the only resistant spore wall structures in algal/land plant transitional forms? - *W. Taylor*	52
09:30	09:50			Organic-walled microphytoplankton from the Lower Devonian (Lochkovian) Ross Formation, Tennessee, USA - *R. Wicander*	60
09:50	10:10			Spore assemblages from the Lower Devonian La Vid Group (and equivalents) from northern Spain - *C. Wellman*	59
10:10	10:30			Devonian and early Carboniferous spore assemblages from the Old Red Sandstone rocks of the Dingle Peninsula, Ireland: their stratigraphic and tectonic implications - *K. Higgs*	18
10:30	11:00			Morning Coffee Break + Posters	
11:00	11:20	Session 10 Palaeozoic Palynology	Chair: Philippe Steemans	Global diversity and disparity of phytoplankton in the Palaeozoic: Progress report - *D. Kröck*	22
11:20	11:40			Palynology, age and provenance of the Lower Palaeozoic Sandstone of Stonehenge - *S. Molyneux*	31
11:40	12:00			Ordovician to Early Devonian miospores from South America: a state of the art review - *P. Steemans*	41
12:00	12:20			Palynological assemblages across the Hercynian unconformity in Western Iraq - *M. Stephenson*	46
12:20	12:40			Palynology of the latest Devonian to basal Carboniferous in Rügen Island (NE-Germany, Baltic Sea) - *H. Jäger*	19
12:40	13:00			Palynology of the Permian in the British Isles, and independent age constraints - *G. Warrington*	57
13:00	14:00			Lunch + Posters	
14:00	14:20	Session 11 Mesozoic Palynology, Geochemistry, and Nomenclature	Chair: Jen O'Keefe	A review of the Jurassic dinoflagellate cyst genus *Gonyaulacysta* Deflandre 1964 - *E. Mariani*	29
14:20	14:40			Middle Jurassic burst of radiation in dinoflagellates: a north-western Carpathian record - *T. Segit*	44
14:40	15:00			A Palynological Analysis of the Late Jurassic Ula Formation, Ula Field, NOCS: BP PalaeoGIS Project - *S. Stukins*	49
15:00	15:20			Sporopollenin chemistry: a treasure-trove to plunder - *B. Lomax*	25
15:20	15:40			Dual or unified taxonomy and nomenclature in dinoflagellates? – history, present status, and the revelations of molecular phylogeny - *M. Head*	16
15:40	16:10			Afternoon Coffee Break + Posters	
16:10	16:30	Session 12 Cenozoic palynology and methodology	Chair: Barry Lomax	Stratigraphic setting and dinoflagellate cyst assemblages, Wilcox Group and associated strata in Bastrop County, Central Texas - *C. Denison*	11
16:30	16:50			Terrestrial palynofloral assemblages from the Wilcox Group and associated strata in Bastrop County, Central Texas - *T. Demchuk*	10
16:50	17:10			Filling in the Gaps: Palynology at the Birthplace of North American Vertebrate Paleontology - *J. O'Keefe*	50
17:10	17:30			Radiocarbon-dated Holocene pollen and ostracod sequences from a tufa barrage dammed fluvial systems in the White Peak, Derbyshire, UK - *Iain Prince*	51
17:30	17:50			52 More Things you should know about Palaeontology - *A. Cullum*	7
17:50	18:00			Concluding remarks and packing up; bus to leave 18:10	
19:30				AASP and CIMP Luncheon	

Abstracts of the

Oral Presentations

-1-

Irregular depositional dynamics in Northern Spain during the Middle Devonian: evidence from a detailed palynological analysis

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The Middle Devonian was an important time of change for life on Earth, with biotic upheaval in the seas accompanied by early forests appearing on land. Various extinction events also took place throughout the Devonian, usually involving benthic anoxia, heavily affecting marine communities. Unfortunately little is known regarding these extinction events' effects on land. To address this a major palynological analysis has been conducted on the Eifelian and Givetian age Huergas, Naranco and Gustalapiedra formations of Asturias, Castilla y León and Palencia provinces in Northern Spain. These laterally equivalent formations represent a transect from shallow nearshore marine through to deep offshore shelf deposits on Peri-Gondwana. They consist of large sandstone bodies interspersed with black shales, sandwiched between thick limestone formations. Palynological analysis of 30 sites, including 4 logged sections, has revealed a rich biotic assemblage, including marine (acritachs, chitinozoans, scolecodonts) and terrestrial (spores) forms, that is often very well preserved. Biostratigraphical anlysis of the sequences appears to demonstrate an unexpected depositional dynamic. The sandy lower half of the formation covers a much longer time period than the heavily interbedded upper half, suggesting either gaps in sedimentation or slower rates of deposition. While the lower half covers most of the Eifelian interval, the upper half was deposited entirely within a short interval of the Lower Givetian (potentially only 400,000 years). This is deduced using well-defined conodont biomarkers in the overlying and underlying limestones in conjunction with biostratigraphical analysis of fossil spores, acritarchs and chitinozoans, particularly the presence of the important marker spore *Geminospora lemurata*. This step change in the rate and character of deposition appears to occur immediately following the Kačák Event, an important global extinction event in the marine realm. It seems likely that the Kačák Event was responsible for a major change in sedimentation type and rate in Northern Spain during the Middle Devonian.

Keywords: Middle Devonian, Kačák Event, Spores, Acritarchs, Chitinozoans

-2-

Continental record of the Carnian Pluvial Episode (CPE) from the British Keuper (Mercia Mudstone Group, southwestern United Kingdom)

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The generally dry Late Triassic climate was interrupted by a wet phase during the Carnian termed Carnian Pluvial Episode (CPE) accompanied by facies changes, biotic turnovers and global carbon cycle perturbation that lasted ca. 1 million years. In SW England, the terrestrial succession of the Mercia Mudstone Group exposes a Carnian sedimentary series that is equivalent of the Keuper Marls elsewhere in NW Europe and records the CPE. The mainly lacustrine MMG provides evidence for a climate change from a different terrestrial realm compared to the classical areas of the Carnian Pluvial Episode e.g., the fluvial-alluvial facies of the Schilfsandstein (Stuttgart Formation) in the Germanic Basins.

Quantitative and qualitative palynological data from the Sidmouth, Dunscombe and Branscombe Mudstone Formations within the Mercia Mudstone Group are presented in order to reveal vegetation changes and paleoclimate trends. Palynostratigraphy and the integrated bulk organic carbon isotope data enable the correlation to other CPE successions.

A total of 104 samples were processed for palynological analysis from three outcrops and the Wiscombe Park-1 borehole. From the total of 104 processed samples only 36 provided palynomorph assemblages. A total of 81 spore and

pollen taxa and five aquatic palynomorphs are distinguished.

Our new palynostratigraphy contributes to the biostratigraphic subdivision of the MMG. The previous palynological approaches assigned the Dunscombe Mudstone Formation to the Carnian without further dating to a substage level The palynological assemblages indicate that the Dunscombe Mudstone Formation is Julian in age and the lower studied part of the Branscombe Mudstone Formation is still Tuvalian.

The *Aulisporites astigmosus* acme, which is present in the Tethyan realm and the Schilfsandstein, is entirely missing in the studied successions. The quantitative palynological record suggests the predominance of the xerophyte floral elements through the whole CPE with only few horizons with the increase in the hygrophytes. The lack of the clear humid signal might be related to the strong seasonality in the precipitation in the generally dry inner part of Pangea and lack of suitable habitat for the permanent growth of hygrophyte vegetation (e.g. Aulisporites parent plants. However, the most likely explanation for the lack of clear humid signal is the overrepresentation of regional pollen rain in the lacustrine setting of the MMG with the predominance of xerophyte upland floral elements. The bias towards regional pollen rain is further enhanced by the potential increase in continental runoff related to more humid conditions.

Keywords: Carnian Pluvial Episode, palynology, palaeoclimate, England, Mercia Mudstone Group

-3-

Sporoderm ultrastructure of species of the water-fern megaspore genus *Molaspora* from a Cenomanian deposit in western France

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A new species of the water-fern megaspore *Molaspora* from a Cenomanian deposit in western France is distinguished from previously described species of the genus in being sculptured with irregular bulbous to meandering, fold-like elements that are usually tightly packed close to the acrolamella but arranged to form a reticulate pattern with increasingly wide lumina towards the equator and onto the distal face. This reticulation commonly breaks down close to, and around, the distal pole where instead the sculpture consists of irregular masses of similarly bulbous aggregations. The sporoderm structure of four specimens of this species has been studied and compared with that of one specimen of *Molaspora lobata* from the same mesofossil assemblage. Halves of the spores were examined in reflected light, in semithin sections in transmitted light and under a scanning electron microscope (SEM), and in ultrathin sections under a transmission electron microscope (TEM).

The sporoderm consists of an exospore (or exine) and an epispore (or perine). The thickness of the exospore is relatively constant, but it is thicker proximally than distally, especially close to the proximal pole. It appears homogeneous in semithin sections under the SEM and under low magnification in ultrathin sections in the TEM, but highly magnified TEM micrographs show that the middle of this layer contains narrow, interrupted channels that are directed more or less perpendicular to the surface of the sporoderm. The inner surface of the exospore is slightly uneven, and in two specimens it appears torn, with more distinct channels that extend to this surface.

The epispore, which consists of two main layers, is at least four times as thick as the exospore. The inner layer consists of a complex of thin, variously directed threads that are more densely packed adjacent to the exospore than away from it. It is c. 7 µm thick and not clearly layered in regions where the epispore is thinnest, but elsewhere it is divisible into four sublayers. The innermost of these is < 3 µm thick, above which is a sublayer up to 30 µm thick that consists of the same structural elements but very loosely arranged: in one specimen, it is partly replaced by a cavity of comparable thickness over a considerable part of the sporoderm. The overlying sublayer is similar to the innermost sublayer in its construction but more variable in thickness (up to c. 15 µm), and in one specimen it contains numerous large spherules that occasionally reach 14 µm in diameter. The ultrastructure of these spherules seems to be entirely homogeneous even under very high magnifications. In the same sublayer of two of the other specimens studied there are holes of comparable dimensions, but they are much less numerous than spherules and their outlines are more irregular. A rim that demarcates the holes can be present. A few small spherules 0.4–1 µm in diameter were found in these specimens. The fourth specimen examined lacks both spherules and holes in this layer. The outermost sublayer is thin (c. 1 µm). It also comprises threads, but these are more densely packed than those of the underlying sublayer.

The outer epispore is up to c. 14 µm thick and regularly alveolate. The alveolae are directed more or less perpendicular to the sporoderm surface, although they can be partly fused together and branched. The partitions are <1 µm thick and lined with fine threads. There are elevations over this layer that consist of slightly thinner partitions. These form the surface sculpture of the spore. The proximal pole is covered by an acrolamella. This is composed of outer epispore and the outermost sublayer of the inner epispore, and surrounds an exosporal tetrad scar.

Hitherto, morphological data in the literature provide unequivocal evidence of the presence of an exospore aperture in only one species of *Molaspora* (*M. fibrosa*), and it has yet to be demonstrated in megaspores of closely similar fossil and extant *Regnellidium*. In *Molaspor*a it is completely hidden by the acrolamella, but we observed a proximal scar in reflected light during the course of embedding the megaspores of the new species that were cut in half, and its presence was confirmed in sections. It was also encountered for the first time in *M. lobata*.

The presence of spherules in one specimen of the new species, their presumed analogues, holes, in two specimens that contain only a few, much smaller spherules, and the absence of both from the fourth specimen, suggest that these structures are secondary developments that took place either when the plants were alive or on fossilization. The rims around the holes might indicate a protective reaction of the sporoderm to some hostile activity, such as bacterial or fungal infection, during its development. Since the structures are present in the middle layer of the sporoderm rather than on its surface, we suggest that the changes took place when the developing sporoderm was partially permeable. The cavity replacing part of the epispore in one of the four specimens may be a preservational feature or have served to increase buoyancy of the spore in water. A cavity was also observed in the specimen of *M. lobata* examined.

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Permo-Carboniferous Palynostratigraphy and Paleoenvironments of Central and Eastern Saudi Arabia

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Three regionally occurring biozones (Oman and Saudi Arabia Palynological Zones (OSPZ)) were recognized in fifty six palynological samples, collected from five boreholes in central and eastern Saudi Arabia. The samples were selected from the Basal Khuff Clastics Member, Khuff Formation; Wudayhi Member, Nuayyim Formation, and Jawb Member, Juwayl Formation.

The OSPZ6 assemblage is recognized in the Basal Khuff Clastics Member. The palynomorph assemblages consist of abundant and diverse bisaccate and monosaccate pollen, and fern spores. The following taxa are characteristic of OSPZ 6: *Protohaploxypinus uttingii*, *Falcisporites stabilis*, *Lueckisporites virkkiae*, *Thymospora opaqua*, *Pyramidosporites cyathodes,* ?*Florinites balmei*, *Distriatites insolitus*, and ?*Tiwariasporis granulatus.* The OSPZ6 assemblage, also, contains abundant fungal/algal palynomorphs (>10% *Reduviasporonites chalastus*) and a few marine acritarchs that indicate a proximal marine paleoenvironment with fresh water influence. OSPZ6 is tentatively assigned to the Middle Permian, late Wordian-Capitanian.

The OSPZ3 assemblage is recognized in the Wudayhi Member. The palynomorph assemblage consists of abundant colpate pollen. Important short-ranging taxa are *Divarisaccus* sp. A of Stephenson and Osterloff (2002), *Marsupipollenites scutatus*, *M. striatus*, *Mabuitasaccites ovatus*, *Circumstriatites talchirensis* and *Striasulcites tectus*. In addition, the rare occurrences of *Striatopodocarpites fusus* and *S. cancellatus* are important bioevents in the OSPZ3. The palynomorph assemblage indicates a terrestrial paleoenvironment for the interval represented by the OSPZ3. The age of the OSPZ3 assemblage is Early Permian, late Sakmarian-early Artinskian.

The OSPZ2 assemblage occurs in the Jawb Member. The palynomorph assemblage consists of abundant monosaccate pollen and fern spores. The OSPZ2 was subdivided into three subzones. The OSPZ2a, the stratigraphically highest, is marked by the first down-hole occurrence (FDO) of *Converrucosisporites confluens*, *C. grandegranulata*, *Microbaculispora tentula* and *Psomospora detecta*. It is also characterized by low abundance (typically 2% or less) of cavate-zonate spores. The second subzone, OSPZ2b, is marked by increase in the percentage of the cavate-zonate spores, more than 10%. The cavate-zonate spores include *Lundbladispora braziliensis*, *Vallatisporites arcuatus* and *Spelaeotriletes triangulus*. The third, and stratigraphically lowest, subzone, OSPZ2c, is marked by the FDO of *Anapiculatisporites concinnus*. OSPZ2 consists mainly of terrestrial palynomorphs. The age of OSPZ2 ranges from ?latest Carboniferous(Pennsylvanian) to the Early Permian, Asselian-early Sakmarian.

The palynomorph assemblage changes during the Late Carboniferous (Pennsylvanian)- Early Permian reflect Gondwanan paleoclimate variations. The abundant fern spores and monosaccate pollen in the Jawb Member imply moist cold climatic conditions. Significant change occurs during the Wudayhi Member deposition and the assemblages are characterized by taeniate sulcate, taeniate bisaccate, taeniate monosaccate and pseudo-bisaccate pollen. This reflects a post-glacial transition to cool/temperate and increasingly arid climatic conditions. During deposition of the Basal Khuff Clastics Member, climate became warmer and moister reflected by overall increase in palynological recovery and diversity, particularly increased diversity of fern spores and abundance of fungal/algal palynomorphs.

Keywords: Saudi Arabia, Permo-Carboniferous, Palynostratigraphy, Basal Khuff Clastics Member, Wudayhi Member, Jawb Member.

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Biostratigraphy and Paleo environmental Reconstruction of the Triassic of the Central North Sea

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The Skagerrak Formation is a Mid-Late Triassic clastic succession from the Central North Sea comprising alternating fluvial sandstone dominated and playa/lacustrine mudstone dominated members. The Sandstone members form important primary and secondary reservoirs in the Central North Sea whilst the mudstone members can act as potential baffles/seals and lead to the compartmentalisation of these reservoirs. Hydrocarbon extraction has been hampered by a lack of knowledge regarding correlation at a basinal, sub-basinal and field scale and to date the identification; distribution and correlation of the different members is still poorly understood

Palynology is a powerful tool for well correlation, age assessment and environmental reconstruction and is routinely used within the petroleum industry, however previous palynologcial analysis from Triassic sediments within the Central North Sea have generally yielded poor recovery due to a combination of PDC drilling techniques, oil based muds, poor palynomorph preservation and the heavily oxidised nature of these sediments. By utilising refined palynology processing techniques this study aims to maximise and concentrate palynomorph content from drillcore and well cuttings to construct a robust age model providing the chronostratigraphic framework needed to accurately correlate the different members within the Skagerrak formation as well as allowing for detailed environmental reconstruction with the aid of Multivariate statistical techniques.

The focus of this study is on quadrants 22, 29 & 30 from the UKCS and Quads 7, 15 and 16 of the Norwegian sector with results providing a better regional understanding of the Skagerrak Formation, further aiding hydrocarbon exploration and exploitation.

Keywords**:** Palynology, Triassic, Skagerrak Formation, Central North Sea

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Chitinozoan biostratigraphy of the Sharawra Member (Qalibah Formation, Silurian) in the 802-5 shallow borehole, Saudi Arabia.

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Eighteen samples from the Sharawra Member (Qalibah Formation, Llandovery-Wenlock Silurian) recovered from the 802-5 shallow borehole (outcrop belt of central Saudi Arabia) were processed using standard palynological procedure. The organic residues were analysed with the aim of providing an age constraint to the samples using chitinozoans, and proved to be very rich in well-preserved organic matter, displaying a high diversity of taxonomic groups including chitinozoans, acritarchs, spores, and arthropods.

Chitinozoan specimens were picked representatively from the residues and mounted onto scanning electron microscope (SEM) stubs for analysis using an adapted negative-film technique, and imaged using a Zeiss Evo MA10 SEM. Twenty-three chitinozoan taxa were recognised from the samples, and of these thirteen provided age constraint for the strata.

The vertical distribution of the chitinozoan taxa shows two distinct assemblages; a lower one characterized by the presence, among others, of *Euconochitina silurica*, *Plectochitina alisawyiahensis*, *Pl. alnaimi*, *Sphaerochitina longicollis*, and an upper one characterized by the occurrence of *Ancyrochitina parafragilis*, *Angochitina* aff. *qusaibaensis*, and *Pseudoclathrochitina sharawraensis*. Based on the known stratigraphical distribution of the recognized taxa both in Saudi Arabia and other northern Gondwanan regions, the first (lower) assemblage is attributed to the Telychian Stage of the Llandovery Series; this assemblage can also be attributed to the *E. silurica* regional biozone (Paris et al, 2015). The stratigraphically higher assemblage can be attributed confidently to the Sheinwoodian Stage of the Wenlock Series (e.g., Al-Hajri and Paris, 1998).

The present study confirms that the age of the Sharawra Member of the Qalibah Formation is Telychian (Llandovery) to Sheinwoodian (Wenlock) in age in the study area. The palynological assemblages are largely dominated by marine elements (chitinozoans and acritarchs), although rare to uncommon cryptospores do occur throughout the section, indicating a fully marine, shelfal depositional paleoenvironment.

The study provides further data for occurrences (both geographical and stratigraphical) of several endemic taxa, in these economically-important strata.

Keywords: chitinozoa, biostratigraphy, northern Gondwana, Saudi Arabia, Silurian, biostratigraphy

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52 *More* Things you should know about Palaeontology

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In 2014 we published a book that contained 52 short essays on a wide range of paleontological subjects. It's an entertaining read and easy to pick up and enjoy in short chunks or as a longer exploration. We received much feedback, most of it positive, though some didn't like that it couldn't cover all the major fossil groups. Our response was that we hadn't set out to create a text book and that we chose the essays by how interesting and fun they were to read rather than trying to cover a logical plan or curriculum. However, the only real solution was to start building another book and collect even more stories to further showcase the thrill that so many palaeontologists experience from their work and the unbridled enthusiasm this builds for their chosen studies. At the end of all this, we still haven't covered everything, sorry. Maybe next time.

52 *more* essays on palaeontology takes us on a discovery journey through animal kingdoms and paleaogeography to

reveal a wide range of characters. From the fantastic re-discovery of tiny Palaeocene frogs in the middle of Bombay, to Balearic Mouse Goats, snakes with four legs, and the beautiful insects preserved in Cretaceous amber. It illustrates how far our analytical techniques, based on indirect information have developed by contrasting the legend of the Virgin.

Mary ascending a vertical rock face in Portugal with the exciting application of the rapidly developing field of extracting genomic information from extant organisms. In the Carboniferous, it takes us out on a swim in a shrimp-infested and thermally-stratified freshwater lake, and a walk through arborescent swamp forests conquered by lycophyte. According to one of the contributors, you don't even have to get out of your mother-in-law's shower to study some of the world's finest palaeontology.

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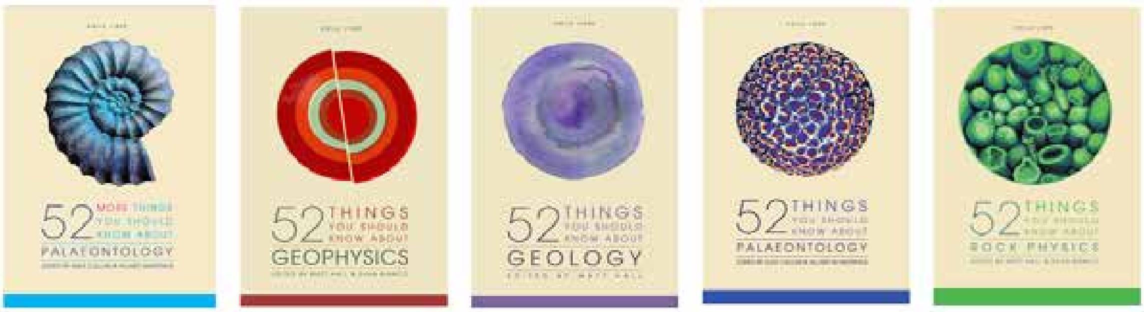

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An attempt to date the Utsira Formation used for CO_2 storage in the North Sea, using dinoflagellates

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Norway has extensive experience with storage of CO_2 in geological structures. Since 1996, approximately 1 Mt of CO_2 have been separated from gas production annually at the Sleipner Vest Field in the North Sea for storage in the Utsira formation. Although this northern North Sea unit has been subjected to several geological and monitoring studies, its lateral distribution and stratigraphic position is still not fully understood. The unit was considered to be late Neogene and deposited in neritic environments on the Norwegian shelf, in an area from the Viking Graben to Tampen area. Here we present marine palynomorph (dinoflagellate cysts, acritarchs) data extracted mainly from cutting samples of eight industry wells that cover the entire distribution area of the Utsira Formation to provide an age and palaeoenvironmental reconstruction for this unit. We conclude that deposits classified as Utsira Formation are Late Miocene/Early Pliocene to Early Pleistocene in age. Early Pliocene sediments are mainly found in the Viking Graben area, whereas sediments with an Early Pleistocene age occur over the entire distribution area of the Utsira Formation. All sediments were deposited in neritic environments that gradually become shallower from the Early Pliocene to the Pleistocene. At the same time, the dinoflagellate cysts also indicate a cooling that corresponds well with late Neogene global cooling.

Precise dating of the Utsira Formation is still difficult, but can be much improved by (1) using samples from cored section, (2) a clear and unquestionable lithological definition of the Utsira Formation and (3) a continuous, calibrated reference section in the Neogene North Sea for comparison of the bioevents.

Keywords: Utsira Formation, marine palynomorphs, dinoflagellate cysts, acritarchs, Late Miocene, Pliocene, Pleistocene

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Fifty years of AASP-The palynological society: where we have been, where we are, and where we are going

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For fifty years, AASP-The Palynological Society (AASP-TPS) has been serving its membership and the general palynological community in numerous positive ways, most importantly sponsoring annual meetings and other scientific conferences, publishing the journal Palynology in addition to the AASP Contribution Series and providing travel and research grants to graduate students worldwide. The American Association of Stratigraphic Palynologists was formed on December 8, 1967 by a small entrepreneurial group of industry and academic palynologists, following a decade of high-profile palynological research published by numerous palynological pioneers, and involvement by palynologists with the Paleobotanical Section of the Botanical Society of America. The original belief was the Society would be dominated and focused on industry needs: however, through the decades the Society has become a focus for all aspects of palynology including Quaternary, forensics and melissopalynology. Through the 1970s and 1980s, membership increased dramatically, and through donations from oil companies offsetting the cost of printing and postage, the revenue base also increased to allow for the introduction of student scholarships and travel grants. In 1976 the AASP Foundation was formed to allow for tax-free donation to AASP: the Foundation continues to oversee all AASP publications, as well as accepting and distributing funds for student scholarships. The Society Newsletter was first published in 1968 and along with the website which first came on-line in 1995, continue to be the main means for transferring information to the membership. Today the Society has its own Facebook and LinkedIn pages, as well as a Twitter account. Annual meetings are held in diverse localities either as standalone AASP-TPS meetings or in conjunction with other geological organizations: AASP-TPS is an Associated Society of the Geological Society of America, and is an Affiliated Society of the American Association of Petroleum Geologists. In 2008 the Association voted to pull away slightly from its industrial roots and changed its name to AASP-The Palynological Society to reflect the diverse nature of the membership and associated research.

The last decade has continued to see AASP-TPS evolve into a truly international society, embracing technology and overseeing the appointment of the CENEX Chair at Louisiana State University. Of significance over the past many decades, there has been an unfortunate decrease in North American based universities that are teaching graduate studies in palynology. In the 1960s and 1970s as many as 10 to 12 major universities trained the large number of paleo-palynologists that went on to work in the energy industry, or went to set up additional research programs at other universities. In addition, there were several other universities that trained students in Quaternary palynology. Over the past two decades, the training of palynologists at universities has declined owing to fluctuations in oil prices and the declining numbers of biostratigraphic staff at multi-national energy companies. In 1989, the idea of the Center for Excellence in Palynology (CENEX) was promoted by the AASP Board of Directors: In 1990, Louisiana State University was chosen as the host institute for CENEX. The history of CENEX is long and remarkable, and in 2016 the Chair of CENEX was appointed. The Center is currently undergoing major renovations to house the massive library and reprint collection, creating guest offices to host visiting scientists, and new laboratory facilities that will facilitate high-quality research in all facets of palynology. With additional input from the AASP-TPS Board and retired members, CENEX is prepared to train a new generation of global palynologists for industry and academia.

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Terrestrial palynofloral assemblages from the Wilcox Group and associated strata in Bastrop County, Central Texas

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The upper Wilcox/Carrizo (Paleocene-Eocene) succession in Central Texas consists of, in ascending order, the Calvert Bluff and Sabinetown formations (Wilcox Group) and Carrizo Formation (Claiborne Group). Where these strata outcrop in Bastrop County sedimentary structures, trace fossils and dinocysts provide new datasets that add to the growing body of evidence that the up-dip succession along the outcrop belt is marine, with widespread tidal influence.

New investigations of the palynoflora have revealed extremely rich and diverse terrestrially-derived pollen and spore assemblages that have been transported into shallow marine depositional settings. Significant pollen of the *Momipites-Caryapollenites* lineage are common components of these assemblages and provide important age information: *Caryapollenites veripites* is the most common species from this lineage, with frequent *C. wodehousei* and *C. imparalis*. In addition, various species of *Momipites* (including *M. anellus* and *M. ventifluiminis,* but lacking early Paleocene species) suggest a late Paleocene age. Eocene-restricted species are absent from these diverse and rich assemblages despite being documented (as rare specimens) in a previous study of one of the outcrop localities. A late Paleocene age is corroborated by the presence of *Apectodinium homomorphum*, with an acme interval indicating the vicinity of the Paleocene-Eocene boundary and the associated PETM. Additional sedimentological and stratigraphic information, with quantitative data from these assemblages, may help confirm the presence of the PETM.

In additional to species of *Momipites* and *Caryapollenites*, the diverse assemblages contain elements of palynofloras from the Western Interior Paleocene basins, including abundant triporates, tricolpates and tricolporates, finely reticulate *Tillaepollenites*-like pollen (*Intratriporopollenites/Bombacacidites*), palm-like pollen, and frequent algae of lacustrine origin. Species include *Thomsonipollis magnificus, Pistillipollenites mcgregorii, Langiopollis* sp., *Casuariniidites* spp., *Arecipites* sp., *Margocolporites* sp., *Carpiniidites/Betulaceoipollenites*, *Nypa/Spinozonocolpites* sp., and *Cicatricosisporites dorogensis* (for example) in addition to reworked Cretaceous pollen and dinoflagellates (e.g. *Aquilapollenites* sp. and *Chatangiella* sp.).

These pollen and spore assemblages, in addition to the marine dinocysts, help to relocate the late Paleocene paleoshoreline in Central Texas much further to the north and west than previous interpretations suggest. The assemblages also aid in refining the Paleocene-Eocene paleoclimate of the Gulf Coast: additional quantitative data will help define and understand the late Paleocene warming trend, culminating at the PETM thermal maximum. This has implications for better understanding the age and provenance (source-to-sink) of the Wilcox Group in the deepwater Gulf of Mexico where these strata are a major hydrocarbon play.

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Stratigraphic setting and dinoflagellate cyst assemblages, Wilcox Group and associated strata in Bastrop County, Central Texas

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In Central Texas the upper Wilcox/Carrizo (Paleocene-Eocene) succession consists of, in ascending order, the Calvert Bluff and Sabinetown formations (Wilcox Group) and Carrizo (Claiborne Group) Formation. Onshore, thick lignites in the Calvert Bluff are mined for electricity generation and offshore, the Wilcox is a major hydrocarbon play. Fluvial delta and barrier bar models developed in the 1960's, based on the Mississippi Delta, still result in the Wilcox being regarded as dominantly fluvial to fluvio-deltaic, but a growing body of evidence shows that most, if not all, of the up-dip succession along the outcrop belt is marine, with widespread evidence of tidal influence. Separate North and South America continents allowed a tidal bulge to traverse the proto-Caribbean unimpeded, with amplification across a broad, shallow continental shelf, generating a mesotidal regime.

Using a combination of sedimentary structures, ichnology, and palynology, depositional environments and the age of the Calvert Bluff and Sabinetown formations (uppermost Wilcox Group) and Carrizo Formation (lowermost Claiborne Group) in Bastrop County have been re-evaluated. The well-known Red Bluff and Golf Course outcrops in Tahitian Village have been complemented with lesser-known outcrops in the immediate vicinity.

The Calvert Bluff is poorly exposed except in inaccessible lignite mines. Based on the lignites and lack of macrofossils, older literature emphasizes non-marine deposition, but in Bastrop County and elsewhere along the outcrop belt, at least the upper part definitely consists of tidal flats dissected by coarser grained tidal channels, with some inclined tidal heterolithics. The uppermost Calvert Bluff includes sand-filled tidal channels and tidal sand flats with Ophiomorpha, which can be abundant.

A unit possibly coeval with the Sabinetown has a transgressive lag with a marine macrofauna at its base and consists of several prograding parasequences with tidal sedimentary structures and shallow marine trace fossils. At Red Bluff and Copperas Creek, the uppermost Sabinetown parasequence is initially siltstone-dominated but becomes increasingly heterolithic upwards; muddy tidal heterolithics transition upwards to sandy tidal heterolithics. Marine dinocysts are sparse to rare, and are dominated by *Apectodinium homomorphum*, consistent with a latest Paleocene age. Accessory dinocyst species are *Cordosphaeridium* spp., sparse examples of *Achomosphaera*, *Adnatosphaeridium* and *Spiniferites*, and additional rare species, including *Ifecysta*. So far, the latest Paleocene marker *Axiodinium augustum* has not been recorded, but assemblages from these tidally-dominated deposits are depauperate compared with fully marine assemblages of similar age elsewhere.

At all outcrops there is a muddy to silty, locally lignitic unit informally termed the Dark Band: it erosionally overlies the Sabinetown and is in turn erosionally overlain by the Carrizo. Assemblages from Dark Band siltstones at Manawianui Drive include common/abundant *A. homomorphum*, which constitute over 80% of the dinocysts. In assemblages from the Dark Band at Copperas Creek *A. homomorphum* is common/abundant and can be over 90% of the dinocysts. This acme of *A. homomorphum*, the worldwide marker for the PETM, is the basis for a preliminary interpretation that we have located the PETM in Bastrop County, the first documentation of this important stratigraphic boundary in Texas, although this remains to be corroborated with carbon isotope analysis to identify the Carbon Isotope Excursion (CIE) at the PETM.

Given the consistent stratigraphic succession in these outcrops, the much-visited Golf Course channel exposure is anomalous. Uppermost Sabinetown muddy and sandy tidal heterolithics, capped by a poorly exposed Dark Band, are present, but across most of the outcrop both are truncated by a channel. Flaser and wavy bedded units in the lower part of the heterolithic channel-fill produced sparse marine dinocysts including low numbers of *A. homomorphum*. In the upper part, and at a smaller, but probably correlative channel at Manawianui Drive, lignitic material forms the final channel-fill. None of the dinocysts observed are necessarily indigenous - some may have been carried up-channel on flood tides and others may be reworked from the subjacent Dark Band. This channel may be the up-dip limit of an arm of the Yoakum Canyon, which has been mapped in the subsurface into southernmost Bastrop County.

At all outcrops a marine Glossifungites surface marks the base of the Carrizo, with some Thalassinoides descending as much as 0.5 m. This fine grained sandstone is mostly planar cross-bedded but in places siltstone rip-ups are draped on sigmoidal cross-beds and there are rare examples of bi-directional cross-bedding. Trace fossils are largely absent, but robust Ophiomorpha are present at Red Bluff and Manawianui Drive. Although most previous interpretations invoke a fluvial channel concept, these newly recorded features demonstrate that the Carrizo is definitely a marine deposit, possibly a tidal delta.

The fragmentary nature of this up-dip succession is shown by the stratigraphic breaks between each lithological unit, but even though the base Carrizo surface may represent a time gap of several million years, this and other breaks are below the currently possible biostratigraphic resolution. Translation of sediment across a shallow shelf to feed shelf edge deltas and deepwater Gulf of Mexico turbidites must have occurred during the time represented by these breaks. While the Sabinetown and Carrizo are progradational into shallow shelf seas, and may represent late highstand deposition, the

Dark Band is transgressive, related to a thermally driven maximum sea level at the PETM.

Keywords: Paleocene, PETM, dinocysts, tidalites, sedimentology

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Miospore assemblage associated with plant, fungal and animal fossils from the Lower Devonian alluvial deposits from the Bukowa Góra Quarry, Holy Cross Mountains, Poland

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The Lower Devonian clastic sediments from the Bukowa Góra Quarry (Holy Cross Mountains) were palynologicaly investigated. Macerated samples revealed the abundance of plants and animals remains, but also presence of fungi and algae. The age of analysed deposits have been established as the *douglastownense-eurypterota* Miospore Zone (Emsian) based on rich miospore assemblage. Miospores are represented here by highly differentiated assemblage. Among them following ones were identified: *Acinosporites lindralensis*, *Apiculiretusispora brandtii, A. plicata, Camptozonotriletes caperatus, Dibolisporites echinaceus, D. capitellatus*, *Grandispora protea, Hystricosporites* cf. *H. corystus, H. microancyreus,* Retusotriletes dubiosus, *Rhabdosporites minutus, Samarisporites eximius* and *Verruciretusispora dubia*.

Except for microfossils, plants are preserved also as compressions, coalfield stems and tracheids, and fragments of cuticles. Investigated material also contains long tubes classified as *Porcatitubulus* and more enigmatic *Nematothallus* cuticles. Along with floral, animal remains have been recognised. Those particles are represented by well-preserved cuticles and respiratory organs (Kiemenplatten) probably belonging to eurypterids. Animal cuticles possess both pitted and unpitted, sometime wavy surfaces, but their origin is problematic.

Discernible is the strongly restricted presence of acritarchs. Together with the occurrence of land plants, fungi and animal (mainly arthropod) components, rarity of acritarchs may indicate marginal-marine, alluvial depositional environment. Similar in composition palynofacies were noticed previously from the Dyminy IG2 and Klucze 1 boreholes (southern Poland; Filipiak and Zatoń, 2011).

Keywords: Lower Devonian, Holy Cross Mountains, plant remains, fungi, miospores

References: **Filipiak, P. & Zatoń , M.** 2011: Plant and animal cuticle remains from the Lower Devonian of southern Poland and their palaeoenvironmental significance. Lethaia, Vol. 44, pp. 397–409. This project was financially supported by the NCN grant nr 2015/19/ B/ST10/01620 (for P. Filipiak, University of Silesia, Poland).

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Early Cretaceous deltaic deposits of the Main Pay Reservoir, Zubair Formation, SE Iraq: integrated palynostratigraphy

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Rumaila is one of the world's super-giant oil fields. At the end of 2009, BP entered into a Technical Service Contract as the lead contractor with the South Oil Company of Iraq (SOC) and PetroChina to develop the remaining resource. The Early Cretaceous Main Pay is one of the largest reservoirs in the field. A rich dataset has recently become available including access to nearly 1 km of core, wireline image logs, open hole logs, formation pressure tests and cased hole saturation logs.

Biostratigraphic analysis of the core indicates that most samples contain both marine and terrestrial mircoflora, confirming a marginal marine gross depositional environment. Palynology has proved to be of particular value, with diverse and abundant recovery of algal and dinoflagellate cysts from fine grained deposits allowing for a high resolution bio-chronostratigraphic model to be built. A set of marginal marine genetic elements was interpreted through the integration of core sedimentology and palynofacies.

Reservoir units in the south of the field are dominated by distributary channels, whereas more heterolithic sediments in the north also include mouth bar, shoreline and tidal flat deposits. Non-reservoir elements in the Main Pay are dominated by prodelta "fluid" mudstones picked primarily based on their palynological assemblages. These elements typically overlie a transgressive deposit and flooding surface and mark the early phase of deltaic advance. These deposits tend to be laterally extensive and form the foundation for the stratigraphic framework.

The stratigraphic and depositional descriptions have been extended away from cored wells using cuttings, well logs, formation pressure tests and fluid saturation data. The current description suggests the potential for targeted development of bypassed oil beneath flooding shales and in the mouth bar, shoreline and tidal flat genetic elements.

Keywords: Early Cretaceous, deltaic, reservoir, oil field, Iraq

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Palaeovegetation responses to Oligocene glacial events and orbital eccentricity in NW Spain

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The Oligocene was an epoch of significant palaeoclimatic and palaeogeographic changes around the world, and particularly in Western Europe. During this period, the tectonic activity of the Alpine Orogeny produced a number of sedimentary basins in NW Spain. Most of them were filled with sediments deposited in palustrine/lacustrine environments during the Oligocene to Early Miocene.

A high resolution palynological study of the 300m thick sedimentary series of one of these basins has allowed accurate definition of the diversity and evolution of the vegetation during a time span of 7.5 Ma covering part of the Rupelian, the entire Chattian and the lowermost Aquitanian. The area was dominated by evergreen forests composed of taxa whose descendants are living today in tropical and subtropical regions of Africa, Asia and America. The palaeoenvironmental interpretation of the results indicates that multiple types of vegetation developed in the basin, which can be grouped under two major categories that experienced very different dynamics: the azonal and the zonal vegetation.

The first consisted of a hygrophytic flora developed in the surroundings of the lacustrine system. Its dynamic was controlled by repetitive phases of lake transgression and regression, which were orbitally-driven. The eccentricity modulated the precession and, as a consequence, the precipitation and the water/sediment supply to the basin. The oscillations in the lake level determined an ecological succession, of which we have recorded 18 consecutive cycles. Each of them started during the expansive phase of the lacustrine setting, when the sedimentation was of a relatively higher energy and clastic facies (claystone) deposited. These materials contain abundant palynomorphs of swampy taxa such as *Nymphaeapollenites*, *Cupressacites*, *Inaperturopollenites*, *Orapollis*, and various species of algal spores. As the water level decreased, taxa with lower hydric requirements represented by *Sparganiaceaepollenites* and *Cyperaceaepollis* replaced these ecosystems. At a later stage of the regressive phase, *Cyrillaceaepollenites* and *Myricipites*, among many other genera, dominated the vegetation reflecting the establishment of forested bogs and the accumulation of extensive coal units.

The zonal vegetation was associated to more elevated areas of the basin and was completely independent of the orbital control. On the other hand, it was sensitive to the major glacial events that occurred during the Oligocene as shown by marine isotope records. Thus, the palynological assemblages reveal the effects of the five main glaciations recognised in the studied interval (*Oi2**, *Oi2a*, *Oi2b*, *Oi2c* and *Mi1*), which are associated with the marine depositional sequence boundaries Ru3, Ch1, Ch2, Ch3 and Aq1. These data show that the main climatic processes that occurred in the oceans are coupled with and can be tracked in the continental records.

Keywords: Paleogene, Oligocene, palaeovegetation, orbital control, glacial events

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A Comparative Palynofacies Study of Two Methods Used for Source Rock Validation

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A master study is carried out to test two different methods for palynofacies analysis using both point counting and relative area measurement based on the free image analysis software ImageJ. A pre-study to assess the validity of visual estimation of relative areas was first performed. The study was then conducted from analysis of twenty-nine kerogen slides of Tournasian and Visean age, collected from an outcrop section on Spitsbergen, Svalbard. In both cases, the OM classification based on Bujak *et al.* (1977) was applied as the basis. All five kerogen types defined for this study (hylogen, melanogen, phyrogen, AOM and pseudoAOM) were present in the twenty-nine samples, with most of the particles being dark brown in color. Images captured with a camera connected to a transmitted light microscope were analyzed using both methods, and a total of 1789 frames and 16 266 particles were counted, and their area measured. Fluorescence analysis was conducted in order to clarify the presence of *Botryococcus* specimens. The results for each individual kerogen group were analyzed in order to compare both methods.

Keywords: Palynofacies analysis; Point counting; Relative area measurement; Spitsbergen Mississippian; Norway

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Dual or unified taxonomy and nomenclature in dinoflagellates? – history, present status, and the revelations of molecular phylogeny

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Two separate taxonomic traditions have arisen in dinoflagellates at the generic level and below: one centred on the living motile cell but potentially incorporating all aspects of the biology, and the other based exclusively on resting cyst morphology including the fossil record. Where a cyst has been described and named as a fossil and subsequently shown through life-cycle observations to be equivalent to a named living species, the cyst morphotype may then bear two names (this has also sometimes been done for un-named species, where a name has then been created for the motile stage). This dual nomenclature is supported for all algae (diatoms excepted) by the International Code of Nomenclature for Algae, Fungi and Plants (ICN) through Articles 1.2, 11.1, and 11.7 (Head, M.J. et al., 2016, *Taxon* 65: 902–903). The ICN acknowledges that a fossil-taxon (having a fossil as its type) is conceptually distinct from its living (non-fossil) counterpart, and that equivalency need not mean synonymy. This distinction reflects the different species concepts involved, based on different stages of the same life cycle, and acknowledges that cyst morphology alone retrieves only limited genetic information from the fossil record. But of course, dual nomenclature has the undesirable effect of decoupling living species from their fossil record. While cyst-based taxonomy strives to reflect evolution, there is in some cases a clear mismatch between fossil-defined genera and the genera of living equivalents. Molecular phylogenies from living material now expose these discrepancies and others with new clarity. This requires the reassessment of our current taxonomic schemes if they are to be more reflective of evolution, although any major nomenclatural changes should be balanced against the value of stability in connecting living dinoflagellates to their fossil lineages.

Keywords: Dinoflagellates, life cycles, cysts, taxonomy, nomenclature, molecular phylogeny

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Cerodinium and related cavate peridiniod cysts

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Fossil dinoflagellate cysts of the order Peridiniales were first observed by Ehrenberg (1838) and constitute an important group of dinoflagellates for several reasons, e.g., 1) they are abundant in Cenomanian to Oligocene strata where they are useful stratigraphic markers, and 2) they can represent fresh to brackish water environments or relatively shallow, coastal marine environments. As an initial step toward accurate interpretations of this group, it is vital to establish a consistent taxonomy of the most important genera. We propose revision of the genera *Cerodinium, Senegalinium* and *Phelodinium*, plus add a new genus, "*Gabonidinium*." At present the assignments of species to the three genera are applied inconsistently with the original descriptions, holotypes and accepted concepts of these genera. Such taxonomic inconsistencies can be a source of errors in identification of species which are applied to stratigraphic and paleoenvironmental interpretations.

We have concluded that *Senegalinium* is a junior synonym of *Cerodinium* and that *Phelodinium* is better constrained to cysts >100μm. The new genus, "*Gabonidinium"* comprises some species currently assigned to *Senegalinium* and to *Phelodinium*. We have used morphometric analyses for redefining the genera and constructing the synonomies of the species.

Keywords: Morphometric taxonomy, Fossil Peridinioid dinoflagellates, *Cerodinium*, *Gabonidinium*, *Phelodinium*

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Devonian and early Carboniferous spore assemblages from the Old Red Sandstone rocks of the Dingle Peninsula, Ireland: their stratigraphic and tectonic implications.

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The geology of the Dingle Peninsula is predominately composed of a thick (6300m) succession of red continental Devonian and early Carboniferous rocks that comprise the most complete Old Red Sandstone magnafacies in Ireland. The succession is characterised by a range of fluvial, lacustrine and aeolian sedimentary associations. Stratigraphically, it is subdivided into seven lithostratigraphic groups that are separated by unconformities or faults. The absence of biostratigraphic data has previously prevented the accurate age dating of these groups, their correlation across the peninsula and the tectonic events separating them. The present study describes several poorly to moderately preserved spore assemblages from a limited number of horizons within the succession. Correlation of these assemblages with the standard western European Devonian and Carboniferous spore zonation schemes indicate the Old Red Sandstone succession ranges from early Devonian (Lochkovian) to early Carboniferous (Tournaisian) in age. The important Acadian Unconformity between the lower and middle divisions of the Old Red Sandstone succession is shown to be no older that mid-Emsian in age.

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Palynology of the basal Carboniferous to latest Devonian of Rügen Island and its implication for the development of the Variscan Foreland Basin (NE-Germany, Baltic Sea)

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The Upper Devonian to Lower Carboniferous successions of Rügen Island, only preserved in deep wells, are interpreted as shallow marine carbonate shelf deposits of the passive continental margin north of the Variscan Basin, continosly deposited across the Devonian/Carboniferous boundary. Rarely questionable minor gaps are described from the uppermost Devonian. The recent structural setting of the Devonian /Carboniferous of Rügen - a half-graben, compartmentalized in several blocks - is ment to be related to late Carboniferous final Variscan tectonic overprint. The first palynological study of the Tournaisian of Rügen supported the interpretation of continuous sedimentation across the D/C boundary (Burmann 1975). But later detailed palynological studies of two wells from Rügen Island (Carson & Clayton 1997) recorded a significant stratigraphic gap at the base of the Carboniferous in both wells, questioning the continuous deposition across the D/C boundary.

A detailed palynological study of the Lower Carboniferous and latest Devonian in Rügen was performed, based on 10 deep wells. All wells show a significant stratigraphical gap in the early Carboniferous, up to the middle Tournaisian in some wells, in others up to the late Tournaisian. Also the latest Devonian (Strunian) is missing in most wells, except one well where the basal Strunian is preserved. This proves a significant hiatus at the D/C boundary in Rügen, from the latest Devonian (Strunian) to the middle to upper Tournaisian, in contrast to the previously described continuous D/C boundary successions. Nevertheless, basal Visean sediments in the Variscan basin, derived from the passive continental margin north of the basin, include partially high amounts of Upper Devonian (particularly Strunian) miospores also (Jäger 2002). This indicates widespread primary deposition of latest Devonian strata at the passive continental margin, including the area of Rügen Island, and consequent erosion and recycling in the basal Carboniferous. Thus palynology gives evidence, that the globally well-known end-Devonian (Strunian) regression is - at least in the southern Baltic Sea - is more a basal Carboniferous regression, most probably reaching its maximum in the lower Tournaisian. The different stratigraphy at the top Devonian and for the onset of the Carboniferous gives evidence for a significant palaeo-topography of the carbonate shelf around Rügen Island (southern Baltic Sea) already at that time. It might even indicate the initial break-up of the carbonate shelf, a precursor to the major break-up phase during the Visean due to the tectonical activitiy related to the final Variscan Orogeny.

Keywords: D/C boundary, palynostratigraphy, spores, reworking, D/C boundary, Variscan basin

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Middle Devonian miospore assemblage biozones of the Sahara, Algeria Synclines: Geological implication and Evidence for Stages Boundaries.

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The classic exposed Devonian sedimentary sequences of Oued Saoura west Sahara Algeria and Devonian succession of Steh borehole of eastern Sahara Algeria Syncline are studied. The investigated data show that most palynomorphs occur in grey to dark grey clayey siltstone and very fine argillaceous sandstone layers. Fossils of exposure rock sam-

ples are mainly mature to highly mature and poorly preserved. While those of Steh borehole samples are moderately to well preserved. The assemblages contain associations of miospores, tetrads, plant remains (cuticles, tissues and tubular structures) and few acritarch individuals. The studied miospore assemblages are identified and keyed into previously described palynostratigraphic miospore assemblage biozones of deep wells from the Tidikelt Plateau, central Saharan, Algerian and Oued Saoura out croups Hassan Kermandji *et al.*(2008, 2009, 2016) and those of the Old Red Sandstone Continent and adjacent regions by Richardson and McGregor (1986) and those from marine Devonian of the Ardenne-Rhenish regions by Streel *et al.* (1987).

The biostratigraphical data illustrate that the basal strata of Teferguenite Formation exposed in the Mongar Debad Km 30 section confirm faunal ages that are established on limited rock interval, are of Eifelian age. Subsequently the occurrence of characteristic miospore taxa in the higher studied sequence above the basal strata of the same formation indicate Givetian age.

The miospore assemblages contain diagnostic elements of Middle Devonian Algerian succession and those are common with contemporaneous miospore assemblages from Libya, Tunis, Saudi Arabia implying reasonably impressive correlation between northern Gondwanan regions and to some extent to those of Northern Hemisphere. The occurrence of distinguished miospore taxa, permit determining the boundary between Eifelian and Givetian strata.

Keywords: Devonian, miospore, palynostratigraphy, east-west sahara synclines, Algeria

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A Cenozoic southern hemisphere rainforest record of climate, floral evolution and fire

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The Eocene-Miocene brown coals of the Gippsland Basin in Australia represent one of the best southern hemisphere peatland rainforest records of climate, floral evolution and fire. The close correlation between the $\delta^{13}C$ of these brown coals and the global benthic marine record suggests a strongly coupled marine-terrestrial system from the Eocene to Miocene. Changing palaeotemperatures produced major vegetation shifts within the Latrobe Valley peatlands from the Middle Eocene through to the Middle Miocene climatic optimum. An increased abundance of gymnosperms, including *Lagarostrobos*, is recorded in the warm Eocene and Middle Miocene coals. In contrast, the coals of the Oligocene and Early Miocene are characterized by a greater abundance of southern beech (*Nothofagus*) and cooler climate podocarps such as *Dacrycarpus*. It is likely that the overall increased abundance of the decay-resistant gymnosperms in the warmer periods amplified the heavier $\delta^{13}C$ events of the Eocene and Middle Miocene coals. The correlation between the Latrobe Valley brown coals and marine $\delta^{18}O$ records suggests that warm high-stand periods promoted the development of the low-lying back-barrier peatland systems. Detailed palynological analysis of the Early Oligocene to Middle Miocene M2A, M1B, M1A and Yallourn coal seams suggests that the variation in charcoal abundance and sclerophyllous flora within these coals is entirely controlled by the abundance of particular facies and paleoenvironments within the peatland, and is not a result of drier climates as has been previously suggested. Charcoal and sclerophyllous flora are associated with emergent and meadow marsh environments that produced dark lithotypes. Counter-intuitively, these low-nutrient, fire-prone marsh environments that fringed the ever-wet rainforests of the Latrobe Valley peatlands appear to represent an ideal setting for Australia's modern fire-adapted flora to evolve in.

Keywords: Latrobe Valley, brown coal, $\delta^{13}C$, palynology, sclerophyllous flora, charcoal

Global diversity and disparity of phytoplankton in the Palaeozoic: progress report

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Phytoplankton plays a major role for the ecosystems of the world. It constitutes the base of all marine food chains and, thus, is the starting point for nearly every biological activity in the oceans. Moreover, it represents the biggest producer of oxygen on Earth. Changes in the populations of phytoplankton must have had considerably strong effects on the environment, but their impact on the climate, as well as their influence on the establishment of the modern marine ecosystems, remain largely unknown. Therefore, it is most important for the understanding of the marine ecosystems of ancient times to investigate the evolution of the populations of phytoplankton on regional but also on global scale.

The study of the diversity of the Palaeozoic phytoplankton can reveal valuable insights relevant for expanding our knowledge of past life in a wide range of areas. Based on an unpublished database comprising more than 4,400 species, a comprehensive analysis of the diversity of the Palaeozoic marine phytoplankton is being conducted of which the first results are shown here. This database, originally started for the phytoPal Project (Mullins et al. 2005) summarizes data of all published literature on Palaeozoic phytoplankton, including taxonomic and stratigraphic information.

A major goal of this study is the creation of an unbiased trajectory of diversity of phytoplankton throughout the entire Palaeozoic. Further, it tries to answer questions as to how marine food chains in the Palaeozoic worked and how the modern marine ecosystems were established, as well as how the development of the phytoplankton changed the amount of O_2 and CO_2 in the atmosphere and, therefore, which effect it had on Earth's climate. By highlighting the evolutionary consequences of radiation and extinction events, the results of the diversity analysis allow assessing not only the evolutionary dynamics of the phytoplankton, but also, on a larger scale, its influence on the entire marine ecosystems.

The diversity curve shows clear trends with several diversification and extinction events. Major diversification events can be seen in Middle to Late Cambrian, in Middle Ordovician, in the Llandovery, and in Middle to Late Devonian times. Distinct declines of diversity are shown in Early to Middle Ordovician, in Late Ordovician, from the Sheinwoodian to the Eifelian, and in Early Carboniferous. This latter decline marks the beginning of what is known as the late Palaeozoic phytoplankton blackout, with no clear recovery throughout the Carboniferous to the Triassic.

The research of the diversity of ancient phytoplankton faces different problems. Monographic effect represents the major bias. As the number of occurrences is sampling-dependent, certain regions or time intervals, which receive more attention in palaeontological studies than others, would have a higher apparent diversity. Indeed, the diversity curve based on the total number of taxa shows a close correlation with the curve of the number of publications. Methods of sampling standardization, including subsampling with a rarefaction analysis, are conducted in order to correct for these biases.

Furthermore, the fossil record of phytoplankton is far from complete. First, most palynological studies ignore palynomorphs smaller than 20 µm. Recent studies suggest that the major part of the plankton consists of nano- and picoplankton. Second, because many acritarchs are considered cysts of different organisms, and therefore, represent only a temporary life stage, only a small part of the actual phytoplankton communities is preserved. In recent dinoflagellates the amount of species producing fossilizable resting cysts lies below 20 %. Both these issues could account for the apparent phytoplankton "blackout" in the late Palaeozoic that is shown in the diversity curve. These problems are difficult to be corrected for, but nevertheless should be taken into consideration when correlating the diversity fluctuations with palaeoecological or palaeoclimate data.

Keywords: phytoplankton; acritarchs; diversity; disparity; Palaeozoic; palaeoclimate; palaeoecology

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Marine palynomorphs from the Permian-Triassic transition in Well QIBA-1, Northern Saudi Arabia

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The end of the Paleozoic and the beginning of the Mesozoic is a time of crisis and profound changes in ecosystems on Earth. In this study, we examined the effects on the marine palynomorph assemblages in proximity to the Permian-Triassic boundary in northern Saudi Arabia. Hitherto they have received much less attention than the rich and well preserved assemblages of land derived spores and pollen, particularly important to dating the Permian part of the Khuff Formation, a major gas reservoir in Saudi Arabia and other Gulf countries. The Arabian Peninsula, as well as Africa, Iran, and India, were situated on the Neotethys Ocean margin, and formed part of the Gondwana continent - the southern part of the Pangean supercontinent which amalgamated at the end of the Paleozoic. The Permian-Triassic transition was penetrated in Saudi Aramco QIBA-1, located in northern Saudi Arabia. The section studied includes the Khuff Formation, represented by limestones and dolomites and the basal shales of the Sudair Formation, which is the regional top seal for the Khuff Reservoir. Marine palynomorphs have been found in cutting samples from QIBA-1. The relatively sparse assemblages show acritarchs and prasinophycean phycomata, in low concentrations, associated with spores, pollen and fungi (*Reduviasporonites chalastus*) over the Late Permian, uppermost Khuff Formation, and an acritarch spike in the Early Triassic, basal Sudair Formation, representing a possible marine maximum. In the lower Sudair Formation, the assemblage from the shallowest sample is the most diverse, including *Micrhystridium*, *Veryhachium and Navifusa* showing Paleozoic characteristics, coenobia of *Quadrisporites,* and smooth and ornamented leiospheres. In contrast, the lower assemblage from the lowermost Sudair Formation, is characterized by a mass-occurrence of veryhachids with a few leiosphaerids. The *Veryhachium* Acme, in the aftermath of the Permian/Triassic boundary, represent an event that is widespread and recognized in Europe, Africa, Jordan, Israel, Pakistan and Western Australia. In QIBA-1 interesting morphological variants of *Veryhachium* from the basal Sudair Formation are also observed.

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Timing is everything – a new correlation of Triassic–Jurassic boundary successions and the Central Atlantic Magmatic Province

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Understanding mass extinctions requires a clear insight into the stratigraphy of boundary sections, which allows for long-distance correlations and correct distinction of the sequence of events. However, even after the ratification of a Global Stratotype Section and Point, global correlations of Triassic–Jurassic boundary (TJB) successions are hampered by the fact that many of the traditionally used fossil groups were severely affected by the end-Triassic mass extinction (ETE). A new correlation of key TJB successions in Europe, U.S.A. and Peru, based on a combination of biotic (palynology and ammonites), geochemical ($\delta^{13}C_{org}$) and radiometric (U/Pb ages) constraints, has an impact on the causality and temporal development during the end-Triassic event. The new correlation indicates that the bulk of the hitherto dated, high-titanium, quartz normalized intrusive and extrusive volcanism of the Central Atlantic Magmatic Province (CAMP) preceded or was contemporaneous to the onset of the mass extinction. It further shows that in Europe, the maximum phase of the mass extinction was associated with increased abundance of fern spores assigned to *Polypodiisporites polymicroforatus*, and further coincided with a major regression and repeated, enhanced earthquake activity. A subsequent transgression resulted in the formation of hiati or condensed successions in many areas in Europe. Later

phases of volcanic activity of the CAMP, producing low titanium, quartz normalized and high-iron, quartz normalized basaltic rocks, continued close to the first occurrence of Jurassic ammonites and the defined TJB. This new correlations enables a reconstruction of the sequence of events; including records of e.g. pCO2 from soil carbonates and plant fossils, rare earth elements, biomarkers, charcoal, which allows an insight into the causality of this biotic crises.

Keywords: Triassic–Jurassic boundary; end-Triassic event; Central Atlantic Magmatic Province; palynology; ammonites; correlation

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Sporopollenin chemistry: a treasure-trove to plunder

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The spore and pollen fossil archive represents one of, if not the most complete records of life that is available to palaeobotanists. This record is driven by separate but complementary aspects; production in truly vast numbers combined with their highly recalcitrant chemistry. The end result of these factors is a high fidelity (temporal and spatial) fossil record which has been used to answer big picture questions such as the origins of land plants, the radiation of angiosperms and the terrestrial response to mass extinction events to both determine the degree of extinction and infer climate change. These discoveries have been based on identifying biological affinities of fossils while changes in abundance and or composition through time have been used to infer climate change. Effectively the sporomorph record has been used as a passive archive for monitoring species occurrence, abundance and diversity though time. However one factor that has stymied palynological research is the lack of taxonomic resolution with identification at the species level often proving very problematic if not impossible. A well-known example of this problem is the grasses which despite comprising ~11 500 species are often recorded as one species of pollen. These issues often become more problematic with increasing age and a loss of recognisable relatives.

Over the last decade we have been looking at specific aspects of sporopollenin chemistry to establish if this biomacromolecule can be used to as a proxy to track changes in UV-B radiation and from this infer changes in total solar irradiance. Our work has emphasised that the chemical composition of sporopollenin is plastic and that these chemical signals reflect changes in the light environment in which the plant grew. The stability of sporopollenin means that this primary biogeochemistry is preserved through a wide diagenetic window, allowing for this information to be extracted from suites of fossil spores and pollen grains. Furthermore, broad brush fingerprinting of sporopollenin has revealed that a significant taxonomic signature can be recovered from pollen grains and that aspects of pollen chemistry appear to be influenced by temperature.

These findings, together with ever improving analytical capabilities offer the potential for the fossil spore and pollen archive to be used in a dynamic manner to address long standing and newly emerging questions linked to the evolution of the terrestrial biosphere. This presentation will outline these findings and the exciting possibilities that are achievable.

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Palynostratigraphic analysis of the Mississippian Birger Johnsonfjellet Section, Spitsbergen, Svalbard

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An outcrop section in the Birger Johnsonfjellet area, Spitsbergen, was studied for palynology. 38 samples were collected and analysed from the *ca.* 260 m of continental, siliciclastic rocks comprising theHørbyebreen and Mumien formations. Resting unconformably on folded basement strata, the Hørbyebreen Formation consists of a sequence that starts with fluvial sandstones and conglomerates and thins upwards into a shale-dominated interval with intercalated sandstones, coals and coaly shales. The Mumien Formation is characterized by thick cross-stratified sandstones at the base and poorly exposed dark shales and coaly shales interbedded with thin siltstones, sandstones and coal seams towards the top of the unit. The palynological assemblages contain abundant, moderately preserved palynomorphs with diverse assemblages including *Camptozonotriletes velatus, Cirratriradites* spp., *Convolutispora vermiformis, Corbulispora cancellata, Cristatisporites echinatus, Diatomozonotriletes* spp., *Hymenospora caperata, Lophozonotriletes triangulatus* (= *L. rarituberculatus*), *Lycospora pusilla, Murospora aurita, Potoniespores delicatus, Reticulatisporites peltatus, Schulzospora* spp., *Spelaeotriletes balteatus, Tetraporina* spp., *Vallatisporites foveolatus, Verrucosisporites gobbettii* and *Waltzispora* spp.. The recorded assemblages are more diverse than those described by Playford (62/63) from the same area, indicating that more productive levels exist in the various sections. Most of the species described by Playford (62/63) were also observed in this study and both of the assemblages that he established can be recognized (the Rarituberculatus and Aurita assemblages). The miospore assemblages described are correlated with assemblages from other on- and offshore sections in the region and their ages are discussed.

Keywords**:** Palynomorphs, Spores, Tournaisian, Visean, Billefjorden Group, Norway

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The bearing of the stratigraphy and palynology of the Pennsylvanian Buçaco Basin on the geodynamic evolution of NW Iberia

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The Buçaco basin is a Pennsylvanian continental basin located along an important NNW-SSE strike shear zone that separates the Ossa-Morena Zone (OMZ, to the West) and Central Iberian Zone (CIZ, to the East) in NW Iberia – the Porto-Tomar Shear Zone. The basin's structure is now a highly asymmetrical syncline with a long, normal eastern flank and an overturned to vertical short western flank. The OMZ units are thrust on top of the basin and both are covered unconformably by Upper Triassic sediments. The basin has been interpreted as a pull-apart basin, based on the current outcrop pattern, field structural evidence and the relation with the Porto-Tomar shear zone (PTSZ). This shear zone controlled the major sedimentary phases of the basin as the Eastern block (CIZ) was uplifted and eroded, as well as its post-sedimentary deformation.

Here we present newly obtained palynological data, the sedimentology of several sections including XRD data, paleocurrents data and vitrinite reflectance measurements. The lithostratigraphy of the basin is reviewed.

The sedimentary fill is alluvial for the basal 200m, with characteristic red breccias, conglomerates and sandstones. This basal unit constitutes the Algeriz Formation, subdivided into two Members, based on the matrix- or clast-supported nature of their breccias/conglomerates. The 600m above are essentially fluviatile in nature (and probable lacustrine) with monotonous fining-upward cycles of gravel conglomerates, sandstones and organic-rich mudstones with occasional coal seams. This upper unit constitutes the Monsarros Formation, divided in two Members, based on the dominance of coaly mudstones (at the base) or gravel conglomerates and sandstones (towards the top). Clast lithologies and paleocurrent analysis clearly show sediment source of from the East, in the CIZ.

XRD results from the <4μm fraction of fine-grained samples show a diverse and irregular clay mineralogies in the basal Algeriz Fm., with high and highly oscillating illite/kaolinite (I/K) ratio, the presence of chlorite, feldspars (s.l.) and vestigial amounts of oxides (hematite), gypsum and nepouite (genthite). The overlying Monsarros Fm. samples have more stable I/K ratios and very similar proportions of quartz, kaolinite and illite (mostly $2M_1$ polytype, occasionally muscovite) throughout the section, with the occasional presence of vermiculite up to ca. 8%.

Three representative sections were sampled for palynology and seventeen yielded observable sporomorphs, with moderate to poor preservation and restricted to the fluvial/lacustrine intervals. The samples providing diversified assemblages were dominated by *Potonieisporites* spp., *Florinites* spp., *Schopfipollenites* spp. and *Laevigatosporites* spp. Other common genera are *Cheiledonites* spp., *Densosporites* spp. (decreasing abundance towards the top), *Crassispora* spp. (not present in the uppermost sample), *Dictyotriletes*-like sporomorphs (mostly fragments), *Lycospora* spp. (slight decrease towards the top), *Thymospora* spp., *Verrucosisporites* spp. and *Wilsonites* spp. The presence and considerable abundance of *Potonieisporites novicus*, *P. bhardwajii* and *Cheiledonites major* is indicative of middle to upper *Potonieisporites novicus-bhardwajii – Cheiledonites major* (NBM) miospore biozone of Clayton et al., 1977, corresponding to late Stephanian (Early Gzhelian). The decrease of the frequency of *Densosporites* spp. and the disappearance of *Crassispora konsakei* (and all *Crassispora* spp.) to the top of the sequence are further indications of this biozone. Other relevant genera such as *Spinosporites, Thymospora* and *Triquitrites* have fairly constant frequencies throughout the sequence. *Vittatina* spp. and *Disaccites striatti* are also present throughout but always rare to frequent.

The thermal maturation of the basin, with Vr (%Ro) around 1% is similar to the overlying Upper Triassic units, suggesting that the maximum thermal peak occurred during the Mesozoic. Alternatively, over 2km of sediments and/or tectonically emplaced nappes would have been overlying the basin and completely eroded during latest Pennsylvanian to Late Triassic times.

Based on existing and novel detailed stratigraphic and sedimentological data, vitrinite reflectance data as well as the geometrical and temporal relations of the basin with the surrounding units, a major tectono-thermal event in NW Iberia can be bracketed between the Gzhelian and the Carnian (Triassic).

Keywords**:** Buçaco Basin, Gzhelian, continental sedimentation, Ossa-Morena Zone, Central Iberian Zone, NW Iberia

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New data on the biostratigraphy of Upper Visean (Mikhailovian) deposits from the Mstikhino Quarry (Kaluga Region) based on the miospores and foraminifers

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Upper Visean (Mikhailovian) dark-gray bluish organic-rich shales and siltstones from the south wing of Moscow Syneclise are unique source of the well-preserved and diverse miospore assemblages. The deposits (siliciclastic unit MH_{T1}, Kabanov et al., 2014) are easily correlated in the boreholes and quarries from the Moscow, Tula and Kaluga Regions. The age of the deposits has been defined as Mikhaylovian based on the regional stratigraphic markers (Makhlina et al. 1993; Kabanov et al., 2014). Additionally the Mikhailovian regional stage is well documented by abundant foraminifer assemblages from the shallow marine limestones assigning to *Eostafella ikensis* Zone (Makhlina et al. 1993). Unfortunately the miospore sequences from the Mikhaylovian have been poorly characterized providing indistinguishability with the underlying Aleksinian ones. This problem was previously announced by Umnova and Byvscheva (Makhlina et al. 1993). Significantly, there are few data on foraminifers relating with defined miospore assemblages from this stratigraphic level of south wing of Moscow Syneclise. This study improves our results from the Mstikhino quarry (Mamontov & Orlova, 2014) in expanding characteristic and dating of the miospore assemblage in combination with the data of foraminifer assemblages. The foraminifer assemblages have been carried out for the first time from this locality.

In previous research the age of the single miospore assemblage from the Mstikhino section was not clearly defined and suggested as the Aleksinian-Mikhailovian. At present study to express its distinction from the Aleksinian miospore assemblage, the miospore association was evaluated by counting 300 miospores without dominant element (e.g. *Lycospora pusilla*) for the additional assemblage.

As a result the additional miospore assemblage is characterized by high species diversity including 120 miospore species. It is dominated by the pseudosaccate *Schulzospora campyloptera* (13.3%), *S. elongata* (11.3%), *S. rara* Kosanke (3%), *S. ocellata* (2.3%), *S. conforma* (1.3%), *Colatisporites decorus* (3%), *Endosporites pallidus* (1%), *Rugospora polyptycha* (1%), *R. minuta* (1%). Subdominant is defined by the cingulizonate *Cingulizonates bialatus* (6.3%), scabrate *Punctatisporites densiminutus* (3.3%) and laevigate *Calamospora microrugosa* (3.3%), *C. parva* (3%), *Calamospora* sp

(3%). The other assemblage components are rare in occurrence (0.3 – 2%) and defined by the rich miospore association: laevigate *Waltzispora albertensis*, *W. polita*, *W. sagittata*, *Leiotriletes ornatus*, *L. gulaferus, Punctatisporites admirabilis*; apiculate miospores *Cyclogranisporites firmus*, *C. lasius* (Waltz) Playford, *Cyclogranisporites* sp., *Granulatisporites granulatus*, *G. microgranifer*, *G. pennatus*, *Iugisporis pennatus*, *I. parvispinus*, *I. microsaetosus*, *Apiculatisporis pineatus*, *A. aculeatus*, *Anapiculatisporites conscinnus*, *Anaplanisporites baccatus*, *Lophotriletes parviverrucosus*, *Raistrikia nigra*, *Neoraistrickia grovensis*, *Verrucosisporites quasigobbettii*, *V. gobettii*, *Horriditriletes cf. curvibaculosus*, cingulate *Knoxisporites stephanephorus*, *K. triradiatus*, *K. triangularis*, *K. literatus*, *Dillspora disjuncta*, *Densosporites dentatus*, *Anulatisporites anulatus*, *Murospora aurita*, crassitude spores *Simozonotriletes intortus*, *Stenozonotriletes* simplex, *Cymbosporites aff. varius*, tricrassate *Diatomozonotriletes trilinearis*, *D. saetosus*, *Camarozonotriletes ergonulii*, zonocavate *Grandispora spinosa*, *Spelaeotriletes arenaceus*, *Auroraspora granulata*, *A. solisorta*, cingulizonocavate *Cirratriradites radialis*. Auriculate miospores provide continuous variation in their morphology. It is evidenced by co-occurrence *Tripartites vetustus*, *T. nongueriekei*, *T. trilinguis*, *T. incisotrilobus*, *Triquitrites comptus*, *T. marginatus*, *T. trivalvis*. The significant feature of the additional assemblage is occurrence of isospores *Spencerisporites radiatus* which have never been described from the Visean of the Moscow Syneclise. Also trilete miospores with reticulate-foveolate sculpture (e.g. *Microreticulatisporites*-type) demonstrate wide range of the morphologic variation in shape and sculpture. The co-occurrence of the rare species such as *Spencerisporites radiatus*, *Tripartites nongueriekei, T. vetustus*, *T. trilinguis, Grandispora spinosa, Lophotriletes parviverrucosus, Schulzospora campyloptera* and *S. conforma* should be considered as indicative for the palynozone **Tripartites vetustus** (**Ve**) of Moscow Syneclise. Besides this miospore association close corresponds with the palynozone **Tripartites vetustus – Rotaspora fracta** (**VF**) of West Europe.

The obtained palynological results are supported by the data on rich foraminifer assemblages from the limestones occurring below and above miospore-abundant shales. The lower foraminifer assemblage is recorded from the limestone 2 m below the shales. It contains well preserved *Paraarchaediscus krestovnikovi, P. convexus, Archaediscus karreri, Omphalotis omphalotis, Endothyranopsis crassa, Eostaffella mosquensis, Eostaffella mosquensis, E. proikensis, E. ragushensis, E. ovesa, E. accepta, Bradyina rotula* etc. This association is very distinctive for the provincial Zona **Eostaffella proikensis-Archaediscus gigas** of Aleksinian regional stage. However it could be defined as younger by incoming *Neoarchaediscus* sp., *Rugosoarchaediscus tumefactus, Janischewskina sp.* which are more significant for Zone **Eostaffella ikensis** of Mikhailovian regional stage. The upper foraminifer assemblage is studied from the limestone 2.2 m above the shales. In contrast with lower one it yielded large forms of *Archaediscus maximus*, *Neoarchaediscus cf. parvus, Howchinia gibba longa, Climacammina* spp. and very abundant *Eostaffella ikensis.* This assemblage is clear assigned to the Zone **Eostaffella ikensis** of Mikhailovian regional stage.

Well-preserved Mikhailovian miospore assemblage shows co-occurrence of the distinctive miospore association in combination with the high morphologic diversity of rare species derived from the Aleksinian strata. Consequently, the palynological differences of Aleksinian and Mikhailovian assemblages could be better expressed in terms of continuous morphological variation of auriculate miospores. It needs special research in future. In summary we anticipate that high-resolution of abundant miospore assemblages, combined with foraminifer data, will lead to improvements in the Upper Visean palynostratigraphy of the Moscow Syneclise.

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A review of the Jurassic dinoflagellate cyst genus *Gonyaulacysta* Deflandre 1964

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The distinctive, cosmopolitan Jurassic (Bathonian–Tithonian) dinoflagellate cyst genus *Gonyaulacysta* is characterised by, for example, an epicyst which is much larger than the hypocyst, and an opisthopyle in the posterior sulcal (ps) plate. The ventral plate configuration can be either longitudinal (l-type) or sigmoidal (s-type). The type is the quintessential Jurassic species *Gonyaulacysta jurassica*, which occurs in the Oxfordian to Kimmeridgian and the Bathonian to Kimmeridgian in the northern and southern hemispheres respectively. A total of 151 species have been assigned to *Gonyaulacysta*; the vast majority of these have now been transferred to more appropriate genera. Prior to this study, there were 21 valid species; this has now been reduced to eight by recombining 13 species. The eight valid species are: *Gonyaulacysta adecta*; *Gonyaulacysta australica; Gonyaulacysta ceratophora; Gonyaulacysta desmos*; *Gonyaulacysta dualis; Gonyaulacysta jurassica; Gonyaulacysta longicornis*; and *Gonyaulacysta quadrata*. They form a closely related plexus with an absolutely unique morphology; the species are distinguished on differences in cavation style, morphology of the sutural crests/ridges and the size of the apical horn. All the species, except *Gonyaulacysta australica,* are reliable regional index taxa. The principal taxonomic change here is that all subspecies and varieties in the true species of *Gonyaulacysta* are either elevated to species status, or synonymised to avoid complicated and cumbersome names. At the species level, *Gonyaulacysta* exhibits significant provincialism, for example *Gonyaulacysta dualis* is confined to the Oxfordian–Kimmeridgian of the Arctic. *Gonyaulacysta adecta, Gonyaulacysta desmos* and *Gonyaulacysta longicornis* are present in the Bathonian to Oxfordian of Euramerica and surrounding areas. The species *Gonyaulacysta australica, Gonyaulacysta ceratophora* and *Gonyaulacysta quadrata* are restricted to the Oxfordian to Tithonian of Australasia. *Gonyaulacysta adecta* and *Gonyaulacysta jurasssica* both exhibit steady overall size increases in the Bathonian to Kimmeridgian of Europe.

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Palynology and paleoecology of Haida Gwaii (former Queen Charlotte Islands), British Columbia, and implications for glacial refugia.

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Research that began in the early 1980's has produced a detailed glacial history and paleoecological reconstructions that span two glacial episodes (MIS 4 and MIS 2) as well as an interstadial and the postglacial. Although plant macrofossils have produced valuable paleoenvironmental information, most of the vegetation and climatic history during the past 67,000 years has been reconstructed from pollen and spores preserved in lakes, bogs, and sea cliff sediments. A debate has raged for decades on whether or not glacial refugia were present on the islands during the last (Fraser) glaciation, or during the penultimate glaciation (MIS 4 or early Wisconsinan). Glacial geology has identified evidence for a large glacial refugium that is now submerged by higher postglacial sea levels in Hecate Strait, between the islands and the mainland. Pollen of several plant species (*Ligusticum calderi, Polemonium pulcherrimum,* and others has been identified in sea-cliff sediment exposures from both glacial periods, and in postglacial sites as well as the modern flora, suggesting survival of these species in the Haida Gwaii area during glaciation. The first identifications on Haida Gwaii of coprophilous fungal spores (*Sporormiella* and *Podospora type*) in large quantities indicate the presence of unknown grazing mammals at Cape Ball on the east coast of Graham Island during the MIS 4 glacial interval.

Keywords: Haida Gwaii, glaciation, paleoecology, pollen, fungal spores, refugia

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Palynology, age and provenance of the Lower Palaeozoic Sandstone of Stonehenge

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Stonehenge is among the most iconic of English landmarks, and together with features in its surrounding landscape has been a UNESCO World Heritage Site since 1986. Its stones comprise two groups: 'sarsens' and 'bluestones'. The sarsens are the large stones of the outer circle and form the trilithons of the sarsen horseshoe. They are silica-cemented Cenozoic sandstones from the Marlborough Downs and Kennet Valley, some 30 km (18–19 miles) to the north. The bluestones are smaller blocks of more exotic lithologies; investigations into their provenance are ongoing.

The bluestones comprise a variety of volcanic, intrusive and tuffaceous igneous rocks, along with rarer sandstones. The last include the 'Altar Stone', two buried orthostats and a number of sandstone blocks in the debitage. The Altar Stone is petrographically similar to fine- to medium-grained calcareous sandstones in the Lower Devonian Senni Formation of South Wales. Sandstone fragments from the debitage, however, include specimens of greenish-grey, indurated, fine-grained, feldspathic sandstone that have been subjected to low-grade metamorphism, with a suggestion of a spaced cleavage. They are more deformed than the Devonian sandstones exposed in South Wales, form a coherent lithological group, now referred to as the 'Lower Palaeozoic Sandstone', and contain characteristic clasts of dark mudstone.

An initial palynological investigation of the Lower Palaeozoic Sandstone was undertaken in 1993, and has been followed up more recently. Preparations made for both investigations yielded Ordovician acritarch assemblages, albeit with some differences in composition. The acritarch assemblage from the recent investigation has three components: acritarchs of Late Cambrian–Early Ordovician, Early–Middle Ordovician and Late Ordovician age. Late Cambrian–Early Ordovician acritarchs comprise about 50% of species, the majority having ranges that are restricted to the Lower Ordovician Tremadocian Stage. They include species of *Acanthodiacrodium*, *Cymatiogalea*, *Stelliferidium*, *Timofeevia* and *Vulcanisphaera*. Acritarchs of Early–Middle Ordovician age include species of *Arkonia*, *Coryphidium*, *Frankea*, *Micrhystridium*, *Stellechinatum* and specimens of the *Vogtlandia coalita*/*Evittia flosmaris* group. Late Ordovician acritarchs include *Fractoricoronula trirhetica*, *Multiplicisphaeridium irregulare*, *Ordovicidium elegantulum* and *Villosacapsula setosapellicula*. No definite post-Ordovician acritarchs were recorded. The mixture of forms present shows that at least some acritarchs have been recycled. The assemblage from the older preparation also consists exclusively of acritarchs and none of the forms recorded are post-Ordovician in age. Tremadocian species again comprise the largest taxonomic component, but post-Tremadocian forms were also recorded, although no Late Ordovician species are present.

The preservation of the acritarchs is the same throughout, with specimens generally being more or less intact, but dark grey-brown to black, showing that they have undergone some thermal alteration. Their preservation is comparable to that in the Lower Palaeozoic Welsh Basin, especially west of the Tywi Lineament, where Late Ordovician and Silurian palynological assemblages from mid Wales also contain recycled Ordovician acritarchs. Indirect ordinations of binary data using non-metric multidimensional scaling (NMDS) and detrended correspondence analysis (DCA) demonstrate the similarity of the Stonehenge assemblages to Late Ordovician assemblages from mid Wales.

The comparison suggests a Late Ordovician age for the sampled Lower Palaeozoic Sandstone from Stonehenge. However, it is most likely that the mudstone clasts are the source of the recycled acritarchs, and if so raises the question of whether all the acritarchs, including the youngest, might be recycled. The recycled Ordovician acritarchs present in Silurian rocks of the Welsh Basin are subordinate to Silurian species, but sampling during BGS mapping, when the samples were collected, would have targeted finer grained lithologies. The question this raises is whether assemblages from Silurian sandstones contain only reworked Ordovician acritarchs, or are Silurian forms present as well?

The palynological data, coupled with petrography, show that the Lower Palaeozoic Sandstone of Stonehenge is not older than Late Ordovician, and it is most probably from a Late Ordovician unit in the Welsh Basin. However, the possibility that it is from a Welsh Basin Silurian unit cannot be discounted without more information on acritarch assemblages from Silurian sandstones, including the nature of any recycling.

Keywords: Acritarchs, provenance, Ordovician, Silurian, Welsh Basin, Stonehenge

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The value of integrated palynological, lithological, wire-line and seismic studies in providing new insights into the regional geological development of the Dutch Neogene

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In the Netherlands, the bulk of Miocene to earliest Pliocene sedimentary sequences are currently assigned to a single lithostratigraphical unit, the Breda Formation. Although already introduced more than 40 years ago, this formation is still poorly defined. Two main problems are involved with the current definition of the Breda Formation:

- Well log correlations show that the new lecto-stratotype well section for the Breda Formation in well Groote Heide overlaps in part with the reference section of the (considered older) Veldhoven Formation in the nearby well Broekhuizenvorst.
- The difficult distinction between the Breda and the overlying Oosterhout Formation gives rise to unceasing discussion, in particular due to changing concentrations of glauconitic content within both formations.

In order to resolve the first major problem the results of dinocyst analyses were integrated with wire-line, lithological and seismic studies on multiple wells, including the wells Groote Heide and Broekhuizenvorst. In this process, we used an updated dinocyst zonation of Munsterman & Brinkhuis (2004), recalibrated to the Geological Time Scale of Ogg et al. (2016).

To establish a consistent top for the Breda Formation use was made of an additional NE-SW oriented correlation-panel, located relatively westbound from the distribution area of the Kieseloölite Formation. This panel runs from the center (well Sint Michielsgestel-1) towards and across the edge (well Goirle-1) of the Roer Valley Graben.

The results of this study show the value of an integrated multidisciplinary approach, including palynology in establishing consistent lithostratigraphic units and in geological interpretations of the Dutch subsurface.

Keywords: Neogene, southern North Sea, palynology, dinoflagellate cysts, lithostratigraphy

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Upper Jurassic-Lower Cretaceous Palynostratigraphy of the Husky Formation in the Canadian Arctic

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The Mackenzie Delta area of the Northwest Territories, Canada, is a major basin from which much of our knowledge of Jurassic-Lower Cretaceous geology of Canada is based. It has been a focal point for petroleum exploration since the 1950's upon discovery of organic-rich rocks with hydrocarbon potential in the region. Regional correlations between rock units in this area are essential for evaluating the hydrocarbon resource potential in Canadian frontier basins. In this study, we investigate Upper Jurassic-Lower Cretaceous strata that have potential as petroleum source rocks. We address a lack of detailed chronostratigraphy for this globally undefined system boundary and its locally unknown position. The boundary is difficult to define for many reasons such as: i) a lack of change in fauna and flora across the boundary; ii) a paucity of index fossils, such as ammonites and bivalves, in high-latitude regions; and iii) biogeographical provincialism of Tethyan and Boreal biota. Palynomorphs are pervasive, abundant and exceptionally well-preserved in both Boreal and Tethyan provinces in comparison to other micro- and macrofossils, permitting the potential for refinement of chronostratigraphy and interpretation of Mesozoic depositional environments and paleoclimates, and providing insight into the terrestrial and marine ecosystems in which they occur.

Palynological samples were collected from two localities in the Aklavik Range, Richardson Mountains, Northwest Territories. This study is primarily focused on the Husky Formation, a mudstone-dominated formation with four members; in descending order, they are the Upper, Red-Weathering, Arenaceous, and Lower members. The Jurassic-Cretaceous transition is thought to exist at, or near, the contact between the Red-weathering and Arenaceous members. This is inferred from the presence of *Buchia okensis*, a bivalve considered diagnostic of the Berriasian, within the first few metres above the contact between the Red-weathering and Arenaceous members. This research project aims to: i) provide insight into paleoenvironments represented by Upper Jurassic-Lower Cretaceous strata in high northern latitude regions by using quantitative statistical analyses of spores, pollen grains, and dinoflagellate cysts; ii) create new knowledge on terrestrial and marine paleoecology and its dynamics in high-latitude Jurassic-Cretaceous ecosystems; and iii) improve regional correlations of Mesozoic strata in the Mackenzie Delta area. This project is expected to expand on the stratigraphic and depositional history of northern Canada, the tectonic evolution of Mesozoic source rocks, and help define the Jurassic-Cretaceous boundary globally.

Keywords: Jurassic, Cretaceous, Canada, Arctic

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Arctic Cretaceous to Neogene palyno-biostratigraphy from Greenland, Canada, Faroe Islands and Norway

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Over the past 30 years intensive palynological studies of Cretaceous to Neogene successions onshore Greenland and Canada and offshore Greenland, Canada, Faroe Islands and Norway have been carried out by GEUS resulting in an unique biostratigraphic database.

Since the eighties GGU (the former Geological Survey of Greenland) has focused on sequence stratigraphic analysis of the Cretaceous to Palaeogene sediments in East Greenland and palynostratigraphy's have been established for the Kangerlussuaq area in the south to Peary Land in the north (e.g. Nøhr-Hansen 1993, 2012) and correlated with adjacent areas offshore the Faroe Islands and offshore Norway.

During the same period similar studies have been carried out for central onshore and offshore west Greenland and correlated to Canadian on- and offshore sections resulting in a detailed event stratigraphy's (e.g. Nøhr-Hansen 1996, 2003, Pedersen & Nøhr-Hansen 2014, Nøhr-Hansen et. al 2016).

The palynostratigraphy's have been tested against data from stratigraphic boreholes from east and west Greenland and correlated with ammonite zonation, when possible.

The studies include dating and correlations, palaeoenvironmental analysis and record of reworking, essential informations for sequence stratigraphic analysis.

The palynological studies of sediments from numerous surface sections, 16 shallow to deep stratigraphic boreholes, one exploration well from the Disko–Nuussuaq–Svartenhuk Halvø area, central west Greenland and 19 explorations wells from Davis Strait, Hudson Strait and Labrador Sea have led to detailed dinocyst event stratigraphy's of the Lower Cretaceous to Neogene successions, and mapped out several major regional unconformities.

Brackish water dinocyst and miospores from the Nuussuaq Basin indicate that the oldest Mesozoic sediments that onlap the basement were deposited in a non-marine to brackish water environment spanning the Albian to Cenomanian, followed by a late Cenomanian marine transgression indicated by the influx of marine dinocyst (Pedersen & Nøhr-Hansen 2014). The observations accord well with Labrador Sea observations (Nøhr-Hansen et. al 2016), and suggest that the sea in the entire region fluctuated between non-marine and marginal marine in a narrow elongate Lower Cretaceous basin. The west Greenland assemblages may be correlated with similar Lower Cretaceous non-marine to brackish water dinocyst assemblages recorded from the Western Interior seaway and the Sverdrup Basin, Arctic Canada.

Keywords: Arctic, Greenland, Dinocysts, Cretaceous, Cenozoic, Biostratigraphy.

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Diversity patterns of land plants across the Permian–Triassic boundary

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The mass extinction at the Permian–Triassic boundary (PTB) is famous for being the most severe faunal extinction event. Diversity analyses based on land plant macrofossil taxa have previously found this to be the only mass extinction that affected animals and plants alike. A mass extinction among plants also seems intuitive considering the dearth of plant macrofossils in Lower Triassic strata (which can probably partly be attributed to differential taphonomy), and the resulting differences in the composition of existing Lower Triassic macrofossil assemblages from Permian ones. The former are often strongly dominated by lycopsids, i.e., classical pioneer plants, while the latter are diverse assemblages dominated by conifers. However, while well-preserved macrofossils of land plants from the Early Triassic are rare, sporomorphs (spores and pollen) are more recalcitrant and commonly found even in marine sediments. They consequently have the potential to document ancient floras more faithfully. Abundant data on sporomorphs from the PTB interval are available in the existing literature, but sporomorph diversity has so far only been studied on limited scales. In order to gain a more coherent picture of land plant macroevolution, a detailed, comparative assessment of the stratigraphic ranges and diversities of sporomorphs and macrofossil taxa is necessary. To this end, a comprehensive digital database of global sporomorph and plant macrofossil records from the Lopingian (upper Permian) to the Middle Triassic has been assembled. The records are corrected for taxonomic synonymies and obvious errors, and correlated to the current international stages. Based on this, diversity indices are calculated, and the results are tested for biases, gaps, and inconsistencies. This enables a realistic assessment of extinction and recovery patterns in plants and correlation with trends in the animal fossil record.

The taxonomic diversity (or richness) of land plant macrofossil species exhibits a decline through the Lopingian, followed by a loss of more than half of the species across the PTB and subsequently a partial recovery in the Olenekian. This is essentially the expected pattern that has been observed in previous studies. However, on the level of genera, diversity trends are much less pronounced, and the loss of generic diversity at the PTB is not catastrophic. The difficulties in identifying species, specifically in plant fossils from this time, imply that genera give us a more realistic view on diversity trends. In the Induan, the diversity of genera even overtakes the number of named species, which clearly indicates a problem with the quality of the species record – and possibly more generally with the macrofossil record – from this stage. Compared to the late Permian, macrofossils from the Early Triassic are currently under-represented in the available data, meaning that the apparent extinction pattern is most likely exaggerated.

Sporomorph diversity shows no extinction trend at the PTB, but rather increases to a peak in the Induan and subsequently declines towards the Olenekian. This pattern is at odds with expectations and with the macrofossil record, but at least the differences between the two fossil categories can be explained by the clear limitations of the macrofossil data in this particular timeframe. The overall much higher diversity of sporomorphs also attests to the relative completeness of their fossil record.

In summary, the loss of diversity in land plants at the PTB, that was often assumed or could seemingly be observed in both single sections and global diversity curves derived from macrofossils, is not unequivocal. The present data compilation rather points to a significant turnover and ecological disturbances affecting the vegetation in the Early Triassic, which however, do not translate to a proper mass extinction, and are not coeval with the mass extinction in animals, but succeeding it.

Keywords: Permian–Triassic boundary, mass extinction, diversity, land plants, macrofossils, sporomorphs

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Megaspores and associated palynofloras of the Late Triassic (late Carnian – Rhaetian) Kapp Toscana Group on Hopen, Arctic Norway

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The island of Hopen represents an excellent stratigraphic reference locality for the Upper Triassic succession in the Barents Sea region. The island is located in the southeastern-most corner of the Svalbard Archipelago, approximately 600 km north of the Norwegian mainland. The sedimentary succession on the island is assigned entirely to the Late Triassic age (late Carnian – Rhaetian) Kapp Toscana Group, including in ascending stratigraphic order, the De Geerdalen, Flatsalen and Svenskøya formations.

The palynostratigraphy of Hopen has been extensively documented by previous studies, with assemblages independently calibrated by an early Norian age ammonoid fauna from the Flatsalen Formation. The sedimentology of the island has been equally well-described, with palaeoenvironmental interpretations refined by recent micropalaeontological and palynofacies studies. In comparison, Triassic megaspores on Svalbard are rather poorly documented, with descriptions restricted to specimens recovered from a single *ex situ* sample, which was discovered somewhere on the SW shores of Hopen. Despite its vague provenance, this sample has received considerable attention from previous authors, yielding a single megaspore taxon, *Triletes hopeniensis*, in association with autochthonous roots and stems of bennettitaleans and lycopsids, and parautochthonous leaves, sporangia, spores and pollen of pteridophytes and gymnosperms.

The aim of the present investigation was to provide a more extensive documentation of the stratigraphical distribution of megaspores through the Upper Triassic succession on Hopen using *in situ* samples, and to relate this to the published palynological, palaeobotanical and micropalaeontological data from the island. The results of our study show that megaspore assemblages from the De Geerdalen Formation are dominated mainly by *Dijkiastraisporites beutleri* and *Echitriletes* spp., with localised influxes of *Nathorstisporites* aff. *hopliticus*. The micro-biofacies evidence from the formation is generally consistent with a fluvio-deltaic depositional environment. However, the intermittent presence of marine elements, including agglutinated foraminifera and sponge spicules, may be indicative of shallow marine or prodeltaic deposition, thus suggesting a greater variation in depositional environment than indicated by previous field-based lithofacies descriptions. Megaspores were notably absent in assemblages from the overlying Flatsalen Formation, which were instead dominated by agglutinated foraminifera, consistent with previous interpretations of a shallow marine depositional environment for the formation. A marked change in the micro-biofacies was observed within the overlying Svenskøya Formation, including an increase in phytoclasts and the super-abundant occurrence of megaspores including *Dijkiastraisporites beutleri, Verrutriletes preutilis* and *V. utilis.* Collectively, the micro-biofacies evidence is interpreted as being indicative of a delta-plain peat-mire environment, and is generally consistent with previous interpretations of the lithofacies.

The results of this investigation complement the previous palynological analyses and contribute to a growing understanding of the palaeoenvironments in the region during the Late Triassic. This study provides the most extensive documentation of Triassic megaspores in the Barents Sea region to-date, and therefore offers important new data concerning the floras of the northern Pangaean margin during that time.

Keywords: Upper Triassic, megaspores, Kapp Toscana Group, Hopen, Svalbard, Barents Sea

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Re-examination of the palynological content of the Lower Cretaceous deposits of Angeac (Charente, south-west France)

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Further to the work published by Néraudeau et al. (2012), palynological matter recovered from the lignitic bone bed of Angeac (Charente, SW France) has been re-examined, an additional sample having been processed in order to provide more evidence of its age, the previous determination being regarded as controversial (Benoit et al., in press). The samples come from four sedimentological units (An2–An5), which together yielded an assemblage of 31 species, taxonomically dominated by verrucate spores, including *Concavissimisporites montuosus, Concavissimisporites verrucosus*, *Trilobosporites apiverrucatus*, *Trilobosporites canadensis*, *Verrucosisporites major*, and other taxa. The criteria for their identification commonly being regarded as problematic, a PCA has been carried out on 60 well-enough preserved specimens from the most productive unit An2, taking into account eight morphological variables. The results show one group consisting of specimens referred to *Trilobosporites*, and a second larger group comprising *Concavissimisporites*, *Verrucosisporites*, and various morphologically intermediate forms, thus underscoring the subjectivity of their generic and specific attributions. A few bisaccate pollen grains, including *Vitreisporites pallidus*, have been recovered, but the gymnospermous pollen spectrum is clearly dominated by the cheirolepidiaceous genus *Classopollis*, representing 60% of the total assemblage. This dominance, coupled with the great abundance of *Trilobosporites* and *Concavissimisporites*, along with the presence of other spores typical of Lower Cretaceous deposits, such as *Aequitriradites spinulosus*, renders this assemblage most similar to those of the Hastings Group of southern England, and the Bückeberg Formation in north-western Germany. The time of deposition is therefore more likely to be Berriasian–Valanginian than Hauterivian–Barremian, as previously stated (Néraudeau et al., 2012; Allain et al., 2014).

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Keywords: Berriasian; Valanginian; verrucate spores; Charentes; Cretaceous palynoflora; Wealden facies.

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Oceanic environments, vegetation and climate from the Middle to Late Miocene Brassington Formation, UK

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The Brassington Formation is the most extensive Miocene sedimentary succession onshore in the UK. Because of its unique position at the margin of NW Europe, the pollen, spores, fungal remains and macrofossils from this lithostratigraphical unit provide evidence on the development of environments and vegetation affected by North Atlantic currents and hypothesized atmospheric circulation changes that accompanied the Middle to Late Miocene climatic cooling. Palynostratigraphy suggests that the uppermost Kenslow Member of the Brassington Formation is not coeval. Previously, all occurrences of the Kenslow Member were assumed to be contemporary. This new dating of the Brassington Forma-

tion now means that a sequence of fossiliferous horizons is present, rather than one. Multiple palaeobotanical horizons has allowed the development of a new vegetation and climate record for the Atlantic margins of northwest Europe. To develop this new archive of Middle to Late Miocene palaeoenvironment and palaeoclimatic data we have taken fresh palynological samples. For the first time the fossil fungal remains are documented and utilized to better understand the palaeoenvironment. From the fresh palynological analysis, the oldest pollen assemblage is from the more southern Bees Nest Pit, which represents a subtropical conifer-dominated forest of late Seravallian age (c. 12 Ma). A younger assemblage was observed from the more northern Kenslow Top Pit and indicates that a subtropical mixed forest was present during the early Tortonian (11.6–9 Ma).

Keywords: Miocene, pollen and spores, fungi, wood, climate.

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Post-extinction recovery of terrestrial vegetation following the End Devonian Mass Extinction: palynological evidence from the Tournaisian (early Carboniferous) of the UK

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As part of an investigation into the earliest Carboniferous tetrapod world, palynomorphs have been studied from a fully cored 500 m science borehole (West Mains Farm) in the Scottish Borders. Together with an outcrop section at Burnmouth, these encompass most of the Tournaisian Ballagan Formation. Both miospores and megaspores have been examined throughout, however, it is only at Burnmouth that the lowest palynological zone (VI) is present. Quantitative abundances of key spore taxa enable a robust correlation between Burnmouth and the borehole. In total, some eight distinct assemblages can be recognised through a CONISS analysis of the data. These assemblages map onto the palaeosol types present and reveal an inter-connection, with changes in climate ultimately driving a succession of vegetation types. The immediate post-extinction pattern of recovery was a simple vegetation represented by the VI palynomorphs, followed by increasing spore diversity. The vegetation then became dominated by the creeping lycopod *Oxroadia* (*Anaplanisporites baccatus*), including abundant megaspores (*Lagenicula subpilosa*). This was then replaced by an assemblage dominated by *Prolycospora claytonii*, which, although its parent plant is currently unknown, it was not necessarily a lycopod. Palaeosol evidence indicates that this may represent a wetter interval with more permanent vegetation and, hence, increased landscape stability. Further upsection, *Oxroadia* returned in abundance but was succeeded by larger arborescent lycopods with established *Stigmaria* root systems. However, this predates the first occurrence of *Lycospora pusilla*. In these younger parts of the succession, there are a number of inceptions of distinctive spore types that will further permit palynological sub-division of the interval. This eight-fold subdivision of the Tournaisian can now be mapped onto long Milankovitch cycles identified in shallow marine sections.

Keywords: Tournaisian, spores, Scottish Borders, environmental changes, borehole

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Cenozoic biogeography of *Striatopollis catatumbus* (Fabaceae – Detariae)

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Striatopollis catatumbus is a pantropical fossil pollen grain known from the early Paleocene to the Holocene (65-0.01 Ma). First described by Gonzales-Guzman (1967), this fossil pollen type has been associated with fluvial-deltaic depositional environments. Previous studies have suggested to be related to four Fabaceae genera of, tribe Detariae including *Macrolobium*, *Anthonotha*, *Isoberlinia* and *Crudia* (Germeraad et al. 1968). In this study, we compare the morphology of *S. catatumbus* to 15 Detariae genera.

We applied two innovations to morphological pollen analysis. First, we use an Airyscan confocal superresolution microscopy. Airyscan allows to visualize both external and internal morphological details at a resolution comparable to scanning and transmission electron microscopy (Sivaguru et al. 2016). Second, we introduce the use of deep-learning computer vision algorithms to reconstruct ancestral morphologies. We interpolate between visual shape and texture features extracted from images of known samples to synthesize images of candidate intermediates. These algorithms produce explicit hypotheses of ancestral morphology and provide a computational approach to placing our fossil specimens on the known phylogeny of Detariae.

At least three different fossil morphotypes of striate pollen have been named as *S. catatumbus*, two in the Neotropics and one in Africa. These results also suggest a relationship between the phylogenetic radiation of the modern genera of Detariae and the biogeographic expansion of *S. catatumbus* across the tropics during the Eocene. Previous studies suggest that the biogeography of Fabaceae is related to temperature, with higher abundances in warmer environments (Punyasena et al. 2008). The genera to which *S. catatumbus* has its closest affinities (*Crudia*, *Anthonotha* and *Macrolobium*) are also restricted to tropical latitudes today. We plan to reconstruct the paleoclimatic distribution of *S. catatumbus* and assess the relationship between abundance and temperature in both the modern and fossil taxa.

The biogeographic history of *S. catatumbus* provides a snapshop into the evolution of the Neotropical Fabaceae, the most abundant family of tropical plants. This study also shows that Airyscan superresolution microscopy and convoluted neural networks enhance the amount of morphological traits of fossil pollen, thus provide additional information to assess its phylogenetic relationships. This is relevant considering that more than 50% of the fossil palynomorphs have unknown natural affinities or are only known to belong to an order or family.

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Keywords: *Striatopollis catatumbus*, Fabaceae-tribe Detariae, Cenozoic, Airyscan microscopy, Convolutional Neural Network-CNN

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Ordovician to Early Devonian miospores from South America: a state of the art review

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For a long time, the miospore palynology of pre-Middle Devonian beds from South America has been little studied. Besides inaccessible private data belonging to petroleum societies and others, many papers on that matter have however recently been published, mostly on Brazilian and Argentinian localities. In this contribution, we critically review the current evidence.

The oldest cryptospores have been found in a Dapingian locality from Argentina. The material is poor and badly preserved. Those cryptospores have been interpreted as the earliest evidence for embryophytes (land plants). Despite of the presence of a tetrahedral tetrad, generally accepted as being exclusively linked to land plants, some authors questioned the embryophyte affinities of the Dapingian Argentinian cryptospore assemblage.

Late Ordovician cryptospore occurrences are infrequent in South America. In the Salar del Rincón Formation (Puna,northwesternArgentina), an assemblage of cryptospores has been isolated. The age of the Salar del Rincón Formation has been widely discussed. On the basis of various fossil evidences, the section crosses the Ordovician/Silurian boundary, ranging from the Hirnantian up to the Rhuddanian. Cryptospores are rare but diversified in the latest Ordovician part of the section. A typical assemblage has been collected from the Hirnantian beds, including among others *Pseudodyadospora petasus*, *Rimosotetras problematica*, *Segestrespora laevigata*, *S.membranifera*, ?*S. rugosa*, *Sphaerasaccus glabellus*.

The Hirnantian Caspalá Formation (Cordillera Oriental, northwestern Argentina) contains a rich assemblage of cryptospores, similar to the previous Ordovician one. The earliest trilete spores from the whole American continent are observed in the Caspalá Formation. They are: *Ambitisporites avitus*, *Leiotriletes* spp., *Aneurospora*? sp. and *Chelinospora* cf. *prisca*.

The early Silurian is represented by the lower part of the post-glacial Lipeón Formation, in Cordillera Oriental and Sierras Subandinas, which yields less diverse cryptospore assemblages and only a few trilete spores (i.e. *Ambitisporites avitus*, *Leiotriletes* spp.) exclusively in the Caspalá section (Cordillera Oriental).

Three wells have penetrated Silurian beds from east Paraguay. Samples have been taken from the Itacurubi Group of the ParanaBasin. A biozonation has tentatively been established for the miospores observed in the Llandovery. However, recent observations in South America and other countries have demonstrated that the criteria used for this biozonation are no more relevant, except the first incoming of *Archaeozonotriles chulus*, close to the Aeronian/Telychian boundary.

Two other wells have been drilled through the upper part of the Eusebio Ayala, the Vargas Peña and the Cariyformations from east Paraguay and have been studied for miospores and chitinozoans. The *Archaeozonotriletes chulus/nanus* Morphon biozone characterizes the middle and upper Vargas Peña Formation and the lower Cariy Formation. The base of the *A. chulus/nanus* biozone of miospores corresponds approximately to the base of the chitinozoan *Conochitina proboscifera* biozone, *Desmochitina* cf. *densa* sub-biozone, and is probably close to the Aeronian/Telychian boundary.

Acritarchs and spores of the Tucunuco Group have been inventoried in different localities where the La Chilca and Los Espejos formations are outcropping, in the Central Precordillera of San Juan. No trilete spores were recorded in the Llandovery-Wenlock La Chilca Formation. In general, the abundance of trilete spores increases towards the upper levels of the Los Espejos Formation. Of special palaeogeographical and biostratigraphic interest is the presence of a possible, badly preserved ?*Streelispora newportensis* in the northern locality of Río Jáchal. Because of its importance a new sampling is necessary to confirm its presence. Moreover, *Chelinospora* cf.*cantabrica* is present in the lowest studied level of the same section, which appear in the *reticulata-sanpetrensis* (RS) biozone, suggesting a Ludlow–Early Pridoli? age. *Chelinospora retorrida*, *Cymbosporites paulus*? in Wellman 1993 and *Dictyotriletes* cf. *emsiensis*Morphon allow recognizing the Lochkovian *micrornatus-newportensis* (MN) biozone in the uppermost beds of the Los Espejos

Formation. Thus, the Silurian/Devonian boundary was identified in that locality. Acritarchs and brachiopods support this age attribution.

Eighteen samples have been studied from Petrobras well 1-JD-1-AM in the Jandiatuba area, Solimoes Basin, northern Brazil. Fifty-three species were identified and it was possible to correlate the assemblage with the biostratigraphical scale of the Lower Devonian established in Europe. Authors have considered the samples as belonging to the biozone Z of the Oppel zone BZ. Numerous *Dictyotriletes* were recorded. Those ones that showed a morphological evolution from specimens similar to *Dictyotriletes granulatus* up to *D. emsienis* and *D.* cf. *subgranifer* were incorporated into the newly created morphon, *Dictyotriletes emsiensis*.

Hereby, we compare the successions of the main miospore events in South America with those from other palaeoplates. We also discuss the relationships between miospore and early land plant assemblages. The palaeogeographic implications of all those observations are herein evaluated.

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Cenozoic terrestrial climate change and the demise of forests on Wilkes Land, East Antarctica

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The lack of long and well-dated sediment records from Antarctica puts considerable constraints on a spatial and temporal reconstruction of palaeoenvironmental change after the formation of a continent-scale cryosphere at the Eocene–Oligocene boundary, 33.9 million years ago. The marine IODP Site U1356 at the Wilkes Land margin, East Antarctica, provides a unique opportunity to reconstruct with a single sediment record, the long-term Antarctic terrestrial climate and vegetation change over a period 53 million to 10 million years ago. Interrupted by several hiatuses, the site U1356 yields pollen bearing sediment layers covering the early- to mid-Eocene, Oligocene and Miocene. We applied a new quantitative approach using red fluorescence to separate reworked sporomorph assemblages, that have been transported into Antarctic marine sedimentary records by waxing and waning ice sheets, from non-reworked palynomorph assemblages, that can be used to reliably reconstruct past vegetation and climate for the time interval during which the sediment was deposited.

The palynological record shows a change from a diverse early Eocene paratropical rainforest (54–51 Ma) to a cooler temperate rainforest dominated by the southern beech (*Nothofagus*) at ca. 51 million years ago (Ma) The early Oligocene assemblages (33.9-23 Ma) indicate further cooling and are characterised by cool temperate *Podocarpus-Nothofagus* forests with *Dacrydium* and *Lagarostrobos* (both common in southern forests of New Zealand and Tasmania today). A decline in *Dacrydium* and *Lagarostrobos* (Huon Pine) and absence of Proteaceae indicate climate cooling during the late Oligocene (~25-23 Ma). Lowland tundra shrub became dominant on Wilkes Land following a strong cooling at the Oligocene-Miocene transition characterized by a sharp decline in tree ferns along with an increase in bryophytes. A return of some cool-temperate woody plants can be recorded for the Middle Miocene Climate Optimum (MCO 17-15 Ma). Following a return to polar tundra conditions at the end of MCO, vegetation appears to have been disappeared from the Wilkes Land after ca. 10.8 Ma.

Our pollen record suggests that throughout the Cenozoic, mean temperatures at Wilkes Land were higher than in the Ross Sea region (i.e. Andrill, Cape Roberts) and the Antarctic Peninsula (i.e. Shaldril). We conclude that the Wilkes Land margins were possibly one of the last refugia for temperate forest taxa on Antarctica during the Late Oligocene and Miocene.

Keywords: Antarctica, Paleogene, Neogene, pollen, vegetation

The mid-Piacenzian warm period in the Asian interior: Assessing palaeoclimate variability with high-resolution pollen records from the Qaidam Basin and Chinese Loess Plateau

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The climate of the Asian interior is mainly controlled by the East Asian Monsoon providing warm and wet air directed north and westwards in summer, and cold and dry air directed south and eastwards in winter. Furthermore, westerly winds transport comparatively small amounts of precipitation from the Atlantic Ocean and Mediterranean Sea into the Asian interior which, however, are significant in arid regions that lie outside of monsoonal influence.

During the mid-Piacenzian warm period (mPWP; 3.264 – 3.025 Ma) multiple palaeorecords indicate a strengthening of the East Asian Winter Monsoon (EAWM) whereas the response of the East Asian Summer Monsoon (EASM) is subject of controversy. Being the main source of precipitation for the Asian interior, it is of fundamental importance to understand the intensity and variability of the EASM during the warm Pliocene, which had climatic conditions similar to what climate models predict for the end of the 21st century.

Our study reconstructs vegetation and climate changes during the mPWP from two sites located at the northwestern limit (Qaidam Basin, Chinese Loess Plateau) of the EASM using high-resolution pollen records. Whereas the source of precipitation on the Chinese Loess Plateau can be attributed to the EASM, the source of precipitation in the Qaidam Basin depends on the actual site location (north/west – westerlies; south/east – EASM). Preliminary results show that between 3.339 – 3.097 Ma the vegetation in the western Qaidam Basin (SG-1b drilling site) was dominated by xerophytic shrubland with Chenopodiaceae and *Artemisia* spp. usually contributing more than 50% of pollen grains. Broadleaved and coniferous trees comprise only a small fraction, however, they repeatedly reach 15-20% of the total pollen count during short intervals that represent wetter periods during the mPWP. Spectral analysis of *Artemisia*/Chenopodiaceae ratios as a relative precipitation proxy suggests that palaeoprecipitation changes are controlled by 41ka and possibly 100ka orbital cycles. A strong increase in coniferous trees and pollen concentrations suggest a distinctly wetter phase around 3.17 Ma.

The palynogical results of the SG-1b record from the western Qaidam Basin will be compared with a new pollen record from the Chinese Loess Plateau (Chaona), allowing a high-resolution temporal and spatial reconstruction of mid-Piacenzian palaeoprecipitation changes in the Asian interior.

Keywords: mid-Piacenzian warm period, Qaidam Basin, palaeovegetation

Middle Jurassic burst of radiation in dinoflagellates: a north-western Carpathian record.

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Mesozoic diversity of cyst-forming dinoflagellates generally displays gradual increasing trend up to the Early Cretaceous, punctuated by some intervals of more rapid evolution. The Bajocian time was of special significance in phytoplankton evolution due to massive radiation of gonyaulacacean dinoflagellates and an onset of their long lasting dominance accompanied by experimentation in archeopyle styles. This diversification burst has been widely recognized both across northwestern Europe and in Australia, but has remained overlooked in the Eastern Europe despite extensive palynological studies in the Carpathians.

Late Early to Middle Jurassic shales and marls of the Pieniny Klippen Belt (Carpathians of Poland and Slovakia) yielded well preserved and abundant dinoflagellate cyst assemblages. Because of magnitude of tectonic perturbations these successions are discontinuous and hard to reconstruct. However, the sequence combined from several sections represents a fairly complete, in part ammonite-calibrated stratigraphic record throughout the Toarcian - Lower Bathonian interval. The Toarcian deposits are particularly sparse and were studied in few sections. The studies revealed low diversity of the dinoflagellate cysts of the *Nannoceratopsis*, *Scriniocassis*, *Mancodinium*, *Valvaeodinium* genera, and rare cysts of the *Parvocysta* suite. The total number of species found so far do not exceed ten, and is lowest in the lowermost Toarcian. The Aalenian stage, much extensively exposed and sampled, shows slight increase in dinoflagellates diversity, with up to dozen or so species attributed primarily to the *Nannoceratopsis*, *Phallocysta/Andreedinium*, *Scriniocassis*, *Kallosphaeridium*, *Batiacapshaera*, *Pareodinia*, *Evansia* and *Dissiliodinium* genera. The ammonite control in the supra-Aalenian strata is limited, but the stratigraphic succession of the dinoflagellate cyst co-occurrences allows to distinguish the Lower and lowermost Upper Bajocian within the shaley-turbiditic Szlachtowa Formation. These deposits yielded the species of *Durotrigia*, *Gongylodinium* and *Aldorfia* genera which have their lowest occurrences and common *Dissiliodinium* spp. (predominantly *D. giganteum*). The assemblages recovered from the lower part of the overlying marly Opaleniec Formation show lowest occurrences of the *Chytroeisphaeridia*, *Gonyaulacysta*, *Meiurogonyaulax* and *Valensiella/Ellipsoidictium* genera, whereas *Ctenidodinium* (usually the dominant taxa), *Carpathodinium*, *Endoscrinium*, *Korystocysta* and *Willeidinium* appear upsection, indicating the Upper Bajocian. The uppermost few meters of the Opaleniec Formation yielded also species belonging to, e.g., *Adnatosphaeridium*, *Ambonosphaera*, *Atopodinium*, *Cleistosphaeridium*, *Dichadogonyaulax*, *Tubotuberella* and *Wanaea* genera. Thus, this part may be attributed to the uppermost Bajocian to Lower Bathonian interval. The total number of hitherto recognized species having their lowest occurrences within a few metres of the Opaleniec Formation exceeds 35, which, in line with the predominance of the Gonyaulacacea, may be referred to the Bajocian explosion of Dinoflagellates as observed elsewhere.

The rapid radiation of dinoflagellates in the Upper Bajocian of the Pieniny Klippen Belt coincided with some facies changes. Both palynofacies and lithofacies indicate significant deepening which culminated at the time of deposition of radiolarites in the Bathonian - Oxfordian interval. The significant changes in paleobathymetry probably correspond to opening and intense expansion of the Carpathian branch of Tethys. This observation supports some earlier speculations that Jurassic radiation pulses of dinoflagellates were related to opening of important seaways that enabled deep water ventilation.

Keywords: dinoflagellate cysts, radiation, Middle Jurassic, Bajocian, Carpathians, Pieniny Klippen Belt

Why cryptospores are acritarchs (and why not)

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Evitt (1963) defined the acritarchs as an informal group of organic-walled microfossils, as follows: 'small microfossils of unknown and probably varied biological affinities consisting of a central cavity enclosed by a wall of single or multiple layers and of chiefly organic composition ; symmetry, shape, structure, and ornamentation varied ; central cavity closed or communicating with the exterior by varied means, for example : pores, a slitlike or irregular rupture, a circular opening.' The term 'acritarch' is today generally accepted and widely used to group organic-walled microfossils (palynomorphs) of unknown origin.

Subsequently, Richardson et al. (1984) included in the description of Scottish Devonian miospores the diagnosis of another informal grouping, the 'anteturma *Cryptosporites*,' with the following definition : *'non-marine sporomorphs (non-pollen grains) with no visible haptotypic features such as contact areas or tetrad marks. Single grains or monads, 'permanent' dyads and tetrads are included.'* The term 'cryptospores' is today also largely accepted to classify primitive spore-like palynomorphs of which the biological affinity is not clearly established.

Since the description of the terms 'acritarchs' and 'cryptospores' many other (incorrect or restrictive) definitions have been proposed for both informal groups. To date, almost no palaeontological text-book or website cites correctly the original definition of the 'acritarchs' as published some 50 years ago, nor the definition of the 'cryptospores' as published over 30 years ago. Instead, many ambiguous interpretations of the terms circulate in literature. The main problem with both terms is this confusion of the definition (based on morphologies) and the biological interpretation.

Evitt´s (1963) definition was purely morphological, without a biological interpretation. However, many Proterozoic specialists consider the acritarchs as representing many different types of organisms, from bacteria to unicellular (protists) or multicellular eukaryotes (e.g., fungi, algae and/or animal eggs), while most Palaeozoic palynologists consider the acritarchs as unicellular, marine microphytoplankton. Many dinoflagellate workers name acritarchs all those objects that cannot be classified as cysts of dinoflagellates, because they do not present all the significant morphological criteria of the dinocysts (cingulum, sulcus, 'tabulation,' etc.). Then again, some authors, in particular from North America, consider the acritarchs as 'organic-walled microphytoplankton.' This interpretation of biological affinities is partly incorrect, because surely not all acritarchs are planktonic or of algal origin. Furthermore, not all acritarchs are marine, and the group does not include exclusively unicellular organisms. There is thus clearly a confusion between the definition (Evitt 1963) and the interpretation of the term 'acritarch'.

Likewise, the term cryptospore was defined on morphological grounds for organisms that ressemble spores, but that do not have all the morphological criteria to classify them as land-plant derived (mio-)spores. As for the acritarchs, the definition of this informal grouping does not include a biological affinity. Interestingly, the term cryptospores has been altered by several authors after its original definition, partly to include a biological affinity as land plant derived spores. As such, some authors consider the cryptospores being organisms solely produced by embryophytes.

The different subsequent definitions of the terms acritarchs and cryptospores, mixing morphological criteria and biological affinities, have let to increasing confusion. A major common misunderstanding is to consider the acritarchs as marine algae and the cryptospores as land-plant derived spores. Theoretically, however, most cryptospores could be classified as acritarchs, as they perfectly fit in Evitt's original diagnosis.

We advocate that, as long as the exact biological affinity of most of the individual morphotypes remains unknown, the informal groupings of the acritarchs and the cryptospores are still valuable and the original definitions should be retained.

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Keywords: acritarchs, cryptospores, Palaeozoic palynology

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Palynological assemblages across the Hercynian unconformity in Western Iraq

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Recent study of samples from borehole KH-5/1 has allowed an assessment of the duration of the hiatus associated with the so-called Hercynian unconformity (also known as the 'Late Carboniferous unconformity' or 'pre-Unayzah unconformity') in western Iraq. KH-5/1 was drilled as a deep water well and fully cored to TD at 1620m. The well section spans the unconformity at 670m depth with the Raha Formation below and the Ga'ara Formation above. The unconformity appears to be associated with non-deposition or erosion of rocks corresponding approximately in age to part of the Serpukhovian and Bashkirian (latest Mississippian to early Pennsylvanian), similar to the duration associated with the same unconformity in well ST-8 situated to the south of KH-5/1 in northern Saudi Arabia.

The Ga'ara Formation assemblages above the unconformity in KH-5/1 are similar in character to those described from 4620 to 4200 feet in ST-8. The age of these assemblages in both KH-5/1 and ST-8 is considered in this paper to be Westphalian. The composition of the Ga'ara Formation assemblages in KH-5/1 also shows some similarity to glacigene post-unconformity beds of the 2165 Biozone of the Al Khlata Formation of Oman.

Keywords: palynology, Permian, Carboniferous, Iraq

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Permian palynostratigraphy: a global review

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Palynostratigraphy (the use of palynomorphs in biostratigraphy) aims to correlate sedimentary rocks, and to relate geological resources or events to each other and to other important geological or scientific phenomena. In the Permian, palynostratigraphy has been used primarily to correlate coal- and hydrocarbon-bearing rocks within basins and between basins, sometimes at high levels of biostratigraphic resolution. Though these palynostratigraphic schemes related to resource extraction have been very successful, their main shortcoming has been a lack of correlation with schemes outside the basins, coalfields and hydrocarbon fields that they serve, and chiefly a lack of correlation with the international Permian scale. The benefits of a better integrated general palynostratigraphy are very great scientifically because there are numerous events of global scientific interest in the Permian, for example the timing and order of deglaciation events and the detailed characteristics and timing of mass extinction events within the Permian and at the Permian-Triassic boundary.

Permian palynostratigraphy is strongly affected by phytogeographic provinciality particularly from the Middle Permian onwards, as predicted by palaeobotanical studies. This makes correlation between regional palynostratigraphic schemes difficult. For these reasons it is unlikely that a single comprehensive palynostratigraphic scheme for the Permian globally will ever be developed. However local high resolution palynostratigraphic schemes for regions are being linked either by precise assemblage-level quantitative taxonomic comparison or by the use of single well-characterised palynological taxa that occur across Permian phytogeographical provinces. Such taxa include: *Scutasporites* spp., *Vittatina* spp., *Weylandites* spp., *Lueckisporites virkkiae*, *Otynisporites eotriassicus* and *Converrucosisporites confluens*. These palynological correlations can be facilitated and supplemented with radiometric, magnetostratigraphic, independent faunal, and strontium isotopic dating.

None of the Permian GSSPs involve palynological definitions, which may be problematic given the importance of palynology in correlation in the commercial and academic worlds. However there appear to be taxa that occur at GSSPs or well-dated boundary sections that could be used to correlate those boundaries. For example *Aratrisporites* and *Otynisporites eotriassicus* may be useful to correlate the Permian-Triassic boundary into non-marine sections or sections without radiometric dates. *Converrucosisporites confluens* may be useful in correlating the Carboniferous-Permian boundary.

Keywords: Permian, review, palynostratigraphy

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New fossil protists from the basal Neoproterozoic Nonesuch Shale

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The Nonesuch Shale is an ancient lake deposit deposited in the Mid-Continent Rift System, which outcrops in the Upper Peninsula of Michigan, USA. It has an age of about 1050 Ma and consists of approximately 150 meters of laminated, dark grey mudstones that are conformably sandwiched between the underlying Copper Ridge Conglomerate and the overlying, arkosic Freda Sandstone. Fossiliferous samples were recovered from drill cores, outcrops along the Big Iron and Presque Isle Rivers in, and from supplemental drill cores in Wisconsin. The composite palynological assemblage contains over 50 distinct taxa, most of which would be considered as sphaeromorph acritarchs. Here we present a few distinctive forms that stood out during our preliminary taxonomic assessment of the formation. Some of these are based on the original unpublished work of Gordon Wood who documented distinctive microfossils in a series of annotated photomicrographs. These forms are morphologically distinct enough to warrant classification as separate genera. The first new genus is a discoidal sphaeromorph with a medial laesura that can run nearly the entire diameter of the vesicle. Rather that representing a tear or cut in the wall, the laesura appears to represent a thinning of the wall. A second form has possesses an inner body that tapers distally, which is enclosed in a veil characterized by spirally-aligned folds. The complete structure can be attached to a short, broken stalk, or, a basal darkens ring, ore disc. Our interpretation is that this was a stalked, benthic protist. A third taxon was recovered from samples originally studied by Gordon Wood. He recognized a new coenobial form based on cells that form a radial, structural pattern with somewhat diffuse crosswalls. The forth form is represented by distinctive clusters of ovoid bodies that appear to be amassed together, either within a degraded membrane or, perhaps, some form of EPS. The forms documented by Wood are similar to *Satka colonialica* Jankauskas, but are far less organized and not planar, as with *S. squamifera*. Intriguingly, they do resemble the reproductive bodies of the extant ichthyosporean, *Creolimax fragrantissima*, a basal holozoan. As we become more familiar with living forms, the well-preserved material from the Nonesuch Shale may provide justification for splitting *Satka* into two separate genera. While it is possible that many of the sphaeromorph acritarchs recovered from these freshwater deposits were chlorophytes, there is very little demonstrable homology between the freshwater phytoplankton of today and these sphaeromorph acritarchs of the Meso-Neoproterozoic transition.

Keywords: Precambrian, microfossils, acritarchs, ancient lakes, paleopalynology

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A Palynological Analysis of the Late Jurassic Ula Formation, Ula Field, NOCS: BP PalaeoGIS Project

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In the 1970s and '80s, British Petroleum extensively cored the Late Jurassic Ula Formation in the Ula Field, Norwegian Offshore Continental Shelf, to better understand the nature of this primary reservoir unit. The samples and prepared

slides that now reside at the Natural History Museum, London provide an excellent subsurface laboratory to explore the spatial and temporal dynamics of shallow marine palaeoenvironments. This study is the preliminary findings of the palynological investigation from the wells 7/12-3 and 7/12-5.

All palynomorphs recovered indicate a Kimmeridgian age which is consistent with the industry reports and published literature of the formation in this area. Dinocysts dominate the assemblages with the following common constituents: *Oligosphaeridium* species*, Cribroperidinium* spp. *Occisucysta balios, Systematophora* spp. and *Cyclonephelium distinctum.* There are also varying numbers of rich assemblages that include other taxa such as *Subtilisphaera (Corculodinium) inaffectum* and *Glossodinium dimorphum.* Pollen and spores are rare in 7/12-3, however they are consistently present throughout 7/12-5 suggesting the two sites differing proximities to fluvially-linked sediment fairways.

This study will present new assemblage data and how it can be used to assist depositional and environmental conditions during the Kimmeridgian of the Norwegian Offshore Continental Shelf.

Keywords: Kimmeridgian; NOCS; shallow-marine; palaeoenvironment

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Filling in the Gaps: Palynology at the Birthplace of North American Vertebrate Paleontology

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The discovery of vertebrate remains at Big Bone Lick along the Ohio River in what is now northern Kentucky in 1739 and their subsequent study in France and England in the late 1740's-1760's marked the beginning of vertebrate paleontology in North America. Associated plant remains have been known from these deposits since expeditions in the 1950's, however, until this study, no meaningful palynoflora has been documented. Eight samples were obtained from profile 2 of Tankersley et al. (2015) and processed using enzymes, rather than acetolysis. This resulted in successful extraction of palynomorphs. Reworked material present in the samples, including *Veryhachium* sp., *Tasmanites* sp., *Convolutispora* sp., and marine dinoflagellates, indicates that the primary sediment source for the terrace deposits that comprise the Pleistocene sediments at Big Bone Lick were Devonian and younger rocks, rather than the underlying Ordovician Kope Formation, as had been previously suggested. The Pleistocene palynoflora is both abundant and diverse, with 65 plant taxa and 55 non-pollen palynomorph (NPP) taxa present, including fungi, algae, amoebae thecae, tardigrade eggs. It does not match the macro- and meso-botanical remains recovered from the site; notably, *Liriodendron tulipifera*, *Acalypha* sp., *Oxalis* sp., *Silene* sp., and *Vitis* sp. pollen are not present, nor are liverwort and lichen spores. This likely reflects preservational bias (significant quantities of "unidentifiable" grains are present, and many others show characteristic damage patterns caused by fungi) and flooding of local signals by transported taxa (Poaceae, *Picea* sp., *Abies* sp., *Pinus* sp., etc.). Of note, many aquatic and emergent taxa, such as *Azolla* sp., *Myriophyllum* sp., *Nuphar* sp., *Nymphaea* sp., and *Typha latifolia* occur, as does *Juncus* sp. These taxa together represent the first concrete evidence for ponded water during the Pleistocene at Big Bone Lick. The NPP flora is dominated by fungal remains. These include mutualistic (mycorrhizal), parasitic, and saprophytic taxa, including known dung fungi. The mycorrhizal fungal flora is dominated by *Monoporisporites* sp., which is representative of ecto- and ericoidmycorrhizal fungi, known to be predominant in wet soils. Diverse dung fungi point toward the presence of a variety of herbivores and carnivores already known from their bones, but also toward the presence of geese (*Saccobolus* sp. has only been isolated from goose dung), the bones of which are not preserved at Big Bone Lick. The presence of *Lacrimasporites* sp. is interesting, as it has previously been documented from salt-marsh settings, where it is an obligate saprophyte on *Juncus* sp. An unidentified taxon is present in many of the samples; this taxon is also found in the ponds directly adjacent to modern salt springs at Big Bone Lick and may provide additional evidence that the salt licks were present as postulated during the Pleistocene.

Keywords: Pleistocene, NPP, Fungi, Pollen, Big Bone Lick

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Radiocarbon-dated Holocene pollen and ostracod sequences from a tufa barrage dammed fluvial systems in the White Peak, Derbyshire, UK

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Sedimentary evidence, in the form of pollen, ostracod and radiocarbon-age data from three barrage tufa-dammed systems in the White Peak area of Derbyshire, is used to reconstruct the region's environmental history from 10000 to 4000BP. The data highlight the useful role that such fluvial systems can play in environmental reconstructions, through their ability to act as sumps for a wide range of proxy indicators, in a region where environmental change during the Holocene period has been relatively poorly documented. Pollen data suggest that the period of climatic amelioration following the last (Devensian) glaciation facilitated the spread of thermophilous woodland taxa on the White Peak, although there are some indications that the first immigrant trees were not established until a relatively late date. Forest clearance commencing during the mid-Holocene, and possibly as early as the late Mesolithic, was most probably to provide land for grazing, and was virtually complete by 4000BP. Ostracod data reveal fluctuations in discharge of the River Lathkill draining the White Peak, particularly lower flow rates after 7400 BP, which are difficult to explain simply in terms of climate change.

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Are laminae the only resistant spore wall structures in algal/land plant transitional forms?

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It has been widely discussed and broadly accepted that the primitive sporopollenin-containing wall elements in transitional algal/early land plant forms are flat. These units originate from the surface of a cell membrane, and accumulate in various ways to form a resistant covering over the resting spore. Some coverings are produced over the entire cell surface at once to form one continuous layer; several such pulses may contribute to the formation of a thicker composite wall. A second mode of construction involves flat wall elements that form over a more limited portion of the cell surface. This mode requires that overlapping edges of these smaller units be fused in order to ensure a continuous covering, and in some bryophytes (and later appearing land plants) this process is directed by the earlier formation of a scaffold that controls the placement of the elements. This second mode is not known in extant algae, and is limited today to embryophytes. Tracing the distribution of these flat wall elements in lower Paleozoic spore walls is informative, but is only one piece of the puzzle when trying to uncover the evolution of the first true land plants. There are other recognizable structural subunits in fossils, as well. Describing these forms, recognizing their distribution in time and space, and comparing them to earlier certainly algal forms, as well as later certainly land plant spores will be the focus of this presentation.

Keywords: Lower Paleozoic; early land plants; ultrastructure; Cambrian; cryptospores

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Kirusillas Formation: new Silurian insights from high palaeolatitudes

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Silurian geological research is often focused in regions which occupied low palaeolatitudes where the fossil groups that are used to sub-divide marine Silurian sequences: graptolites and conodonts are most abundant and offer the potential for high resolution biostratigraphy. Similarly, carbonate lithologies are more common at low palaeolatitudes which makes comparing isotopic signatures with carbonate poor high palaeolatitudes challenging. As our perceptions about the stability of the ocean-atmosphere system in the Silurian become more refined, calibrations with high palaeolatitudes become extremely important.

South America occupied a high palaeolatitude position in Gondwana during the Silurian and, importantly, Silurian rocks are widely distributed across the continent with world class exposures in the Andes of Peru, Bolivia and Argentina. In Bolivia, clastic rocks of Silurian age were deposited over much of the country, commencing in the Llandovery. The focus of this study is the late Silurian Kirusillas Formation in the Cordillera Oriental.

The Kirusillas Formation is regarded as a hydrocarbon source rock. In addition, despite being poorly fossiliferous, it has also yielded the first record of the early land plant *Cooksonia* in South America. Biostratigraphic control in the Kirusillas Formation is based on sparse records of graptolites, conodonts and a relatively small database of published palynological studies compared to neighbouring countries such as Argentina. To further enhance the resolution of the biostratigraphy and geochemistry in the Kirusillas Formation, a comprehensive dataset of 212 samples were collected from a 300 m section in the type area of Kirusillas village, near Tarabuco, Chuquisaca Province.

A preliminary investigation of the samples has been completed including analysis of 212 TOC%, 81 $\delta^{13}C_{TOC}$ together with RockEval and chitinozoan reflectivities. In addition, 22 palynological samples have been investigated. The palynomorph assemblage recovered from the measured section is dominated by long ranging cosmopolitan marine palynomorphs (e.g. *Leiofusa* spp., *Multiplicisphaeridum* spp., *Veryhachium* spp., *Angochitina* spp. and *Ancyrochitina* spp.) associated with rare but distinctive, ornamented trilete spores. The palynology data constrain the age of the Kirusillas Formation to the Ludlow with the majority of the samples demonstrably Ludfordian in age. This result is compatible with previous palynology studies in Bolivia and other investigated coeval sections in Argentina and Brazil. Moreover, this Ludfordian age assignment infers that the measured section should span the Lau Event; one of the largest Phanerozoic isotope excursions. As this section is late Silurian in age it provides a useful comparative data point with the paucity of rocks of this age from Saudi Arabia.

Keywords: Silurian, Gondwana, Bolivia, Kirusillas Formation, palynology, geochemistry

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Lower Paleozoic Palynology of the Arabian Plate: a synopsis and historical perspective

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Palynological investigations of the Paleozoic rocks of Saudi Arabia have developed in parallel with the growing need for detailed understanding of the complexities of subsurface stratigraphy, in order to meet the demands of hydrocarbon exploration activities in the Kingdom. Pioneering work of early palynologists in Saudi Aramco since the '60s demonstrated the presence of exceptionally abundant and well preserved assemblages of fossil microplankton and spores of primitive vegetation and their huge potential for establishing reliable operational biozonations (e.g., Hemer and Nygreen, 1966). A major impetus for further development and refinement of palynological biozonations followed the important hydrocarbon discoveries from Saudi Arabian Paleozoic successions during the late '80s and the '90s, with an increased need for an improved understanding of the Paleozoic sediments, and their geological and paleogeographical

relationships to successions in neighboring countries and adjacent plates. The establishment of a successful, long-term collaboration between Saudi Aramco and academic researchers belonging to the CIMP (Commission Internationale de Microflore du Paléozoïque) was highly beneficial and resulted not only in the establishment of a robust biostratigraphic zonation of the Cambrian to Permian strata (Al-Hajri and Owens, 2001; Wellman et al., 2015), but also in a number of important scientific discoveries such as the oldest known spores from primitive land plants (Steemans et al., 2009; Strother et al., 2015). At the present time we face new challenges of discovering and unlocking unconventional hydrocarbon resources or small conventional fields. The contribution of palynology is therefore even more crucial in all phases of exploration and development, allowing reliable age dating and correlation of rock units during regional exploration studies, play fairway mapping, and providing real-time stratigraphic data during drilling operations.

This presentation will focus on the Lower Paleozoic palynostratigraphy of Saudi Arabia, with comparison and correlation with equivalent strata in adjoining regions, as well as worldwide. The present Lower Paleozoic (Cambrian – Silurian) Saudi Aramco Operational Zonation comprises 17 palynological zones (2 in the Cambrian, 8 in the Ordovician, 7 in the Silurian) which are defined by First Downhole Occurrences (FDOs) of highly distinct palynomorph taxa of cryptospores, trilete spores, acritarchs and chitinozoans. Within each zone, further stratigraphic subdivision is provided by distinct bioevents (e.g., FDOs and acmes) of regional importance. In total, 80 palynomorph taxa form the basis of the zonation in the Cambrian – Silurian stratigraphic section of the Arabian Plate. Some of the key taxa have a worldwide distribution and allow calibration of the zonation with type sections of Global Stages; in other instances, co-occurrence of macro- or meso-fossils (e.g., graptolites, trace fossils) permit even more accurate correlation with the standard Global Chronostratigraphic scale. In the lower Silurian, the detailed study of graptolites recovered from extensively cored sections have provided a robust integrated palynological-graptolite biozonation which has formed the basis for the establishment of a chronostratigraphic and depositional model for the organic-rich "Hot Shales" of northwestern Saudi Arabia (Hayton et al., 2017). Other applications of the palynological zonation concern the subsurface mapping of source rocks and reservoir horizons in the Cambrian - Ordovician (e.g., Saq and Qasim formations), and the contribution to the understanding of the stratigraphic development and depositional paleoenvironment of other important stratigraphic units such as the glaciogenic Sarah Formation (Upper Ordovician; Miller and Al-Ruwaili, 2007) and the mid-Qusaiba sandstones (lower Silurian; Miller and Melvin, 2005).

Keywords: Palynology, Lower Paleozoic, Saudi Arabia, Stratigraphy, Exploration.

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Integration of acritarch morphological analyses with organic carbon isotope chemostratigraphy in the Kallholn section (early Silurian, central Sweden): complementary evidence for sequence stratigraphy

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The early Silurian is widely recognised by global sea-level fluctuations resulting from the advances and retreats of Gondwanan ice-sheets. The focus of this research is to examine how these environmental changes influenced the diversity of macro- and microplankton of the Siljan Ring area, central Sweden. The Siljan Ring area has been subjected to numerous studies due to its hydrocarbon potential and associated economic value.

Graptolite biostratigraphy has dated the 14.95 m Kallholn section to the upper Aeronian (beginning in the *leptotheca* Biozone) through to the early Telychian (*crispus* Biozone). Organic carbon isotope excursions present within the section have been dated through integrated graptolite and conodont biostratigraphy. A new carbon isotope excursion in the *turriculatus* Biozone (lower Telychian) is identified, which may be associated with the onset of the Valgu Event, a global conodont extinction event.

Morphological characteristics of palynological assemblages are applied as proxies for identifying Silurian eustatic relative sea-level changes in the Siljan Ring area. Exceptionally well-preserved palynomorphs from both shale and nodule samples were extracted by processing using the standard HCl-HF-HCl palynological method. Regression and transgression trends are interpreted through the study of the acritarchs' vesicle, number of processes, process bifurcation, and length. The relationship of palynological and geochemical data correlates well with the interpretations suggested by sequence stratigraphy, and is suggested to be related to changes in the depositional environment.

Keywords: Silurian, biostratigraphy, palynology, acritarchs

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Palynological record of changing environments across the Triassic-Jurassic boundary interval in Northern Ireland

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The Triassic-Jurassic boundary is a globally important transition that has been under-studied in Northern Irish sections. Using material from a completely-cored record of the late Triassic to earliest Jurassic interval, this project aims to provide both a biostratigraphic and palaeoenvironmental context for the section in the Carnduff-1 Borehole near Larne. The assemblages from Carnduff-1 are quite well-preserved and diverse, but dominated by *Classopollis* type palynomorphs and a variety of bisaccate pollen. Dinoflagellate cyst abundance varies through the section, but diversity is low. The palaeoenvironmental interpretation will be achieved using both quantitative statistical methods, as well as semi-quantative palynofacies approaches.

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Palynology of the Permian in the British Isles, and independent age constraints

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Permian successions in the British Isles comprise predominantly coarse-grained continental formations, some with volcanics, succeeded by ones that include carbonates and evaporites of marine origin. The older formations typically rest unconformably on rocks folded during the Variscan orogeny and form the Exeter and Aylesbeare groups (SW England), the Enler Group (Northern Ireland), and the Appleby and Rotliegend groups (NW and eastern England respectively); miospores occur very sporadically in parts of the Exeter and Appleby groups. The younger formations, which form the Zechstein Group (eastern England), the Cumbrian Coast Group (NW England and SW Scotland) and the Belfast Group (Northern Ireland) have yielded most of the Permian palynomorph assemblages known from the British Isles. The Permian-Triassic boundary is usually placed arbitrarily in unfossiliferous continental deposits but in Co. Cavan, in the Republic of Ireland, palynological evidence affords some constraint on its position.

Early Permian (Cisuralian) miospores have not been documented from successions onshore in the British Isles. Dates

of 'Autunian' and 'Late Carboniferous to Permian' for beds in, respectively, the Plymouth Bay and St Mary's basins in the western English Channel may be based on palynology but there are no published details.

In Devon (SW England) the lower part of the continental Exeter Group has not yielded palynomorphs but includes volcanics dated isotopically as late Sakmarian to Artinskian and early Kungurian (Cisuralian: Early Permian). It is succeeded unconformably by the upper part of the group which lacks volcanics but has yielded a miospore assemblage that includes Lueckisporites virkkiae. In the Euramerican palaeobotanical province this taxon ranges from the early Mid-Permian to the end of the Permian. An early to mid-Guadalupian (Mid-Permian) age for this occurrence in Devon is constrained by that of the first appearance of L. virkkiae (early Roadian?) and the end, at c. 266.5 Ma (mid-Wordian), of the Kiaman Superchron, a magnetostratigraphic event which is recognised near the top of the Exeter Group. That group is succeeded unconformably by the Aylesbeare Mudstone Group which has only yielded reworked miospores and is, on magnetostratigraphic evidence, early Capitanian to early Changhsingian (late Mid- to Late Permian) in age. It is overlain unconformably by Early Triassic deposits and the system boundary is not represented in the Devon succession.

It is 55 years since Permian miospores were first reported from the British Isles. These were recovered from the Eden Shales (Cumbrian Coast Group) at Hilton Beck, in the Vale of Eden (NW England). Comparable assemblages have subsequently been recorded from that group elsewhere in NW England, SW Scotland and offshore in the East Irish Sea. They are also known from correlative formations in Northern Ireland, the Republic of Ireland, offshore west of Ireland and from the Zechstein Group in eastern England and offshore in the Southern North Sea, the Forth Approaches, the Moray Firth and north of Orkney. Spores are rare and the associations are dominated by pollen, principally bisaccates, but include monosaccates. They are characterized by Lueckisporites virkkiae and include representatives of other bisaccate taeniate genera, including Lunatiporites, Protohaploxypinus, Striatoabeites and Vittatina. Non-taeniate bisaccate genera include Jugasporites and Klausipollenites; the monosaccates include Perisaccus. These assemblages, from the Zechstein Group and its correlatives, are characteristic of the Euramerican palaeobotanical province. Acritarchs occur in some preparations from these deposits.

The Zechstein Group is, on biostratigraphic, isotopic and magnetostratigraphic evidence, mid-Wuchiapingian to Changhsingian (Lopingian: Late Permian) in age, between c. 257.3 Ma and c. 251.9 Ma, the isotopic ages for the Kupferschiefer, at the base of the group, and the Permian-Triassic boundary respectively.

Keywords: spores, pollen, acritarchs, Mid- and Late Permian, isotopic and magnetostratigraphic age constraints

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Mid-Triassic palynology in the Cheshire Basin (NW England) – a mine, a cemetery, a 'dungeon', and boreholes

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The Cheshire Basin is an asymmetric post-Variscan half-graben that covers much of Cheshire and N Shropshire. The basin fill comprises a Permian to Jurassic succession that was eroded after late Mesozoic inversion and crops out over an area of at least 3500 sq. km that extends for *c.*100 km N-S and up to 60 km E-W. The fullest succession was proved in the south where a borehole that commenced in the Lower Jurassic entered Carboniferous rocks at 3600 m. Exposure of parts of the succession is poor and deep boreholes are scarce. Palynomorph assemblages have been recovered from parts of the Permian and Triassic successions, mainly from scattered exposures and mostly shallow boreholes in the northern half of the basin.

The Triassic succession includes formations of the Sherwood Sandstone and succeeding Mercia Mudstone and Penarth groups. The Permian-Triassic boundary is not defined. The Manchester Marls, below the Sherwood Sandstone at the north end of the basin, have yielded Late Permian miospores but none have been reported from beds between that level and the appearance of Mid-Triassic miospores at the top of the Sherwood Sandstone, in the Helsby Sandstone Formation. The Triassic-Jurassic boundary occurs between the Penarth Group, with Rhaetian palynomorphs, and the appearance of ammonites (*Psiloceras erugatum*) in the lowest few metres of the Lias Group.

Miospores of Anisian (early Mid-Triassic) age were recovered from the Helsby Sandstone at a mine at Alderley Edge (NE Cheshire) and were the first reported from the Trias in the Cheshire Basin; there are few other records from the formation in that area.

The overlying thick (>1500m) Mercia Mudstone succession comprises the Tarporley Siltstone, Sidmouth Mudstone, Branscombe Mudstone and Blue Anchor formations. Miospores of Anisian age have been reported from exposures of the Tarporley Siltstone at Liverpool, on the Wirral peninsula (NW Cheshire), and up to a level above the Northwich Halite Member in the succeeding Sidmouth Mudstone in boreholes in N Cheshire. The Anisian-Ladinian boundary is in the Byley and Wych Mudstone members which occur between that halite and the Wilkesley Halite Member. The Wilkesley Halite, at the top of the Sidmouth Mudstone, may be Ladinian to Carnian or entirely Carnian in age; palynological evidence from this member and the overlying formations is scarce and inconclusive.

These records are now augmented with ones of assemblages from sections of the Tarporley Siltstone in boreholes on the Wirral and near Manchester airport, from road works at Daresbury (N Cheshire), and from new investigations of sections of that formation in a cemetery at Liverpool and 'The Dungeon' valley on the Wirral. Additional records are also now available from the Bollin Mudstone Member, at the base of the succeeding Sidmouth Mudstone, in boreholes near Knutsford (N Cheshire).

An Anisian age for the succession from the Helsby Sandstone to the middle of the Sidmouth Mudstone is indicated by miospore associations that include *Perotrilites minor*, *Angustisulcites* spp., *Illinites* spp., *Protodiploxypinus* spp., *Stellapollenites thiergartii* and *Tsugaepollenites oriens*. Preparations from the Tarporley Siltstone and the Bollin, Byley and Wych members in the Sidmouth Mudstone also contain small numbers of acritarchs.

Keywords: Cheshire Basin, palynology, Mid-Triassic, Helsby Sandstone, Tarporley Siltstone, Sidmouth Mudstone

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Spore assemblages from the Lower Devonian La Vid Group (and equivalents) from northern Spain

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The Devonian deposits of the Cantabrian Mountains of northern Spain represent two distinct facies: (i) the Asturo-Leonian domain (rocks of nearshore facies in Asturias, Leon and northwest Palencia); (ii) the Palentian domain (rocks of offshore facies in northern Palencia). Here we report on a palynological investigation of the Early Devonian (Lochkovian to Emsian) deposits of this sequence that are included in three equivalent rock groups: the Raneces Group (Asturias); the La Vid Group (Leon); equivalent strata such as the Lebanza and Abadia formations (Palencia). Palynological investigation by Cramer and colleagues in the 1960s-1970s demonstrated the recovery of abundant and diverse palynomorph assemblages containing elements that are both marine (acritarchs, chitinozoans, scolecodonts) and continental (spores). Revision of the dispersed spore assemblages is long overdue following major developments in this field regarding our understanding of early land plant spore taxonomy, biostratigraphy and palaeophytogeography. Systematic collection of samples from throughout the region has yielded numerous palynomorph assemblages containing abundant and well preserved spores. Thermal maturity is variable, but many of the assemblages clear well during oxidation, to reveal beautifully preserved spores. These spore assemblages from PeriGondwana are compared with coeval assemblages from Gondwana (North Africa and Arabia) and Euramerica: Old Red Sandstone Continent (inland intermontane basins of Scotland, nearshore floodplain deposits of the Anglo-Welsh Basin, shallow marine deposits of the Ardenne-Rhenish region). PeriGondwanan spore assemblages from the late Silurian-earliest Devonian are most similar to those from Gondwana, but those from the Early Devonian appear to be more similar to those from EurAmerica.

Keywords: early land plants, EurAmerica, PeriGondwana, Gondwana

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Organic-walled microphytoplankton from the Lower Devonian (Lochkovian) Ross Formation, Tennessee, USA

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An abundant, diverse, and finely preserved assemblage of organic-walled microphytoplankton was recovered from measured sections of the Ross Formation at three localities in Benton and Decatur counties, Tennessee. Based on invertebrate faunas and stratigraphic relationships, the Ross Formation is considered Early Devonian (Lochkovian) in age.

Initial analysis of the palynoflora reveals some 42 taxa of acritarchs and prasinophytes, together with a diversity of chitinozoans and few miospores and scolecodonts. The best recovery and preservation was from grey shales and grey argillaceous limestones.

Noteworthy acritarch and prasinophyte species represented in the samples include: *Actinophasis complurilata, Ammonidium cornuatum, Baltisphaeridium cravattense, Chuttecloska athyrma, Demorhethium lappaceum, Fimbriaglomerella divisa, Hapsidopalla sannemannii, Oppilatala vulgaris, Ozotobrachion pulvinus, Pterospermella cerebella, P. circumstriata, P. reticulata, P. verrucaboia, Riculasphaera fissa,* and *Thysanoprobolus polykion*.

Species that are restricted to the Lochkovian and have a cosmopolitan distribution, thus rendering them applicable to global stratigraphic correlation, are: *Demorhethium lappaceum, Riculasphaera fissa,* and *Thysanoprobolus polykion*.

The Ross Formation's acritarch/prasinophyte assemblage closely resembles that reported previously from the Haragan and Bois d'Arc (Lochkovian) formations of Oklahoma, and many of the co-occurring species are evidently restricted to Laurentia. Based on species thus far identified in the Ross assemblage, a 62% similarity exists between it and the Oklahoma assemblage.

Although studies of Early Devonian palynofloras are relatively sparse, organic-walled microphytoplankton assemblages have been reported from Laurentia, Armorica, and Gondwana. There appears to be some provincialism between the mid-palaeolatitude assemblages of Laurentia and Armorica/North Africa, as well as greater provincialism on the whole with the higher palaeolatitude assemblages of Gondwana.

Keywords**:** organic-walled microphytoplankton, Lower Devonian (Lochkovian), Ross Formation, Tennessee, USA

Abstracts of the Poster Presentations

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Saudi Arabian Red Sea event Palynostratigraphy of Middle –Early Miocene Kial, Jabal Kibrit and Burqan sub-salt formations

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Three formations of Miocene age, Kial, Jabal Kibrit and Burqan in the Saudi Arabian Red Sea subsurface were studied to establish an event palynostratigraphy and enhanced stratigraphic control below the prominent Mansiyah Formation halite. The penetration of Kial sediments is palynologically identified by the first occurrence of large, thick-walled hyaline algal cysts, some of which are related to marine Tasmanites (Ki-1 event). Large algal cyst records increase often substantially within clastic members in the middle of this formation (Ki-1 Acme). Jabal Kibrit deep marine sediments contain a series of dinoflagellate markers, i.e., Nematophaeropsis lemniscata, Paleocystodinium golzowense, Impagidinium velorum which identify a series of palynoevents (FDOs) occurring in broad stratigraphic order from top to bottom (JbK-1 to JBK-3 events). At the base of the Jabal Kibrit Formation, terrestrial markers such as several genera/species of Acanthaceae occur more consistently (JbK-4 event). They are often associated with an upward increase of charred Gramineae cuticle. A clear unconformity called the mid-clysmic event separates Jabal Kibrit from Burqan deep marine horizons. The latter comprises distinct dinoflagellate markers such as Distatodinium paradoxum (BRQ-1 event), Exochosphaeridium insigne (BRQ-2 event), Cordosphaeridium cantharellum and Chiropteridium spp. (BRQ-3 event) and the LDO of Sumatradinium soucouyantiae (BRQ-4 event) underlying the base of strong marine evidence within the Red Sea syn-rift.

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StrataBugs biostratigraphy software

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StrataBugs is the industry standard data management software used to record, manipulate and display biostratigraphic and related geological data. The poster display is a summary of all aspects of the software and a related workshop presentation will demonstrate some of the ways in which StrataBugs can lead to a better understanding of biostratigraphy.

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Palynological investigation of Carnian succesions from the Transdanubian Range, western Hungary

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In the Triassic, the depositional area of the TR was located on the western shelf of the Tethys between the Northern Calcareous Alps, Drauzug and the Southern Alpine realms. The Late Triassic marine succession of the Transdanubian Range (TR) Hungary shows a significant change in sedimentation during the Carnian. The pelagic carbonate deposition was replaced by a short-termed interval with the formation of marly sediments of the Veszprém Marl Formation (VMF). The VMF was deposited in two transgressive-regressive cycles, each cycle referring to a member (Mencshely and Csicsó Marl Members) with the VMF.

The VMF hosts diverse and well-persevered palynological assemblages. Besides a few pioneer studies with only few sampled horizon, detailed palynological studies have not been carried out yet. Our new palynological and palynofacies data contribute to the biostratigraphic subdivision and palaeoenvironmental interpretation of the Veszprém Marl Formation.

A total of 63 samples from two boreholes: Mencshely (MET-1) and Veszprém (V-1) were processed for palynological analysis. Both quantitative and qualitative analyses have been performed. The identified taxa correspond to typical Carnian morphospecies in Europe e.g., *Camerosporites secatus*, *Duplicisporites* spp., *Partitisporites* spp., *Enzonalasporites vigens*, *Patinapsorites densus*, *Vallasporites ignacii*,., *Alisporites* spp., *Infernopollenites* spp., *Lueckisporites singhii*, *Lunatisporites acutus*, *Ovalipollis ovalis*, *Staurosaccites quadrifidus*, *Aulisporites astigmosus* including various spores e.g., *Aratrisporites* spp., *Paraconcavisporites lunzensis*, *Converrucosisporites* sp. and *Verrucosisporites moruluae*.

Based on the quantitative palynological study three assemblages are recognized. The oldest assemblage (acutus-vigens-singhii) in the lower part of the Mencshely Marl Member is characterized by the predominance of *E. vigens, L. acutus, L. singhii* with many *Circumpolles* species. *Lueckisporites singhii* is far less common in the second assemblage (vigens-acutus). The youngest assemblage (astigmosus-densus) is marked by the common occurrence of *Aulisporties astigmosus, Patinasporites densus*, *Partitisporites maljawkinae* and various *Aratrisporites* species in the uppermost few metres of the Mencshely Marl Member and in the overlaying Csicsó Marl Member. The correlation to ammonite biozontion suggests that the whole studied succession is late Julian (Julian 2, *austriacum Zone*). The palynological assemblages and stratigraphic range of selected taxa enables the correlation to other alpine Triassic areas and the NW European Germanic Basin.

The palynofacies indicates strong terrestrial influx in a marine setting inferred from the common presence of acritarchs, foraminiferal tests linings and scarce occurrence of dinocysts. The terrestrial input increases in the Csicsó Marl Member. The changes in spore-pollen assemblages can be linked to climatic variations and can be regarded as the manifestation of the Carnian Pluvial Episode.

Keywords: Carnian, Hungary, palynology, palynostratigraphy, palaeoclimate, *Aulisporites*

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Middle Jurassic (uppermost Bathonian–lower Callovian) dinoflagellate cysts from Cabo Mondego, Lusitanian Basin, Portugal: preliminary results

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During the Callovian, dinoflagellate cysts underwent a significant diversification, where many genera and species emerged. The main aim of this work is to document the Callovian dinoflagellate cyst record in the Cabo Mondego section, Lusitanian Basin, Portugal, in order to contribute to the biostratigraphy and palaeobiology/palaeoecology of this area, and to compare with coeval successions. The Lusitanian Basin is a marginal depocentre located in central western Portugal, and the basin fill is mainly Jurassic. The Cabo Mondego section is located near the city of Figueira da Foz. This section comprises a well exposed upper Toarcian to Callovian succession of marine marl and limestone interbeds of the Cabo Mondego Formation. The Cabo Mondego section was sampled for palynomorphs and here we present preliminary dinoflagellate cyst data from the Bathonian-Callovian transition. A low diversity assemblage was recorded and the most significant taxa are *Chytroeisphaeridia chytroeides, Ctenidodinium* spp., *Ellipsoidictyum* spp., *Endoscrinium acroferum, Gonyaulacysta* spp., *Impletosphaeridium* sp., *Korystocysta* spp., *Meiourogonyaulax spp., Pareodinia ceratophora, Sentusidinium* spp., *Systematophora* spp., *Tubotuberella dangeardii* and *Wanaea acollaris*. In general, the dinoflagellate cysts were abundant and relatively well preserved, and compare well with Bathonian and Callovian assemblages elsewhere in Europe.

Keywords: biostratigraphy; dinoflagellate cysts; Lusitanian Basin; Middle Jurassic; palaeobiology

Application of FE-EPMA to sedimentary organic matter characterization of Permian Karoo black shales

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Permian black shales of South Africa's Karoo Basin have been classified as potential unconventional gas resources, the Whitehill Formation of the southern basin parts being the main target formation for future shale gas exploration and production (Mowzer and Adams, 2015). To determine the original source potential for shale gas it is necessary to know (1) the sedimentary environments in which the potential source rocks formed, (2) how much sedimentary organic matter the shales contained when they originally formed, and (3) what kind of organic matter these shales contain. Palynofacies analysis of Whitehill shales revealed their marine origin within a complex basin architecture of marginal to deep stratified settings and with high terrestrial input from the hinterland (Götz et al., 2017). TOC values range from 2.1% to 6.1%, and a high thermal maturity was encountered with vitrinite reflectance values of >3.0 % in the southern basin parts.

Here, we report on sedimentary organic matter characterization of Whitehill shales from two deep boreholes (KZF-1, KWV-1) which were recently drilled within the framework of the Karoo Research Initiative (KARIN) in the south-western and south-eastern part of the Karoo Basin (De Kock et al., 2016a, 2016b). We conducted high-resolution BSE imaging, modal mineral analysis, and quantitative carbon analysis, as well as WDS element mapping of carbon, and trace element analysis and mapping using a JXA-8530F Hyperprobe with field emission (FE-EPMA).

Whitehill shales intersected by borehole KWV-1 display prominent lamination with sedimentary organic matter accumulated in distinct layers, alternating with silty layers thus classifying them as carbonaceous siltstone of a deep shelf environment. By contrast, shales of borehole KZF-1 lack a distinct lamination and sedimentary organic matter occurs as dispersed particles in a silty matrix. Both shale types exhibit high sulfur contents of up to 10 wt. %. K/Rb and U/Th ratios reveal marine anoxic conditions.

On a basinal scale, Whitehill shales are interpreted as transgressive organic-rich shelfal deposits ("maximum flooding black shales") with high levels of primary productivity in the surface waters with the nutrients being supplied by terrestrial influxes. The water circulation may have been restricted due to postglacial stratification of the water column, leading to intense anoxia caused by the degradation of the OM and the formation of organic-rich sediments.

Keywords: FE-EPMA, SOM, black shales, Permian, Karoo Basin, South Africa

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52 *More* Things you should know about Palaeontology

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In 2014 we published a book that contained 52 short essays on a wide range of paleontological subjects. It's an entertaining read and easy to pick up and enjoy in short chunks or as a longer exploration. We received much feedback, most of it positive, though some didn't like that it couldn't cover all the major fossil groups. Our response was that we hadn't set out to create a text book and that we chose the essays by how interesting and fun they were to read rather than trying to cover a logical plan or curriculum. However, the only real solution was to start building another book and collect even more stories to further showcase the thrill that so many palaeontologists experience from their work and the unbridled enthusiasm this builds for their chosen studies. At the end of all this, we still haven't covered everything, sorry. Maybe next time.

52 *more* essays on palaeontology takes us on a discovery journey through animal kingdoms and paleaogeography to reveal a wide range of characters. From the fantastic re-discovery of tiny Palaeocene frogs in the middle of Bombay, to Balearic Mouse Goats, snakes with four legs, and the beautiful insects preserved in Cretaceous amber. It illustrates how far our analytical techniques, based on indirect information have developed by contrasting the legend of the Virgin

Mary ascending a vertical rock face in Portugal with the exciting application of the rapidly developing field of extracting genomic information from extant organisms. In the Carboniferous, it takes us out on a swim in a shrimp-infested and thermally-stratified freshwater lake, and a walk through arborescent swamp forests conquered by lycophyte. According to one of the contributors, you don't even have to get out of your mother-in-law's shower to study some of the world's finest palaeontology.

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Late Eocene–Oligocene dinoflagellate cysts of the Dabaa Formation, Qattara Depression, north Western Desert, Egypt: age and paleoenvironments

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The palynological investigation of 30 surface samples from seven sites in and near the Qattara Depression, north Western Desert, Egypt, has yielded six samples from three sites containing well-preserved assemblages including dinoflagellate cysts (dinocysts), freshwater algae, acritarchs, pollen and spores. Dinocyst species include *Cleisto-*

sphaeridium placacanthum, *Dapsilidinium pastielsii*, *Dinopterygium cladoides* sensu Morgenroth, *Distatodinium paradoxum*, abundant *Impletosphaeridium* spp., *Lentinia serrata*, *Pentadinium laticinctum*, and *Samlandia chlamydophora*. The sites have not been dated previously, but dinocyst evidence (overlapping ranges of *Tuberculodinium vancampoae* and *Phthanoperidinium comatum*) reveals an Early Oligocene (Rupelian) age for one sample, establishing time equivalence with the Late Eocene–Oligocene Dabaa Formation. The dinocyst assemblages reflect neritic conditions on the southern margin of the Mediterranean Sea, and the frequent co-dominance of *Homotryblium floripes* points to the development of hypersaline lagoonal paleoenvironments. The abundance of *Pediastrum* and *Botryococcus* in several samples attests to nearby freshwater bodies and/or seasonal rains. Outcrops in the north Western Desert typically have deep weathering, and this is significantly the first report of dinocysts from surface sections of the Qattara Depression and its surroundings.

Keywords: Eocene, Oligocene, dinoflagellate cysts, Egypt, biostratigraphy, paleoenvironments

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Palynofacies of the Pennsylvanian Brejeira Formation, South Portuguese Zone, SW Portugal

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The Baixo Alentejo Flysch Group (BAFG) is the Westernmost unit of the South Portuguese Zone and consists of siliciclastic gravity-flow deposits forming a turbiditic succession, over five km thick, prograding from NE to SW. The Brejeira Formation (Bashkirian to upper Moscovian in age; Pereira, 1999) is the youngest of the three litostratigraphic units of BAFG, with one km in thickness. It is composed of greywackes, quartzwackes and impure quartzites interbedded with shales (*e.g.* Oliveira *et al.* 1979).

Dark grey shales from Brejeira Fm were studied in this work to obtain data on palynofacies with the aim to characterize palaeoenvironments and source rock potential.

Over 40 samples were collected from several outcrops of the Brejeira Formation, mostly from coastal cliffs, between Zambujeira do Mar beach and Cordoama beach. Organic matter was extracted using standard palynological methods, involving treatment with hydrochloric and hydrofluoric acids. Non-sieved residues of each samples were mounted in addition to 15µm-sieved residues. At least 300 organic particles were counted in each slide. In the selected palynomorph classification, opaque phytoclasts were divided by their shape in lath and equant. The diameter of several equant opaque phytoclasts was measured until a stable average value was obtained. The residues selected for oxidation were exposed to Schultze solution for three hours until organic matter turned medium to light brown.

The non-oxidized organic residues consist of dark brown to black opaque organic particles. In all samples, the proportion of the three main kerogen groups are similar: marine AOM dominant, followed by phytoclasts (opaque > translucent; lath opaque > equant opaque) and palynomorphs (spores > marine palynomorphs). The average diameters of equant opaque phytoclasts are considered small, most of them under 40µm. Leiospheres, algae and rare acritarchs are the marine palynomorphs existent in the assemblages. When projected in the Tyson diagram, the samples fall in the marine palynological fields VI and IX that range between “Proximal suboxic-anoxic shelf” and “Distal suboxic-anoxic basin”.

The palynological data indicate a marine depositional environment with sea floor anoxia and reducing conditions, that enhanced AOM preservation. The abundance of phytoclasts materializes the input of turbiditic currents in the distal basin. Additionally, the phytoclast ratios indicate distance from the sediments source area. The *phytoplankton black out* in the late Palaeozoic explains the low abundance of marine palynomorphs.

The kerogen from Brejeira Fm is presently overmatured, but it must have had potential to generate hydrocarbons since the palynological association indicates type II > I kerogen and therefore oil prone.

Keywords: Palynofacies, Gravity-flows, Source rock potential, Pennsylvanian, Brejeira Formation, South Portuguese Zone

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Integration of new palynostratigraphic data of Permian age in the Moatize - Minjova Basin, Mozambique

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A comprehensive palynostratigraphic study is undergoing in the Permian of the Karoo Moatize-Minjova Basin, in Mozambique. The results here presented include the palynological analysis of eight coal exploration boreholes. Boreholes ETA 65 and ETA 72 comprise only the coal bearing Moatize Formation and yield a well-preserved palynomorph assemblage of Kungurian/Roadian age based on the presence of *Alisporites potonie*, *A. ovatus*, *Cirratriradites africanensis*, *Lueckisporites virkkae*, *Platysaccus papilionis*, *Protohaploxypinus* spp., *Striatopodocarpites cancellatus*, *S. fusus*, *Vittatina costabilis* and *Weyllandites lucifer*.Boreholes ETA 25, ETA 135, ETA 71, ETA 75, DW 123, and DW 132 crossed the Matinde Formation revealing a Lopingian age. Detailed studies on the palynomorph groups, species associations, and correlations, enable the establishment of a preliminary assemblage scheme for the Lopingian of the Moatize-Minjova Basin.

Palynoassemblage 1 is characterized by dominant non-taeniate and taeniate bisaccate pollen grains (*Alisporites* spp., *Protohaploxypinus* spp. and *Striatopodocarpites* spp., abundant *Guttulapollenites hannonicus* and common *Weylandites lucifer*). Spores are relatively rare in this assemblage and include *Calamospora* sp., *Horriditriletes* sp., and *Osmundacidites senectus*.

Palynoassemblage 2 contains moderate to well-preserved and abundant non-taeniate and taeniate bisaccate pollen grains (*Alisporites* spp., *Protohaploxypinus* spp., and *Striatopodocarpites* spp.) together with abundant *Guttulapollenites hannonicus*, *Pakhapites* sp. (of large dimensions), *Vittatina* spp., and *Weylandites lucifer*. Common taxa occurring for the first time in this assemblage are *Corisaccites alutas*, *Lueckisporites virkkiae,* and *Praecolpatites sinuosus*. Spores are common to abundant and include *Calamospora* sp., *Horriditriletes* spp., *Indotriradites* spp., *Kraeuselisporites* spp., *Microbaculispora* spp., *Osmundacidites senectus,* and *Verrucosisporites* sp. Monolete spores are also common (*Laevigatosporites* spp.), and the following taxa occur for the first time in this assemblage, *Polypodiisporites mutabilis*, *Polypodiidites* sp., and *Thymospora pseudothiessenii*. The spore dominance recorded in Palynoassemblage 2 is associated with humid and warm depositional and palaeoenvironmental environments that led to the formation of coal seams.

Palynoassemblage 3 represents a microfloral turnover where, for the first time, specimens of *Lunatisporites pellucidus* are recorded. Common lycopod spore taxa such as *Lundbladisporites* spp. are also present. This assemblage is characterized by the presence of the diagnostic species of Palynoassemblage 2, however, a decline in the dominance of taeniate bisaccate pollen grains (*Protohaploxypinus* and *Striatopodocarpites)* and nontaeniate *Alisporites* specimens is observed. Palynoassemblage 3 is assigned to the Early Triassic and occurs at the top of borehole DW 132, within the

Matinde Formation.

The coal deposits in the Moatize-Minjova Basin were deposited until the latest Permian and are possibly more extensive temporally than previously described, opening new economic perspectives for this basin.

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Unexpected palynomorph abundance from the Late Permian British Zechstein of north east Yorkshire

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The Late Permian Zechstein Sea was a semi-isolated inland sea located in the continental interior of Pangaea approximately 255 Ma in the Southern Permian Basin. The sea endured for 5 to 7 million years during which it underwent five cycles of sediment accumulation, resulting in dramatic changes in the marine and surrounding terrestrial ecosystems as the climate alternated between arid and increasingly hypersaline during regressions and wetter during transgressions. The drivers behind the cyclical ariditisation and changes in environment remain unclear, but understanding how the palynomorph assemblages responded could help resolve this issue. British Zechstein palynology has previously focused on the earlier cycles due to the absence of the later cycles at outcrop. New core material provided by Sirius Minerals has enabled the first modern palynological analysis of British Zechstein deposits. Classical Zechstein reconstructions assume an increasingly arid climate in conjunction with Late Permian climate trends. Contrary to these reconstructions, initial exploration into the British Zechstein deposits of North East Yorkshire has yielded unexpectedly high numbers of palynomorphs from the upper part of the sequence, specifically from the third (EZ3) to upper fourth (EZ4) cycles. The most exceptionally preserved palynomorphs come from the Carnallitic Marl Formation, a thin sequence of red and subsidiary greyish green mudstones and siltstones less than 5m thick at the boundary between the fourth and fifth cycles. These assemblages are composed of taeniate and striate bisaccates, monosaccates, triletes and a great deal of amorphous organic matter. These preliminary findings suggest that the upper cycles were not quite as desolate as previously assumed.

Keywords: Late Permian, Zechstein Sea, Carnallitic Marl Formation, bisaccates.

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The impact of sedimentary organic matter on the silicification of Anisian Muschelkalk oolites

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Muschelkalk carbonates of the Triassic Germanic Basin, a peripheral basin of the western Tethys Ocean, cover large parts of central Europe. During the Anisian, the basin was bordered by landmasses and open to the Tethyan shelf by three tectonically controlled gates in the south. Major transgressive phases are recognized by phytoplankton peaks, documenting the interaction between a restricted, intracratonic basin and an open ocean system. Furthermore, changes in the basin interior are well displayed in lateral phytoplankton distribution patterns pointing to a stratified water body in the basin centre and well oxygenated marginal and gate areas (Götz and Feist-Burkhardt, 2012). However, besides the interpretation of distinct spatial patterns of phytoplankton assemblages, reflecting the basin configuration, the effect of increased bioproductivity and sedimentary organic matter supply from the basin's hinterland on the seawater's pH conditions has not been addressed yet.

In the present study, Anisian Muschelkalk carbonates of the southern Germanic Basin containing silicified ooidal grainstones are interpreted as evidence of changing pH conditions triggered by increased bioproductivity (marine phytoplankton) and terrestrial influx of plant debris during maximum flooding. High-resolution BSE imaging and WDS element mapping of silicified ooids revealed three distinct stages of calcite ooid replacement by silica. Stage 1 (calcite stage) reflects autigenetic quartz development during the growth of the ooids, suggesting a change in the pH-Temperature regime of the depositional environment. Stages 2 and 3 are found in silica-rich domains. In stage 2 (calcite–silica stage) silica replaces certain concentric bands in the calcitic ooid structure, and the concentric structure is broken by the silica band which is connected to the exterior of the ooid; in stage 3 (silica stage), thin Ca-rich zones are still preserved in the structure of the ooid, however most of it is replaced by silica. Furthermore, the composition of silica-rich ooids shows significant Al_2O_3 and SrO but no FeO and MnO, indicating that late diagenetic alteration was minor. Silicified inter-particle pore space is characterized by excellent preservation of prasinophytes as documented in thin sections. Palynological slides reveal the high amount of terrestrial phytoclasts.

The implications of our findings for basin dynamics reach from palaeogeography to cyclo- and sequence stratigraphy since changes in the seawater chemistry and sedimentary organic matter distribution reflect both the marine conditions of the Muschelkalk Sea as well as the conditions of the hinterland. Basin interior changes might overprint the influence of the Tethys Ocean through the southern gate areas. Stratigraphically, such changes might enhance marine flooding signals.

To understand the complex interaction between an intracratonic basin and an open ocean system during the early stage of the break-up of Pangea, integrated sedimentological-palaeontological-geochemical studies including the western- and easternmost Anisian Muschelkalk series in Spain and southeastern Europe are needed in ongoing research.

Keywords: silicification, SOM, Muschelkalk, Anisian, Germany

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Palynofacies of the Cenomanian Saint Laurent Marl (Col de Braus, Maritime Alps)

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The Col de Braus pass, located in the southern Maritime Alps of SE France, exposes a continuous Jurassic–Cretaceous succession recording different stages of the evolution of the palaeo-European passive margin of the Tethys ocean and is thus regarded as key section of the Provençal domain in the Western Alps (Barale and d'Atri, 2016; Barale et al., 2016; d'Atri et al., 2016).

Here, we present the first palynological study of the Cenomanian Saint Laurent Marl, an 80 m thick succession of marls with thin limestone beds, exposed at the western side of the Col de Braus pass. Our study focuses on the analysis of stratigraphic variations in the sedimentary organic matter content with regard to relative sea-level changes. Palynofacies parameters used to decipher transgressive-regressive trends within the succession are: (1) the ratio of continental to marine constituents (CONT/MAR ratio); (2) the ratio of opaque to translucent phytoclasts (OP/TR ratio); (3) the phytoclast particle size and shape; and (4) the relative proportion and species diversity of marine phytoplankton. A large-scale transgressive-regressive trend during the Early Cenomanian, followed by a transgressive trend during the Middle and Late Cenomanian is documented in the CONT/MAR ratio and phytoplankton abundance. Superposition of high frequency, low-amplitude sea-level fluctuations on the larger-scale sea-level trend is detected by pronounced cyclic signatures in changes of terrestrial input, preservation and sorting of phytoclasts, and prominent phytoplankton peaks indicating major flooding phases.

Ongoing research addresses the identification of palynofacies patterns in the Milankovitch frequency band for high-resolution cyclostratigraphic interpretation.

Keywords: Sedimentary organic matter, sea-level changes, Cenomanian, Upper Cretaceous, Col de Braus, Maritime Alps, SE France

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Comparing the yield of 'fast' and 'slow' palynological processing methods

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Palynological material (organic-walled microfossils) is traditionally extracted from fine-grained sedimentary lithologies via acid maceration, then sieved (with or without heavy liquid) to separate the fine sediments from the palynomorphs. The 'standard' processing techniques (e.g. Sutherland, 1994; Green, 2001) includes using hydrochloric acid (HCl) to remove carbonates, hydrofluoric (HF) acid to remove silicates, then HCl once again to deal with any remaining fluoride ions. After each stage of maceration, and subsequent dilution, the samples are left to settle before the liquid is decanted off. For industrial well-site applications that are focussed upon rapid turnaround for biostratigraphical purposes, the time allowed for the settling of particulate matter is only about 1-2 hours. In scientific research situations, however, dealing with more detailed analyses, settling time is generally longer (often overnight) leaving sufficient time for all small, light palynomorphs to sink to the bottom of the containers so they are collected in the sieving stage, ensuring minimal loss of palynomorphs/data. Studies by Mertens et al. (2009; 2012) demonstrated the different settling times used by 22 different laboratories, which varied anywhere between 15 minutes and 42 hours per decantation. For the purposes of the study herein, samples will be equally subjected to the 'fast, industry' techniques and the 'slow, research' technique to compare whether any differences and/or biases can be observed in palynomorph diversity, preservation or abundance between the methods – statistical methods will be utilised to analyse and compare the data.. The research project will provide useful data for other palynologists in order to know whether they will lose key palynomorphs if they perform the 'fast' technique, or whether they can speed up processing time from an average of 2-4 weeks processing time to a matter of days. Three samples from different geological periods will be subjected to the test, comprising the London Clay (Eocene), the Kimmeridge Clay (Jurassic) and a sample from the Silurian. All samples were collected from precise horizons to minimise biases depositional/ichnological biases of concentration. , and the varying ages of the strata will ensure that a diverse range of palynomorphs are encountered and analysed.

Keywords: palynology, palynological techniques, Kimmeridge Clay, London Clay, Silurian.

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Preliminary results of the palynological investigation of Haer and Boulongour profiles, Xinjiang, northwestern China

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Two profiles from northwestern China (Xinjiang region) have been investigated for palynofacies and biostratigraphy.

First of them, the Haer profile is included into Hongguleleng Formation (Namu member). 11 samples from the 49 meters thick profile were analyzed. The whole palynomorph assemblage was poorly preserved, mostly because of the overheating of the analyzed rocks. A considerable number of palynomorphs was described as a undetermined ones (palyno-debris). The rest of the palynomorphs was dominated by miospores and opaque phytoclasts. Miospores are black in colour and frequently corroded but some taxonomical observation were still possible. Among anonymous miospore remains of *Vallatisporites* spp., *Retusotriletes* sp. were noticed. Lack of older, the Upper Devonian taxa (e.g. *Retispora lepidophyta* and *Diducites* spp.) in the analysed assemblage may indicate on the Lower Carboniferous (Tournaisian) as the age of analysed samples. Marine palynomorphs occurred only as a single specimens, but in the topmost samples were absent and this may also support the stratigraphical diagnosis. According to observed material, an environment of deposition seems to be a proximal one, close to the shoreline.

Second profile, the Boulongour is also included into Hongguleleng Formation (Saerba member). Seven samples from the 54 meters thick profile were investigated. All of them contained poorly preserved assemblage of palynomorphs. Palynomorphs are strongly thermally altered – dark brown in colour. The palynological assemblage consist from miospores, the land origin component (both opaque and non-opaque phytoclasts) and phytoplankton (mainly acritarchs, marine in origin). Among analysed samples a few of them yielded useful information for palynostratigraphy. In samples from the bottom of analysed section miospores similar to *Archaeoprisaccus* were observed, what may tentatively indicate on the Frasnian/Famennian interval. Above, in the sample 30, based on the presence of *Hymenospora intertextus, Grandispora famenensis* var. *minuta*, *Diducites* spp., *Cristatisporites lupinovitchi* and *Retusotriletes* sp. the age of this sample was tentatively established as the Middle Famennian (CVa miospore Zone). Besides miospores, phytoplankton are represented by the taxonomically differentiated assemblage here. *Gorgonispharidium* spp. is dominated, with less common *Veryhachium*, *Micrhystridium* and other acritarcha and prasinophyta taxa.In the topmost samples acritarchs dominated (mostly short-processes spherical forms). Prasinophytes occurred as a very limited single specimens. A great amount of palynomorphs was defined as undetermined. The samples from the lower part of the profile point deposition in more proximal conditions, and samples from the top of the profile indicate deposition in more distal environment.

In both profiles also scolecodonts and fragments of animal tissue occurred, but in a very limited number.

Keywords: palynofacies, Upper Devonian, Lower Carboniferous, China, Xinjiang

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Palynology in frontier exploration: deepwater Gabon

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Gabon has a long history of hydrocarbon exploration, producing from both Pre-Salt (Aptian and older, non-marine) and Post-Salt (Albian and younger, marine) reservoirs. In 2014 and 2015, Shell and CNOOC drilled three deepwater wells in the BC-9 and BCD-10 Blocks, targeting the N'Komi and Léopard prospects. Wellsite biostratigraphy was carried out for two of these wells, and palynology played an important role subdividing the stratigraphy. Goals of the wellsite biostratigraphy were to interpret the stratigraphic position and depositional environment while drilling, identify unconformities and help with calling TD of the well. Special focus was on differentiating the late Aptian Gamba Formation and the early Aptian to Barremian Dentale Formation.

The Léopard wells penetrated the Post-Salt Azile, Cap Lopez, and Madiela Formations, the Ezanga (Salt) Formation, the Pre-Salt Gamba and possibly the Dentale Formation. The distinctive Vembo Shale Member of the Gamba Formation corresponds to a regional lacustrine phase, but it could not be confidently identified in the Léopard area. It may be absent or, more likely, its time equivalent section at Léopard is more sand-prone (diluted via a northerly sourced fluvial system). Given the similar and dominantly fluvial-lacustrine environment of deposition of much of the Gamba and (Upper) Dentale Formations, together with a relatively constant climatic setting, it proved difficult to differentiate the two with palynological assemblages at Léopard. *Classopollis* gymnosperm pollen dominates the assemblage, with the other main components being *Ephedripites* spp. and *Exesipollenites tumulus* (an arid assemblage). Typical Dentale markers as seen in the onshore and more proximal offshore wells were not (consistently) found, e.g. INCR *Alisporites* spp., INCR *Concavissimisporites* spp., first downhole occurrences (FDO) of *Aequitriradites*, *Afropollis zonatus, Afropollis operculatus*, and *Tucanopollis crisopolensis.* The Gamba Formation was thicker than expected, when compared with more proximal and onshore wells. Tentative Dentale Formation in the wells has been picked mainly on regional log correlation. It is possible is that the top Dentale marker distribution could be ecologically driven and that conditions in the Léopard/distal location were unfavorable for the parent plants of these spore/pollen taxa.

Palynomorph groups were useful when making correlations to the conjugate margin (e.g. Brazil). A broadened view to the Brazil margin is necessary to explain depositional environment of the sediments. The main palynology taxa/groups used as zonal markers in Brazil and West Africa Pre-Salt sediments are *Afropollis, Tucanopollis crisopolensis, Dicheiropollis etruscus, Parvisaccites minimus, Cedridites* and other bisaccates. Bisaccates clearly have a different distribution on the Brazil margin in terms of their consistent/abundant occurrence and it is possible that highlands persisted longer on the Brazil side. One unresolved question is the nature and origin of the first marine incursions, seen in the Pre-Salt on the Brazil side, but never convincingly in the Gabonese or Congolese wells. More work needs to be done to understand inconsistencies between ostracod and palynology ranges across the Atlantic.

Keywords: Gabon, exploration, Cretaceous, Pre-Salt

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Quaternary pollen and spores in China: an illustrated handbook

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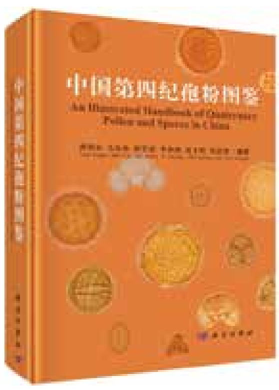

In the past several decades, some books on pollen and spores of modern plants have been published as important references in palynomorphs' identification for Quaternary pollen analysis in China. However there's still no publication on atlas of pollen and spores identified from Quaternary deposits so far in china. A new book *An illustrated handbook of Quaternary pollen and spores in China* (in Chinese with English contents and short introduction) has been published (Tang, Mao, Shu et al., 2016) by China Science Press (www.sciencep.com).

The book has three chapters: Chapter 1 introduces modern vegetation landscape mainly by different climatic regions, and reviews Quaternary vegetation and climate chages in China since the Pleistocene; Chapter 2 outlines major types and characteristics of Quaternary pollen and spores in each region of China, and presents comparisons of identification keys to some representative types of pollen and spores in each region. Detailed diagnostic descriptions on the pollen morphology of some selected genera and families are also illustrated, for instance, *Sonneratia* and Rhizophoraceae of mangroves in tropical China; identification keys of pollen for Fagaceae in Southeast China; comparisons of Pinaceae in Southwest China; identification keys to some important arid and semi-arid pollen types in Northwest China; identification keys and diagnostic descriptions for Betulaceae, and comparisons of fossil pollen morphological characteristics for *Pinus*, *Abies*, and *Picea* in Northern China; Chapter 3 is the key part of the book, mainly illustrations/plates on pollen and spore.

The book can be a useful guide both for beginners and palynology researchers, and also an important handbook for international Quaternary palynologists to conduct pollen analysis in China, and a book to have a brief knowledge of vegetation history and climate changes in China as well.

Keywords: Quaternary, Pollen, Spores, atlas, China; 621 pages; 409 plates

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The 'last' Tentaculitoids

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An earliest Famennian (Late Devonian) record of tentaculitoids (an extinct 'class' of small calcareous conical shells) preserved as palynomorphs is documented from Sosnogorsk in the Komi Republic of Russia. These were preserved in considerable abundance in a near-shore shallow lagoon subjected to marine flooding with euxinia. Some four forms of nowakiid tentaculitoid plus aberrant forms are documented. They represent evidence for survival of the nowakiids into the earliest Famennian and hence post-dated the Frasnian-Famennian Mass Extinction. It is hypothesised that the Frasnian and younger occurrence of tentaculitoids as palynomorphs may relate to a changing balance of carbonate and organic matter in their shells driven by the environmental conditions of the Frasnian-Famennian Mass Extinction.

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First Appearance Data of selected acritarch taxa and correlation of Lower and Middle Ordovician Stages

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The bases of the global stages of the Ordovician System are all defined on the first occurrence of either a conodont or a graptolite species. Complementing the graptolite and conodont biozonations, chitinozoan biozonation schemes have also been used in global correlation although no chitinozoan marker species is used to define any chronostratigraphical division. Acritarchs have long been used for biostratigraphical dating and correlation of Ordovician successions, often in sediments devoid of other fossils, but biozonation schemes to complement those of the graptolites, conodonts and chitinozoans have not been developed. Nevertheless, acritarchs have the potential to correlate global stages and stage slice boundaries in the Lower and Middle Ordovician. First Appearance Data (FADs) of selected acritarch morphotypes have been assessed to determine their potential contribution to correlation of Lower and Middle Ordovician stages and substage divisions along the Gondwanan margin and between Gondwana and other palaeocontinents. The FADs of nineteen genera, species and species groups are recorded throughout their biogeographical ranges. The taxa investigated fall into three groups. Some have FADs at about the same level throughout their biogeographical ranges, and are useful for long-distance and intercontinental correlation. Among these are: *Coryphidium*, *Dactylofusa velifera*, *Peteinosphaeridium* and *Rhopaliophora* in the upper Tremadocian Stage; *Arbusculidium filamentosum*, *Aureotesta*

clathrata simplex and *Coryphidium bohemicum* in the lower–middle Floian Stage; *Dicrodiacrodium* in the upper Floian Stage; *Frankea* in the Dapingian–lower Darriwilian stages; and *Orthosphaeridium* spp., with FADs in the Dapingian–lower Darriwilian stages of Perigondwanan regions and at about the same level in Baltica. Other taxa, however, have diachronous FADs, and this needs to be taken into account when using them for correlation. A second group of genera and species, comprising *Striatotheca*, the *Veryhachium lairdii* group and the *V. trispinosum* group, have a recurring pattern of FADs in the Tremadocian Stage on Avalonia and in South Gondwana and West Gondwana, but in the Floian Stage of South China and East Gondwana. The third group, consisting of *Arkonia*, *Ampullula*, *Barakella*, *Dasydorus*, *Liliosphaeridium* and *Sacculidium*, have FADs that are markedly diachronous throughout their biogeographical ranges, although the global FADs of *Arkonia*, *Ampullula*, *Liliosphaeridium* and *Sacculidium* are apparently in South China and/or East Gondwana. It is possible that diachronous FADs are only apparent and an artefact of sampling. Nevertheless, an alternative interpretation, suggested by recurring patterns, is that some as yet undetermined factor controlled a slower biogeographical spread over time, resulting in diachroneity.

Keywords: Acritarchs, Ordovician, FADs, correlation

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The last Earth's Climate State Transition and its Impact on the Ecosystems

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The Eocene-Oligocene transition (E/OT: ~34 Ma) is the largest climate transition of the past 65 million years. In less than 0.5 Ma, deep-ocean benthic foraminiferal oxygen isotope ratios ($\delta^{18}O$) record a large (>1‰) positive step-change, corresponding to a deep-water cooling and massive increase in the terrestrial cryosphere, as Antarctic ice sheets grew to a continental extent. This coincided with a long-term transition from high to low-pCO_2 levels, and from a greenhouse to icehouse climate state. Recently produced coccolith-dominated high-resolution bulk carbonate isotopic records from the eastern Equatorial Pacific show a pronounced negative shift in both $\delta^{18}O$ and $\delta^{13}C$ between ~35.5 and 34.5 Ma, prior to the E/OT. Here we present new data from this pre-cursor interval, through into the E/OT, from continuously cored continental shelf section on the US Gulf Coast. Composed of ~137m (15-152m deep) Yazoo Formation clays, these yield high quality microfossil, and palynomorph preservation. A new high resolution fine-fraction (<20µm) bulk carbonate stable isotope record has been generated. The $\delta^{18}O$ shows an overall positive trend, which is in accordance with a global cooling. Based on the isotope data from both oxygen and carbon, two steps were detected across the core: the first one, with a sharp negative shift, representing a local/regional increase of continental/freshwater influence due to a potential global sea level drop; and a second one possibly related to the Eocene-Oligocene boundary itself. More than a hundred palynological slides provided a ~28kyr resolution biostratigraphy, including a number of potentially useful palynomorph bioevents and palaeoenvironmental reconstruction. The first step is characterised by a gradual drop in dinoflagellate diversity and a simultaneous increase in the abundance of all terrestrial groups (*Pediastrum* spp. and palynodebris in general), which confirms a decreasing influence by marine conditions. X-ray fluorescence data also indicates the lowest Ca concentration in the same interval. The next procedures include the generation of a TEX_{86} record for the Sea Surface Temperature, in order to verify the consistence of the isotope and palynological data. This would be the first detailed record of Atlantic tropical / sub-tropical oceans temperatures through this transition and a major expansion of our current state of knowledge on the dynamics and relationships between ice volume and planetary climate. The work was supported by CNPq, National Council for Scientific and Technological Development (Brazil).

Keywords: palynology, Eocene-Oligocene Transition, climate dynamics

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Mid-Piacenzian variability of Norwegian Sea surface circulation linked to terrestrial climate change

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During the mid-Piacenzian warm period (mPWP, 3.264–3.025 Ma), North Atlantic sea surface temperatures (SSTs) were higher than today. While SSTs provide crucial climatic information, they do not allow a reconstruction of potential underlying changes in water masses and currents. New assemblage records of dinoflagellate cysts and acritarchs from Ocean Drilling Program Hole 642B are presented to evaluate changes in the northward heat transport via the Norwegian Atlantic Current (NwAC) and shifts in the Arctic Front (AF) between 3.320 and 3.137 Ma. The records are compared with published vegetation and SSTs reconstructions from the same site to identify links between SSTs, ocean currents and vegetation changes. The dinocyst records shows that strong Atlantic water influence via the NwAC, and high obliquity, corresponds to higher-than-present marine and terrestrial temperatures during the transition from Marine Isotope Stage (MIS) M2 to M1 and MIS KM5. In contrast, a reduced Atlantic water inflow relative to the warm stages and an eastward shift of the AF coincides with near-modern SSTs and boreal vegetation in northern Norway during the first half of MIS M2 and KM6, and from KM4 to KM2. We conclude that repeated changes in the relative influence of Atlantic and Arctic water masses due to changes in the NwAC and the proximity of the AF to the site, together with changes in obliquity forcing, are responsible for the observed climatic changes.

Keywords: Pliocene, Arctic, Norwegian Atlantic current, dinoflagellate cyst, pollen

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Palynostratigraphy of the Northern Pulo do Lobo Domain, SW Iberia: a palynological contribution

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For the first time, a palynological research in the northern sector of the **Pulo do Lobo Domain** combining sections studied in Portugal and Spain is presented. A total of 139 samples were studied, of which 56 are positive for palynology. The first age determination for the Pulo do Lobo Formation was achieved indicating the mid-Frasnian age (*Verrucosisporites bulliferus* and *Pustulatisporites rugulatus*). The sediments of Peramora Mélange (Spain) yielded the same palynoassemblage as that of the Pulo do Lobo and are interpreted as a part of the Pulo do Lobo Formation. The Ribeira de Limas Formation yielded a miospore assemblages assigned to the mid-Frasnian age, the same age as that obtained for the Pulo do Lobo Formation. The Santa Iria and Horta da Torre Formations present spore assemblages assigned to the VH Biozone of late Famennian age (*Grandispora echinata*) both in Portugal and in Spain. The phyllites interbedded with the quartzites of the Alájar Mélange yielded a palynoassemblage of the late Famennian age that can be correlated to the Horta da Torre Formation. Therefore, the Alájar quartzites are interpreted as a lateral equivalent in Spain of the Horta da Torre Formation. The palynological results obtained for the units of the northern sector of the Pulo do Lobo Domain are very consistent and in agreement with the stratigraphic mapping and structural interpretations. The palynological results obtained from this study and its comparison with the Upper Devonian worldwide palynological record

available suggest a close affinity with NW Europe palynofloras, placing the Pulo do Lobo Domain in an Avalonian paleobiogeographical province.

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Palynological data revealing correlation between turbidity currents and their source area: an example from the early Eocene in the Gulf of Mexico

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Analysis of palynological data was crucial to correlate an offshore turbidite system in the Gulf of Mexico with its onshore source area, in the Gulf Coastal Plain. Compared to other methods, palynology has several advantages in provenance investigations: it can be applied in settings with deformation complexities, where seismic is difficult to interpret; it provides a better constrain of the source area compared to heavy minerals analysis; palynomorphs can be found in terrestrial settings, where other microfossils are often difficult to recover.

Palynological data of nine wells from the onshore Wilcox Group and seven wells from the time-equivalent offshore Wilcox Formation (Late Paleocene-Early Eocene) are the object of the study.

Multivariate Statistical Analysis was successfully applied to the palynological data set in order to link and characterize a diversified system, passing from prograding fluvial-deltaic, to shallow marine, to deep-water turbidite fan deposits. In order to avoid major stratigraphic controls on the analysis and to improve system characterization, the study was carried at a zonal resolution. After dividing marine palynomorphs from terrestrially sourced palynomorphs, running summary and diversity statistics, reducing and normalizing the data set, multivariate statistical analysis was applied. Non-metric multidimensional scaling (NMDS), cluster analysis and transformation-based principal component analysis (tb-PCA) were run to visualize similar wells, and therefore to investigate provenance of turbidity currents. Groups of taxa were identified through detrended correspondence analysis (DCA), and their examination confirmed previous findings on provenance, and allowed reconstructing the relationships between relative sea-level curve, sedimentological processes and vegetation response.

This approach has proved to be a valuable tool to describe the distribution of palynomorphs in the system from shelf to deep-marine, identify co-occurring groups of taxa in different locations, delineate a provenance map for the turbidite system and detect relationships between palynoflora and major sea-level changes.

Keywords: Palynology, turbidite system, provenance, multivariate statistical analysis, Gulf of Mexico

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Palynological data from the Hauterivian Avile Member, Agrio Formation, Neuquen Basin, Argentina

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The Neuquén Basin, North Patagonia, is famous for a well exposed sedimentary record, rich fossil content, and very productive oil and gas reservoirs in subsurface. The Jurassic and Cretaceous infill of the Neuquén Basin include a complex series of transgressive-regressive cycles of different magnitude controlled by the combination of changes in subsidence rates, local uplift, and eustatic sea-level oscillations known as Mendoza Group. The Agrio Fm., which is one of the units of the group, is divided into three members: Pilmatué (lower), Avilé (middle) and Agua de la Mula (upper). The lower and upper members represent a mixed clastic carbonate succession, comprising shales, sandstones, and limestones, interpreted as storm influenced shoreface to offshore deposits. The Avilé Member corresponds to non-marine deposits that represent a low-order regressive event. Based on facies and architectural analysis fluvial, aeolian and lacustrine systems were recognized within the unit. A long-term wetting-upward trend is recorded throughout the entire unit, with an increase in fluvial activity towards the top and the development of a more permanent fluvial system. The upward increase in water-table influence might be related to relative sea-level rise together with a long-term climatic change towards wetter conditions (Veiga et al. 2002).

The only previous record of palynomorphs from this unit, come from Cerro La Parva section (Prámparo et al. 1999). New palynological data from the Avilé Member, Agrio Fm. Neuquén basin, Argentina are presented here. The studied samples were collected from the upper part of the Avilé Member, at Pampa Tril and San Eduardo outcropping sections, central-eastern part of the basin. High-sinuosity channels associated with floodplain deposits characterize the upper part of the unit. A continental palynological association was recovered which is mainly represented by: *Cyclusphaera radiata*, *Cyclusphaera psilata*, *Balmeiopsis limbatus*, *Classopollis* spp., *Callialasporites dampieri*, *Podocarpidites* spp., *Alisporites* sp.,*Araucariacites australis*, *Cycadopites* sp., among gymnosperms. Trilete spores related to ferns, bryophytes and lycophytes are mainly characterized by *Anapiculatisporites dawsonensis*, *Interulobites lajensis*, *Interulobites variabilis*, *Taurocusporites* sp., *Januasporites* sp., *Foraminisporis* sp., and *Triporoletes reticulatus.* Furthermore, oxidized small pieces of cuticles and plant tissues complete the association. The palynoflora of the Avilé Member provides important data about the paleovegetation of this particular moment (late Early to early Late Hauterivian) related to a sea fall in the basin.

Keywords: Avilé Member, Agrio Formation, Palynology, Hauterivian, Neuquén Basin

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Latest Cretaceous winter sea-ice in the Arctic?

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Dinoflagellate cyst records from Albian to late Maastrichtian successions in the Greenland-Norwegian Seaway (Norwegian and Barents seas) indicates a sea-surface salinity reduction towards the end of the Cretaceous. This is explained by enhanced influx of fresh water into a more isolated Arctic Basin via river discharge from the surrounding continents. Simultaneously, a distinct change in dinoflagellate cyst abundance in the upper Maastrichtian together with an influx of high-latitude dinoflagellate cysts provide indirect evidence for sea-level fall and further global cooling that may have been initiated as early as in the early Campanian. One explanation for this cooler sea-surface temperatures and reduced salinity could be connected to presence of sea-ice. Similar conditions are recorded for the same time interval in the Antarctica (Bowman et al., 2013), where dinoflagellate cyst data supports the presence of ephemeral ice sheets. Our numerical model simulations supports the reconstructed sea surface freshening, and suggests the possibility of sea-ice in the Arctic, with implemented 3x pre-industrial CO_2 level. The data thereby supports the hypothesis that the greenhouse Late Cretaceous experienced a change from hot to glacial conditions in the high latitudes towards its end.

Keywords: dinoflagellate cyst, sea ice, Late Cretaceous, model simulations

Reference: **Bowman, V. C., Francis, J. E., Riding, J. B.**, 2013, Late Cretaceous winter sea ice in Antarctica?: Geology, v. 41, p. 1227-1230, doi: 10.1130/G34891.1

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The Caspian Sea: 30 Million years of biostratigraphic change

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The present-day Caspian Sea is like a photograph frozen in time. If you take that photograph today, by tomorrow something, somewhere will have changed. It is only over time that those changes become clearly visible. An example would be the gradual rise in Caspian Sea level of several metres between 1977 and 1995, and the subsequent fall observed over the last 20 or more years. But to understand the origins of the present (and potentially future) Caspian biota, as far as that is possible, we need to look back in time for hundreds, thousands and even millions of years.

30 million years ago, in the middle of the Oligocene Epoch, the Caspian Sea was fully connected to the world's oceans during the Maykopian regional stage. Open marine conditions deposited organic-rich sediments throughout Paratethys, including the Caspian Sea. These 'oil source muds' are now buried more than 10000 m below the Caspian Sea bed, so deep that they have not been studied in the offshore region. Maykopian sediments, however, can be studied in onshore Azerbaijan, where they contain rich assemblages of pollen, marine dinocysts, foraminifera and calcareous nannofossils. Maykopian deposition ended at the end of the Early Miocene, around 16 million years ago, but marine conditions persisted in the Caspian Sea until the Middle Miocene (Sarmatian) more than 12 million years ago, calibrated to world-wide nannofossil zones NN5 and NN6. Subsequently, the Caspian Sea, as part of Paratethys, gradually became disconnected from the world's oceans. This is reflected in the palynofloras that show similar changes from the Pannonian Basin of Eastern Europe, to the Black Sea and the Caspian Sea. Dinocyst assemblages are characterised by the emergence of restricted marine, low-salinity adapted taxa. Some of these evolved as species / morphotypes related to *Spiniferites bentorii* (described by Soliman and Riding, 2017), *Galeacysta etrusca* and various morphotypes of '*Pontiadinium*' (sensu Süto Szentai). An expansion of the acritarch *Mecsekia*, first described from Hungary (Hajos, 1966), can be tracked eastwards to the Caspian Sea during the Sarmatian and early Pannonian (latest Middle Miocene to basal Late Miocene).

Towards the end of the Miocene, it is well-known that the Mediterranean Sea was periodically desiccated during the Messinian period. At more or less the same time, during the Pontian regional stage, the Caspian Sea supported mainly brackish water ostracod faunas and dinocysts, for example at the Ajiveli locality in Azerbaijan (Grothe, 2016; Van Baak et al., 2016). In Pontian-aged sediments at Kirmaky Valley, Azerbaijan, the dinocysts include frequent *Caspidinium rugosum* and *Spiniferites cruciformis* which indicate a low salinity regime. Occasional peaks of the dinocyst *Lingulodinium machaerophorum* (long-spined forms) point to periods of increased salinity, although the absence of associated in-situ foraminifera and nannofossils suggests that a connection to oceanic waters did not occur at this time. Throughout most of the Pliocene (ca. 5.3 Ma to ca. 2.6 Ma), the Caspian Sea was an isolated fluvio-lacustrine basin, present only in the deeper water central and southern regions. Pollen assemblages are rich and diverse and often include reworked taxa from the Paleozoic, Mesozoic and Paleogene. The non-pollen components include various algae (e.g. *Pediastrum* and *Botryococcus*), fungal bodies and dinocysts (e.g. *Caspidinium rugosum* and *Spiniferites cruciformis*).

Renewed marine influences are evident in the Caspian Sea more or less coincident with the onset of northern hemisphere glaciations at the end of the Pliocene (Piacenzian) and beginning of the Pleistocene (Gelasian) during the Akchagylian regional stage. Limited marine influence is confirmed by the presence of a rich, but very low diversity, foraminiferal assemblage characterised by calcareous benthonics *Cassidulina reniforme*, *C. obtusa* and *Cibicides lobatulus*. This association is well-known in the northern (i.e. Arctic) oceans and strongly suggests that the dominant marine influence during the Akchagylian was from the north, and not from the Black Sea or Mediterranean (Richards et al, in review). During the remainder of the Pleistocene, the Caspian Sea has undergone several major (and many more minor) phases of transgression and regression. Each of the major transgressions is associated with a distinct ostracod and palynological signal. The Early Pleistocene, early Apsheronian transgression is characterised by dinocysts of 'Pannonian' affinity, with varied morphotypes of '*Pontiadinium*', *Impagidinium* and *Chytroeisphaeridia* present. The late Apsheronian typically contains increased numbers of *Caspidinium rugosum*. In the Middle Pleistocene, the Bakunian regional stage is marked by a major increase in frequency and morphological variety of *Spiniferites cruciformis*. The 'cross-shaped' morphology and varied ornament are probably adaptations to allow buoyancy at differing water depths and salinities (Mudie et al., in press). The Khazarian regional stage (Middle to Late Pleistocene) sees the first significant presence of

Pterocysta cruciformis, a dinocyst that was until recently only known from the Black Sea (Rochon et al., 2002). It occurs frequently in the Late Pleistocene and Holocene of the northern Caspian Sea. Assemblages of this age further south tend to contain varied representations of *Impagidinium caspienense*, *Caspidinium rugosum* and *Spiniferites cruciformis*, among others. These taxa persist to the present-day in the Caspian Sea with variations in relative abundances occurring in response to changes in Caspian Sea level, salinity, temperature and nutrient availability.

Keywords: Caspian Sea, dinoflagellate cysts, dinocysts, Azerbaijan, Paratethys, Maykopian, Sarmatian, Pannonian, Pontian, Oligocene, Miocene, Pliocene, Pleistocene, Holocene

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Earliest Permian palynology from the Muse excavation, Autun Basin, France, in relation to the palaeobotanical record

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Palynological material has been investigated from bituminous shales of the palaeontologically investigated Muse sections near Autun in Burgundy, France. Although there have been earlier palynological studies focussing on the composition and the age of the Autunian strata in the basin, the present study was mainly carried out considering the following subjects:

Too little is still known about earliest Permian palynology and its assemblage elements to create reliably palynozones for wider geographical use. Recently, radiometric datings of the Muse section were made available by French colleagues. These reveal Asselian chronostratigraphic ages, and consequently give precise ages for the palynological record of the Muse sections.

Remains of plant fossils, mostly foliage compressions, were sampled along the palynologically investigated Muse sections. The quantitative and qualitative macrofloral analysis provides information about the individual vegetational and depositional patterns. The data serve as a basis for identifications and comparisons regarding the main and additional components within the palynological record, and allow more detailed taxonomic and ecological interpretations.

Overall, the palynological assemblages are dominated partly by small monolete and trilete spores from the Marattiales (Filicopsida, ferns) (including some unknown spore forms), and typically by larger monolete pollen, mainly produced by *Cordaites* (dispersed as *Florinites* species).

Such relatively monotonous palynological assemblages are difficult to handle in terms of stratigraphy (e.g. for correlation purposes), furthermore, some of the macrofloral elements are partly reminiscent of Stephanian (late Carboniferous) assemblages. For new insights and a progress in early Permian biostratigraphy, the main features of the palynological record from the Asselian Muse section are depicted and discussed.

Keywords: Permian, palynology, Asselian, Autunian, radiometric dating, macroflora, Marattiales, fern spores, *Cordaites*, monolete pollen, stratigraphy

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New dinoflagellate cysts from the Danian of the Ormen Lange Field (Norway)

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The Ormen Lange field is located in the Møre Basin, Norwegian Continental Shelf. The reservoir interval comprises deep marine turbidite deposits of Late Cretaceous (Maastrichtian) to Early Paleocene (Danian) age. Across the Ormen Lange field, high-resolution palynological studies been performed, targeting the intra-reservoir shales and siltstones. These studies revealed diverse dinoflagellate cyst assemblages, allowing the establishment of a finely detailed biostratigraphic zonation for the field.

In addition, a high-resolution palynological study of a recently acquired core from the southern part of the field, over the Danian reservoir interval, allowed the opportunity to formally describe the occurrence of some dinoflagellate cysts previously left in open nomenclature and other species recognised for the first time in this well. The new species are *Achomosphaera eggadania* sp. nov., *Achomosphaera progranulata* sp. nov., *Areoligera constricta* sp. nov., *Areoligera pauciornata* sp. nov., *Deflandrea variabilis* sp. nov., *Eurydinium ovatum* sp. nov., *Glaphyrocysta pseudoreticulata* sp. nov., *Hystrichosphaeridium pachydermum* sp. nov., *Operculodinium runtata* sp. nov. and *Phthanoperidinium ormenlangei* sp. nov.

During this study, all the key diagnostic and morphological features of each species have been discussed and compared with other previously published known taxa.

All the new types range within the Danian and can be used in conjunction with other previously published age diagnostic marker species to support and enhance the stratigraphic breakdown and subdivision of the reservoir interval across the Ormen Lange field, and potentially complement further subdivision across coeval sediments within the North Sea basin.

Keywords: Danian, biostratigraphy, palynology, dinoflagellate cysts

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Integration of acritarch morphological analyses with organic carbon isotope chemostratigraphy in the Kallholn section (early Silurian, central Sweden): complementary evidence for sequence stratigraphy

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The early Silurian is widely recognised by global sea-level fluctuations resulting from the advances and retreats of Gondwanan ice-sheets. The focus of this research is to examine how these environmental changes influenced the diversity of macro- and microplankton of the Siljan Ring area, central Sweden. The Siljan Ring area has been subjected to numerous studies due to its hydrocarbon potential and associated economic value.

Graptolite biostratigraphy has dated the 14.95 m Kallholn section to the upper Aeronian (beginning in the *leptotheca* Biozone) through to the early Telychian (*crispus* Biozone). Organic carbon isotope excursions present within the section have been dated through integrated graptolite and conodont biostratigraphy. A new carbon isotope excursion in the *turriculatus* Biozone (lower Telychian) is identified, which may be associated with the onset of the Valgu Event, a global conodont extinction event.

Morphological characteristics of palynological assemblages are applied as proxies for identifying Silurian eustatic relative sea-level changes in the Siljan Ring area. Exceptionally well-preserved palynomorphs from both shale and nodule samples were extracted by processing using the standard HCl-HF-HCl palynological method. Regression and transgression trends are interpreted through the study of the acritarchs' vesicle, number of processes, process bifurcation, and length. The relationship of palynological and geochemical data correlates well with the interpretations suggested by sequence stratigraphy, and is suggested to be related to changes in the depositional environment.

Keywords: Silurian, biostratigraphy, palynology, acritarchs

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Palynological record of changing environments across the Triassic-Jurassic boundary interval in Northern Ireland

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The Triassic-Jurassic boundary is a globally important transition that has been under-studied in Northern Irish sections. Using material from a completely-cored record of the late Triassic to earliest Jurassic interval, this project aims to provide both a biostratigraphic and palaeoenvironmental context for the section in the Carnduff-1 Borehole near Larne. The assemblages from Carnduff-1 are quite well-preserved and diverse, but dominated by *Classopollis* type palynomorphs and a variety of bisaccate pollen. Dinoflagellate cyst abundance varies through the section, but diversity is low. The palaeoenvironmental interpretation will be achieved using both quantitative statistical methods, as well as semi-quantative palynofacies approaches.

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Palynofacies of an end-Permian Marker Mudstone in the Galilee Basin, Australia

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The Permo-Triassic Boundary in terrestrial deposits remains difficult to study around the world. In eastern Australia, recent progress has been made in the use of high-resolution zircon dates and the recalibration of the regional Permian biostratigraphic scheme. This has also revealed the need for other techniques to be used in interbasinal correlation and palaeoenvironmental reconstruction. One such tool is palynofacies analysis, which can provide insight into palaeoenvironmental conditions present during end-Permian times.

In parts of the Bowen and Galilee basins, an organic-rich Marker Mudstone is present above the last coals deposited in the Permian. Above this mudstone lie the coal-free sandstones of the Triassic Rewan Formation. Thusly, this Marker Mudstone may potentially record the palaeoenvironmental conditions present during the Permo-Triassic transition in Australia. Five samples were obtained from the Marker Mudstone in the Tambo 1-1A well in the Galilee Basin. These samples were processed for biostratigraphic assessment and palynofacies analysis.

The palynofacies data show a switch from a translucent phytoclast-dominated assemblage at the base of the Marker Mudstone to an opaque phytoclast-dominated assemblage at the top. This trend is the opposite of palynofacies shifts observed in similar age strata in western Australia, and may be indicative of an extreme shift in the redox conditions of the lake in which the mudstone was deposited rather than reflecting a continent-wide or global event. The palynological assemblage within the Marker Mudstone is consistent with other end-Permian assemblages found in eastern Australia, though no index taxa have yet been identified, which prevents an accurate age assignment. Though very rare in abundance, some specimens of *Micrhystridium* acritarchs have been identified within the mudstone. No freshwater algae have been observed. This may be due to preservation biases or extreme environmental conditions but it remains difficult to draw significant conclusions about the palaeoenvironment. Another rare component of the assemblage is *Reduviasporinites chalastus*, which has commonly been identified in other end-Permian assemblages in Australia, though its affinity to either fungal or algal groups remains questionable.

While only from a single locality, the palynofacies data suggest dynamic local environmental conditions. These conditions may be attributed not just to the shifting palaeoclimate but also to regional tectonics as base level rises in response to foreland loading. As more datasets are added to this one, the details about conditions present during the end-Permian in eastern Australia will become clearer.

Keywords: Palynology, Palynofacies, Galilee Basin, Late Permian, Permo-Triassic, Australia

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